



Interoceptive exposure exercises for social anxiety[☆]



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ABSTRACT

Individuals with social anxiety disorder (SAD) commonly experience panic attacks and evidence increased anxiety sensitivity (AS) specific to noticeable anxiety sensations. Interoceptive exposure (IE) is an effective treatment for reducing AS, but few IE tasks target fears of blushing, sweating, or trembling, which are incorporated within AS social concerns and especially feared by individuals with SAD. The primary study aims were trifold: (1) identify novel IE tasks that produce blushing, sweating, and/or trembling; (2) assess the intensity of sensations and anxiety produced by a series of novel and validated IE tasks; and (3) evaluate the incremental validity of combining an IE task and a speech task. Individuals ($N=55$) with heightened fear of noticeably blushing, sweating, and/or trembling completed a control task and 8 IE tasks (e.g., hot sauce, hyperventilation). All tasks produced greater intensity of anxiety and sensations compared to the control task ($ps < .001$; range of $\eta_p^2 = .20-.50$). Responses to the combination of an IE task and social task compared to a social task alone did not differ significantly. Future directions for research and clinical implications of the findings are discussed.

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1. Introduction

Defined as the fear of anxiety-related sensations based on their perceived harmful physical, social, and/or psychological consequences (Reiss & McNally, 1985), anxiety sensitivity (AS) is an important component in the development, maintenance and treatment of anxiety disorders (McNally, 2002; Olatunji & Wolitzky-Taylor, 2009; Taylor, 1999). Extensive research has established the connection between AS and panic disorder (McNally, 2002; Taylor, 1999). In addition, many individuals with social anxiety disorder (SAD) experience panic attacks (Jack, Heimberg, & Mennin, 1999; Potter et al., 2014b) and exhibit elevated AS specific to socially-relevant anxiety symptoms (Anderson & Hope, 2009; Kanai et al., 2009; Olatunji & Wolitzky-Taylor, 2009; Scott, Heimberg, & Jack, 2000; Taylor et al., 2007).

The social concerns dimension of AS refers to the fear of anxiety symptoms based on their perceived social consequences (e.g., negative evaluation from others due to noticeably trembling; Taylor et al., 2007) and is conceptualized as the integration of the fear of negative evaluation and AS (McWilliams, Stewart, & MacPherson, 2000). Several studies have shown that individuals with SAD have elevated AS social concerns (Deacon & Abramowitz, 2006; Taylor et al., 2007; Wheaton, Deacon, McGrath, Berman, & Abramowitz, 2012), and that social anxiety symptoms are uniquely predicted by AS social concerns (Carter, Sbrocco, & Avati, 2009; Olthuis, Watt, & Stewart, 2014; Thibodeau, Gomez-Perez, & Asmundson, 2012). For socially anxious individuals with high AS social concerns, the noticeability of the sensations may be explicitly feared (e.g., others will think I'm stupid when they see me blush), or the fear may be secondary to the social consequences of the sensations, such as trembling contributing to spilling a drink at a party (Roth, Antony, & Swinson, 2001). Consistent with cognitive-behavioral models of SAD (Clark & Wells, 1995; Hofmann, 2007; Rapee & Heimberg, 1997), these fears related to experiencing observable anxiety sensations may influence self-focused attention and overestimation of catastrophe in social situations (Kanai et al., 2009), which are posited to contribute to a vicious cycle of negative thoughts, behavioral avoidance, and increased anxiety sensations (Rapee & Heimberg, 1997; Roth & Heimberg, 2001).

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Interoceptive exposure (IE) is a powerful strategy for reducing AS (Boswell et al., 2013; Smits, Berry, Tart, & Powers, 2008; Smits, Powers, Cho, & Telch, 2004). IE involves repeated exposure to feared anxiety-related body sensations elicited by tasks like hyperventilation and chair spinning. This intervention produces substantial reductions in anxiety and threat beliefs related to previously feared sensations (Deacon et al., 2013; Smits et al., 2004). IE is considered an essential component in empirically supported cognitive behavioral treatments for panic disorder (Craske & Barlow, 2014) as well as a transdiagnostic cognitive behavioral treatment strategy for targeting AS (Boswell et al., 2013). Several investigations have demonstrated the efficacy of IE in the treatment of problems as diverse as post-traumatic stress disorder (Wald & Taylor, 2010), irritable bowel syndrome (Craske et al., 2011), and smoking cessation (Zvolensky, Yartz, Gregor, Gonzalez, & Bernstein, 2008). Yet, the utilization of IE in the treatment of SAD has not been empirically evaluated, and only one study has examined fear response to IE tasks among individuals with SAD (Collimore & Asmundson, 2014).

Collimore and Asmundson (2014) examined the intensity of anxiety and physical sensations in response to six standard IE exercises in a sample of individuals with SAD and nonclinical control participants. Individuals with SAD responded with significantly more intense anxiety and sensations compared to the nonclinical controls. This study also explored the influence of social context on response to IE exercises by comparing differences between individuals with SAD who completed the IE exercises in front of one person (i.e., experimenter) versus two persons (i.e., experimenter and observer). However, no significant between-group differences were found, which may have been attributable to the similarity of the contexts. As the first study to examine IE exercises in individuals with SAD, the results demonstrated that individuals with SAD respond more fearfully to IE exercises and suggest that IE may be a useful strategy in the treatment of SAD.

In Collimore and Asmundson's study (2014) as well as other IE evaluation studies (e.g., Schmidt & Trakowski, 2004), standard IE exercises have been evaluated, which are primarily associated with panic-related arousal connected to respiratory, cardiovascular, and dissociative fears (Lee et al., 2006). To optimally evaluate IE for SAD, an important consideration is that IE tasks should elicit observable sensations associated with AS social concerns and the symptoms that are relevant to individuals with SAD. Indeed, panic attacks in SAD are associated with intense visible sensations (e.g., sweating; Potter, Drabick, & Heimberg, 2014a), and blushing, sweating, and trembling are most commonly feared by individuals with SAD (Amies, Gelder, & Shaw, 1983; Bögels, 2006; Bögels et al., 2010; Bögels & Reith, 1999; Ginsburg, Riddle, & Davies, 2006; Scott et al., 2000). There are some IE tasks elicit these visible sensations; however, additional work is needed to thoroughly assess the sensations induced by IE tasks.

Current IE tasks have not targeted blushing, which is distinguished from flushing or hot flashes (see Leary, Britt, Cutlip, & Templeton, 1992). Consistent with panic attack criteria, "chills or hot flushes" are typically assessed in IE studies (Antony, Ledley, Liss, & Swinson, 2006b; Collimore & Asmundson, 2014), rather than "hot flushes" or the intensity of blushing. Additionally, only a few IE exercises have been identified that frequently elicit sweating or trembling/shaking in individuals (i.e., sensations experienced by >50% of individuals; Collimore & Asmundson, 2014; Schmidt & Trakowski, 2004). Muscle tension commonly elicits trembling and shaking (Collimore & Asmundson, 2014), and there is some evidence that running/jogging and spinning frequently elicit sweating (Collimore & Asmundson, 2014; but not Schmidt & Trakowski, 2004). Prior to initiating cost-intensive treatment studies to evaluate the value of augmenting SAD

treatments with IE, an important step is to more thoroughly examine and identify additional IE exercises that produce sensations specific to social anxiety, namely blushing, sweating, and trembling.

The purpose of the current study was to evaluate IE exercises for individuals who fear the negative social consequences of blushing, sweating, and/or trembling, given the prominence of these sensations in individuals with SAD (Amies et al., 1983; Bögels, 2006; Bögels et al., 2010; Bögels & Reith, 1999; Ginsburg et al., 2006). To this end, the first objective was to identify novel and previously validated IE tasks to elicit blushing, sweating, and/or trembling. The second objective was to comprehensively evaluate subjective responses to the IE tasks. To achieve this, the frequency and intensity of blushing, sweating, and trembling sensations experienced by individuals with concerns about blushing, sweating, and/or trembling were assessed. It was hypothesized that the eight IE tasks (described below) would produce significantly greater anxiety and intensity of sensations compared to a control task. Finally, similar to Collimore and Asmundson's evaluation of IE responses depending on the social context, this study examined the additive value of combining an IE exercise with a social task (i.e., a speech task). To test this objective, participants completed an IE task combined with the social task or the social task only. It was hypothesized that participants in the combined IE and social task condition would evidence greater anxiety and sensation intensity compared to ratings for the social task only condition.

2. Method

2.1. Participants

College students ($N=956$) completed the Anxiety Sensitivity Index-3 (ASI-3) in a psychology pre-screen assessment. Students ($n=181$) who specifically endorsed "much" or "very much" fear of blushing, sweating, or trembling in social situations on corresponding ASI-3 items were eligible for the study. Prior to enrolling in the study, students were informed of the exclusion criteria, which included history of seizures, hypertension, diabetes, heart problems, or asthma, current pregnancy, or other medical diagnosis that could be exacerbated by exercise. Fifty-eight students enrolled in the current study. It was later discovered that three participants did not meet the ASI-3 eligibility criteria; their data were omitted. The final sample ($N=55$) was predominantly female (65.5%), White (94.5%), and the mean age was 20.35 ($SD=4.34$). The ethnic and racial diversity of the sample was limited and comprised of individuals who identified as Hispanic or Latino/a (3.6%), Asian (3.6%), and Native Hawaiian or Other Pacific Islander (1.8%).

Most participants (81.8%) reported they were not currently taking medication for mental health problems, and the remainder of participants indicated their psychiatric medication was stabilized (i.e., consistent daily dosage at prescribed time, no medication changes in the last month). The following medications were reported by these participants (18.2%; $n=10$): selective serotonin reuptake inhibitors ($n=6$), stimulants ($n=2$), serotonin-norepinephrine reuptake inhibitors ($n=1$), and combined benzodiazepines and serotonin-norepinephrine reuptake inhibitors ($n=1$). In addition, a small portion of participants (18.2%; $n=10$) indicated they were currently in psychotherapy or counseling; however, treatment history was not assessed. Of the participants currently in treatment, three participants reported they were in treatment for depression, and the remaining participants ($n=7$) did not report the nature of their treatment.

2.2. Experimental design

The first part of the study utilized a repeated-measures design. All participants completed the control task and eight IE tasks in a randomized order. Post-exercise ratings were completed after each task to assess anxiety, the perceived similarity of the sensations, and the intensity of sensations. After completion of all the tasks, participants identified the most personally relevant IE task. For the second part of the study, a between-group design was implemented and participants were randomized to complete either (a) a 3-min speech task ($n=28$) or (b) the identified most personally relevant IE task and a 3-min speech task ($n=27$). All procedures were approved by the university's Institutional Review Board.

2.3. Measures

2.3.1. Anxiety Sensitivity Index-3 (ASI-3)

The ASI-3 (Taylor et al., 2007) measures fear of anxious arousal on a 5-point scale (0 = *very little* to 4 = *very much*) scale. In this study, the ASI-3 was completed during the initial psychology pre-screen. This 18 item questionnaire measures physical concerns (e.g., “It scares me when my heart beats rapidly”), cognitive concerns (e.g., “When my thoughts seem to speed up, I worry that I might be going crazy”), and social concerns (e.g., “I worry that other people will notice my anxiety”). Importantly, the social concerns subscale includes items related to blushing (i.e., “It scares me when I blush in front of other people”), sweating (i.e., “When I begin to sweat in a social situation, I fear people will think negatively of me”), and trembling (i.e., “When I tremble in the presence of others, I fear what people might think of me”). Each subscale has been shown to possess good internal consistency in past research (Taylor et al., 2007). Additionally, the ASI-3 has been shown to have excellent convergent, discriminant, and criterion-related validity (Taylor et al., 2007). The ASI-3 total and subscale scores were computed by summing the relevant itemized responses (i.e., all items, social concerns items). In the present study, good internal consistency was demonstrated for the ASI-3 total ($\alpha = .88$), the physical concerns subscale ($\alpha = .84$), and the cognitive concerns subscale ($\alpha = .86$). The social concerns subscale had relatively low reliability in the current study ($\alpha = .62$).¹

2.3.2. Social Phobia Inventory (SPIN)

The SPIN (Connor et al., 2000) is a measure utilized for social anxiety screening and treatment response. The SPIN consists of 17 items that evaluate range and severity of social anxiety symptoms including fear (e.g., people in authority, parties and social events), avoidance (e.g., parties, being center of attention), and physiological arousal (e.g., distressed by trembling or shaking, bothered by blushing) on a 0 (*not at all*) to 4 (*extremely*) scale. The clinical cut-off for this measure is a score of 19, which identifies clinical SAD with 84.3% specificity and 72.5% sensitivity. The SPIN has demonstrated good internal consistency, test-retest reliability, and convergent validity in previous research (Antony, Coons, McCabe, Ashbaugh, & Swinson, 2006a). In this study, SPIN internal consistency was excellent ($\alpha = .91$).

2.3.3. Post-exercise questions

For each study task, participants provided ratings of peak anxiety on an 11-point scale (0 = *none* to 10 = *extreme*) and the

similarity of the sensations produced by the IE task to the specific sensations they fear in a social situation (0 = *not at all similar* to 10 = *extremely similar*). This questionnaire also assessed the intensity of 21 sensations on an 11-point scale (0 = *not at all* to 10 = *extremely strong*). The list included specific blushing, sweating, and trembling sensations reported by individuals with SAD (Bögels & Reith, 1999) as well as other panic-related sensations identified by the *Diagnostic and Statistical Manual for Mental Disorders, 4th Edition* (American Psychiatric Association, 1994). Specifically, four items assessed intensity of sensations related to blushing (e.g., general blushing, face feels warm), four items assessed sweating (e.g., sweating in the hands, sweating in the face), five items assessed trembling sensations (e.g., trembling in arms, trembling in legs), and the remaining eight items were related to other panic symptoms (e.g., breathlessness, heart palpitations, dizziness). This study examined the frequency of the itemized sensations, and a composite score was used to examine the over intensity of each sensation category. Composite scores for blushing, sweating, trembling, and other panic symptoms were generated by averaging the relevant items for each task. In the current study, the range of internal consistency was adequate to excellent across IE tasks for the subscales of blushing ($\alpha = .69-.92$), sweating ($\alpha = .82-.92$), trembling ($\alpha = .71-.90$), and other panic ($\alpha = .60-.87$).

2.4. Selection of exercises

Previous investigations evaluated the descriptive properties of IE exercises in individuals with panic disorder, SAD, and high AS and reported the intensity of sensations, anxiety, and similarity of the sensations (Antony et al., 2006b; Collimore & Asmundson, 2014; Lickel, Nelson, Lickel, & Deacon, 2008; Schmidt & Trakowski, 2004). These investigations,² treatment manuals for social anxiety and panic, and the authors' clinical experiences were utilized to identify potential tasks that would elicit blushing, sweating, and/or trembling for the current study. To increase clinical applicability, easily implementable tasks were selected that involved minimal, inexpensive materials. The final list of tasks (described below) largely relied on IE exercises reported to elicit “flushes or chills”, sweating, or trembling and IE tasks recommended for socially anxious individuals in Antony and Swinson's *Shyness and Social Anxiety Workbook* (2008; e.g., placing heat near one's face). Previously validated IE tasks included push-ups, hyperventilation, running, and head between legs (Antony et al., 2006b; Collimore & Asmundson, 2014; Lickel et al., 2008; Schmidt & Trakowski, 2004). The heat on face, hot sauce, hot drink, and weights tasks were novel tasks identified through research and clinical recommendations (e.g., Antony & Swinson, 2008; Schmidt & Trakowski, 2004).

2.5. Description of exercises

2.5.1. Slow breathing (control task)

As per Antony et al. (2006b), participants were instructed to breathe slowly and at a comfortable pace for 1 min.

2.5.2. Push-ups

Participants were asked to complete as many continuous standard push-ups as possible. If participants were unable to complete a standard push-up, they were asked to remain in the “up” position for as long as they were able or they completed push-ups with knees on the ground. Previously, this exercise produced sweating

¹ The screening procedure may contributed to the low observed alpha for the social concerns subscale by affecting the variance and reliability of participant responding to the other items on the subscale.

² Collimore and Asmundson's report (2014) was published after the initiation of the current study and was not available as a resource when the exercises were selected.

and shaking in some individuals with panic disorder (Schmidt & Trakowski, 2004). This task is similar to the muscle tension task, which has elicited trembling/shaking (Antony et al., 2006b; Collimore & Asmundson, 2014).

2.5.3. Hyperventilation

Participants were asked to breathe deeply and rapidly through their mouth for 2 min. They followed an audio recording that repeated the words “in” and “out” at a rate of 3 breaths per 4 s. Hyperventilation is one of the most intense IE exercises and produces sensations like hot flashes, sweating, and trembling/shaking (Antony et al., 2006b; Collimore & Asmundson, 2014; Schmidt & Trakowski, 2004).

2.5.4. Heat on face

Antony et al. (2006b) found that sitting near a heater for 2 min elicited sweating and hot flushes/chills. To increase the task's adaptability, a homemade rice sock was utilized to create a heat pack. The rice sock was heated in a microwave for 90 s, and then participants placed the heat pack across their face and onto their cheeks for 2 min.

2.5.5. Hot sauce

Spicy foods are known to elicit flushing and sweating (Allison & Work, 2004; Culp & Scheinfeld, 2009). Participants were asked to consume one teaspoon of hot sauce (i.e., Tabasco sauce) within thirty seconds and to allow the sensations to “kick in.” At the beginning of the study, participants were screened for acid reflux problems and food allergies (i.e., red pepper, vinegar, salt); one participant did not complete this task due to allergies. After completing the post-exercise ratings, participants were offered water and crackers in order to relieve any sensations.

2.5.6. Hot drink

Participants were asked to drink six ounces of hot water as quickly as possible and within 2 min. Participants were instructed to not blow on the beverage to cool it. For this task, the water was heated to approximately 140 °F ($\pm 4^\circ$) in an electric tea kettle with a thermometer. The temperature was previously identified as an “ideal” temperature for serving hot drinks and preventing scalding (Brown & Diller, 2008). Antony and Swinson (2008) recommended consumption of hot drinks to elicit sweating, blushing, and hot flushes.

2.5.7. Running

Participants were asked to vigorously run in place with high knees for 1 min. Schmidt and Trakowski (2004) reported that sweating, shaking/trembling, and hot flashes were experienced by a small number of individuals in their sample (2%). Individuals with SAD commonly experienced sweating (70%) and trembling/shaking (43%) in response to this task (Collimore & Asmundson, 2014).

2.5.8. Head between legs

Participants were asked to stand up with legs apart, lean over, put their head between their legs for 30 s, and then quickly stand upright. This task produced some trembling/shaking (Schmidt & Trakowski, 2004) and in clinical practice, this task elicited some facial flushing.

2.5.9. Weights

For this task, participants placed their arms out to their sides (i.e., in a “T” position), and with their palm facing “up,” they held a 5-pound book in each hand for as long as they were able. This task is similar to an exercise (i.e., hold weights) recommended to produce trembling and shaking in the upper body (Antony &

Swinson, 2008) and to the muscle tension exercise found to produce shaking/trembling (Antony et al., 2006b; Collimore & Asmundson, 2014). For this study, two copies of the paperback version of the *Diagnostic and Statistical Manual, 4th Ed. – Text Revision* (APA, 2000) were utilized.

2.6. Procedure

Eligible individuals were invited to participate in the current study via an e-mail that included the study description, instructions for signing up for a timeslot, and a request for participants not to engage in intense physical activity prior to their study timeslot. Upon entry to the laboratory, the experimenter provided participants with a description of the study and screened for exclusionary criteria. Graduate students extensively trained in the delivery of IE for anxiety disorders served as study experimenters. Informed consent was obtained from all participants.

After completing baseline measures, participants engaged in the nine study tasks. The order of the tasks for each participant was determined a priori by a computer randomizer (www.random.org). Participants were instructed to engage in each task for the full duration, to pay close attention to the sensations, and not to avoid or suppress the sensations. Additionally, for standardization purposes, participants were asked to maintain the same clothing layers throughout the tasks (e.g., sweatshirt, scarf). The experimenter provided instructions for each task, demonstrated certain tasks (e.g., push-ups, running, weights), and then the tasks were completed by the participant in the presence of the experimenter. Between each task, participants completed the post-exercise questions and a minimum 1-min break was provided to allow for symptom reduction and eliminate carryover effects from the previous task. Participants did not continue to the next task until their sensations had resumed to resting level.

After completion of all nine tasks, participants identified the IE exercise that produced the reaction most similar to their response in social situations. Specifically, participants were asked, “Of all 9 tasks, which task produced the response (i.e., sensations, anxiety) most similar to what you fear experiencing during social situations?” If this task was different from the task that participants rated the highest for similarity or anxiety, the experimenter posed a follow up question. In most cases, the participants either identified the IE task that was consistent with the highest anxiety or similarity ratings or broke a tie between two highly rated IE tasks. Next, participants were randomized a priori by a computer randomizer (www.random.org) to either the speech task only condition or the combined IE and speech task condition. All study procedures for the speech task were the same, except participants assigned to the combined IE and speech task condition completed the IE task they identified as most personally relevant immediately before delivering the speech.

The speech task procedures were described to the participants. Participants had 3 min to choose a speech topic and prepare the speech. At the end of the 3-min preparation period, participants directly delivered the speech or engaged in the IE task and immediately delivered the speech. The 3-min speech was delivered in an adjoining room to an audience comprised of the experimenter and two research assistants. The audience was instructed to respond to the speech in a neutral, expressionless manner in order to standardize nonverbal feedback. After the speech, participants completed the Post-exercise Questions. The study concluded with a full debriefing of the study procedures, and a list of resources was provided for participants interested in pursuing treatment for social anxiety. Upon completion of the study, participants received \$5.00 and course credit.

Table 1
Descriptive data for self-report measures.

	<i>M</i> (<i>SD</i>) Total (<i>N</i> =55)	<i>M</i> (<i>SD</i>) Speech only (<i>n</i> =28)	<i>M</i> (<i>SD</i>) Combined (<i>n</i> =27)	<i>t</i> (53)	<i>p</i>
ASI-3	24.09 (11.46)	24.39 (11.64)	23.78 (11.48)	.20	.84
ASI-3 social	13.87 (4.28)	14.18 (4.23)	13.56 (4.40)	.54	.59
ASI-3 physical	4.65 (4.43)	4.82 (4.21)	4.48 (4.73)	.28	.78
ASI-3 cognitive	5.56 (5.15)	5.39 (4.91)	5.74 (5.47)	-.25	.81
SPIN	28.91 (13.00)	27.50 (12.38)	30.37 (13.70)	-.82	.42

Note: ASI-3 = Anxiety Sensitivity Index – 3; ASI-3 social = ASI-3 social concerns subscale; ASI-3 physical = ASI-3 physical concerns subscale; ASI-3 cognitive = ASI-3 cognitive concerns subscale; SPIN = Social Phobia Inventory; Speech only = speech task only condition; Combined = combined IE and speech task condition.

3. Results

3.1. Baseline analyses

Means and standard deviations for the self-report measures are presented in Table 1. On the SPIN, most participants (76.4%) scored at or above the recommended clinical cut-off of 19 ($M=28.91$, $SD=13.00$). Similarly, the mean ASI-3 social concerns subscale score in this sample ($M=13.87$, $SD=4.28$) was comparable to previous means found for individuals with SAD (e.g., $M=14.08$, $SD=5.13$, Collimore & Asmundson, 2014; $M=15.21$, $SD=5.84$, Wheaton et al., 2012). In this sample, social concerns about sweating (69.1%) were the most common, followed by trembling (50.9%) and blushing (16.4%).

A series of *t*-tests were conducted to examine whether psychiatric medication status or psychotherapy status influenced responses to the IE and speech tasks. Analyses indicated non-significant differences ($ps>.05$) for 119 of the 120 tests (i.e., 2 between-group variables, 10 within-subjects tasks, 6 dependent variables). Individuals who were currently taking psychiatric medication reported significantly more trembling in response to the hot sauce task compared to individuals who were not taking psychiatric medication, $t(52)=-2.35$, $p=.02$ ($M=2.76$, $SD=3.21$; $M=1.26$, $SD=1.37$, respectively). Medication status was not ultimately included as a covariate in subsequent analyses given that the findings largely suggested non-significant findings at the non-corrected alpha level.

Finally, to confirm that the experimental groups for the speech task were comparable, a series of *t*-tests were conducted examining between-group differences on demographic variables and baseline measures (see Table 1). Participants in each condition did not differ significantly with respect to age, $t(53)=1.13$, $p=.27$, or sex, $\chi^2(1)=0.15$, $p=.70$ and *t*-tests of differences in ASI-3 and SPIN

scores were non-significant (all $ps>.40$), indicating that the randomization procedure was successful.

3.2. Response to interoceptive exposure tasks

Descriptive information for peak anxiety, similarity of the task to sensations feared in social situations, and intensity of sensations (i.e., blushing, sweating, trembling, and other panic symptoms composite scores) is reported in Table 2. A full range (0–10) of reported intensity of sensations, anxiety, and similarity was observed for the majority of IE tasks. Consistent with previous studies (e.g., Antony et al., 2006b; Collimore & Asmundson, 2014; Schmidt & Trakowski, 2004) and in order to assist clinicians in identifying exercises likely to produce feared sensations, Table 3 presents the most frequently experienced sensations. Only the top eight sensations for each task are displayed due to space considerations.

After completion of all 9 IE tasks, participants identified the task that was most similar to the anxiety reactions they feared experiencing in social situations (see Table 2). Hyperventilation was the most commonly identified task (25.5%), followed by running (16.4%), hot sauce (14.5%), heat on face (12.7%), and push-ups (12.7%).

3.3. Within-subjects response to interoceptive exposure tasks

To examine the differences for each outcome variable across the IE tasks in the repeated-measures design, a series of repeated measures analyses of variance (rANOVAs) were conducted with IE task as the within-subjects factor. The multivariate tests were significant ($ps<.001$). The univariate statistic was interpreted for each outcome variable due to the interest in examining the differences for each dependent variable across the IE tasks. Mauchley's

Table 2
Response to IE tasks.

Task	Intensity of anxiety <i>M</i> (<i>SD</i>)	Similarity of sensations <i>M</i> (<i>SD</i>)	Blushing <i>M</i> (<i>SD</i>)	Sweating <i>M</i> (<i>SD</i>)	Trembling <i>M</i> (<i>SD</i>)	Other panic <i>M</i> (<i>SD</i>)	Identified as most similar task (% of 55)
Head between legs	2.03 (1.89)	2.64 (2.26)	2.33 (1.99)	1.22 (1.61)	1.09 (1.65)	1.55 (1.27)	1.8
Slow breathing	.78 (1.36)	1.51 (2.27)	.26 (.56)	.57 (.99)	.33 (.62)	.25 (.62)	3.6
Weights	3.11 (2.43)	3.64 (2.66)	2.37 (2.41)	3.30 (2.69)	3.30 (1.85)	1.09 (1.37)	5.5
Hot drink	3.56 (2.57)	3.70 (2.56)	3.61 (2.71)	2.65 (2.43)	.88 (1.42)	.94 (1.15)	7.3
Push-ups	3.91 (2.72)	4.49 (2.47)	3.95 (2.55)	4.10 (2.83)	3.88 (2.36)	2.09 (1.90)	12.7
Heat on face	2.96 (2.33)	3.56 (2.51)	4.80 (2.14)	3.78 (2.47)	1.06 (1.60)	.50 (.74)	12.7
Hot sauce ^a	4.69 (2.95)	3.91 (2.54)	4.89 (2.60)	3.56 (2.54)	1.54 (1.90)	1.95 (1.83)	14.5
Running	4.27 (2.51)	4.62 (2.56)	3.86 (2.38)	3.92 (2.52)	2.22 (2.17)	2.35 (1.93)	16.4
Hyperventilation ^a	4.54 (2.57)	4.78 (2.80)	2.12 (2.29)	2.26 (2.36)	1.66 (2.07)	3.39 (2.00)	25.5
Speech task only	7.67 (2.50)	7.83 (2.60)	4.66 (2.80)	4.24 (2.86)	3.88 (2.25)	1.38 (1.32)	–
Combined speech	6.42 (2.96)	7.11 (2.88)	4.09 (3.18)	4.59 (2.99)	3.94 (2.70)	2.30 (2.25)	–

Note: Slow breathing was the control task. Similarity of sensations = participants rated the similarity of sensations experienced during the task to the sensations they feared experiencing during a social interaction; blushing, sweating, trembling, and panic means are composite scores based on the calculated mean for the associated symptoms; means and standard deviations for intensity of anxiety, similarity of sensations, blushing, sweating, trembling, and other panic sensations are based on ratings ranging from 0 (none or not at all) to 10 (extreme or extremely strong).

^a $n=54$.

Table 3
Most frequent sensations elicited by IE tasks.

IE task, sensations	Frequency of sensations (%)	IE task, sensations	Frequency of sensations (%)
Push-ups		Hot drink	
Trembling hands	96.4	Face feels warm	90.9
Face feels warm	87.3	Sweating (general)	80.0
Sweating	87.3	Blushing	67.3
Breathless	83.3	Flushing	64.8
Trembling legs	76.4	Sweating – face	63.6
Blushing	72.7	Ears feel hot	61.8
Heart palpitations	72.7	Sweating – armpits	60.0
Faintness	47.3	Sweating – hands	52.7
Hyperventilation^a		Running	
Breathless	92.6	Breathless	96.4
Dizziness	90.7	Face feels warm	90.9
Faintness	87.0	Sweating (general)	90.9
Heart palpitations	72.2	Sweating – armpits	87.3
Face feels warm	70.4	Flushing	76.4
Trembling	68.5	Heart palpitations	74.5
Sweating	68.5	Blushing	72.7
Blushing	63.0	Sweating – face	70.9
Heat on face		Head between legs	
Face feels warm	94.5	Dizziness	83.6
Sweating (general)	87.3	Faintness	78.2
Sweating – face	85.5	Face feels warm	72.7
Blushing	81.8	Flushing	65.5
Flushing	80.0	Blushing	54.5
Sweating – hands	74.5	Ears feel hot	54.5
Ears feel hot	63.6	Trembling	47.3
Sweating – armpits	52.7	Sweating – armpits	47.3
Trembling hands	40.0	Breathless	47.3
Hot sauce^a		Weights	
Face feels warm	96.3	Trembling hands	96.4
Ears feel hot	83.3	Trembling	92.7
Sweating (general)	79.6	Sweating	81.8
Sweating – face	77.8	Sweating – hands	74.5
Sweating – armpits	71.7	Face feels warm	72.7
Blushing	70.4	Sweating – armpits	72.7
Flushing	70.4	Blushing	60.0
Sweating – hands	68.5	Sweating – face	60.0

^a $n = 54$.

test indicated that the assumption of sphericity was violated for each rANOVA; therefore, degrees of freedom were estimated with the conservative Greenhouse–Geisser correction. Simple contrasts were conducted to compare the control task to the IE tasks. Finally, all possible comparisons among IE tasks and outcome variables were examined utilizing Fisher's least significant difference (LSD) post hoc pairwise comparisons tests. A Bonferroni correction was utilized to control the familywise error rate given the number of post hoc tests. Specifically, 36 pairwise comparisons were conducted for the six outcome variables, resulting in 222 comparisons. Consequently, the alpha level was set at .0002 ($\alpha = .05/222$) to identify significant differences for the LSD post hoc tests. Only the pairwise comparisons yielding significant differences between tasks are reported.

3.3.1. Peak anxiety

A significant omnibus effect was found for differences in peak anxiety related to IE tasks, $F(6.00, 311.92) = 23.93, p < .001, \eta_p^2 = .32$. Within-subjects simple contrasts revealed that the eight IE tasks each produced significantly more anxiety than the control task ($ps < .001$, range of $\eta_p^2 = .33-.70$). Of the 36 post hoc Fisher's LSD pairwise comparison tests, 16 comparisons yielded significant differences between tasks ($p < .0002$), including the control task comparisons. The heat on hot drink, push-ups, running, hyperventilation, and hot sauce tasks produced significantly more intense anxiety than the head between legs task. The running and hyperventilation tasks produced significantly more intense anxiety than

the heat on face task. Finally, the hyperventilation task also produced greater anxiety than the weights task.

3.3.2. Similarity

A significant omnibus effect for differences in reported similarity of the IE tasks to natural social anxiety was found, $F(6.49, 337.57) = 12.75, p < .001, \eta_p^2 = .20$. Within-subjects simple contrasts revealed the eight IE tasks were rated as significantly more similar to natural anxiety in social situations compared to the control task ($ps \leq .01$, range of $\eta_p^2 = .14-.49$). Of the 36 post hoc Fisher's LSD pairwise comparison tests, 10 comparisons yielded significant differences between tasks ($p < .0002$). The Bonferroni corrected post hoc tests revealed that the heat on face, hot drink, hot sauce, hyperventilation, running, weights, and push-ups tasks produced greater similarity of sensations than the control task. Additionally, the push-ups, running, and hyperventilation tasks resulted in significantly greater similarity of sensations compared to the head between legs task.

3.3.3. Blushing

A significant omnibus effect for differences in blushing intensity produced by the IE task was obtained, $F(6.22, 323.25) = 40.50, p < .001, \eta_p^2 = .44$. Within-subjects simple contrasts revealed that the IE tasks all produced significantly more intense blushing than the control task ($ps < .001$, range of $\eta_p^2 = .41-.83$). Of the 36 post hoc Fisher's LSD pairwise comparison tests, 21 tests yielded significant differences between tasks ($p < .0002$), including the control task

comparisons. Specifically, the hot drink, running, push-ups, heat on face, and hot sauce tasks produced significantly greater intensity of blushing than hyperventilation. Additionally, the running, push-ups, heat on face, and hot sauce tasks produced significantly greater blushing sensations compared to the head between legs and weights tasks ($ps < .05$).

3.3.4. Sweating

A significant omnibus effect was found for differences in sweating intensity related to IE task, $F(5.65, 293.97) = 28.55$, $p < .001$, $\eta_p^2 = .35$. Within-subjects simple contrasts revealed that the eight IE tasks all produced significantly more intense sweating than the control task ($ps \leq .001$, range of $\eta_p^2 = .18-.68$). Of the 36 post hoc Fisher's LSD pairwise comparison tests, 15 tests yielded significant differences between the tasks ($p < .0002$). The Bonferroni corrected post hoc tests revealed that the heat on face, hot drink, hot sauce, hyperventilation, running, weights, and push-ups tasks elicited significantly greater sweating than the control task. The weights, hot sauce, heat on face, running, and push-ups tasks produced significantly greater sweating sensations than the head between legs task. Additionally, the heat on face, running, and push-ups tasks produced greater sweating sensations than the hyperventilation task.

3.3.5. Trembling

A significant omnibus effect was found for differences in trembling intensity related to IE task, $F(5.87, 305.38) = 40.86$, $p < .001$, $\eta_p^2 = .44$. Within-subjects simple contrasts revealed all IE tasks produced significantly more intense trembling than the control task ($ps < .001$, range of $\eta_p^2 = .14-.75$). Of the 36 post hoc Fisher's LSD pairwise comparisons, 22 tests yielded significant differences between tasks ($p < .0002$). The Bonferroni corrected post hoc tests revealed that the heat on face, hot sauce, hyperventilation, running, weights, and push-ups tasks elicited significantly greater trembling than the control task. Additionally, the running, weights, and push-ups tasks evoked greater trembling sensations than the hot drink task than the hot drink, heat on face, and head between legs tasks. Finally, the weights and push-ups tasks also elicited greater trembling sensations than the hot sauce, hyperventilation and running tasks.

3.3.6. Other panic

A significant omnibus effect was found for IE task differences in the intensity of other panic symptoms, $F(4.24, 220.34) = 47.96$, $p < .001$, $\eta_p^2 = .48$. Within-subjects simple contrasts revealed that all IE tasks produced significantly more intense panic symptoms than the control task ($ps < .01$, range of $\eta_p^2 = .15-.74$). Of the 36 post hoc Fisher's LSD pairwise comparisons, 26 tests yielded significant differences between tasks ($p < .0002$). The Bonferroni corrected post hoc tests revealed that the hot drink, hot sauce, hyperventilation, running, weights, and push-ups tasks elicited significantly greater trembling than the control and heat on face tasks. The hot sauce, push-ups, and running tasks produced significantly more intense panic sensations compared to the hot drink and weights tasks. Finally, hyperventilation induced significantly more intense panic symptoms compared to all the other IE tasks.

3.4. Examination of between-group responses to speech task

A series of independent t -tests were conducted to test the hypothesis that compared to participants in the speech only condition, participants in the combined IE and speech task condition would report more anxiety, greater intensity of sensations, and increased similarity of sensations. Unexpectedly, no significant between-group differences were observed for peak anxiety ($t[48] = 1.60$, $p = .12$), intensity of blushing sensations ($t[48] = .67$,

$p = .51$), intensity of sweating sensations ($t[48] = -.42$, $p = .68$), intensity of trembling sensations ($t[48] = -.10$, $p = .92$), intensity of other panic sensations ($t[48] = -1.76$, $p = .09$), and reported similarity of the task to fear experienced in a social situation ($t[48] = .94$, $p = .36$).

4. Discussion

The current study investigated IE exercises to elicit blushing, sweating, and trembling sensations. Novel IE tasks (i.e., hot sauce, heat on face, hot water, weights) and previously validated IE tasks (e.g., hyperventilation, running) were evaluated to examine the intensity of anxiety response in a sample of individuals with elevated AS social concerns. IE tasks produced mild to moderate levels of anxiety, blushing, sweating, and trembling, which is consistent with the intensity ratings reported by previous IE task evaluation studies (e.g., Antony et al., 2006b; Collimore & Asmundson, 2014). This study also examined significant differences between tasks. The simple contrasts revealed that all IE tasks produced significantly higher peak anxiety, greater intensity of sensations, and were rated as more similar to natural social anxiety compared to the control task.

This was the first study to specifically examine blushing in response to IE tasks. Many of the tasks elicited blushing-related sensations, and relevant to other tasks the heat on face and hot sauce tasks produced higher levels of blushing sensations. Collimore and Asmundson (2014) found that spinning and jogging frequently elicited sweating in individuals with SAD. Spinning was not evaluated in the current study, but sweating was frequently elicited by most of the IE tasks. Notably, the heat on face, running, and push-ups tasks produced significantly more intense sweating sensations than many of the other tasks. With regard to trembling, the push-ups and weight tasks induced significantly more trembling sensations than most of other IE tasks. This finding is consistent with Collimore and Asmundson's results demonstrating that muscle tension frequently elicited trembling/shaking in individuals with SAD. Finally, the most intense other panic symptoms were elicited by hyperventilation, which is consistent with previous panic-related research (Antony et al., 2006b; Schmidt & Trakowski, 2004).

After completing all the IE tasks, participants identified the task that induced the response that was most similar to what they experience in anxiety-provoking social situations. The most commonly identified task was hyperventilation, which was identified by one-fourth of participants. Considerable variability was observed for the other tasks that were identified by participants. Interestingly, hyperventilation elicited the most panic symptoms, but was less likely to elicit blushing, sweating, and trembling relative to some of the other IE tasks. One possible explanation is that hyperventilation is one of the most intense physiological exercises, whereas the "dose" of the some of the other IE tasks may have been too weak for the brief assessment in this study. Although speculative, it is possible that the aggregate of participants' AS concerns may have influenced the selection of this task. That is, participants' AS physical or cognitive concerns may have also influenced their subjective experience of the tasks. Several studies have supported a context-sensitivity vulnerability model of panic, wherein the response to interoceptive induction tasks is predicted by an interactive effect between specific AS concerns and threat context (e.g., Telch, Harrington, Smits, & Powers, 2011; Telch et al., 2010). In this study, there was insufficient power to examine the interaction effects of specific sensitivities (e.g., individuals with high versus low trembling sensitivity) and the perception of threat provoked by the different IE tasks or the task selected as most-personally relevant. Accordingly, this is an important direction for future research.

Given the array of tasks identified as most personally-relevant, it would be important to conduct an IE assessment with numerous AS-relevant IE tasks to identify personally-relevant IE tasks for tailoring IE treatment.

This study also examined the incremental value of combining an IE task with a social task (i.e., speech task) in order to evaluate whether social IE tasks can be combined with in vivo exposure to better elicit social anxiety symptoms. The combination of an IE task and a social task was hypothesized to produce higher ratings of task similarity, anxiety, and sensations than the social task alone. Contrary to prediction, the between-group differences were statistically non-significant. Collimore and Asmundson (2014) similarly found no significant differences between participants with SAD who completed the IE tasks in front of one versus two individuals. Although examined through different procedures, these findings suggest that the addition of IE tasks to in vivo exposure may not convey additive benefit. Yet, the potential clinical value of combining IE tasks with social in vivo exposures should not be discounted as several explanations may account for the null findings.

In the current study, participants were completing the IE task for the second time in the combined IE task and social task condition, which may have resulted in less intense response to the IE task due to an exposure effect. Alternatively, participants' awareness of the imminent speech task may have inadvertently decreased how intensely they engaged in IE task. Participants immediately delivered the speech after the IE exercise without reporting the intensity of the anxiety and sensations elicited by the IE task. Therefore, it is unknown whether the IE exercise elicited a similar response as the first time or if it evoked additional anxiety and sensations beyond anticipatory anxiety associated with the speech task. An increase in the duration and/or the intensity of the IE task may have been necessary for the combined IE and social task component of the study. Additional research is necessary to determine whether the integration of IE exercises into SAD treatment can enhance outcomes or uniquely target social fears. In future studies, researchers should consider these possible explanations and alternative social exercises (cf. Collimore & Asmundson, 2014) when evaluating the utility of combined IE and social tasks. Furthermore, the context-sensitivity model should be considered to examine differential fear responding for specific social sensitivities in the presence and absence threat-relevant contexts. This research may be beneficial for improving treatment outcomes in individuals with elevated social AS or who fail to respond to standard in vivo exposure tasks.

The present findings have several clinical implications for the treatment of SAD and utilization of the novel IE tasks. SAD is a heterogeneous disorder that is characterized by a range of feared situations and social outcomes (Hoffman, Heinrichs, & Moscovitch, 2004). Accordingly, it is important to conduct an accurate functional analysis to determine exposure tasks that optimally facilitate corrective learning. For instance, the fear of eating in public may be due to fear of negative evaluation based on inappropriate dining etiquette or due to the feared consequences of noticeably trembling while eating. The precise feared outcome is important to understand as it can ensure that a relevant series of in vivo exercises are selected. In vivo exercises may sufficiently target the fear of negative evaluation of one's dining etiquette. However, the novel IE tasks (e.g., weights) may be instrumental for exposures focused on the fear of noticeably trembling while eating. Clinicians should consult the intensity ratings and the most frequent sensations associated with each IE task reported by the current study and Collimore and Asmundson (2014) to identify IE tasks for individuals with AS social concerns.

The current findings are also relevant for the treatment of panic disorder, especially given the rates of co-occurrence for SAD and panic disorder (e.g., 25–33%; Barlow, DiNardo, Vermilyea,

Vermilyea, & Blanchard, 1986; Perugi et al., 2001). Although blushing is defined as a socially relevant sensation (Leary et al., 1992), sweating and trembling may be feared by individuals with panic disorder due to socially relevant (e.g., negative evaluation) and/or panic relevant (e.g., heart attack, stroke) concerns, depending on the interpretation of the sensation (e.g., Chambless & Gracely, 1989; Uren, Szabó, & Lovibond, 2004). Social concerns about physiological sensations are common among individuals with panic disorder (e.g., Wheaton et al., 2012), and among panickers, embarrassment has been found to be the most common feared consequence of panic attacks (Raffa, White, & Barlow, 2004). Hicks et al. (2005) found that panickers with high social AS had poorer treatment outcomes compared to individuals with high cognitive or physical AS. Taken together, this literature suggests that it may be beneficial to incorporate the current IE tasks into interoceptive exercise assessments and panic treatment protocols to improve IE outcomes for individuals with fears of blushing, sweating, or trembling.

Several limitations of this study should be considered. First, this study utilized an analog sample of individuals who identified significant fear of noticeably blushing, sweating, and/or trembling rather than a sample of individuals with SAD diagnoses. Based on self-report measures, the current sample evidenced levels of symptoms similar to clinical samples, which suggests that a SAD clinical sample should extend the current findings by examining responses to the current IE tasks in a sample of treatment-seeking individuals with SAD. Second, the sample was primarily comprised of White, female college students. Future studies should evaluate the responses to these tasks in a more diverse sample. Third, limited psychiatric and health information was collected. It would be beneficial for future studies to include assessments of medical, physical, sleep, psychiatric, and/or substance use information, as these factors may affect response to IE tasks. Fourth, many of the tasks were piloted in this study (i.e., weights, heat on face, hot sauce, drinking hot water), and it is unclear whether an appropriate dose was examined or if the duration or intensity should have been increased for some of the tasks (e.g., weights). Future investigators should evaluate optimal duration and intensity of the IE tasks, especially for an initial IE assessment of sensations. Fifth, the intention of this study was to investigate blushing, sweating, and trembling, and other AS social concerns were not specifically evaluated. Therefore, it would be beneficial for future studies to examine IE tasks that may elicit other noticeable symptoms, such as appearing nervous, trembling voice, or appearing "blank." Finally, this study relied on self-report measures and did not utilize concurrent physiological assessment (e.g., galvanic skin response) or objective feedback related to noticeability of sensations (e.g., mirror, video). Although several studies have demonstrated that individuals with SAD may not actually evidence increased physiological arousal or noticeability of sensations (e.g., Dijk & de Jong, 2012; Drummond & Lazaroo, 2012), the findings are inconsistent (Dijk, Voncken, & de Jong, 2009). A multi-method approach would enhance our understanding of psychological and physiological responses to IE tasks.

Overall, the findings from the current study provide an important contribution to existing IE and SAD research. In particular, the novel IE exercises evaluated in this study expand the current repertoire of IE exercises through the inclusion of tasks that evoke the socially-relevant sensations of blushing, sweating, and trembling. The identification of IE tasks that elicit blushing, sweating and trembling is important for expanding the utilization of IE for SAD and panic disorder in clinical and research settings. In continuing this line of research, these results should be integrated with the findings from Collimore and Asmundson (2014), to evaluate the prolonged, intense delivery of the current IE exercises in individuals with SAD. Future research should examine the extent to which the IE tasks examined in this study may be used to improve the

efficacy of exposure-based treatments for panic disorder, SAD, and other problems associated with elevated AS social concerns. Additive research designs are recommended to examine the immediate and long-term outcomes for utilizing IE to augment treatments for SAD. In addition, examination of moderators that may amplify or dampen the affective and physiological responses to IE exercises is necessary to enhance our understanding of the situations and sensitivities that may intensify anxious responding. For instance, researchers could expand upon the context-sensitivity vulnerability model (e.g., Telch et al., 2011, 2010) by examining the intensity of responses to certain IE tasks among individuals with high blushing sensitivity in a specific context, such as performance situations and social interactions. This information may be fruitful for understanding anxiety processes and for enhancing the relevance of exposure exercises. Continued research is needed to further cultivate the utilization of IE and to expand prior work by examining the potential benefits of utilizing IE to augment treatments for a wider range of psychological and health conditions.

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