Know Yourself:

Effects of Interoception and Emotion Conceptualization on Anxiety

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Abstract

Anxiety is a major cause of distress for many Americans. Much could be gained from understanding the fundamental processes that cause this maladaptive state. According to a psychological constructionist perspective, anxiety may arise when people perceive and make meaning of their internal physical sensations as an instance of threat. As part of a separate experiment involving stress induction, we collected self-report data intended to measure interoceptive sensibility, emotion conceptualization and differentiation, and anxiety. Participants completed the Trier Social Stress Test (TSST) in order to induce higher physiological arousal and state anxiety. I hypothesized that interoceptive sensibility, emotion conceptualization, and emotion differentiation would serve as a buffer against anxiety resulting from the TSST. I argued, however, that after a certain point the relationship between interoceptive sensibility and anxiety would shift to positive, demonstrating a curvilinear relationship between interoceptive sensibility and anxiety. A negative relationship was found between interoceptive sensibility and trait anxiety. Alexithymia, measured as lack of emotion conceptualization, was positively correlated with trait anxiety. These findings both add to and challenge the current literature on contributing and mitigating factors underlying anxiety.

*Keywords*: interoception, emotion conceptualization, emotion differentiation, anxiety
Effects of Interoception and Emotion Conceptualization on Anxiety

As many as 1 in 5 Americans experience an enduring form of anxiety. Although the popular perception of an approaching “epidemic” of anxiety and depressive disorders has been contested by the scientific community, anxiety disorders still comprise the most common group of mental illnesses in the United States (Baxter et al., 2014; Walters, Kessler, Demler, & Chiu, 2005). Anxiety is characterized by excessive worry and intrusive thoughts. Physical manifestations of anxiety range from mild sweating and trembling to shortness of breath and loss of motor function (Kazdin, 2000). At clinical levels, mundane tasks become insurmountable, and one’s daily experience is fraught with debilitating mental and physical symptoms such as excessive worrying, nervousness, high blood pressure and hyperventilation. One of the most common anxiety disorders, Generalized Anxiety Disorder (GAD), is marked by excessive worrying which persists for 6 months or more, and it alone is a significant cause of disruption and disability in daily life (Ballenger et al., 2001; Stein & Sareen, 2015). Left untreated, anxiety disorders can incapacitate an otherwise able-bodied individual.

Identifying the underpinnings of anxiety is an important step toward proper management and resolution of this often unwelcome emotion. A basic view of emotion emphasizes that anxiety is an irrational dread of future happenings resulting from neurological dysfunction of a single circuit or area (Steimer, 2002). On the other hand, a psychological constructionist approach to emotion, outlined by the Conceptual Act Theory (CAT; Barrett, 2014; Lindquist, 2013), offers two mechanisms through which we can understand anxiety: core affect and emotion concept knowledge. Core affect includes perception of bodily sensations such as interoception and sensorimotor input, although it is most often defined in terms of valence and arousal (Oosterwijk & Barrett, 2014).
The present report attempts to assess the extent to which a person’s interoception and emotion concept knowledge act separately and in tandem to predict anxiety during a stressful moment.

**The Conceptual Act Theory**

Emotions are a mainstay of everyday life. Alone and in interactions with others, humans may experience the gamut of emotions within a single day. The origin of emotion has been at the heart of psychological inquiry since the birth of the field. Pioneer of psychology William James hypothesized that bodily sensations follow exchange with a stimulus, and our perceptions of these bodily sensations constitute an emotion (James, 1884). In stating this, James provided much of the scaffolding for contemporary notions of emotion. Contrary to the general public’s belief in the basic emotion theory, which states that emotions are distinct, basic, and innate (Ekman, 1992), psychological constructionist theories hypothesize that general affective states are interpreted by way of concept knowledge, which transforms those states into the experience of distinct emotion (Barrett, 2011; Lindquist, 2013; Russell, 2009). Thus, emotions are not tied to distinct locations in the body and brain, but the basic “ingredients” of affect and conceptual knowledge are represented by functional brain networks that together combine to create emotions (Barrett, 2014).

The Conceptual Act Theory (CAT) details the core tenets of the constructionist perspective on emotion. It emphasizes the roles of bodily sensations, environmental cues, and concept knowledge in the momentary contextualization or grounding of an affective experience as a distinct emotional event (Barrett, 2014; Oosterwijk & Barrett, 2014). The CAT posits that emotion concept knowledge and bodily sensations are two key mechanisms in an emotional event.
Core affect and interoception. A first component of an emotional event is bodily sensations. Bodily sensations contribute to what is known as core affect, a basic affective state that all individuals possess and which is informed by external sensory information and interoceptive information. Core affect is best described as a mental state resulting from interpretation of bodily sensations (Barrett & Bliss-Moreau, 2009). As mentioned previously, it can be described by the dimensions of valence and arousal. Valence is defined as ranging from pleasant to unpleasant, while arousal is the energy level or activation of the state (Russell & Barrett, 1999). The bodily sensations which contribute to affective experiences are visceromotor sensations and sensorimotor input (MacCormack & Lindquist, in press; Oosterwijk & Barrett, 2014).

Core affect is in part detected via interoception. Interoception can be defined as the extent to which one detects subtle changes in the body, namely internal sensations of hunger and pain, heartbeat perception, or any other sensation which could be defined as internal (Dunn et al., 2010). Expanding into other fields of study, we find that neurological evidence confirms that the processes of interoception and emotional experience activate similar brain areas in the anterior insular cortex, providing further support for the Conceptual Act Theory by suggesting that interoceptive information is processed during emotional experiences (Zaki, Davis, & Oschner, 2012). In support of this, people who display better interoception have higher arousal in emotional events (Barrett et al., 2004).

Conceptual knowledge and language. A psychological constructionist view of emotion suggests that concept knowledge is essential to making meaning of core affective states as specific emotions and that language serves as a foundation for this knowledge. Specifically, emotion concepts are formed through a compounding of past experiences and are primarily
acquired through socialization and language (Barrett, 2014; Lindquist, MacCormack, & Shablack, 2015). Research suggests that when the meaning of an emotion word is blocked through a process called semantic satiation, individuals find it difficult to recognize and label others’ emotions (Lindquist, Barrett, Bliss-Moreau, & Russell, 2006; Barrett, Lindquist, & Gendron, 2007). Semantic satiation entails being exposed to a word repeatedly until its meaning is temporarily barred from access in the brain (Balota & Black, 1997; Black, 2001). Lindquist, Gendron, Barrett, and Dickerson (2014) also found that patients with an inability to tie meaning to words as a result of the neurodegenerative disorder semantic dementia were unable to label or perceive discrete emotions when completing a facial expression card-sorting task. However, patients still displayed an understanding of general pleasure or displeasure. Here, perception of distinct emotions was unachievable without the tool of language, further supporting the constructionist view.

A Constructionist Account of Anxiety

Mounting evidence suggests that interoception and emotion concept knowledge combine to create emotional experiences (Lindquist, Gendron, Barrett, & Dickerson, 2014; MacCormack & Lindquist, in press; Oosterwijk & Barrett, 2014; Zaki, Davis, & Oschner, 2012). As such, understanding changes in interoception and emotion concept knowledge may help us understand the etiology of anxiety. Research suggests that anxiety stems from both high interoception and low emotion differentiation, although to date there have been no investigations of the role of these predictors concurrently (Furman, Waugh, Bhattacharjee, Thompson, & Gotlib, 2013; O’Toole et al., 2014). Under the CAT, individuals with a rich array of emotion concepts would display a higher level of emotion differentiation. As constructs, emotion conceptualization and differentiation both appear to measure the number of emotion concepts individuals possess.
Better conceptualization and differentiation provides individuals with context-specific emotion knowledge, allowing them to better respond to a potentially intense negative affective experience. Researchers have argued that better emotion differentiation, then, leads to better emotion regulation, a core component in anxiety management (Kashdan, Barrett, & McKnight, 2015). In this fashion, anxiety may be characterized by dysfunctional emotion conceptualization.

A variety of mental illnesses have both physical and emotional components which typically present as symptoms. For example, clinical forms of anxiety often present with fatigue, muscle weakness, and shortness of breath. Depression, which is often comorbid with anxiety, shares many of the same physical symptoms (Cyranowski et al., 2012; Shah and Han, 2015). Anxiety and depression are fundamentally tied to disordered thinking and motivational states which often invoke emotion in a major fashion. Szanto et al. (2012) found that late-life depressed individuals with previous suicide attempts were less able to recognize emotions in others than their non-depressed counterparts. In clinical-level anxiety, emotion dysregulation is tied to severity of anxiety symptoms (Wirtz, Hofmann, Riper, & Berking, 2014). Through the lens of psychological constructionism, it follows that these disorders represent the myriad ways in which making meaning of core affective states go awry. Thus, the proposed component to the formation of anxiety may be the inability to characterize changes in the body as belonging to distinct emotions. Examining this relationship could provide crucial insight into the mechanisms behind disordered emotions.

**Interoception and anxiety.** Although psychologists do not fully understand the role of interoception in clinical and sub-clinical levels of anxiety and depression, recent research suggests that anxiety and depression are deeply tied to disordered interoception (Dunn et al., 2010; Paulus & Stein, 2010; Pollatos, Trauth-Mattausch, & Schandry, 2009). For example,
Furman et al. (2013) demonstrated that when asked to monitor their heartbeats, women with Major Depressive Disorder (MDD) exhibited lower levels of heartbeat perception accuracy than did women without MDD. Forrest, Smith, White and Joiner (2015) further found that persons with depressive disorders exhibiting suicidality had significantly lower levels of interoception than controls. Given that individuals with MDD exhibit low levels of interoception and have difficulty perceiving emotions in others, we can acknowledge the possibility of a link between low levels of interoception and impaired emotion recognition (Szanto et al, 2012; Forrest at al., 2015). An established link would appear to further support the constructionist approach and the CAT’s emphasis on interoceptive information as a critical factor in emotion formation (Oosterwijk & Barrett, 2014).

In regards to the directionality of the relationships between interoception and these disorders, Furman et al. (2013) argue that anxiety and depression influence interoception in contrasting manners, such that anxiety increases with interoceptive awareness. That is, individuals who display a more acute sensitivity to internal bodily changes have heightened anxiety. This finding that interoception is positively related to anxiety ratings has been upheld by some other research in the field (Dunn et al., 2010; Pollatos, Herbert, Kaufmann, Auer, & Schandry, 2007; Pollatos, Trauth-Mattausch, & Schandry, 2009). Pollatos, Traut-Mattausch, Schroeder, and Schandry (2007) conducted research on non-clinical student populations and further found that high interoceptive awareness may play a key role in the development of enduring anxiety by way of increased sensitivity to initial sensations of anxiety.

**Emotion conceptualization and anxiety.** No current research has specifically explored the relationship between emotion conceptualization and management of negative emotions such as anxiety. However, a psychological constructionist view might argue that better emotion
conceptualization leads to greater range and differentiation of emotions. Furthermore, emotion differentiation leads to better emotion regulation, which is vital for anxiety management (Kashdan, Barrett, & McKnight, 2015).

Research adhering to the emotional dysregulation model of anxiety disorders suggests a positive relationship between emotional intensity and anxiety, especially in instances of GAD (Carthy, Horesh, Apter, & Gross, 2010). On the other hand, labeling affective states lowers amygdala activity, which has been argued to be a form of implicit emotion regulation (Lieberman et al., 2007). It is important to note that labeling and thus categorizing affective states is a step toward emotion conceptualization and differentiation, as it necessarily distinguishes between and categorizes modes of affect. Thus labeling affective states may also be seen as a way of making something less ambiguous or uncertain by way of conceptualization.

**The Proposed Study**

Given the present ambiguity in the literature regarding the effects of interoception and emotion differentiation on anxiety and the lack of research in non-clinical populations, further exploration of these relationships is necessary. To this end, we will be using a subset of data from a larger experiment to assess the role of interoception and emotion conceptualization in stressful experiences. This project utilizes a Trier Social Stress Test to induce affect in participants. The TSST is a motivated performance task known to produce high levels of activation in participants, and it is an established method of evoking a physiological stress response (Kirschbaum, Pirke, & Hellhammer, 1993). In support of its efficacy, individuals completing the TSST have been found to exhibit heightened levels of stress hormone in comparison with individuals completing a placebo task (Het et al., 2009).
During the first session, participants complete a battery of questionnaires examining constructs of interest and are screened for eligibility for the second, experimental session. The major constructs measured were interoception, emotion differentiation, alexithymia, and various forms of emotional awareness and suppression. It is important to note that interoception refers to both interoceptive sensitivity, actual awareness of internal physical changes, and interoceptive sensibility, which is self-reported interoceptive ability (Garfinkel, Seth, Barrett, Suzuki, & Critchley, 2015). For the purposes of this study, we were limited to measuring the latter by way of the Multidimensional Assessment of Interoceptive Awareness (MAIA; Mehling et al., 2012). As we had no clear way of measuring emotion conceptualization, we opted to use the construct of alexithymia as measured by the Toronto Alexithymia Scale (TAS-20; Taylor et al., 1986). Alexithymia describes a condition in which individuals have difficulty conceptualizing, labeling, and differentiating between affective input. As a result, researchers argue that alexithymia is a lack of emotion conceptualization, having near-opposing definitions (Barrett et al., 2004; Lindquist and Barrett, 2008).

In the second session, participants undergo an emotion concept priming manipulation which we will not examine further in this report, a Trier Social Stress Test (TSST; Kirschbaum, Pirke, & Hellhammer, 1993), and report their emotional experiences in subsequent questionnaires.

To argue that better physical and emotional knowledge is key to managing anxiety, I hypothesized that interoceptive sensibility, emotion conceptualization, and emotion differentiation (as measured by self-report data from the initial session) would serve as a buffer against anxiety during the Trier Social Stress Test, such that individuals with higher levels of interoception, emotion conceptualization, and emotion differentiation would exhibit a lowered
stress/anxiety response as measured by physiological responses throughout the TSST and subsequent self-report data. However, after a certain point, I predicted that high interoceptive sensibility would actually contribute to overall anxiety, creating a “hypervigilance” effect and demonstrating a curvilinear relationship between interoceptive sensibility and anxiety.

Methods

Participants

The study consisted of a target sample size of 150 undergraduate students (75 male; 75 female) from the University of North Carolina Introduction to Psychology participant pool, although at time of analysis only 141 students had completed the initial session (60 male, 81 female), and 46 students (26 male, 20 female) continued to the experimental session. Students were from a variety of career paths and backgrounds, although the overwhelming majority of the students were in their first year of college. In the initial session, 67.5% identified as White/Caucasian, 11.9% as Asian, 5.3% as Black/African-American, 1.3% as Native American, 3.3% as multiracial, and 10.7% as other. 7.9% of participants identified as Hispanic or Latino. Participant ages ranged from 17 to 27 (M = 19). All collected data, including prescreening data containing sensitive personal information, were de-identified. Students were compensated for their time with credit hours which are necessary for completion of the course.

Procedure

Participants completed two in-lab sessions: a survey and pre-screening session (Session 1) and an experimental session (Session 2). Session 1 lasted an hour, while Session 2 lasted approximately 2 hours. Session 2 occurred anytime from two days to one month following Session 1.
Session 1 and eligibility confirmation. Participants attended an initial screening and survey session which determined their eligibility for participation in Session 2. During this initial session, participants completed a range of questionnaires and an eligibility screening (refer to Measures for full report). Following this, participants were recruited for Session 2 upon expression of interest. As Session 2 consisted of hormone measurement from saliva samples, physiological measures, and a stressful task, a set of eligibility requirements must have been met. Non-native English speakers, pregnant participants, individuals with a heart condition, pacemaker, a body mass index above 33, or with an affective, psychotic, anxiety, or otherwise similar disorder were not eligible to continue to Session 2. Female participants with an irregular menstrual cycle also were not eligible to continue on to Session 2 due to measures that will not be discussed herein. During eligibility confirmation, if participants expressed discomfort at any point or did not wish to continue to Session 2, they were given the option to withdraw participation. Eligibility status was revealed to the participant only after all questions had been completed in order to avoid participant discomfort. Following eligibility screening, Session 2 was scheduled on a different date. Consistent with guidelines from previous research, female participants were scheduled 7 to 10 days after the onset of their next predicted menstrual cycle, and male participants were scheduled based on availability.

Session 2. Over the course of the second, experimental session, five researchers were present with the participant at various points. For the sake of clarity, we delineate the role of each researcher. The lead experimenter guided the participant through the session, the operator interacted with the participant during the manipulation and, on occasion, during connecting of physiological equipment. The confederate was present only during the manipulation, and the
interviewers led the Trier Social Stress Test (TSST). The manipulation will not be referenced in the analyses.

**Phase 1: Initial screening.** During Session 2, participants completed an initial screening designed to eliminate possible aberrances in the physiological data collected during the session. For example, participants who had consumed caffeine or yogurt before the session were not qualified to continue and were rescheduled for a later date.

**Phase 2: Physiological measures.** Following the intake screening, the lead experimenter connected the participant to physiological equipment intended to measure electrocardiography, blood pressure (measured by the Continuous Non-Invasive Arterial Pressure Device, or CNAP), and cardiac impedance. Cardiac impedance and electrocardiogram were measured using a standard electrocardiogram test (ECG). If the gender of the lead experimenter and the participant differed, another in-lab researcher, typically the operator but never the confederate, would enter the room to connect the participant to the physiological equipment. Following well-established paradigms, participants relaxed during a 5-minute baseline period of physiological data collection. After this, participants were asked to provide a saliva sample. Saliva was collected using a “passive drooling” method to allow for the assessment of time-sensitive hormones as part of the larger study. We will not consider physiological measures of reactivity further in this report.

**Phase 3: Baseline affect, manipulation, and manipulation check.** Following the saliva sample, participants completed an affect grid in which they marked their affective state. As the lead experimenter feigned moving to the next task, the operator interrupted the session, claiming that a previous participant (in actuality the confederate) had arrived who had yet to be compensated for the study the prior week. The lead experimenter and operator exited together,
presumably to retrieve the compensation, while the confederate was ushered into the room with
the participant. During this time, the confederate and participant exchanged greetings, and the
confederate implemented the manipulation. In the anger condition, the confederate stated, “I
probably shouldn’t tell you this, but I did this study last week, and it made me, like, pretty mad.”
The embarrassment and heightened arousal/stress conditions were executed in the same fashion,
substituting the final words with “pretty embarrassed” or “it made my heart beat, like, really
fast.” In a control condition, the confederate exchanged greetings with the participant.
Immediately following this, the lead experimenter re-entered the room, handing the cash to the
confederate who then exited. The experimenter hastily discarded the previously completed affect
grid and asked the participant to complete another, explaining that this must be gathered just
before the next portion of the task, and that the lead experimenter didn’t want to “get in trouble
with my supervisor.” The second affect grid was used to ensure that the manipulation itself has
no undue, immediate influence on the participant’s emotional state. Again, we will not consider
the priming manipulation further in this report as a result of lack of statistical power. Instead, we
will collapse across conditions when analyzing self-report data which followed the TSST.

**Phase 4: Modified Trier Social Stress Test.** Following the affect grid completion,
participants then consented to complete the TSST and were introduced to two interviewers. In
accordance with similar paradigms, participants were told that they would be giving a speech on
their dream job position, followed by an arithmetic task (Kirschbaum, Pirke, & Hellhammer,
1993). Participants were given 2 minutes to mentally prepare for their speech. During the TSST,
the participant gave a 10-minute speech to the two interviewers. Participants who did not speak
for the full 10 minutes were prompted to answer questions pertaining to the speech, mirroring a
real job interview. After 10 minutes, the mental arithmetic task was introduced and the
participant was instructed to count backwards from the number 996 in steps of 7. Variations were introduced should the participant have found the math task too difficult or too simple. Interviewers remained neutral throughout the task.

**Phase 5: Recovery.** At the conclusion of the TSST, the interviewers exited the room. The lead experimenter re-entered and prompted the participant to rest for a five-minute recovery period. Participants then provided a second saliva sample.

**Phase 6: Post-measures.** The participant was disconnected from the ECG and CNAP. Participants then completed follow-up questionnaires to assess their physical and emotional states, as well as to gather evaluations of the experiment and the researchers involved. A funneled debriefing survey was administered by the experimenter to ensure the participant did not have any assumptions that approximated the larger study’s hypothesis. Participants were fully debriefed on the task and provided with contact information for the university’s counseling services in the event that the session caused undue stress or anxiety.

**Measures**

**Session 1.**

In Session 1, participants completed a battery of randomly presented questionnaires to measure interoception, emotion conceptualization, emotion differentiation, state-trait anxiety levels, and other aspects of emotion. The Multidimensional Assessment of Interoceptive Awareness (MAIA; Mehling et al., 2012) and the Body Awareness Questionnaire (BAQ; Shields, Mallory & Simon, 1989) were administered to assess interoceptive sensibility. For the purpose of our analyses, we focused solely on the MAIA. The Social Phobia Inventory (SPIN; Connor et al., 2000), the Brief Fear of Negative Evaluation Scale (BFNE; Leary, 1983), and a modified State and Trait Anxiety Inventory (STAI; Spielberger et al., 1983) were used as
measures of anxiety and fear. For the purpose of our analyses, we focused solely on the STAI. This STAI was modified to include all 20 items on the trait anxiety scale and 8 items on the state anxiety scale. The Anger Rumination Scale (Sukhodolsky, Golub, & Cromwell, 2001) and the Guilt and Shame Proneness Scale (GASP; Cohen, Wolf, Panter, & Insco, 2011) assessed participants’ tendencies to anger and/or shame, although we did not use these scales in this study’s analyses. To assess emotion differentiation and concept knowledge, participants completed the Range and Differentiation of Emotional Experience Scale (RDEES; Kang & Shaver, 2004) and the Toronto Alexithymia 20-Item Scale (TAS-20; Taylor et al., 1986). Because we did not possess a clear method of measuring emotion conceptualization, we utilized the TAS-20. A high score on the TAS-20 would indicate poor conceptualization (Lindquist & Barrett, 2008; Lindquist, MacCormack, & Shablack, 2015). As a result, one would expect a positive relationship between alexithymia and measures of anxiety. The Behavioral Inhibition/Behavioral Approach Scales (BIS/BAS; Carver & White, 1994), the Emotional Intensity Scale (EIS), and the Emotion Regulation Questionnaire (ERQ; Gross & John, 2003) were also administered.

For the purposes of this study, we analyzed the MAIA, the RDEES, the TAS-20, and the modified STAI. These served as operationalizations of interoceptive sensibility, emotion differentiation, lack of emotion conceptualization, and anxiety, respectively.

**Session 2.**

**Physiological measures.** During the second session, heart rate, heart rate variability, respiration, cardiac output, and pre-ejection time were measured via electrocardiography and cardiac impedance. Pulse and blood pressure were measured by the CNAP. Physiological data was collected prior to, during, and after the TSST. Participants also provided two saliva samples
to be used as measures of cortisol, testosterone, α-Amylase, and DHEA-S. Samples were collected during a baseline period prior to the TSST and during the recovery period that followed the TSST. As mentioned previously, these measures will not be discussed further in this report.

**Questionnaires.** Participants completed an affect grid prior to and following the manipulation, in order to ensure that the manipulation itself did not lead to a change in the participant’s emotional state. Following the TSST and recovery period, participants completed a series of self-report measures. These measures include an evaluation of the experiment and researchers, the MacArthur Scale of Subjective Social Status, the RDEES, the Positive and Negative Affect Schedule (PANAS; Watson, Clark, & Tellegen, 1988), the modified STAI, and a free-response question to discuss their thoughts and feelings about the TSST. Video recordings are also made and participant gestures were coded. From Session 2, we analyzed state anxiety ratings from the modified STAI. We also analyzed the free response using the Linguistic Inquiry and Word Count (LIWC; Tausczik and Pennebaker, 2010) to see if the continuous variables predicted discrete categories (such as the presence or absence of anxiety-related phrases) derived from the free response, or if they predicted percentage of anxiety-related phrases.

**Results**

**Session 1.**

Means and standard deviations were calculated for all variables of interest (Table 1; N = 141). The target sample size was not reached as data collection is ongoing. In order to examine bivariate associations between the constructs of interest, a Pearson correlational matrix was produced for the TAS-20, MAIA, differentiation subscale of the RDEES, and the Session 1 STAI trait-anxiety score (Table 2). The range subscale of the RDEES was not included in the analysis as emotion differentiation is best measured by the differentiation subscale alone. The
trait-anxiety subscale of the STAI was included in analysis in order to verify if interoceptive sensibility and emotion conceptualization were related to enduring anxiety. Interoceptive sensibility as measured by the MAIA was weakly negatively correlated with trait anxiety, $r(141) = -.188$, $p = .025$. Interoceptive sensibility was also moderately correlated with emotion differentiation, $r(141) = .316$, $p < .001$. Alexithymia was moderately positively correlated with trait anxiety, $r(141) = .496$, $p < .001$. There was no relationship between participants’ score on the differentiation subscale of the RDEES and trait anxiety. It is important to note that the MAIA includes subscales which address emotion; in order to see if this contributed to possible relationships, a modified MAIA score was also calculated to look at interoceptive sensibility without the emotion-level subscales. The modified MAIA excluded any items mentioning emotion (the Not-Worrying subscale, which references anxious feelings; the Emotional Awareness subscale, which explicitly references a bodily connection to emotions; the Self-Regulation subscale, which addresses the role of the body in calming oneself down; and the Body Listening subscale, which states “when I am upset, I take time to explore how my body feels,” or “I listen for information from my body about my emotional state”). The MAIA without emotion subscales excluded was weakly negatively correlated with alexithymia, $r(141) = -.254$, $p = .002$, and trait anxiety, $r(141) = -.239$, $p = .004$.

**Regression Analyses.** A multiple linear regression was calculated to predict trait anxiety levels based on interoceptive sensibility and emotion differentiation from Session 1. Centered variables were created for the purpose of analyzing a possible interaction effect. Consistent with the previously reported correlations, only interoceptive sensibility remained a significant predictor of trait anxiety, and there was no interaction (Table 3).
A multiple linear regression was also calculated to predict trait anxiety levels based on centered variables of interoceptive sensibility, alexithymia and an interaction term. Alexithymia significantly predicted trait anxiety, $\beta = .479$, $t(137) = 6.43$, $p < .001$. Interoceptive sensibility and the interaction term were not significant predictors (Table 3).

**Session 2.**

A pairwise t-test was conducted on Session 1 and Session 2 state-anxiety ratings as measured by the modified state-subscale of the STAI in order to determine the effects of the Trier Social Stress Test on anxiety ratings. The state-subscale was modified in number of items presented, although the language of the STAI remained the same (i.e. the measure addressed participants’ feelings in the moment). There was no significant difference in state anxiety ratings between sessions. The eligible sample size ($N = 31$) was smaller than the total number of participants in Session 2, as data collection was underway during the formulation of the variables of interest, and the STAI was not implemented for the first 15 participants. Analyses of anxiety-related word count in free response as well as a logistical regression predicting absence of anxiety-related words with interoceptive sensibility, alexithymia, and differentiation as predictors were not significant. The modified MAIA without emotion subscales also did not significantly predict state anxiety from session 2.

**Regression Analyses.** A multiple linear regression was calculated to predict post-TSST state anxiety levels based on interoceptive sensibility, emotion differentiation, and an interaction term from Session 1. The model was not significant overall, and none of the predictor variables were significant within the model (Table 4; $N = 31$). A multiple linear regression was also calculated to predict post-TSST state anxiety levels based on interoceptive sensibility and
alexithymia from Session 1. Again, the model was not significant, \( p = .057 \), but alexithymia positively predicted state anxiety, \( \beta = .399, t(27) = 2.373, p = .025 \) (Table 4; \( N = 31 \)).

For all regression models, curvilinear analyses including quadratic and cubic functions did not explain significantly more variance than the standard linear multiple regressions performed.

**Discussion**

Overall, the relationships proposed in the hypothesis were supported, with the notable exception of emotion differentiation and the prediction of a curvilinear relationship between interoceptive sensibility and anxiety. Interoceptive sensibility was, in fact, negatively correlated with trait anxiety in Session 1. This goes against previous suggestions that interoception might be positively related to anxiety (Dunn et al., 2010; Furman et al., 2013; Pollatos, Herbert, Kaufmann, Auer, & Schandry, 2007; Pollatos, Trauth-Mattasuch, & Schandry, 2009). We should consider here that previous research exploring this relationship has only definitively looked at interoceptive sensitivity as measured by a heartbeat detection task.

Alexithymia – assumed to be lack of emotion conceptualization – was positively correlated with trait anxiety. However, interoceptive sensibility was no longer a significant predictor when factored into a regression analysis alongside alexithymia. There are several possible explanations for this. Emotion conceptualization may be, far and above, the best predictor of trait anxiety in this situation. Considering the strength of the relationship between alexithymia and trait anxiety, we might also assume that because both measures ask about emotional and core affective states, they cover similar variance, driving the strength of the relationship between the constructs and rendering interoceptive sensibility insignificant. The presence of a positive relationship should not come as a surprise, however, given that
alexithymia coincides with many emotion-level disorders (Nekuoei, Doost, Yousey, Manshaee, & Sadeghei, 2014).

It is rather surprising that there was no identifiable relationship between emotion differentiation and trait anxiety. After all, some researchers have posited that emotion differentiation and emotion regulation, the latter being essential for anxiety management, are conceptually intertwined, and that emotion differentiation leads to better emotion regulation (Kashdan, Barrett, & McKnight, 2015). In fact, with emotion differentiation being weakly negatively correlated with alexithymia and moderately positively correlated with interoceptive sensibility, one might expect to find some relationship between emotion differentiation and trait anxiety. This is certainly a point of further exploration and demonstrates a need for more empirical evidence which either parses apart or supports overlap of the constructs of emotion conceptualization, differentiation, and regulation.

In regards to the findings that interoceptive sensibility and alexithymia from Session 1 do not significantly predict state anxiety ratings from Session 2, we must take into account both the small sample size and the results of the paired t-test for state anxiety ratings from Session 1 and Session 2.

As data collection was ongoing at the time of analysis, the small sample size for eligible Session 2 participants (N = 31) severely limited our analyses. We know that the Trier Social Stress Test invoked negative physiological responses in many participants, as it was reported in all but 7 free responses following the task. As a result, we would have expected the participants’ state anxiety to be significantly higher in Session 2 than in Session 1. Because they were not significantly different, we can only conclude that implementation of the STAI came after participants’ anxiety and stress levels had returned to their base levels. This makes sense, given
that we gave participants a five-minute recovery period, collected saliva samples, and then detached them from the electrodes and blood pressure device. The state subscale of the STAI was also modified to include only 8 items from the 20-item subscale. Finally, the STAI was worded in such a way that it asked participants how they were feeling at the given moment and not during the TSST. Physiological data collected during the TSST for pulse and blood pressure would have been the ideal predictor for activation of the sympathetic nervous system during the TSST, and not the STAI as it was implemented 10 – 15 minutes later. Because the anxiety ratings were not different between sessions, the multiple regression models involved are less meaningful. Additionally, the larger study involves an emotion priming manipulation, which may also have led to different emotional experiences in individuals, including different levels of anxiety.

The findings on interoceptive sensibility, emotion conceptualization, and anxiety have possible implications for the management and prevention of enduring anxiety. For example, individuals who become more in-tune with their bodies and more equipped to label their affective states as discrete emotions may experience less stress and anxiety in day-to-day proceedings. Future studies should be certain to measure interoceptive sensitivity in addition to sensibility, as well as structure studies in such a way as to allow for more causal inferences.

Presently, we cannot know if interoceptive sensibility and emotion conceptualization determines trait or state anxiety, or if the development of anxiety in the lives of individuals leads to poor bodily awareness and emotion conceptualization. Higher levels of interoception and emotion knowledge may mitigate manifestations of anxiety, although the latter mechanism depends on its similarity to emotion regulation, a known component in limiting anxiety; empirical evidence has yet to firmly connect level of emotion knowledge with the capacity to
regulate emotion (Furman, Waugh, Bhattacharjee, Thompson, & Gotlib, 2013; Kashdan, Barrett, & McKnight, 2015; Wirtz, Hofmann, Riper, & Berking, 2014). Longitudinal studies involving novel methods of training in emotion conceptualization and interoceptive awareness would be exceptionally helpful in determining causality and potential effectiveness of new forms of anxiety management.
References

Ballenger, J. C., Davidson, J. R. T., Lecrubier, Y., Nutt, D. J., Borkovec, T. D., Rickels, K...


Table 1

Means and Standard Deviations of Variables of Interest (Session 1)

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>M</th>
<th>M_centered</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interoceptive sensibility (MAIA)</td>
<td>141</td>
<td>3.04</td>
<td>.029</td>
<td>.430</td>
</tr>
<tr>
<td>Emotion differentiation (RDEES)</td>
<td>141</td>
<td>3.95</td>
<td>-.050</td>
<td>1.07</td>
</tr>
<tr>
<td>Alexithymia (TAS-20)</td>
<td>141</td>
<td>48.31</td>
<td>.332</td>
<td>10.32</td>
</tr>
<tr>
<td>Trait anxiety (STAI)</td>
<td>141</td>
<td>40.66</td>
<td>-</td>
<td>10.42</td>
</tr>
<tr>
<td>State anxiety (STAI)</td>
<td>141</td>
<td>14.30</td>
<td>-</td>
<td>4.08</td>
</tr>
</tbody>
</table>

Table 2

Correlation Matrix of Major Variables of Interest (Session 1)

<table>
<thead>
<tr>
<th></th>
<th>Emotion differentiation</th>
<th>Alexithymia</th>
<th>Trait anxiety</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interoceptive sensibility</td>
<td>.316**</td>
<td>-.177*</td>
<td>-.188*</td>
</tr>
<tr>
<td>Emotion differentiation</td>
<td></td>
<td>-.191*</td>
<td>-.025</td>
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<tr>
<td>Alexithymia</td>
<td></td>
<td></td>
<td>.496**</td>
</tr>
</tbody>
</table>

Note. N = 141. Pearson correlations. *p < .05; **p < .01.
Table 3

*Interoceptive Sensibility, Emotion Differentiation, and Alexithymia as Predictors of Trait Anxiety (Session 1)*

<table>
<thead>
<tr>
<th></th>
<th>$\beta$</th>
<th>$t$</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Model 1</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Interoceptive sensibility</td>
<td>-.226*</td>
<td>02.530</td>
</tr>
<tr>
<td>Emotion differentiation</td>
<td>.098</td>
<td>1.109</td>
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<tr>
<td>Interoceptive sensibility x emotion differentiation</td>
<td>-.045</td>
<td>-.528</td>
</tr>
<tr>
<td><strong>Model 2</strong>**</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Interoceptive sensibility</td>
<td>-.122</td>
<td>-1.596</td>
</tr>
<tr>
<td>Alexithymia</td>
<td>.479***</td>
<td>6.428</td>
</tr>
<tr>
<td>Interoceptive sensibility x alexithymia</td>
<td>-.082</td>
<td>-1.084</td>
</tr>
</tbody>
</table>

*Note.* $N = 141$. Criterion variable is trait anxiety for Models 1 and 2. All variables centered. Interaction terms computed from product of centered variables. For Model 1, $R^2 = .045$. For Model 2, $R^2 = .263$. *$p < .05$; **$p < .01$; ***$p < .001$. 
Table 4

*Interoceptive Sensibility, Emotion Differentiation, and Alexithymia as Predictors of State Anxiety after Trier Social Stress Test*

<table>
<thead>
<tr>
<th></th>
<th>$\beta$</th>
<th>$t$</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Model 3</strong></td>
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<td></td>
</tr>
<tr>
<td>Interoceptive sensibility</td>
<td>-.315</td>
<td>-1.632</td>
</tr>
<tr>
<td>Emotion differentiation</td>
<td>.229</td>
<td>1.161</td>
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<td>Interoceptive sensibility x emotion differentiation</td>
<td>.073</td>
<td>.359</td>
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<td><strong>Model 4</strong></td>
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<td></td>
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<tr>
<td>Interoceptive sensibility</td>
<td>-.262</td>
<td>-1.448</td>
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<tr>
<td>Alexithymia</td>
<td>.399*</td>
<td>2.373</td>
</tr>
<tr>
<td>Interoceptive sensibility x alexithymia</td>
<td>.000</td>
<td>.000</td>
</tr>
</tbody>
</table>

*Note. N = 31. For Models 3 and 4, criterion variable is Session 2 state-anxiety from modified STAI. All variables centered. Interaction terms computed from product of centered variables. For Model 3, $R^2 = .124$. For Model 4, $R^2 = .239$. *$p < .05$; **$p < .01$; ***$p < .001$.***