MINDING THE BODY: THE ROLE OF INTEROCEPTION IN LINKING PHYSIOLOGY AND EMOTION DURING ACUTE STRESS

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ABSTRACT

Jennifer Kay MacCormack: Minding the Body: The Role of Interoception in Linking Physiology and Emotion During Acute Stress
(Under the direction of Kristen A. Lindquist)

Affective science has long recognized that emotional experiences are accompanied by physiological concomitants. Although evidence suggests that objective physiological changes do indeed shape affect, findings are often inconsistent. One reason for these inconsistencies might be that more subjective processes—such as people's beliefs and self-construals about their internal bodily or interoceptive experiences—may be more proximal influencers of affective experience than objective physiological indices. Yet little work compares how subjective dimensions of interoception matter for affective experience relative to individuals' physiological changes or objective access to said physiology (i.e., interoceptive ability). In this dissertation, healthy young adults (*N*=250) completed the Trier Social Stress Task with cardiac psychophysiology indices measured before, during, and after the stressor. Immediately after the stressor, individuals reported the kinds and intensity of emotions and somatic sensations they felt. At a prior session, participants completed measures of interoceptive ability, sensibility, and beliefs. Using factor analyses, latent variable structural equation modeling, and hierarchical regressions, I found that physiological reactivity, interoceptive ability, and interoceptive beliefs all mattered for individuals' acute stress experience. Physiological reactivity was associated with more intense stress experiences, whereas both interoceptive ability and beliefs appeared to buffer against intense stress experiences. Interoceptive sensibility was unrelated to acute stress experiences. Importantly, consistent with constructionist and active inference hypotheses that "interoceptive priors" might play a crucial role in shaping subjective experience, interoceptive beliefs showed the most consistent and powerful effect sizes in relation to people's subjective stress responses. Implications for emotion theory, interoceptive science, psychopathology, development, and health are discussed.

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CHAPTER ONE: THE BODY'S ROLE IN EMOTION

"What you experience is in large part a reflection of what your brain predicts is going on inside your body, based on past experience." - Barrett & Simmons (2015), p. 8

Recall how your body felt the last time you were very stressed. You probably noticed that your heart was racing or perhaps you felt a surge of adrenaline, sweaty palms, and a sick pit in your stomach. Affective science has long recognized that emotional experiences, be it anger, joy, stress, or sorrow, are typically accompanied by physiological concomitants such as changes in heart rate, respiration rate, sweat secretion, etc. (Colombetti & Harrison, 2018; James, 1884; Kövecses, 2000; Nummenmaa, Glerean, Hari, & Hietanen, 2014; Oosterwijk & Barrett, 2014; Schachter & Singer, 1962). Accumulating evidence from both psychophysiology and neuroscience suggests that although objective physiological changes can indeed shape emotion (e.g., Dantzer, O'Connor, Freund, Johnson, & Kelley, 2008; Gray et al., 2012; Schachter & Singer, 1962), these objective changes may not matter as much as people's perceptions and interpretations of said bodily changes, known as *interoception*. For example, early studies demonstrated that greater interoceptive ability, such as being able to accurately distinguish or track changes in one's heartbeat, was associated with more intense and subjectively aroused emotional experiences (Barrett, Quigley, Bliss-Moreau, & Aronson, 2004; Pollatos, Herbert, Matthias, & Schandry, 2007; Schandry, 1981; Wiens, 2005; Wiens, Mezzacappa, & Katkin, 2000).

Yet more recent work suggests that interoceptive self-characterizations and beliefs also matter and may be especially powerful in the context of emotional experience and related affective psychopathologies (Ferentzi, Horváth, & Köteles, 2019; Forkmann et al., 2019; Garfinkel, Seth, Barrett, Suzuki, & Critchley, 2015; Garfinkel, Tiley, et al., 2016; Gramer, Schild, & Lurz, 2012; Murphy et al., 2020; Murphy, Millgate, et al., 2018; Palser et al., 2018; Zamariola, Frost, Van Oost, Corneille,

& Luminet, 2019). These emphases on people's expectations, beliefs, and schemas about internal bodily sensations are in line with a long history of psychological literature. For example, patients' expectations can alter treatment effects both in psychotherapy and medicine (e.g., Beecher, 1955; Enck & Zipfel, 2019; Reicherts, Gerdes, Pauli, & Wieser, 2016), perceptions of loneliness may be more detrimental to health than actual time spent alone (Hawkley & Cacioppo, 2010), and subjective socioeconomic status can drive disease etiology above and beyond objective measures of poverty and status (Adler, Epel, Castellazzo, & Ickovics, 2000; Cohen et al., 2008).

These diverse findings underscore that expectations and beliefs exert powerful influences on behavior and wellbeing. These findings are also in line with predictions from constructionist approaches to emotion. For example, the theory of constructed emotion posits that subjective experiences, including emotions, occur when the brain uses probabilistic "priors" rooted in previous experience and the current context to categorize or make meaning of sensory signals (including interoceptive signals) as a given state, such as feeling angry vs. hungry (Barrett, 2017; Lindquist, 2013; MacCormack & Lindquist, 2017; Wilson-Mendenhall, Barrett, Simmons, & Barsalou, 2011). In other words, what transforms an event into an experience of, say, "stress" is ultimately dependent upon what meaning the brain makes with its priors.

It thus stands to reason that people's priors about their bodies and interoceptive signals should also play a central role in subjective experience. The term "interoceptive priors" comes predominantly from emerging computational neuroscience approaches to interoception. These computational approaches tend to either characterize priors as cascading neural signals about previous and ongoing sensory information or more broadly take a computational approach to modeling the brain's "beliefs" (e.g., Allen, Levy, Parr, & Friston, 2019; Barrett & Simmons, 2015; Parr & Friston, 2019). Yet less work has formally investigated the *psychological* nature of interoceptive priors—what people think and believe about their bodies—and compared how different sorts of interoceptive priors, at the psychological level of analysis, may predict emotional experience relative to physiological reactivity or interoceptive ability. In this dissertation, I tested the hypotheses that (1) interoceptive priors, operationalized as interoceptive self-construals (known as "interoceptive sensibility") and beliefs about the value vs. danger of bodily sensations (what I am here calling “interoceptive beliefs”), would be significant predictors of negative, high arousal emotional intensity during an acute stress induction and (2) that these would explain more variance in emotion than physiological reactivity or interoceptive ability. I also tested (3) the extent to which interoceptive ability, sensibility, and beliefs might moderate both physiological reactivity and each other to exacerbate or buffer against negative, high arousal emotions during the stressor.

In order to test these hypotheses, I took an acute stress approach with an *in vivo* laboratory stress paradigm. This approach allowed me to induce robust changes in peripheral psychophysiology and emotional experience while also examining the relative roles of interoceptive ability, sensibility, and beliefs in linking physiology with emotion. Historically, prior studies that jointly focused on some facet of interoception (ability, sensibility, beliefs) and emotion have often relied upon smaller sample sizes (*Ns*=10-50), tended to focus on only one interoceptive measure, or assessed trait reports of mood rather than *in vivo* experience. This study integrates multiple measures of physiological reactivity, interoception, and emotion together in the context of acute stress while capitalizing on latent variable modeling approaches afforded by a larger sample size.

Healthy young adults (*N*=250) completed the Trier Social Stress Task (TSST; Kirschbaum, Pirke, & Hellhammer, 1993) with concurrent autonomic nervous system measures, after which participants reported what emotions they felt during the stressor. At a prior session, participants completed a standard measure of interoceptive ability as well as self-report measures of individuals’ interoceptive sensibility and beliefs. Data were analyzed using factor analyses, latent variable structural equation modeling, and hierarchical regressions in order to establish measurement models for each proposed predictor and to compare each predictor’s efficacy in explaining variance in people’s subjective stress experiences during the acute stressor. I examined negative, high arousal emotions as my primary outcome of interest and conducted secondary analyses on reported somatic intensity as well as positive and low arousal emotions. Next, I discuss more deeply the nature of interoception, what literature already demonstrates about how interoception relates to emotion, and why individuals’ “interoceptive priors”—even at a psychological, not just neural, level— should matter for the construction of subjective experience.

Interoception: How Physiology Transforms into Experience

The construct of interoception was first introduced in the early twentieth century (Sherrington, 1906) and later advanced in the 1970s-80s with the advent of better psychophysiological techniques (e.g., Schandry, 1981; Whitehead, Drescher, Heiman, & Blackwell, 1977). Today, the field of interoceptive science is highly interdisciplinary, unifying approaches from across affective, health, and clinical sciences, as well as psychophysiology, electroencephalography, and functional neuroimaging to better understand how the visceral body can impact experience, behavior, disease, and psychopathology (Cameron, 2001; Khalsa et al., 2018; Tsakiris & De Preester, 2018). This interest has contributed to a proliferation of constructs that presumably tap into different aspects of interoception. The two most commonly measured constructs are (1) the objective *interoceptive ability* to detect changes in visceral signals, such as one's heartbeat (sometimes called cardiac or heartbeat perception) and (2) individuals' subjective tendency to focus on interoceptive sensations in self-reports or to characterize the self as highly interoceptive (*interoceptive sensibility)*. A third much less explored construct is *interoceptive beliefs* about the value vs. danger of one's interoceptive sensations. In this dissertation, I argue that interoceptive sensibility and beliefs represent psychological kinds of interoceptive priors.

One fundamental challenge facing interoceptive science is construct validity. Although interoceptive science is an old field, this area has only really seen substantial growth in the past decade. As such, the broader construct of interoception remains inconsistently defined and operationalized, making it difficult to interpret and integrate evidence. Furthermore, findings with interoception and physiology or emotion are often contradictory or mixed, but this is likely in part due to differences in construct specification and measurement. Recent work has sought to address these issues by providing a formal roadmap to different interoceptive constructs (Khalsa et al., 2018). Yet we still know little about how different constructs (e.g., interoceptive ability, sensibility, beliefs) relate to each other, let alone their predictive validity for linking peripheral psychophysiology measures to emotion. This dissertation serves as an opportunity to provide further clarity and precision to the construct of interoception. Below, I integrate previous literature together to briefly introduce and define the constructs of interoceptive ability, sensibility, and beliefs.

Interoceptive Ability

To date, interoceptive ability remains the most investigated facet of interoception, defined as the objective ability to accurately discriminate and track visceral changes, such as one's heartbeat, respiration, or gastrointestinal sensations. The heartbeat detection task developed by Whitehead and colleagues (1977) is based on signal detection theory, wherein individuals are presented with false vs. true feedback about their heartbeats and must separate out true cardiac signals from false foils. Similarly, the heartbeat tracking task developed by Schandry and colleagues (e.g., Schandry, 1981) asks individuals to count the number of heartbeats they perceive in a random set of time intervals which is then compared against the actual number of heartbeats that occurred. Although other tasks have been designed to assess additional visceral dimensions, such as gastric and respiratory perceptions (Daubenmier et al., 2013; Ferentzi et al., 2018; Garfinkel et al., 2016; Herbert, Muth, Pollatos, & Herbert, 2012; van Dyck et al., 2016), the Whitehead and Schandry heartbeat tasks remain the most popular measures to date, likely because heartbeats are relatively discrete signals that can be easily and cheaply measured (e.g., Brener & Kluvitse, 1988).

Prior work demonstrates substantial between-person differences in heartbeat or cardiac perception (Barrett et al., 2004; Jones, 1994; Katkin, 1985; Schandry, Bestler, & Montoya, 1993; Wiens et al., 2000). For example, men, younger adults, and individuals with lower body mass generally perform better on cardiac perception tasks than women, older adults, and overweight or obese individuals (Herbert & Pollatos, 2014; Jones, 1994; Khalsa, Rudrauf, & Tranel, 2009; Murphy, Geary, Millgate, Catmur, & Bird, 2018; Schandry & Bestler, 1995). Very high or low interoceptive ability is further implicated in psychopathology: for example, individuals with eating disorders or depression tend to perform poorly on cardiac perception tasks (Pollatos et al., 2008; Pollatos, Traut-Mattausch, & Schandry, 2009), whereas individuals with higher trait anxiety, social anxiety, generalized anxiety, or panic disorder tend to perform better (e.g., Domschke, Stevens, Pfleiderer, & Gerlach, 2010; Richards, Cooper, & Winkelman, 2003).

Interoceptive Sensibility

A more recent construct, interoceptive sensibility is the second most commonly investigated facet of interoception. It can be defined as the tendency to notice and focus on interoceptive sensations and to characterize oneself as interoceptive (Garfinkel & Critchley, 2013; Garfinkel et al., 2015). Sensibility reflects a trait-like self-construal about how interoceptive an individual *believes* they are, measured with questionnaires such as the Multidimensional Assessment of Interoceptive Awareness (MAIA; Mehling et al., 2012) and the Body Awareness Questionnaire (BAQ; Shields, Mallory, & Simon, 1989). For example, the MAIA includes items assessing how much people think they notice and pay attention to their bodily sensations. The BAQ similarly assesses how much people think they notice and can track different types of physiological changes such as being hungry, fatigued, or ill.

Interestingly, interoceptive sensibility appears to be independent of interoceptive ability. Indeed, a handful of studies show that sensibility is unrelated to interoceptive ability (Calì, Ambrosini, Picconi, Mehling, & Committeri, 2015; Garfinkel et al., 2015; Murphy et al., 2020), suggesting that people's beliefs about their own interoceptive ability do not always map onto objective performance. As an example of the dissociation between interoceptive ability vs. sensibility, one set of studies found that mindfulness training over time did not improve interoceptive ability but did increase people's confidence in and self-characterizations as being interoceptively attuned (Parkin et al., 2014). A more recent study found that interoceptive sensibility (measured with the BAQ) was negatively associated with both subjective well-being and retrospective reports of recent somatic symptoms (Ferentzi et al., 2019). However, there was no association between heartbeat tracking, gastric sensitivity, or proprioceptive measures of interoceptive ability with wellbeing and somatic symptoms, further underscoring the independence of ability vs. sensibility.

Because interoceptive sensibility can be easily measured in questionnaire format, it is unsurprising how widely this construct has been examined since Garfinkel and Critchley first introduced it in 2013. For example, greater interoceptive sensibility is positively associated with both trait mindfulness and trait anxiety, but negatively associated with trait alexithymia and depression (e.g., Hanley, Mehling, & Garland, 2017; Mehling et al., 2013; Palser et al., 2018). Despite these trait-based associations, how sensibility relates to *state* measures of psychophysiology, emotion, and even somatic sensations remains underexamined. Ultimately, interoceptive sensibility may reflect how much individuals' monitor (or at least *think* they monitor) their physiological changes, but this interoceptive monitoring does not necessarily reveal anything about the evaluative *meaning* that individuals are then applying to said physiology.

Interoceptive Beliefs

In contrast to interoceptive sensibility, there is some work on "interoceptive construals" or "interoceptive fear" that target the negative vs. positive meaning that people make of their internal bodily sensations (e.g., Farb et al., 2015; Pappens et al., 2013; van den Hout, van der Molen, Griez, & Lousberg, 1987; Yoris et al., 2015). In this dissertation, I call these "interoceptive beliefs" for ease of distinguishing them from sensibility[1]. Interoceptive beliefs more broadly encompass the meta-cognitive evaluative frameworks and schemas that individuals have about the nature, value, and management of interoceptive sensations. For example, some mindfulness practices teach the belief that bodily sensations should be treated with acceptance or can serve as valuable sources of self-insight (e.g., Farb et al., 2015). On the other hand, people with eating disorders tend to believe that bodily sensations like hunger must be controlled or ignored (Lattimore et al., 2017; Merwin, Zucker, Lacy, & Elliott, 2010). More generally, some work has already sought to examine individuals' cognitive schemas and beliefs surrounding hunger, illness, and medical treatment (Horne, Weinman, & Hankins, 1999; Proffitt Leyva & Hill, 2018; Weinman, Petrie, Moss-Morris, & Horne, 1996).

However, the largest amount of pre-existing work on interoceptive beliefs has been in the context of anxiety sensitivity and panic disorders. *Anxiety sensitivity* refers to the tendency to fear or catastrophize arousal-related somatic symptoms in part due to negative beliefs about the consequences of that physiological arousal (Deacon & Abramowitz, 2006). To date, several studies have found that both children and adults high in anxiety sensitivity do not generally differ in their physiological reactivity (e.g., heart rate) compared to non-sensitive peers, despite these individuals reporting more intense somatic sensations or state anxiety (Eley, Stirling, Ehlers, Gregory, & Clark, 2004; Stewart, Buffett-Jerrott, & Kokaram, 2001; Sturges, Goetsch, Ridley, & Whittal, 1998; Zoellner & Craske, 1999). On the other hand, individuals prone to anxiety or panic exhibit greater interoceptive ability relative to non-clinical controls, especially during arousing situations (see reviews in

[1] Technically, interoceptive sensibility is a kind of interoceptive belief, specifically as a judgment or belief about one's own interoceptive access or ability. I am distinguishing sensibility from other more evaluative interoceptive beliefs about the value/safety and manageability of sensations.

Domschke, Stevens, Pfleiderer, & Gerlach, 2010). Although interoceptive ability does seem to play a role in anxiety and panic disorders, broader work suggests that individuals' beliefs and schemas that certain bodily sensations (e.g., increased heart rate) are dangerous or threatening may matter more, especially for the anticipation and interpretation of perceived physiological changes (Ehlers, 1993; Harvey, Richards, Dziadosz, & Swindell, 1993; Lee et al., 2006; Melzig, Michalowski, Holtz, & Hamm, 2008; Paulus & Stein, 2010; Richards, Austin, & Alvarenga, 2001; Stevens et al., 2011; van den Hout et al., 1987; Yoris et al., 2015).

Altogether, these disparate data suggest that interoceptive beliefs are likely accumulated via both idiographic experience and cultural transmission (e.g., garnered from upbringing, folk wisdom about the body, traumatic personal experiences, etc.), in line with models of knowledge and belief acquisition from cognitive, developmental, and clinical science (e.g., Barsalou, 2009; Vigliocco, Meteyard, Andrews, & Kousta, 2009; Xu & Griffiths, 2011). However, although some work already examines evaluative beliefs about the body as discussed above, no work to my knowledge has examined interoceptive ability, sensibility, and beliefs side by side in the context of acute stress.

The Felt Body: Linking Interoception to Physiology and Emotion

In sum, interoceptive ability, sensibility, and beliefs are three interoceptive constructs that may represent different psychological avenues by which interoceptive perceptions and priors can help transform peripheral physiology into emotional experience. Next, I briefly summarize what is known about interoception in relation to physiological reactivity and emotion reports, after which I discuss why the priors afforded by interoceptive sensibility and beliefs are likely pivotal in linking the felt body to subjective experience.

Interoception and Physiological Reactivity

If some individuals experience more intense emotional experiences during, say, an acute stressor—this could be because said individuals simply having more reactive peripheral systems (e.g., the autonomic nervous system). This explanation is a "main effect" hypothesis, wherein there is a one-to-one correspondence between psychophysiological reactivity and emotional reactivity. Prior studies affirm that psychophysiology and emotion are indeed coupled (Brown et al., 2019; Mauss, Levenson, McCarter, Wilhelm, & Gross, 2005; Sze, Gyurak, Yuan, & Levenson, 2010). Yet the association between physiology and emotion tends to be weak and subject to individual differences (Campbell & Ehlert, 2012; Sommerfeldt, Schaefer, Brauer, Ryff, & Davidson, 2019). For example, Pennebaker and Hoover (1984) found that self-reported heart rate was a more robust correlate of subjective pleasantness during a behavioral task than objective heart rate. As such, researchers have increasingly turned to interoception—and in particular, interoceptive ability—as a crucial moderator between physiological reactivity and subjective experience. This approach instead can be characterized as a “moderation” (or in some cases, a “mediation”) hypothesis, wherein the effects of physiological signals on subjective experiences can be exacerbated vs. buffered or even mediated by interoceptive processes.

One question that might arise when measuring interoceptive ability is whether or not, as with emotional reactivity or intensity, individuals’ interoceptive perceptions are simply due to having more reactive physiological systems. Interestingly, several studies on interoceptive ability and physiology do not find any differences in physiological reactivity (e.g., heart rate, blood pressure) between those high vs. low in cardiac perception, regardless of task type be it public speaking, social exclusion, or evocative images (e.g., Hantas, Katkin, & Blascovich, 1982; Kindermann & Werner, 2014a, 2014b; Werner, Duschek, Mattern, & Schandry, 2009; Werner, Kerschreiter, Kindermann, & Duschek, 2013). These findings help rule out the hypothesis that individuals with greater interoceptive ability are more perceptive of bodily changes simply because their physiological systems are more robust or reactive; instead, these individuals appear to have *greater access* to visceral signals.

But not all literature is consistent. For example, Eichler and Katkin (1994) administered the Whitehead heartbeat detection task and found that good detectors showed greater shifts in pre-ejection period (a cardiac marker of sympathetic nervous system activity) and marginally greater cardiac output during a mental arithmetic task relative to poor detectors—although they found no group differences for other indices like heart rate, left ventricular ejection time, or stroke volume. Similarly, Herbert et al. (2010) found that better performance on the Schandry task was associated with greater reactivity in heart rate, respiratory sinus arrhythmia, and stroke volume during affect inductions with mental math and evocative pictures. Other studies also find a positive association between interoceptive ability and physiological reactivity (Ludwick-Rosenthal & Neufeld, 1985;

Pollatos, Herbert, Kaufmann, Auer, & Schandry, 2007; Schandry et al., 1993), although some studies show an inverse relation between interoceptive ability and specifically heart rate reactivity (Antony et al., 1995; Eichler, Katkin, Blascovich, & Kelsey, 1987).

On the one hand, these mixed findings could be due to small sample sizes and related issues with false positives. On the other hand, the link between physiological reactivity and interoceptive ability is likely complicated. Although interoceptive theories often focus on the afferent pathway by which peripheral signals feed into central interoceptive and affective representations, it is also likely that these interoceptive representations can feed back to impact physiological reactivity (i.e., efferent pathway), given that the brain and periphery are in constant communication. This could help explain why sometimes interoceptive ability is linked with physiological reactivity. Additionally, the link between interoceptive ability and physiological reactivity may be subject to specific conditions (e.g., state differences at rest vs. under physical or cognitive effort; see Fairclough & Goodwin, 2007; Machado et al., 2019) or between-person heterogeneity in other processes (e.g., executive functions) that have not been captured in existing studies. Beyond interoceptive ability, little to no work has yet (to my knowledge) examined how interoceptive sensibility and beliefs relate to physiological reactivity either at rest or during a stressor.

Interoception and Emotion Reports

Since the earliest days of interoceptive science, researchers have sought to yoke interoception with emotion. For example, several studies have focused on the association of interoceptive ability with trait or state anxiety and emotionality (Calì et al., 2015; Critchley, Wiens, Rotshtein, Öhman, & Dolan, 2004; Dunn, Stefanovitch, et al., 2010; Garfinkel, Tiley, et al., 2016; Lackner & Fresco, 2016; Ludwick-Rosenthal & Neufeld, 1985; Lugo et al., 2017; Lyyra & Parviainen, 2018; Montgomery & Jones, 1984; Montoya & Schandry, 1994; Mussgay, Klinkenberg, & Rüddel, 1999; Schandry, 1981; Sugawara, Terasawa, Katsunuma, & Sekiguchi, 2020; Van der Does, Antony, Ehlers, & Barsky, 2000). In general, these studies assessed state or trait emotion at rest in the absence of an affect induction. On the other hand, most studies examining *in vivo* emotional experience and interoceptive ability have used evocative images or film clips (Dunn, Galton, et al., 2010; Eichler et al., 1987; Ferguson & Katkin, 1996; Hantas et al., 1982; Herbert et al., 2010; Herbert, Pollatos, & Schandry, 2007; Mikkelsen, O'Toole, Lyby, Wallot, & Mehlsen, 2019; Pollatos, Gramann, & Schandry, 2007; Pollatos, Herbert, Matthias, et al., 2007; Pollatos, Kirsch, & Schandry, 2005; Pollatos, Schandry, Auer, & Kaufmann, 2007; Pollatos, Traut-Mattausch, Schroeder, & Schandry, 2007; Schandry, 1981, 1983; Wiens et al., 2000). Finally, only a few studies have used cognitive stressors such as mental arithmetic (Blascovich et al., 1992; Fairclough & Goodwin, 2007; Kindermann & Werner, 2014a, 2014b) or psychosocial stressors such as public speaking (Durlik, Brown, & Tsakiris, 2014; Schandry, 1983; Werner et al., 2009) as other types of affect inductions. Overall, many of these studies found that greater interoceptive ability (in particular, as measured by the Schandry task) was associated with more intense emotion reports, especially negative and/or high arousal emotions as well as greater state or trait anxiety.

However, the link between interoceptive ability and emotion is far more inconsistent than many might suppose. Although many of the above studies are cited widely as evidence for a significant positive association between interoceptive ability and emotional intensity, most studies also include several null or negative effects that tend to be overlooked in current discussions. For example, some studies find significant associations for trait anxiety or emotionality but not state anxiety or emotionality (e.g., Critchley et al., 2004; Durlik et al., 2014; Garfinkel, Tiley, et al., 2016; Van der Does et al., 2000) despite other studies finding significant state anxiety effects (Montoya & Schandry, 1994; Schandry, 1981, 1983; Sugawara et al., 2020; Werner et al., 2009).

In the context of affect inductions, several studies find no significant effects of cardiac perception on valence ratings but do find significant effects on emotional intensity overall or effects specific to arousal reports (e.g., Herbert et al., 2010, 2007; Pollatos, Herbert, Matthias, et al., 2007; Pollatos et al., 2005; Wiens et al., 2000). Barrett and colleagues (2004) found that interoceptive ability on the Whitehead heartbeat detection task was positively associated with greater "arousal-focused" emotion reports in two separate experience sampling studies—but heartbeat detection was negatively related to overall emotional intensity in the first study and unrelated to overall emotional intensity in the second study. Furthermore, several other studies report either no relation or a negative relation with interoceptive ability, such that higher interoceptive ability is unrelated to or significantly associated with *less* intense emotion reports and lower state or trait anxiety (Blascovich et al., 1992;

Fairclough & Goodwin, 2007; Ferguson & Katkin, 1996; Garfinkel, Tiley, et al., 2016; Lackner & Fresco, 2016; Mikkelsen et al., 2019; Montgomery & Jones, 1984; Mussgay et al., 1999; Sugawara et al., 2020; Werner et al., 2009; Zamariola, Luminet, et al., 2019). For example, Werner et al. (2009) found that better performance on the Schandry task was associated with less trait anxiety overall and less state anxiety before and after the TSST. Other work such as Ludwick-Rosenthal & Neufeld (1985) found that better cardiac perception was related to higher state anxiety, but that these effects disappeared when controlling for heart rate.

Altogether, discrepancies in findings could be due to the fact that (1) the majority of these studies, with rare exceptions, used small sample sizes ($N<50$) which are likely underpowered to detect small effects of interoceptive ability on emotion and (2) the diversity of interoception and emotion measures used across studies may confound or mask the underlying true effects of interoceptive ability on emotion. For example, Zamariola and colleagues (2019) conducted integrative data analysis across four studies ($N>500$ participants) that used affect inductions with social exclusion or negative feedback—yet found no effect of interoceptive ability (measured with the Schandry task) on self-reported mood, despite the affect inductions significantly eliciting mood changes. Such findings in a large sample size raises many questions about previous findings. Furthermore, there has been no larger sample sized study assessing the link between interoceptive ability and emotion using the Whitehead task, a gap this dissertation seeks to address. Finally, many studies have not controlled for the shared variance between psychophysiology and interoceptive ability, despite both old and new work indicating the importance of this (Ludwick-Rosenthal & Neufeld, 1985; Murphy, Brewer, et al., 2018). Again, this has obscured the extent to which the body's link with emotional experience may be driven more by psychophysiological reactivity, interoceptive ability, or some degree of both.

Besides interoceptive ability, much less work has examined the associations between interoceptive sensibility or interoceptive beliefs and state or trait emotion. For example, one study showed that interoceptive sensibility (measured with the MAIA) was inversely associated with susceptibility to emotion (Calì et al., 2015), whereas another study found that interoceptive sensibility (measured with the Body Perception Questionnaire) was positively related to trait anxiety (Palser et al., 2018). Still other evidence suggests that interoceptive sensibility is completely unrelated to mood during affect inductions (Zamariola, Luminet, et al., 2019). With regards to interoceptive beliefs, studies on anxiety sensitivity and panic disorders have investigated how catastrophizing beliefs or interpretations of one's interoceptive sensations may lead to more intense and extreme emotional experiences in the context of acute stress (Ehlers, 1993; Pauli et al., 1991).

In sum, most research focuses on interoceptive ability in relation to physiology and emotion, with less work examining how interoceptive sensibility and beliefs relate to *in vivo* physiology and emotion in healthy adults. Certainly, both physiology and to some extent interoceptive ability must serve as the embodied foundation from which subjective experiences arise (Barrett & Bliss-Moreau, 2009; Bechara & Naqvi, 2004; Craig, 2003; Damasio, 1994; Duncan & Barrett, 2007; Gianaros & Jennings, 2018; James, 1884; Seth, 2013; Thayer & Lane, 2009). As such, both physiology and interoceptive ability are likely necessary for emotional experience up to a certain point, much as visually perceiving ("seeing") an object depends upon there being an object for the eyes and brain to perceive in the first place. However, a long history of psychological literature emphasizes that expectations and the attributions people make of stimuli can exert powerful influences on perception, experience, and behavior. Just as the brain's predictions can lead to optical illusions and even somatosensory "illusions" such as that of a rubber hand or phantom limb pain (Flor et al., 1995; Tsakiris & Haggard, 2005), so too may physiological changes and their associated interoceptive signals be insufficient on their own for influencing emotion without the situated inferences afforded by interoceptive priors.

The Power of Priors: Why Physiology and Interoceptive Ability are Insufficient

In traditional models of psychology and neuroscience, the mind, brain, and behavior are described within a "stimulus-response" framework (see discussions in Dewey, 1896; Holland, 2008; Wickens, 1954). In this framework, the brain and mind lie inert until some stimulus or sensory input perturbates the system, leading to an evoked reaction (e.g., neuronal firing, behaviors). Over the past decade, converging evidence and theory suggest that this framework is over-simplistic. Instead, the brain and mind are likely "Bayesian" in nature, making probabilistic predictions based on prior experiences about the causes of and best ways to manage incoming sensations (Clark, 2013;

De Ridder, Vanneste, & Freeman, 2014; Friston, 2010; Knill & Pouget, 2004). Indeed, Von Helmholtz (1867) first raised the issue of how we can infer the physiological causes of sensory perceptions. He argued that causal inference about sensations must require the computation of probability distributions for many different "causes" before determining which distribution is most probable based on the context and prior probabilities.

Importantly, active inference perspectives place a strong emphasis on context and "priors" gained from previous experience, as the ground from which probabilistic inferences are made. Learning occurs via "prediction errors," when incoming sensory signals do not match predictions based on prior probabilities. There is already evidence that the brain operates in this fashion, thanks to pioneering work on the computational neuroscience of vision, audition, and motor movements (e.g., Adams, Shipp, & Friston, 2013; Brown et al., 2013; Chennu et al., 2013; Kok, Mostert, & de Lange, 2017; Mesulam, 1998; Weiss, Simoncelli, & Adelson, 2002). Several neuroscientists have sought to extend active inference accounts to interoception (e.g., Allen, Levy, Parr, & Friston, 2019; Barrett & Simmons, 2015; Seth, 2013). Such models outline how the brain (1) anticipates through "forward inference" what is going to happen to the organism, (2) makes predictions about the body's current state and resources, and (3) orchestrates bodily changes and psychological states such as emotions to help meet those anticipated events (Barrett, 2017; Barrett, Quigley, & Hamilton, 2016; Friston & Kiebel, 2009; Gianaros & Jennings, 2018; Hutchinson & Barrett, 2019; McEwen & Wingfield, 2003, 2010; Parr & Friston, 2019; Sterling, 2020; Sterling & Eyer, 1988; Sterling & Laughlin, 2015).

Although the brain receives direct spinal lamina projections from the periphery, these ascending peripheral signals tend to be slow and to include information across several interoceptive modalities (Berntson, Gianaros, & Tsakiris, 2018). As such, it is likely more efficient for the brain to rely on predictions from prior experiences with the body and to only update those predictions if there is sufficient prediction error from the periphery. As noted by Barrett and Simmons (2015): "This means that interoceptive perception is largely a construction of beliefs that are kept in check by the actual state of the body (rather than vice versa). What you experience is in large part a reflection of what your brain predicts is going on inside your body, based on past experience." (p. 8).

However, active inference models, even in the domains of emotion, tend to emphasize neural or computational instantiations of “prediction” or priors (Allen et al., 2019; Friston, Joffily, & Barrett, 2018; Gentsch, Sel, Marshall, & Schütz-Bosbach, 2019; Hesp et al., 2019; Owens, Friston, Low, Mathias, & Critchley, 2018; Seth, 2013; Seth & Friston, 2016)–and do not formally investigate the *psychological* content that might go into these predictions (although see Smith, Parr, & Friston, 2019). Yet much of psychological science is devoted to understanding how humans acquire, organize, and apply “priors” in the form of expectations, beliefs, and schemas (e.g., Bargh, Chen, & Burrows, 1996; Barsalou, 2009; Bartels et al., 2017; Harris & Rosenthal, 1985; Jamieson, Mendes, Blackstock, & Schmader, 2010; Loersch & Payne, 2011; Nisbett & Wilson, 1977; Reicherts et al., 2016; Wyer & Gordon, 1984).

Similarly, the theory of constructed emotion weds together active inference models from computational neuroscience with a rich literature on concepts and beliefs from psychology, developmental science, anthropology, and linguistics (Atzil, Gao, Fradkin, & Barrett, 2018; Hoemann & Barrett, 2019; Hutchinson & Barrett, 2019; Jackson et al., 2019; Lindquist, MacCormack, & Shablack, 2015). This theory posits that the brain uses accumulated priors to categorize and make meaning of interoceptive signals as specific instances of a given emotion category (Barrett, 2006, 2017, 2018; Lindquist, 2013; Lindquist et al., 2012). Given this hypothesis, many constructionist-inspired studies focus on manipulating or examining variability in individuals’ emotion concepts and beliefs and what impact this has on resultant emotion experiences and perceptions (Anderson & Barrett, 2016; Doyle & Lindquist, 2018; Gendron, Roberson, van der Vyver, & Barrett, 2014; Jackson et al., 2019; Lindquist, Gendron, Barrett, & Dickerson, 2014; Lindquist, Gendron, Oosterwijk, & Barrett, 2013).

However, concepts and beliefs *about the body* have largely been ignored in the context of this theoretical framework. Thus, given these active inference and constructionist approaches, I posit that expectations about interoceptive signals (i.e., interoceptive sensibility and beliefs) should play an especially important role in shaping people’s experiences above and beyond actual physiological changes and access to those changes (interoceptive ability)[2]. Next, I outline my specific hypotheses.

Hypotheses

Based on the constructionist hypothesis that interoceptive priors should play an important role in the construction of emotional experiences, I predicted that (1) interoceptive sensibility and beliefs would relate to emotional intensity during the acute stress induction and (2) that these interoceptive priors would matter for negative, high arousal emotion above and beyond physiological reactivity or interoceptive ability. Furthermore, I reasoned that interoceptive beliefs may be particularly relevant for emotion, even more so than interoceptive sensibility, given that sensibility is more about the monitoring of interoceptive signals and does not imply anything about how said monitoring could help buffer against vs. exacerbate the translation of physiology to emotion. Finally, I expected that all three facets of interoception would moderate the association between physiological reactivity and emotion during the TSST, with interoceptive beliefs serving as the most central moderator.

Based on prior findings that link greater interoceptive ability to more intense, arousal-focused negative emotions (e.g., Barrett et al., 2004; Pollatos et al., 2005; Wiens et al., 2000), I expected that interoceptive ability would *exacerbate* the association between physiological reactivity and negative, high arousal emotions. Similarly, given work linking interoceptive sensibility with greater trait anxiety (Garfinkel, Tiley, et al., 2016; Palser et al., 2018; Terasawa, Shibata, Moriguchi, & Umeda, 2013), I thought that interoceptive sensibility would also *intensify* the association between physiological reactivity and negative, high arousal emotions[3]. Interoceptive beliefs, on the other hand, target people's evaluative beliefs about the value and meaning of interoceptive signals; as such, I hypothesized that more positive or less negative interoceptive beliefs would *buffer* against the link between physiological reactivity and negative, high arousal emotions, as such beliefs could reflect greater comfort with and acceptance of interoceptive sensations.

[2] This of course does not address the fact that individuals' interoceptive priors and expectations, via efferent connections between the brain-to-body, likely also shape physiological reactivity and in-the-moment interoceptive access (i.e., state interoceptive ability).

[3] Although note in my discussion above that there were several studies showing *negative* or even no associations for interoceptive ability and sensibility with emotional intensity, negative, high arousal emotions, and state/trait anxiety.

CHAPTER TWO: TESTING THE ROLE OF INTEROCEPTION IN EMOTION

In Session 1, healthy young adults completed the Whitehead heartbeat detection task to assess interoceptive ability as well as questionnaire measures of interoceptive sensibility and beliefs. In Session 2, participants returned to the laboratory and completed the Trier Social Stress Test (TSST; Kirschbaum et al., 1993), with cardiac psychophysiological measures of the sympathetic and parasympathetic nervous system continuously measured at baseline, throughout the stressor, and at recovery post-stressor. Immediately after the stressor, participants rated their experiences during the TSST, including their emotions, somatic sensations, and appraisals of the situation. In this dissertation, I focused on emotion as the primary self-reported stress outcome of interest, but also include secondary analyses with somatic sensations in the **Appendix** as somatic sensations could serve as a useful parallel in comparison vs. contrast with emotion.

Participants

We recruited 250 healthy young adults from the University of North Carolina at Chapel Hill's Department of Psychology and Neuroscience introductory psychology course participant pool (57.6% female; 57.6% European American, 13.6% African American, 13.6% Asian American, 6.4% Latinx, 6.0% biracial, and 2.8% that were other ethnic identities; M_{age}= 19.20 years, SD_{age}= 1.29 years ranging from 17 to 29 years old; see **Table 1** for other sample characteristics).

Procedure

Participants completed two different laboratory visits, each at least one week but no more than one month apart. The goal of the first laboratory session was to assess interoceptive ability, sensibility, and beliefs as well as other participant characteristics. The goal of the second laboratory session was to induce robust changes to the autonomic nervous system and individuals' emotional experiences in the context of the TSST. During recruitment and throughout all phases of the study, participants were told that the study assessed "individual differences in physiology and cognition." We were careful to never mention emotions or stress to participants in any study documents or experimenter scripts. Participants received study participation credits once both sessions were complete.

Prescreening and Session Screening

All potential participants were first prescreened prior to enrollment. Individuals were excluded if (1) they reported a psychiatric illness including depression, anxiety, or social anxiety either currently or in the past two years, (2) they reported having a diagnosed heart condition (e.g., murmur) or pacemaker, or (3) they reported having an eating disorder or if their self-reported height and weight indicated a body mass index (BMI) over 33. We excluded individuals with any psychiatric conditions or mood disorders with the goal of first establishing effects within a healthy sample to lay the foundation for future extensions to other populations. Second, the TSST might be extremely distressing for some individuals, and we did not want the task to adversely exacerbate existing mental health conditions. We excluded individuals with a heart condition or pacemaker, to promote their safety and to improve the accurate estimation and interpretation of cardiovascular data. Finally, we excluded individuals with eating disorders or obesity given that eating disorders and obesity are both associated with altered interoception (Herbert & Pollatos, 2014; Pollatos et al., 2008; Simmons & DeVille, 2017) and given that high adiposity impedes accurate psychophysiological recording (Frank, Colliver, & Frank, 1986).

In addition to these prescreening exclusions, we provided several instructions to participants prior to their arrival. Prior to each laboratory visit, participants were instructed to avoid certain foods, substances, or health behaviors on the day of their laboratory visit, given that these could temporarily elevate or alter autonomic functioning. Specifically, participants were asked to avoid ingesting alcohol, drugs (e.g., marijuana), caffeine, or excessive sugar within three hours prior to arrival. Similarly, participants could not eat a heavy meal nor engage in aerobic activity within the hour prior to arrival. Upon arrival, all participants first completed a “health” questionnaire asking them about the above behaviors, to serve as a protocol check and screening. We also asked participants more generally about their current health and emotional state. For example, we asked if individuals were currently sick, taking any medications such as acetaminophen or pseudoephedrine, or if participants had recently experienced a family loss or romantic break-up. Participants who failed to follow session instructions, who were currently ill, or taking any sort of medication were either excluded (e.g., if they chronically took ADHD medications) or were rescheduled to a later date (e.g., at a time when they might be feeling better and no longer need to take medication).

Session 1: Interoceptive Assessments

The first laboratory visit lasted for two hours. A trained experimenter greeted participants wearing a white laboratory coat and maintained a neutral affective demeanor throughout the study session. Participants completed Session 1 in a private testing room that included only the testing computer and psychophysiological equipment. Participants removed all jewelry and belts (as these can interfere with the psychophysiological measures), as well as any wearable technology (e.g., Fitbits, Apple Watches that could distract participants or provide them with biofeedback), and left their phones on silent outside the testing room (again, to prevent distraction). Participants first reported on their current health and completed informed consent. After this initial intake, all participants completed an open-ended "Feelings Report" wherein they freely wrote as much as they wished about their current feelings. The experimenter then prepared the participant for electrocardiography (ECG) data collection (necessary for the interoceptive ability task). Participants were instructed to relax and sit as still as possible. We collected five minutes of baseline ECG recordings, which provided individuals' R-peak threshold for use in the interoceptive ability task.

After ECG baseline data collection, participants completed the rest of the session's tasks in counterbalanced order: (1) the Whitehead heartbeat detection task to assess interoceptive ability, (2) a Qualtrics survey that included measures of interoceptive sensibility and beliefs, and (3) an exploratory measure of interoceptive knowledge using a behavioral reaction time task. Tasks were counterbalanced given that completing the heartbeat detection task might make interoceptive construals and associations more accessible, temporarily altering interoceptive sensibility, beliefs, and knowledge. In addition to the tasks themselves being counterbalanced, specific questionnaires within the Qualtrics survey and items within questionnaires were randomized. Similarly, trials within the heartbeat detection task and trials within the behavioral reaction time task were also randomized to prevent order effects. Of note, before the counterbalanced tasks began, the experimenter turned off the room's overhead lights and left a small lamp on in the room. The goal here was to create a calm environment in which participants could better focus on their heartbeats during the interoceptive ability task, in line with recommendations from Kleckner et al. (2015). However, because the interoceptive ability task was counterbalanced with other tasks, we left the lights dim throughout all tasks. After Session 1 tasks were complete, the experimenter thanked the participant and provided reminders about the second laboratory visit.

Session 2: Emotion Experience during an Acute Stressor

Of the 250 total sample who completed the first session, 227 participants (90.8%) returned for the second visit. Session 2 lasted for about two hours. Again, as in Session 1, a trained experimenter greeted participants wearing a white laboratory coat and maintained a neutral affective demeanor throughout the study session. Participants completed Session 2 in a large private testing room that included the testing computer, psychophysiological equipment, and a table with two chairs opposite the participant. As in Session 1, participants removed all jewelry, belts, and wearable technology and left their phones on silent outside the testing room. Also, as in Session 1, participants first completed a "health check" (to check for protocol adherence) as well as an open-ended "Feelings Report."

Baseline Psychophysiology. Next, the experimenter prepared participants for psychophysiological data collection. In Session 2, we collected ECG, impedance cardiography (ICG), and continuous blood pressure. For baseline, participants were instructed to relax and sit as still as possible. We collected five minutes of baseline ECG, ICG, and blood pressure recordings.

Task Consent. After baseline recordings, the experimenter re-entered the testing room and provided a new consent form. As required by the IRB, this consent form specifically told participants that they were about to undertake a cognitive behavioral test that included public speaking so that we could assess their "cognitive performance under pressure." No mention of stress or emotion was made. After consent, the TSST began.

The Trier Social Stress Test. The experimenter invited in two "interviewers" whom the participant learned were experts in nonverbal communication, public performance, and cognitive ability. Interviewers dressed professionally (e.g., neutral clothing, tidy hair, close-toed shoes) and wore white laboratory coats over their clothing. Interviewers introduced themselves to the participant in a neutral manner and sat in the seats opposite the participant across the table. The interviewers then gave participants a laminated card with the following instructions and read them aloud:

> "We would like for you to imagine that this is a preliminary interview for a desirable job in your specific area of interest. You will describe qualities that make you well suited for this dream job during a 10-minute speech to a panel of interviewers. You can talk about your work experience, your work style, and your strengths and weaknesses. During the speech, we would like for you to describe in detail one particular example from your past that demonstrates your work ethic and/or individual philosophy that would be relevant for the job. The interviewers will let you know when the 10 minutes are over. During your speech, please try to demonstrate that you have insight into yourself regarding your strengths and weaknesses as a person, and how you are trying to change aspects of yourself that need changing and augment aspects of yourself that are positive."

After these instructions, the experimenter and interviewers left the room to allow the participant 2-min to mentally prepare their speech. After these 2-min ended, interviewers re-entered the room with clipboards, evaluation sheets, and pens, taking up their seats opposite the participant. One interviewer removed the laminated instructions and was in charge of timing the speech with a stopwatch. The second interviewer reminded the participant of the speech content and told the participant when to begin. Participants talked for the full 10-min. If they paused for more than 10 seconds, interviewers prompted the participant to "Please continue. You still have some time left." As the participant spoke, interviewers watched the participant with a neutral facial expression and wrote notes down periodically on the clipboard. Even if the participant cracked jokes or told an emotional story, interviewers were extensively trained to remain neutral. If participants asked how much time they had left, an interviewer would blandly respond with, "You still have some time left. Please continue." If the participant went silent and did not keep speaking after being asked to continue twice, then interviewers had a set of follow-up prompts to keep the participant talking. Example prompts include: "Could you please provide an example of your specific work ethic?" and "Could you elaborate on your weaknesses and what you'd do to overcome them in this job?"

After the 10-min speech was over, the interviewers introduced a surprise task that the participant was not told about previously. Participants learned that they would count backwards starting at the number 996 in steps of 7 and should count backwards as fast as they can with as few errors as possible. Participants did not know the duration of this task. If participants made an error, an interviewer would interrupt them and say, “That last number was incorrect. Please start again at the number 996.” If participants lost their train of thought or couldn’t recall which number they last completed, they were likewise asked to start again from the beginning. If a participant found the task too easy (i.e., counted quickly with little pause, made no mistakes, or reached the number 324—halfway through the counting set—with no problems), then an interviewer would interrupt the participant and say, “We now have another task for you. Please count backwards starting from 2043 in steps of 17.” On the other hand, if a participant made five mistakes with the original task, the interviewer would interrupt after the fifth mistake and say, “We now have another task for you. Please count backwards starting from 943 in steps of 5.” The goal here was to keep participants engaged with the mental arithmetic rather than allowing them to stop engaging either by giving up due to difficulty or finding the task too easy. After 5-min, interviewers interrupted the participant and told them that the task was complete and that the experimenter would return shortly.

Post-TSST Self-Reports. Immediately after interviewers left, the experimenter re-entered the testing room and provided participants with another open-ended Feelings Report. The experimenter also opened up a Qualtrics survey on the computer and told participants to complete the survey once they finished the Feelings Report. Participants completed the Feelings Report first so that we could observe how participants would most naturally describe their experience and feelings without being prompted with adjectives. Next, in the survey, participants used Likert scales to rate their emotional and somatic experiences during the speech and math tasks, as well as their appraisals of the situation and broader social judgments about the interviewers. (For the purposes of this dissertation, I am only focusing on the emotion self-reports and not these other secondary measures.) Throughout this self-reporting period, we collected 5-min of psychophysiology data to assess individuals’ recovery from the stressor.

After completion of the self-reports and recovery data collection, the experimenter re-entered the testing room and removed the psychophysiological sensors from participants. Participants then completed two other computer tasks that relate to secondary aims of the study. At the end of the session, the experimenter completed debriefing procedures, first interviewing the participant to discover what s/he thought the true purpose of the experiment was, before revealing the study's goals to participants. We also provided participants with information to campus mental health resources (in case the TSST had any adverse effects) and asked participants to avoid discussing study tasks or hypotheses with friends or classmates who might become participants. All participants received four hours' worth of participation credit at the end of the second session.

Session 1 Measures

Psychophysiology

To assess the cardiac cycle at rest for the interoceptive ability task, we collected electrocardiography using Mindware Technologies (Gahanna, OH, USA) BioLab acquisition software. Three non-invasive spot electrodes were placed on participants' torso, with one electrode (-) on the right collarbone and two electrodes (+ and ground) on the lowermost ribs. Baseline data collection lasted for 5-min.

Interoceptive Ability

The Whitehead heartbeat detection task (HBD; Kleckner, Wormwood, Simmons, Barrett, & Quigley, 2015; Whitehead et al., 1977) is considered one gold-standard measure of interoceptive ability. Participants completed the task sitting in a low-light, private testing room with the door closed. Across 60 trials, on each trial, participants heard 10 tones in headphones that were either coincident with their actual heartbeat (200 ms after the R-spike) or not coincident with their heartbeat (500 ms after the R-spike). After each trial, participants indicated "yes" or "no" as to whether the tones did or did not coincide with their heartbeats. Individuals then also rated how confident they were using a slider scale that could range from 0-100% confident.

Prior to the start of the task, experimenters always tested the headphones with the participant to ensure that the headphones were working and that each person could hear task tones. All participants also completed two practice trials beforehand to familiarize themselves with the task. The task was administered with a Matlab program (developed by Kleckner et al., 2015) and accompanying Mindware heartbeat detection software module (v. 3.0.13). The Matlab program generated 60 trials whose order was randomized uniquely to the participant. The PsychToolbox Matlab extension (Kleiner et al., 2007) was used to administer the onscreen instructions and trial-by-trial ratings on the testing computer. Mindware's program collected trigger-based ECG data with the detection threshold set to 70% of individuals' highest baseline R-peak (not including R-peaks that were due to coughing, sneezing, or overt movement).

Using signal detection theory, the task reveals individuals' *hits* (trials where individuals said they felt a heartbeat when it was indeed present), *false alarms* (trials where individuals said they felt a heartbeat even though it was not present), *correct rejections* (trials where individuals said they did not feel a heartbeat and it was indeed not present), and *misses* (trials where individuals said they did not feel a heartbeat even though it was present). Most Whitehead task studies operationalize interoceptive ability as either the *hits ratio* [% of hits / total number of trials] as an index of *accuracy* or compute *d'* as an index of *sensitivity* by subtracting [z-scored hits – z-scored false alarms]. In addition to these performance metrics, the task provides within-person trial-by-trial confidence ratings and reaction times.

Interoceptive Sensibility

Interoceptive sensibility is thought to represent individuals' self-reported trait interoception (e.g., the self-construal about whether I am someone who is generally more in touch with my body relative to other people) and may also encompass a higher tendency to share more interoceptive information in self-reports. Given this construct's multiple dimensions, I chose to collect a couple of different measures that would encompass both individuals' interoceptive self-construals and as well as an exploratory measure looking at people's tendency to focus on interoceptive sensations in open-ended self-reports.

Body Awareness Questionnaire (BAQ; Shields et al., 1989). The BAQ is an 18-item self-report measure of perceived awareness of bodily sensations ($\propto$= .82). In previous validations, this scale was not correlated with hypochondriasis, trait anxiety, trait neuroticism, or self-esteem (Shields et al., 1989), suggesting that it may reflect individuals' self-reported attention or noticing of bodily sensations rather than whether individuals catastrophize or feel distress at those sensations. Example items include, "I can distinguish between tiredness that's caused by hunger and tiredness that's caused by a lack of sleep” and “I know in advance when I'm getting the flu.” Participants responded to items on a 7-point Likert scale from 1 (*not at all true of me*) to 7 (*very true of me*).

Multidimensional Assessment of Interoceptive Awareness (MAIA; Mehling et al., 2012). The MAIA is a 32-item self-report measure of interoceptive sensibility. It was originally developed in focus groups with mind-body instructors (e.g. yoga, meditation) and has since become one of the best-validated and most widely used assessment of interoceptive sensibility. The MAIA measures individuals’ self-reported attentiveness and comfort with bodily sensations. As such, the MAIA is likely not a pure measure of interoceptive sensibility but also assesses evaluative beliefs about interoceptive signals. The MAIA includes eight subscales: *noticing* (awareness of bodily sensations), *not distracting* (accepting uncomfortable sensations rather than distracting or ignoring those sensations), *not worrying* (the tendency to not experience emotional distress during physical discomfort), *attention regulation* (ability to direct and maintain attention to bodily sensations), *emotional awareness* (the tendency to notice bodily sensations during emotions), *self-regulation* (the ability to regulate emotional distress by attending to bodily sensations), *body listening* (the tendency to actively listen to the body for insights), and *body trusting* (the tendency to believe that the body is safe and trustworthy).

Participants responded on 6-point Likert scale from 0 (*never*) to 5 (*always*). In this dissertation, I proposed that the MAIA *noticing*, *not distracting, attention regulation, emotional awareness,* and *body listening* subscales might be most likely to reflect interoceptive sensibility, as items encompass whether or not individuals report noticing, actively attending to, or ignoring interoceptive sensations. Given that this study began in 2014, I used an earlier version of the MAIA. As such, the *noticing* subscale is 4 items ($\propto$= .56; e.g., “When I am tense, I notice where the tension is located in my body”). The *not distracting* subscale includes 3 items ($\propto$= .53; e.g., reverse item example: “I distract myself from sensations of discomfort.”). The *attention regulation* subscale includes 7 items ($\propto$= .81; e.g., “I can maintain awareness of my inner bodily sensations even when there is a lot going on around me.”). The *emotional awareness* subscale includes 5 items ($\propto$= .69; “I notice how my body changes when I am angry.”). The *body listening* subscale includes 3 items ($\propto$= .74; “I listen to my body to inform me about what to do”). I discuss the other MAIA subscales below in the context of interoceptive beliefs.

Interoceptive Free Reporting. At the beginning of Sessions 1 and 2 and also immediately after the TSST, participants completed an open-ended “Feelings Report” where they could write as much as they wanted about how they were feeling in that moment. Report instructions never specified whether the feelings were emotional or physical in nature. Participants thus wrote how they were feeling in whatever way “feeling” meant to them. Participants’ written free reports were transcribed and then two independent coders extracted and counted up how many interoceptive sensations vs. emotional states that individuals reported experiencing. Initial inter-coder reliability was around 80.93% or higher on average across the coded interoceptive sensations and emotions that were extracted from each of the three Feeling Reports, and all disagreements were resolved through discussion. From these data, I calculated [the total *n* of reported interoceptive sensations / the total *N* of feelings written] as a measure of the tendency to focus on and report interoceptive sensations.

Interoceptive Beliefs

To assess individuals’ evaluative beliefs about the value and regulation of interoceptive sensations, I proposed using both some subscales from the MAIA alongside the Body Signal Beliefs Questionnaire. I also was interested in whether people’s schemas (i.e., knowledge) linking interoceptive sensations to emotion might relate in some way to these evaluative beliefs. Thus, I collected a behavioral reaction time task measure to get at individuals’ explicit and implicit interoceptive associations with emotion categories.

Multidimensional Assessment of Interoceptive Awareness. See above for more general information about the MAIA. As one index of interoceptive beliefs, I thought that perhaps some of the subscales in the MAIA were, at face value, more consistent with interoceptive beliefs or evaluative interpretations of bodily signals, above and beyond simply noticing or attending to those signals. These subscales were the *not worrying, self-regulation*, and *body trusting* subscales. The *not worrying* subscale includes 3 items ($\propto$= .50; “When I feel physical pain, I become upset.”). The *self-regulation* subscale consists of 4 items ($\propto$= .71; “When I bring awareness to my body, I feel a sense of calm.”). The *body trusting* subscale includes 3 items ($\propto$= .70; “I trust my body sensations.”). Overall, these subscales may reflect whether individuals are likely to catastrophize bodily sensations vs. believe that their sensations are safe to experience.

Bodily Signal Beliefs Questionnaire (BSBQ). This was a novel 12-item questionnaire ($\propto$= .69) that I created to capture additional beliefs about the value, intensity, and control of bodily signals. Items were meant to expand upon and supplement subscales in the MAIA. Prior factor analyses with this scale suggested a single factor structure of 7 items ($\propto$= .77) which represent negative beliefs. These 7 items were: "My body is unpredictable," "I have a hard time handling my bodily sensations," "I believe that my body's feelings can be misleading," "Listening to my body's sensations can be problematic," "My bodily urges are difficult to control," "Sometimes I'm afraid of my bodily feelings," and "My body is an intense place." All items were rated on a 7-point Likert scale ranging from 1 (*not at all true of me*) to 7 (*extremely true of me*). Here, I reverse coded each item so that higher endorsements suggest more positive or less negative beliefs about the body.

Emotion Association Task (adapted from MacCormack, Henry, et al., 2019*).* Finally, as an exploratory measure, I wanted to assess individuals' explicit and implicit interoceptive associations with emotion categories, given that such schemas might relate to people's evaluative beliefs about their interoceptive sensations. Thus, we administered a cognitive behavioral reaction time association task using Eprime (Pittsburgh, PA, USA). Specifically, this task assessed the extent to which participants associated different features or properties of emotional experience, be they *interoceptive sensations* (e.g., heart racing), *behaviors* (e.g., clenched fists), or *situations* (e.g., insulted), with different emotion categories (e.g., anger). Participants read that the goal was to assess their cognitive associations and that they should work as quickly and as accurately as possible, going with their gut responses. Across 300 trials, on each trial, individuals saw a randomly selected pairing of an interoceptive, nonverbal, or situational property with one of seven negative emotion categories (anger, anxiety, boredom, disgust, embarrassment, fear, sadness). We focused only on negative emotions in this task given that we intended to induce negative feelings during the TSST at Session 2, and thus were most interested in individuals' associations for common negative emotions that they might experience throughout the stressor. On each trial, participants would see on the screen "How much does HOT come to mind when you think about ANGER?" and then used a 1 (*not at all*) to 6 (*extremely*) Likert scale to rate the strength of their explicit association. Reaction time per trial was also collected to assess the strength of individuals' implicit associations and to serve as a control measure of task engagement on a trial-by-trial basis. Participants rated all category-property items, with no category-property item (e.g., HOT with ANGER) shown more than once. From this paradigm, I was interested not only in the strength of explicit associations, but also the complexity or variability in individuals' interoceptive knowledge. As such, I computed both the *mean* and *variance* of people's explicit Likert ratings for interoceptive trials, after removing trials where individuals deliberated too quickly or too slowly.

Session 2 Measures

Psychophysiology

To assess stress-related changes in psychophysiology, we collected electrocardiography (ECG), impedance cardiography (ICG), and continuous blood pressure (cBP) using Mindware Technologies (Gahanna, OH, USA) BioLab acquisition software. For ECG, three non-invasive spot electrodes were placed on participants' torso, with one electrode on the right collarbone (-) and two electrodes on the lowermost ribs (+ and ground). For ICG, two spot electrodes were placed at the top (+) and bottom (-) of the sternum and two more electrodes on the spine, with the lower back electrode being placed two fingers' width below where the front bottom electrode was placed (4 electrodes total). cBP included an arm and finger cuff on individuals' non-dominant arm and hand. ECG, ICG, and cBP were measured throughout a 5-min baseline, 2-min TSST prep period, 10-min TSST speech task, 5-min TSST math task, and 5-min post-TSST recovery period. Trained research assistants visually inspected and independently scored each segment (60 seconds) of data, with disagreements resolved by an expert (JKM). Initial agreement between scorers was 93.7% for ECG (based on the number of R-spikes identified per segment) and 85.3% for ICG (based on pre-ejection period values per segment). In this dissertation, I focused on three cardiovascular indices of autonomic nervous system activity: heart rate, pre-ejection period, and respiratory sinus arrhythmia.

Heart rate or HR is one of the most common measures of psychophysiological change. It is estimated as the number of beats per minute (bpm). HR reflects contributions from both the sympathetic and parasympathetic nervous system and, as such, can only be used as a general or non-specific index of cardiovascular activity. Here, I also examined pre-ejection period as an index of sympathetic activity and respiratory sinus arrhythmia as an index of parasympathetic activity, but included HR (1) given that it is the physiological signal most closely related to interoceptive ability, i.e., cardiac perception, (2) given that HR is most commonly measured and so examining it should help situate findings within prior literature, and (3) given that HR can serve as a control variable. For example, recent findings suggest that HR should be included in models with RSA to further eliminate any possible sympathetic influences on RSA (de Geus, Gianaros, Brindle, Jennings, & Berntson, 2019). Similarly, in recent work on interoceptive ability with the Schandry task, Murphy et al. (2018) found that it was sometimes important to control for resting HR as this may help control for individual differences in cardiac function that could be confounded in heartbeat tasks.

Pre-ejection period or PEP is considered a gold-standard index of sympathetic nervous system activity (Newlin & Levenson, 1979). It is a measure of cardiac contractility, reflecting the time (in milliseconds) between the onset of cardiac depolarization and the start of the left ventricular contraction to expel blood from the left ventricle of the heart. Smaller PEP values suggest faster periods of cardiac contractility driven by the sympathetic nervous system. Larger PEP values suggest slower periods of cardiac contractility, such as when individuals are more relaxed or at rest.

Respiratory sinus arrhythmia or RSA is considered a somewhat reliable marker of parasympathetic nervous system activity, thought to reflect the influence of the vagus nerve on the cardiac pacemaker (Berntson, Cacioppo, & Quigley, 1993). RSA can be defined as heart rate variability that is driven in part by respiration, such that the R-to-R interval (the length of time between heartbeats) speeds up during inhalation and slows down during exhalation. RSA was calculated from the high frequency component of heart rate variability after parsing out effects of respiration that were estimated from ICG. Additionally, all ECG segments were visually inspected to ensure that respiration values remained within the appropriate respiratory bands that are standard for healthy adults. Higher RSA values are thought to indicate greater influence of the parasympathetic nervous system on the cardiac cycle.

Self-Reported Emotions

Emotions experienced during the TSST were measured using an expanded 30-item version of the Positive & Negative Affect Schedule (PANAS; Watson & Clark, 1994). The PANAS is a standard measure assessing emotions across a variety of affective states ranging in valence (positive vs. negative) and arousal (high vs. low). Participants rated how intensely they experienced each emotion on a Likert scale from 0 (*not at all*) to 6 (*extremely*). Items ranged across the four quadrants of valence and arousal: 16 negative emotions (e.g., *embarrassed, stressed, bored, sad*) vs. 9 positive emotions (e.g., *excited, proud, serene*) as well as 18 high arousal emotions (e.g., *excited, stressed*) vs. 12 low arousal emotions (e.g., *bored, serene*). For this dissertation, I specifically examined negative, high arousal emotions (∝= .89; 15 items total) as these were the emotions most likely to be experienced during the TSST. Specific items for negative, high arousal emotion were: *activated*, *afraid*, *alert*, *angry*, *annoyed*, *anxious*, *disgusted*, *distressed*, *embarrassed*, *frustrated*, *guilty*, *hyperactive*, *irritable*, *panicky*, and *stressed*.

Self-Reported Somatic Sensations

The Somatic Sensations Questionnaire is a measure I adapted and expanded from previous measures on somatic symptoms and autonomic sensations (e.g., Shields & Stern, 1979; Søgaard & Bech, 2009; Whitehead et al., 1977). This version assesses 42 different somatic sensations encompassing cardiac changes (e.g. “heart palpitations”), gastric changes (e.g. “pit in your stomach”), respiratory changes (e.g. “rapid or difficulty breathing”), kinesthetic changes (e.g. “limbs heavy”), temperature changes (e.g. “flushed or hot”), and arousal state changes (e.g. “energized”). Participants rated how intensely they experienced these sensations during the TSST on a 7-point Likert scale ranging from 0 (“not at all”) to 6 (“extremely”), from which I computed an overall mean score of “somatic intensity.”

Analytic Strategy

Data Preparation

Histograms confirmed that all means and sum scores were normally distributed, with the exception of reaction time measures which I natural log transformed. Further, I examined the data distributions for reaction times in the heartbeat detection task and the emotion association task and identified outliers on a trial-by-trial basis. Based on common practices with reaction time data (Whelan, 2008), I excluded any trials where reactions times were under 200 milliseconds (ms) and also examined reaction time distributions across participants to identify and exclude trials where individuals were off task (>7000 ms for the heartbeat detection task, >8500 ms for the emotion association task). For psychophysiology data, I examined outliers +/- 3SDs from the mean for HR, PEP, and RSA within each study timepoint (Session 1 Baseline, Session 2 Baseline, TSST Prep, TSST Speech, TSST Math, TSST Recovery). No outliers with undue influence were identified. Reactivity scores were calculated for each physiological index by first averaging the first segment (minute) from TSST Prep, Speech, and Math together to represent physiology during the stressor, and then second, subtracting [stressor-baseline] to derive average change or reactivity from baseline.

Measurement Models

A first goal of this dissertation is to develop the most appropriate measurement models for physiological reactivity during the stressor, as well as trait interoceptive ability, sensibility, and beliefs, with the ultimate goal of data reduction. First assessing measurement structures also afforded the opportunity to integrate a diversity of methods and measures together without overtaxing model estimation. Thus, I conducted two sets of exploratory factor analyses (EFAs) to explore how measures might correlate with one another. After this, I conducted confirmatory factor analyses (CFAs) using latent variable structural equation modeling (Bollen, 1989, 2002) to evaluate how well my *a priori* hypothesized and EFA-clarified manifest indicators ultimately represented the latent constructs of physiological reactivity, interoceptive ability, sensibility, and beliefs.

Exploratory Factor Analyses. EFAs were conducted in R using the *psych* package (Revelle, 2019). I used the promax rotation (Hendrickson & White, 1964) given that I expected factors to be correlated and used χ^2 to assess whether the number of factors used fit the data. Based on my four *a priori* predictors of interest (physiological reactivity, interoceptive ability, sensibility, and beliefs), I decided to start by testing the fit of four or more factors. For *physiological reactivity*, I included HR, PEP, and RSA stress reactivity from Session 2. I also included respiratory reactivity as an additional possible indicator although it was not of primary interest compared to HR, PEP, and RSA. For *interoceptive ability*, I included participant's hit rate across trials (this assesses "accuracy"), the computed *d'* score (this assesses "sensitivity"), as well as mean reaction time (log-transformed), mean confidence, and baseline mean heart rate from Session 1. I include baseline heart rate here based on recommendations discussed above. For *interoceptive sensibility*, I included mean scores for the BAQ, the MAIA *noticing*, *not distracting, attention regulation, emotional awareness,* and *body listening* subscales. In the EFAs, I also tested whether my exploratory "interoceptive focus" measure with the mean proportion of open-ended interoceptive reports loaded together with the BAQ and relevant MAIA subscales to serve as another index of sensibility. Finally, for *interoceptive beliefs*, I included mean scores for the MAIA *not worrying, self-regulation*, and *body trusting* subscales and reverse scores of the BSBQ negative beliefs. In the EFAs, I further tested whether my exploratory "interoceptive knowledge" measure (mean strength and variance of people's explicit Likert ratings for interoceptive trials on the emotion association task) fit with interoceptive belief measures.

Confirmatory Factor Analyses. After conducting the EFAs, I next used latent variable structural equation modeling to conduct CFAs, in order to determine whether my measurement models appropriately fit or loaded onto latent variables for physiological reactivity, interoceptive ability, sensibility, and beliefs. I fit each model in R using *lavaan* (Rosseel, 2012). Any missing data were estimated using full information maximum likelihood (Enders & Bandalos, 2001). Model fit was assessed using the chi-square statistic (χ^2), root mean squared error of approximation (RMSEA), comparative fit index (CFI) and the Tucker Lewis index (TLI). Good model fit is represented by non-significant χ^2, RMSEA ≤ .08, CFI ≥ .95, and TLI ≥ .90 (Hu & Bentler, 1999; Schreiber, Nora, Stage, Barlow, & King, 2006). I also examined residuals to determine whether I should model any covariances between indicators, such as may be required between items from the same measure or method (e.g., MAIA subscales). Indicators were dropped from the model where appropriate following standard model building procedures, depending on path model estimates, fit indices, and residuals. However, I was careful to avoid overfitting the model to the data.

Structural Equation Models

A second goal of this dissertation was to compare the relative path strengths for physiological reactivity, interoceptive ability, and the two types of interoceptive priors (sensibility and beliefs) in predicting people's TSST-induced subjective stress, operationalized as self-reported negative, high arousal emotion. Using the final fitted measurement models obtained from model building, I implemented latent structural equation modeling to examine the relative strength of physiological reactivity, interoceptive ability, sensibility, and beliefs in predicting negative, high arousal emotion, while also assessing possible covariances shared within and across manifest indicators and latent predictors. Here, I examined physiological reactivity, interoceptive ability, interoceptive sensibility, and interoceptive beliefs as exogenous latent predictors of emotion, At each step of model building, I examined model fit and residuals and adjusted accordingly.

Hierarchical Regressions

A final goal of this dissertation was to identify the extent to which physiological reactivity, interoceptive ability, interoceptive sensibility, and interoceptive beliefs each uniquely relate to subjective stress experiences during the TSST (above and beyond their shared overlaps in variance) and how each of these predictors might interact with each other in exacerbating vs. buffering acute stress. For these models, I computed a factor score for each latent factor (the final factors derived from the SEMs testing relative relations to emotion) for use in a hierarchical linear regression framework (which is more feasible than doing moderation analyses in an SEM framework). The factor scores are already standardized, so I did not need to compute any z-scores for these factor scores before computing their respective interaction terms. Again, following model building procedures, Step 1 included physiological reactivity predicting negative, high arousal emotion, Step 2 added in interoceptive ability, Step 3 added in interoceptive sensibility and beliefs, Step 4 added in the various interaction terms between the predictors, and Step 5 controlled for gender and BMI effects. I did not examine any 3-way or 4-way interactions, as these types of interactions require extremely large power to estimate and also given that these types of interactions are difficult to interpret. Significant interactions were probed with simple slopes.

CHAPTER THREE: MEASUREMENT MODELS FOR PHYSIOLOGY AND INTEROCEPTION

Overall, this dissertation sought to test the hypothesis that "interoceptive priors" (sensibility, beliefs) should matter for negative, high arousal emotion above and beyond physiological reactivity or interoceptive ability. In particular, as outlined above, I posited that interoceptive beliefs should be particularly relevant for emotion (i.e., show the largest effect size), given that beliefs as measured in this study reflect *evaluative interpretations* of interoceptive signals, whereas interoceptive sensibility as measured here reflects the *self-perceived monitoring* of interoceptive signals and does not imply anything about how said monitoring could help buffer against vs. exacerbate emotion. More broadly, I aimed to clarify the extent to which physiological reactivity, interoceptive ability, interoceptive sensibility, and interoceptive beliefs might each be uniquely related to subjective stress experiences during the TSST and how each of these predictors might in turn have interacted with each other in exacerbating vs. buffering acute stress. Finally, a secondary goal of this project was to use factor analyses and structural equation modeling to better identify the underlying latent constructs at play across different interoceptive measures. In this chapter, I address this measurement goal using exploratory and confirmatory factor analyses, evaluating the convergent vs. discriminant validity of interoceptive constructs in order to better identify appropriate measurement models for interoceptive ability, sensibility, and beliefs.

Exploratory Factor Analyses

As a first step, I conducted two separate exploratory factor analyses (EFAs): (1) an EFA examining how all my proposed predictors covary with one other, and (2) a more targeted EFA examining interoceptive sensibility and beliefs measures. For both EFAs, I conducted common factor analyses using the maximum likelihood approach (Fuller & Hemmerle, 1966; Young, 1941). In this approach, the researcher conducts a series of model iterations (e.g., with a different number of factor solutions) and examines χ^2 as a goodness-of-fit test at each iteration until χ^2 is non-significant to determine whether there are a sufficient number of factors that fit the underlying data structure.

Importantly, given that I do not believe that resultant factors should be orthogonal (i.e., uncorrelated with one another), I used the promax rotation. Below, I summarize findings from each.

Factor Structure Across Predictors

First, I examined all possible items that might load onto each of my proposed factors of physiological reactivity, interoceptive ability, interoceptive sensibility, and interoceptive beliefs (see **Table 2**). The minimal number of factors to fit the data were six factors (χ^2= 145.52, *df*=130, *p*=.153), explaining about 45% of the variance. Overall, it appeared that task or measurement types covaried together.

For example, physiological reactivity (Factor 4) included loadings of heart rate, respiratory sinus arrythmia, and pre-ejection period reactivity, with heart rate reactivity serving as the primary indicator (loading of 1.00). However, respiratory sinus arrhythmia and pre-ejection period loaded negatively onto this physio factor.[4] Respiratory reactivity did not load sufficiently onto any single factor.

There was a clear factor for interoceptive ability (Factor 3), which included the hit rate or fraction correct from the heartbeat detection task, as well as the sensitivity index of *d'*, and overall mean confidence on the task. Reaction time on the task and Session 1 baseline heart rate did not load onto this interoceptive ability factor nor did they sufficiently load onto any other factor.

Finally, when looking at interoceptive sensibility and beliefs as well as possible exploratory measures of interoceptive focus and knowledge (wherein I thought that focus might covary more with sensibility measures and knowledge might covary more with belief measures), there were 4 factors that emerged. Factor 1 included loadings from the BAQ and almost all the MAIA subscales. Factor 2 consisted almost exclusively of the interoceptive focus items (sum of how many physiological words and a mean proportion of how many interoceptive items that individuals wrote about in their Feelings

[4] Negative loadings for PEP and RSA reactivity here are reasonable in contrast to HR reactivity, given the direction of the reactivity score signs. For example, HR reactivity for *i* individual from stressor minus baseline could be [120 bpm-60 bpm] granting a reactivity score of 60 bpm. On the other hand, during stressors, PEP and RSA values should go down, indicating faster (i.e., smaller) time periods as cardiac contractility and respiration increase. This leads to negative reactivity scores, as demonstrated by hypothetical individual *i*'s PEP reactivity score of -25 ms being calculated as [100ms – 125 ms] change for stressor minus baseline.

Reports). Factor 5 most closely approximated the evaluative beliefs—composed here of the MAIA Non-worry subscale and the BSBQ (reverse scored) mean. Other subscales from the MAIA also loaded onto this “beliefs” factor, but they loaded best onto the BAQ-MAIA Factor 1. Lastly, Factor 6 contained several weak loadings but was predominated by the Emotion Association Task interoceptive trial scores. Altogether, this EFA affirms that physiological reactivity, interoceptive ability, interoceptive sensibility (as measured with the BAQ and most MAIA subscales), interoceptive beliefs, as well as exploratory factors such as interoceptive focus and interoceptive knowledge all represent somewhat unique constructs in this dataset.

Factor Structure of Interoceptive Sensibility and Beliefs

Having examined all of my proposed predictors, I wanted to take a closer look at the BAQ, MAIA subscales, and specific items from the BSBQ (given that this was a novel measure I created) to further clarify which measures might best approximate interoceptive sensibility vs. beliefs. The minimal number of factors to fit the data were five factors (χ^2= 67.46, *df*=50, *p*=.051), explaining about 46% of the variance (**Table 3**). Overall, two clear factors emerged, but were insufficient on their own for explaining variance without the other factors (determined by the χ^2 test of fit). Factor 1 included the BAQ mean and all MAIA subscales except for the Non-distract subscale which did not load clearly onto any given factor. Factor 2 very clearly included only the BSBQ items. Factor 3 was predominated by the MAIA Attention Regulation subscale, although this subscale also loaded onto Factor 1 and other measures only loaded weakly onto Factor 3. Factor 4 included only a weak set of loose loadings. Factor 5 had several weak loadings but also included stronger loadings from the MAIA Body Trust subscale and the BSBQ item “*I am sometimes afraid of my bodily sensations.”*

Confirmatory Factor Analyses

Combining insights from both EFAs, I chose which measures would load onto my *a priori* proposed predictors: *physiological reactivity* (heart rate, respiratory sinus arrhythmia, pre-ejection period), *interoceptive ability* (fraction correct, *d’*, mean confidence), *interoceptive sensibility* (BAQ mean, all MAIA subscales except the Non-distract subscale which did not loading well or at all onto any given factor in both EFAs), and *interoceptive beliefs* (BSBQ items only). I decided to keep MAIA subscales together rather than split some into the interoceptive beliefs factor, given that the more targeted EFA showed a clear differentiation between BAQ/MAIA vs. BSBQ measures.

With this proposed factor structure, I next conducted confirmatory factor analyses (CFAs) using a latent variable SEM approach. I followed standard model building procedures by examining fit statistics, the modification indices, and standardized residuals, in order to evaluate where covariances might need to be added. Model fit was assessed using the chi-square statistic (χ^2), root mean squared error of approximation (RMSEA), comparative fit index (CFI) and the Tucker Lewis index (TLI). Good model fit is represented by non-significant χ^2, RMSEA ≤ .08, CFI ≥ .95, and TLI ≥ .90 (Hu & Bentler, 1999; Schreiber et al., 2006).

Physiological Reactivity Factor Model

For the physiological reactivity latent factor, I first fit a model using the manifest indicators of heart rate reactivity, respiratory sinus arrhythmia reactivity, and pre-ejection period reactivity. However, heart rate reactivity had a negative variance, known as a "Heywood case"; this sort of issue is common in factor analyses and SEMs and is thought to be caused by model convergence issues, model misspecification, or model under-identification (Kolenikov & Bollen, 2012). To address this issue, I added in respiratory reactivity as a manifest indicator. However, heart rate reactivity persisted in exhibiting negative variance.

Heart rate reactivity's persistent negative variance could be explained by both measurement and theoretical reasons. First, PEP, RSA, and respiration as measured here are all indices derived in some way from heart rate. Second, from a theoretical standpoint, heart rate is regulated by both the sympathetic and parasympathetic nervous systems which PEP and RSA respectively represent (Berntson et al., 1994, 1993); as such, heart rate reactivity may be superfluous for the latent factor. As such, when dropping heart rate reactivity, the remaining model with reactivity scores for respiratory sinus arrhythmia, pre-ejection period, and respiration converged successfully after 20 iterations. Given that this model only contained three indicators, it was a saturated model (e.g., the CFI and TFI = 1.0 or perfect fit). Thus, I do not provide fit statistics for this latent factor model. RSA reactivity loaded most strongly onto the latent factor (β=.51, *SE*=.228, *p*=.025), followed by respiratory reactivity (β=-.34, *SE*=.161, *p*=.033) and PEP reactivity (β=.27, *SE*=.136, *p*=.044).

Interoceptive Ability Factor Model

Similarly, the latent factor model for interoceptive ability contained only three indicators, converged successfully after 16 iterations, and was a saturated model (e.g., CFI and TFI= 1.0). Fraction correct was the strongest indicator (β=.91, *SE*=.092, model (e.g., CFI and TFI= 1.0). Fraction correct was the strongest indicator (β=.91, *SE*=.092, *p*<.0001) followed by *d'* (β=.73, *SE*=.084, *p*<.0001) and mean confidence (β=.38, *SE*=.071, *p*<.0001).

Interoceptive Sensibility Factor Model

This initial model exhibited poor fit and indicated that the MAIA Non-worry and Body Trust subscales in particular did not load well onto the latent factor for interoceptive sensibility. This also provided somewhat convergent evidence in line with both EFAs suggesting that these two subscales less reliably loaded onto just one factor. Dropping both indicators significantly improved model fit. Thus, I retained a latent factor model for interoceptive sensibility that contained the indicators of the BAQ, MAIA Notice, MAIA Attention Regulation, MAIA Emotion Awareness, MAIA Self-Regulation, and MAIA Body Listen subscales. Modification indices suggested that covariances between Attention Regulation and Self-Regulation as well as Attention Regulation and Emotional Awareness were needed. This final model converged after 18 iterations (*N*=250) and demonstrated excellent model fit: non-significant χ^2=7.21 (*df*=7), *p*=.407, RMSEA= .01 (*p*=.753), *CFI*=1.0, *TLI*=.99. MAIA Notice was the strongest indicator (β=.76, *SE*=.057), followed by MAIA Body Listen (β=.76, *SE*=.057), MAIA Emotional Awareness (β=.75, *SE*=.057), MAIA Attention Regulation (β=.70, *SE*=.061), MAIA Self-Regulation (β=.66, *SE*=.061), and last, the BAQ (β=.61, *SE*=.061), all *ps*<.0001.

Interoceptive Beliefs Factor Model

This latent factor model with the BSBQ items as manifest indicators converged after 12 iterations (*N*=250) and exhibited good fit, non-significant χ^2=19.48 (*df*=14), *p*=.147, RMSEA= .04 (*p*=.626), *CFI*=.98, *TLI*=.98. Modification indices did not suggest that any covariances needed to be added between indicators. Reverse-scored *Body difficult to handle* was the strongest indicator (β=.62, *SE*=.064), followed by *Bodily urges difficult to manage* (β=.62, *SE*=.064), *Body is unpredictable* (β=.59, *SE*=.065), *Afraid of body* (β=.56, *SE*=.065), *Body is misleading* (β=.56, *SE*=.065), *Listening to body is bad* (β=.53, *SE*=.066), and last, *Body is too intense* (β=.49, *SE*=.067), all *ps*<.0001. I also explored the possibility that MAIA Non-worry and MAIA Body Trust might fit with these indicators (given that they did not fit well with the interoceptive sensibility factor), but this model demonstrated poor fit, again with problematic loadings and fit issues for these two MAIA subscales. Thus, I retained the BSBQ-only latent factor model for interoceptive beliefs.

CHAPTER FOUR: TESTING RELATIVE CONTRIBUTIONS AND MODERATION

In the previous chapter, I used exploratory and confirmatory factor analyses to explore the latent factor structures underlying the constructs of physiology and interoception. Overall, I verified that physiological reactivity, interoceptive ability, interoceptive sensibility (as measured with the BAQ and MAIA), and interoceptive beliefs appear to represent unique (albeit somewhat inter-related) constructs. In particular, the BAQ and almost all MAIA scales fit together onto a single factor that likely represents this idea of *interoceptive sensibility* or how much individuals *think* that they pay attention to and notice their interoceptive sensations. On the other hand, the BSBQ was a distinct factor, with items assessing more evaluative judgments or *interoceptive beliefs* about the difficulties, fears, and safety or predictability of interoceptive sensations. In this chapter, I next assess how these different factors of physiological reactivity and interoceptive ability, sensibility, and beliefs each uniquely relate to the subjective stress experience (controlling for shared variance between factors). I also assess how each of these proposed predictors may interact with each other to moderate the subjective stress experience.

Latent Variable Structural Equation Models

After confirming that the measurement models for my proposed latent variables demonstrated adequate fit, I used latent variable SEM to determine whether covariances ought to be added in between latent variables and to compare the relative effects of each latent factor on my proposed manifest outcome variable of negative, high arousal emotion (see **Table 4**).

The first model (Model 1) converged after 35 iterations (N=188) and demonstrated adequate fit: χ^2=186.20 (df=156), p=.050, RMSEA= .03 (p=.967), CFI=.97, TLI=.96 after including covariances between all the latent factors and also between MAIA Attention Regulation with MAIA Self-Regulation and Emotion Awareness, between MAIA Notice and BSBQ Body Fear, and between MAIA Attention Regulation and BSBQ Listen is Bad. However, to improve model fit further, after examining the modification indices and standardized residuals for Model 1, I considered that it might be more parsimonious to replace the interoceptive beliefs latent factor with a BSBQ mean score, given that this latent factor only contained BSBQ items and ultimately this replacement could help reduce the number of parameters that must be estimated. As such, I ran a second model (Model 2) replacing the interoceptive beliefs latent factor with a manifest BSBQ-reversed mean score. Model 2 converged after 33 iterations (*N*=188) and demonstrated good fit: χ^2=85.05 (*df*=67), *p*=.068, RMSEA= .04 (*p*=.794), *CFI*=.97, *TLI*=.96 after including covariances between the predictors (latent factors of physiological reactivity, interoceptive ability, interoceptive sensibility, and the manifest factor of BSBQ-reversed) and also covariances between MAIA Attention Regulation with MAIA Self-Regulation and Emotion Awareness. Modification indices did not indicate that any other covariances needed to be added. Ultimately, I retained Model 2 as the final model. Findings were however consistent across both models. Below I discuss Model 2 but see **Table 4** for both sets of effect estimates in predicting negative high arousal emotion.

Latent Factor Loadings

Broadly, indicators loaded significantly as would be expected onto their respective latent factors. For the latent factor of physiological reactivity, RSA reactivity (β=.37, *SE*=.137, *p*=.007), respiratory reactivity (β=-.43, *SE*=.149, *p*=.004) and PEP reactivity (β=.37, *SE*=.139, *p*=.007) all loaded well and no covariances needed to be added between these indicators. For the latent factor of interoceptive ability, fraction correct was the strongest indicator (β=.93, *SE*=.090) followed by *d'* (β=.72, *SE*=.087), and mean confidence (β=.35, *SE*=.076), all *ps*<.0001. For the latent factor of interoceptive sensibility, MAIA Body Listen was the strongest indicator (β=.74, *SE*=.065), followed by MAIA Notice (β=.72, *SE*=.066), MAIA Attention Regulation (β=.72, *SE*=.071), MAIA Emotional Awareness (β=.72, *SE*=.067), MAIA Self-Regulation (β=.68, *SE*=.070), and lastly, the BAQ (β=.60, *SE*=.068), all *ps*<.0001.

Parameter Estimates

The latent factor of interoceptive ability was negative and significant in relation to negative, high arousal emotion (β=-.19, *SE*= .077, *p*= .012), such that greater interoceptive ability was related to less intense negative, high arousal emotion, controlling for the other factors and their loadings.

Similarly, the BSBQ manifest variable effect representing interoceptive beliefs was also negative and significant (β=-.15, *SE*= .070, *p*= .031), wherein more positive interoceptive beliefs were associated with less intense negative, high arousal emotions. However, the latent factors for physiological reactivity and interoceptive sensibility were neither significant (*ps*>.500). Contrary to my hypotheses, interoceptive ability demonstrated a stronger effect in relation to stress-related emotions than interoceptive sensibility or beliefs.

Hierarchical Regression Models

Finally, in order to test the moderating role of interoception in the physiology-emotion link, I conducted hierarchical regressions with negative, high arousal emotion as the primary outcome of interest. After extracting factor scores for the latent variables of physiological reactivity, interoceptive ability, and interoceptive sensibility and computing 2-way interactions between all of my hypothesized predictors of interest, I conducted a hierarchical regression where in Step 1, the physiological reactivity factor predicted mean negative, high arousal emotion, Step 2 added in the interoceptive ability factor, Step 3 added in the interoceptive sensibility factor, Step 4 added in the interoceptive beliefs (BSBQ-reversed mean), Step 5 added in interactions between *physiological reactivity x interoceptive ability, physiological reactivity x interoceptive sensibility, physiological reactivity x interoceptive beliefs, interoceptive ability x interoceptive sensibility, interoceptive ability x interoceptive beliefs,* and *interoceptive sensibility x interoceptive beliefs,* and finally Step 6 controlled for gender and BMI. In the final model step, both interoceptive ability and beliefs were negatively associated with negative, high arousal emotion (*bs*= -.22, -.20, *ps*=.031, .026) and there was a significant effect of gender as well (*b*= -.73, *p*<.0001), such that females reported stronger stress-related emotions than males. Similar to the SEM regressions, this model also indicated that interoceptive ability was a slightly stronger predictor than interoceptive beliefs.

However, I found it concerning that the physiological reactivity factor score did not predict emotion at all, neither on its own (*b*=.02, *p*=.885) nor when controlling for everything else (*b*=-.13, *p*=.400). Given both the physiological and theoretical justifications I discussed above for not collapsing multiple physiological indicators into a single factor (Berntson et al., 1994, 1993) and the fact that it is uncommon to combine indicators together in the psychophysiological literature, it is possible that the physiological reactivity latent factor I created is invalid (despite model fit). Thus, I decided to report the hierarchical regression results with this factor score in the **Appendix**, and conducted separate hierarchical regressions with HR reactivity, PEP reactivity, and RSA reactivity on their own. Ultimately, as this study used an acute stress paradigm, I held the strongest physiological hypotheses about HR and PEP reactivity, given their relation to sympathetic nervous system activity (PEP as a purer indicator, HR as a partial indicator). I also wanted to examine RSA reactivity, given its representation of the parasympathetic nervous system. I did not run a model for respiratory reactivity, given that the original EFA model suggested that respiratory reactivity did not covary with the other physiological indicators and given that I only added in respiratory reactivity to the CFA/SEMs due to Haywood issues with HR reactivity.

As suspected, these separate models with HR, PEP, and RSA reactivity revealed weak but significant effects of physiological reactivity in relation to emotion, suggesting to me that the physiological reactivity latent factor was not appropriate. Below I present hierarchical regressions for HR, PEP, and RSA reactivity. See **Table A1** in the **Appendix** for hierarchical regression findings with the latent physiological reactivity factor score. See **Tables 5-7** for regression models with HR, PEP, and RSA, which include standardized betas (β) as effect size estimates. All R^2 reported herein are adjusted R^2.

Heart Rate Reactivity and Interoception

The first model step (**Table 5)**, with just *HR reactivity* on its own was not significant, $F(1, 206)=2.10$, $p=.149$, $R^2= .005$, and HR reactivity was not significant, $b=.13$, $p=.149$, *95% CIs* [-.05, .31].

The addition of *interoceptive ability* in the second model step was significant and resulted in a significant model change, $F(2, 206)=3.29$, $p=.039$, $R^2=.022$, $R^2\Delta= .021$, $R^2\Delta$ $p=.036$. The factor score for interoceptive ability was also significantly and negatively associated with negative high arousal emotion, $b=-.20$, $p=.036$, *95% CIs* [-.40, -.01], such that individuals with higher interoceptive ability reported less intense stress-related emotions.

The third model step, with the inclusion of *interoceptive sensibility,* was only marginal and there was no model change, $F(3, 206)=2.45$, $p=.065$, $R^2=.021$, $R^2\Delta= .004$, $R^2\Delta$ $p=.382$. Furthermore, contrary to my hypotheses, the factor score for interoceptive sensibility was unrelated to negative, high arousal emotion, *b*=-.09, *p*=.382, *95% CIs* [-.28, .11], but interoceptive ability remained significant (*p*=.040).

The fourth model step, with the addition of *interoceptive beliefs,* was significant and led to a significant model change, *F*(4, 206)=3.04, *p*=.018, R^2=.038, $R^2\Delta$= .022, $R^2\Delta$ *p*=.032. In this step, interoceptive ability remained significant (*p*=.020) and, as predicted, interoceptive beliefs also emerged as significant, *b*=-.19, *p*=.032, *95% CIs* [-.37, -.02], such that more positive or less negative evaluative beliefs about one's interoceptive signals were associated with less intense stress-related emotions during the acute stressor.

The inclusion of the 2-way interactions in the fifth model step was significant but resulted in a nonsignificant change, *F*(10, 206)=2.02, *p*=.033, R^2=.047, $R^2\Delta$= .037, $R^2\Delta$ *p*=.250. Interoceptive ability and beliefs remained significant (*ps*=.030, .029) but no interactions were significant, except for a marginal interaction of *interoceptive ability x beliefs*, *b*=.19, *p*=.051, *95% CIs* [.00, .38].

The sixth model step, controlling for gender and BMI, was significant and resulted in a significant model change, *F*(12, 206)=2.91, *p*=.001, R^2=.100, $R^2\Delta$= .058, $R^2\Delta$ *p*=.001. Notably, *gender* was significant, *b*=-.66, *p*<.0001, *95% CIs* [-1.02, -.31] although BMI was not (*p*=.774). In this final model step, *HR reactivity* also emerged as significant, *b*=.18, *p*=.047, *95% CIs* [.00, .37], suggesting that greater HR reactivity is related to more intense negative, high arousal emotion reports, even when controlling for gender, BMI, and the broader main effects and interactions with interoceptive ability, sensibility, and beliefs. Interestingly, interoceptive ability was no longer significant but marginal when controlling for gender and BMI, *b*=-.17, *p*=.077, *95% CIs* [-.36, .02], despite the fact that interoceptive ability was significant at all prior model steps. Interoceptive beliefs however remained significant and actually strengthened as an effect when controlling for gender and BMI, *b*=-.22, *p*=.011, *95% CIs* [-.39, -.05].

There was also a significant interaction of *interoceptive ability x beliefs*, *b*=.22, *p*=.021, *95% CIs* [.03, .41]. Probing this interaction revealed that the slope was significant for lower (-1SD) interoceptive beliefs (i.e., the least positive beliefs), *t*(206)=-3.08, *p*=.002. There was also a marginal slope effect at average (0SD) levels of interoceptive beliefs, *t*(206)=-1.78, *p*=.077, but no slope effects at higher (+1SD) levels of positive interoceptive beliefs (p=.726). These slopes suggest that when both interoceptive ability and positive interoceptive beliefs are low, individuals report the most intense negative, high arousal emotions from the acute stressor. On the other hand, greater positive interoceptive beliefs appear to buffer against negative, high arousal emotions, even at lower levels of interoceptive ability. See **Figure 1**. No other interactions were significant, including no effect of HR reactivity in interaction with any facet of interoception.

Finally, when examining the standardized betas in the final model step, gender had the largest effect size (β=-.25). However, as hypothesized, interoceptive beliefs was the largest effect size amongst my predictors of interest (β=-.17) compared to heart rate reactivity (β=.14), interoceptive ability (β=-.12), and interoceptive sensibility (β=-.08). This model accounted for approximately 10% of the variance in reported negative, high arousal emotion.

Pre-Ejection Period Reactivity and Interoception

The first model step (**Table 6)**, with just *PEP reactivity* on its own was not significant, F(1, 189)=.78, p=.380, R^2= -.001, and PEP reactivity was not significant, b=-.08, p=.380, *95% CIs* [-.26, .10].

The addition of *interoceptive ability* in the second model step was significant and resulted in a significant model change, F(2, 189)=3.17, p=.044, R^2=.022, $R^2\Delta$= .029, $R^2\Delta$ p=.020. The factor score for interoceptive ability was also significantly and negatively associated with negative high arousal emotion, b=-.24, p=.020, *95% CIs* [-.44, -.04], such that individuals with higher interoceptive ability reported less intense stress-related emotions.

The third model step, with the inclusion of *interoceptive sensibility,* was only marginal and there was no model change, F(3, 189)=2.36, p=.073, R^2=.021, $R^2\Delta$= .004, $R^2\Delta$ p=.384. Furthermore, contrary to my hypotheses, the factor score for interoceptive sensibility was unrelated to negative high arousal emotion, b=-.09, p=.384, *95% CIs* [-.28, .11], but interoceptive ability remained significant (p=.022).

The fourth model step, with the addition of *interoceptive beliefs,* was significant but led to a marginal model change, F(4, 189)=2.69, p=.033, R^2=.034, $R^2\Delta$= .018, $R^2\Delta$ p=.061. In this step, interoceptive ability remained significant (p=.010). Interoceptive beliefs however were marginal, *b*=-.17, *p*=.061, *95% CIs* [-.35, .01].

The inclusion of the 2-way interactions in the fifth model step was significant but resulted in a marginal change, *F*(10, 189)=2.35, *p*=.012, R^2=.067, $R^2\Delta$= .061, $R^2\Delta$ *p*=.060. Interoceptive ability remained significant (*p*=.017) and interoceptive beliefs remained marginal (*p*=.056). There was also a significant interaction between *PEP reactivity x beliefs*, *b*=-.25, *p*=.011, *95% CIs* [-.43, -.06]. No other interactions were significant.

The sixth and final model step, controlling for gender and BMI, was significant and resulted in a significant model change, *F*(12, 189)=3.41, *p*<.0001, R^2=.133, $R^2\Delta$= .072, $R^2\Delta$ *p*=.001. Notably, *gender* was again significant, *b*=-.72, *p*<.0001, *95% CIs* [-1.07, -.36] although BMI was not (*p*=.522). In this final model step, *PEP reactivity* remained nonsignificant, *b*=-.14, *p*=.127, *95% CIs* [-.32, .04]. However, when controlling for gender and BMI, interoceptive ability and beliefs were both significant (*ps*=.033, .030).

The significant interaction of *PEP reactivity x beliefs* also remained significant (*p*=.031). Probing this interaction revealed that the slope for lower (-1SD) and average (0SD) interoceptive beliefs were not significant (*ps*>.10). However, the slope for high interoceptive beliefs was significant, *t*(189)=-2.72, *p*=.007, such that at high levels of PEP reactivity, having more positive interoceptive beliefs helped buffer against negative, high arousal emotions during the acute stressor. See **Figure 2**. There was also a marginal interaction of *interoceptive ability x beliefs*, *b*=.19, *p*=.055, *95% CIs* [-.01, .38], in parallel with the significant interaction effect found in the heart rate reactivity model. I also probed this interaction, to determine whether the direction of slope effects remained consistent. Indeed, the slope was significant for lower (-1SD) interoceptive beliefs, *t*(189)=-3.04, *p*=.003. There was also a significant slope effect at average (0SD) levels of interoceptive beliefs, *t*(189)=-2.15, *p*=.033, but no slope effects at higher (+1SD) levels of interoceptive beliefs (*p*=.863). See **Figure 1**.

Finally, when examining the standardized betas in the final model step, gender again had the largest effect size (β=-.28). However, interoceptive ability and beliefs had similar effect sizes (both β=-.15) compared to PEP reactivity (β=-.11) and interoceptive sensibility (β=-.09). This model accounted for approximately 13% of the variance in reported negative, high arousal emotion.

Respiratory Sinus Arrythmia Reactivity and Interoception

The first model step (**Table 7**), with just *RSA reactivity* on its own was not significant, F(1, 206)=.36, p=.551, R^2= -.003, and RSA reactivity was not significant, b=-.06, p=.551, *95% CIs* [-.24, .13].

Accounting for changes in heart rate, the second model step was not significant nor was there a significant model change, F(2, 206)=1.10, p=.334, R^2= .001, $R^2\Delta$= .009, $R^2\Delta$ p=.176. There were also no significant effects of RSA nor HR reactivity (ps=.738, 176).

The addition of *interoceptive ability* in the third model step was marginal and resulted in a significant model change, F(3, 206)=2.24, p=.085, R^2=.018, $R^2\Delta$= .021, $R^2\Delta$ p=.035. The factor score for interoceptive ability was significantly and negatively associated with negative high arousal emotion, b=-.21, p=.035, *95% CIs* [-.40, -.01], such that individuals with higher interoceptive ability reported less intense stress-related emotions.

The fourth model step, with the inclusion of *interoceptive sensibility,* was not significant and there was no model change, F(4, 206)=1.87, p=.117, R^2=.017, $R^2\Delta$= .004, $R^2\Delta$ p=.383. Furthermore, the factor score for interoceptive sensibility was unrelated to negative high arousal emotion, b=-.09, p=.383, *95% CIs* [-.28, .11], but interoceptive ability remained significant (p=.039).

The fifth model step, with the addition of *interoceptive beliefs,* was significant and led to a significant model change, F(5, 206)=2.45, p=.035, R^2=.034, $R^2\Delta$= .022, $R^2\Delta$ p=.032. In this step, interoceptive ability remained significant (p=.019) and, as predicted, interoceptive beliefs also emerged as significant, b=-.19, p=.032, *95% CIs* [-.37, -.02], such that more positive or less negative evaluative beliefs about one's interoceptive signals were associated with less intense stress-related emotions during the acute stressor.

The inclusion of the 2-way interactions in the sixth model step was significant but resulted in a nonsignificant change, F(11, 206)=1.87, p=.046, R^2=.044, $R^2\Delta$= .038, $R^2\Delta$ p=.235. Interoceptive ability and beliefs remained significant (ps=.030, .029) but no interactions were significant, except for a significant interaction of *interoceptive ability x beliefs*, b=.21, p=.036, *95% CIs* [.01, .41].

The seventh model step, controlling for gender and BMI, was significant and resulted in a significant model change, F(13, 206)=2.76, p=.001, R^2=.100, $R^2\Delta$= .062, $R^2\Delta$ p=.001. Notably, *gender* was significant, *b*=-.68, *p*<.0001, *95% CIs* [-1.03, -.32] although BMI was not (*p*=.666). In this final model step, *HR reactivity* was marginal, *b*=.19, *p*=.078, *95% CIs* [-.02, .41], but RSA reactivity remained nonsignificant (*p*=.956). Interoceptive ability also was no longer significant but marginal when controlling for gender and BMI, *b*=-.18, *p*=.071, *95% CIs* [-.37, .02], despite the fact that interoceptive ability was significant at all prior model steps. Interoceptive beliefs however remained significant and actually strengthened as an effect when controlling for gender and BMI, *b*=-.23, *p*=.010, *95% CIs* [-.40, -.06].

There was also a significant interaction of *interoceptive ability x beliefs*, *b*=.24, *p*=.013, *95% CIs* [.05, .44]. Probing this interaction revealed that the slope was significant for lower (-1SD) interoceptive beliefs (i.e., the least positive beliefs), *t*(206)=-3.14, *p*=.002. There was also a marginal slope effect at average (0SD) levels of interoceptive beliefs, *t*(206)=-1.81, *p*=.072, but no slope effects at higher (+1SD) levels of positive interoceptive beliefs (*p*=.680). These slopes suggest that when both interoceptive ability and positive interoceptive beliefs are low, individuals report the most intense negative, high arousal emotions from the acute stressor. On the other hand, greater positive interoceptive beliefs appear to buffer against negative, high arousal emotions, even at lower levels of interoceptive ability. See **Figure 1**. No other interactions were significant, including no effect of RSA reactivity in interaction with any facet of interoception.

Finally, when examining the standardized betas in the final model step, gender had the largest effect size (β=-.26). However, as hypothesized, interoceptive beliefs was the largest effect size amongst my predictors of interest (β=-.18) compared to RSA reactivity (β=.01), HR reactivity (β=.15), interoceptive ability (β=-.13), and interoceptive sensibility (β=-.07). This model accounted for approximately 10% of the variance in reported negative, high arousal emotion.

Secondary Analyses: Subjective Somatic Intensity

In addition to conducting the above hierarchical regressions, I further investigated how physiological reactivity and facets of interoception might interact to predict reported somatic intensity from the TSST. I thus ran the exact some model steps as described above, but with somatic intensity as the outcome rather than negative, high arousal emotions. See **Appendix** for tables and figures with significant interactions. Broadly speaking, in the final model steps, I found that greater HR reactivity was associated with greater somatic intensity, *b*=.14, *p*=.006, *95% CIs* [.04, .25], but this was not the case for PEP reactivity (*p*=.145) nor RSA reactivity (*p*=.690). In contrast to the models with negative, high arousal emotion, interoceptive ability in the final model steps did not relate at all to somatic intensity across any model (*ps*=.797, 167, .599). Interoceptive sensibility was also never significant. However, interoceptive beliefs remained a significant and consistent predictor across all models. For example, in the model with HR reactivity, interoceptive beliefs was negatively associated with somatic intensity, *b*=-.15, *p*=.002, *95% CIs* [-.25, -.06]. Gender was also significant across all models, such that females reported more intense somatic sensations during the TSST relative to males.

In terms of interactions, there were marginal interactions between *interoceptive ability x beliefs* in both the HR reactivity model (*p*=.057) and RSA reactivity model (*p*=.054). Ultimately, these findings replicate the same pattern from the negative, high arousal emotion outcome models. Individuals with lower interoceptive ability and less positive interoceptive beliefs reported more intense somatic sensations from the TSST. However, given that there were no significant main effects of interoceptive ability for somatic intensity, it is not surprising that these interaction terms are weaker for somatic intensity, compared to emotion. On the other hand, physiological reactivity interacted with interoceptive beliefs. Specifically, *HR reactivity x interoceptive beliefs* was marginal, *b*=-.10, *p*=.057, *95% CIs* [-.20, .00], and there was also a significant interaction of *PEP reactivity x interoceptive beliefs*, *b*=.14, *p*=.006, *95% CIs* [.04, .25]. Probing these interactions again showed a pattern consistent with results for the *PEP reactivity x interoceptive beliefs* interaction on negative, high arousal emotion. Here, even when physiological reactivity (HR, PEP) was at high levels, individuals with high interoceptive beliefs reported lower levels of somatic intensity relative to other participants. Interestingly, *RSA reactivity x interoceptive sensibility* also emerged as marginal, *b*=-.12, *p*=.054, *95% CIs* [-.24, .00], although RSA reactivity and the interoceptive sensibility factor as main effects were not significant. Probing this interaction revealed a marginally significant slope for lower (-1SD) interoceptive sensibility, *t*(206)=1.76, *p*=.081, such that when both RSA reactivity and sensibility were lower, individuals reported *less* somatic intensity than when RSA reactivity was high. Slopes for average (0SD) and higher (+1SD) interoceptive sensibility were not significant.

Secondary Analyses: Positive and Low Arousal Emotions

Although I was primarily focused on negative, high arousal emotions in the context of the acute stressor, it could be useful to also examine the same hierarchical regression models for positive and low arousal emotions as a test of the specificity of effects. I thus ran the exact some model steps as described above, but with positive and low arousal emotions as separate outcomes. See **Appendix** for statistical results.

Broadly speaking, in the final model steps for positive emotion, neither physiological reactivity (be it HR, PEP, or RSA), interoceptive ability, nor interoceptive beliefs showed any significant main effects for positive emotion during the TSST, but interoceptive sensibility demonstrated a consistent marginal positive association with greater positive emotion ratings post-TSST. This may suggest that greater interoceptive sensibility was related to more positive emotions throughout the stressor compared to individuals low in sensibility. Beyond these weak effects for interoceptive sensibility, there were no other significant effects nor interactions besides a significant effect of gender.

With regards to low arousal emotion, effects varied somewhat depending on whether the model included HR, PEP, or RSA reactivity. One consistent effect across all models was that greater interoceptive beliefs was inversely related to low arousal emotion reports, in parallel with the negative, high arousal emotion findings. This may suggest that individuals with more positive evaluative beliefs about their interoceptive signals were less likely to report strong emotions in general, regardless of whether those emotions were high or low in arousal. On the other hand, HR and RSA reactivity were unrelated to low arousal emotion (controlling for all the other factors), but greater PEP reactivity was related to more intense low arousal reports, suggesting that individuals with greater SNS-related cardiac contractility were more likely to report stronger arousal experiences of any kind, be it high arousal or low arousal states. Yet interoceptive ability was negatively related to low arousal emotion reports in the HR and RSA reactivity models (but unrelated in the PEP model), consistent with interoceptive ability's inverse relation with negative, high arousal emotions. This again may suggest that individuals who performed better on the heartbeat detection task were less likely to report strong emotions in general, regardless of whether these were high or low in arousal.

Exploratory Analyses: Additional Interoceptive Measures

Given that there were no significant effects for interoceptive sensibility in any model (besides a marginal positive main effect for positive emotions), I considered the possibility that my computed sensibility factor score might somehow be problematic. To investigate this possibility, I re-ran the hierarchical regression models for negative, high arousal emotion but replaced the sensibility factor score with standardized mean scores for the BAQ and MAIA. See **Appendix** for these results. Consistent with my primary findings that sensibility was not predictive of negative, high arousal emotion, the BAQ and MAIA were not significant across HR, PEP, and RSA reactivity models—with the exception of the BAQ being significant in the PEP reactivity model final step, b=-.27, p=.013, *95% CIs* [-.49, -.06], such that individuals who reported greater noticing and attending to their interoceptive cues were less likely to report strong negative, high arousal emotions from the TSST. This may hint that, consistent with my hypothesis, both types of "interoceptive priors" (both sensibility and evaluative beliefs) may indeed matter for emotional experience. Beyond this, it is worth noting that interoceptive ability, beliefs, and gender effects remained consistent with what was found using the sensibility factor.

Finally, in the EFAs, I discovered that my measures assessing *interoceptive focus* (based on open-ended free reports of interoceptive sensations at the S1 and S2 baselines as well as right after the TSST) and *interoceptive knowledge* (from the Emotion Association Task) did not load onto either interoceptive sensibility nor beliefs. As such, I dropped them from the SEM and hierarchical regression analyses. However, as exploratory analyses, I re-ran the hierarchical regression models for negative, high arousal emotion but added an initial model step with the measures for interoceptive focus and knowledge. In general, the interoceptive focus measures were not related to negative, high arousal emotion reports, but there was a consistent main effect for interoceptive knowledge, such that individuals who reported stronger explicit associations between interoceptive sensations and emotion concepts were also more likely to report stronger negative, high arousal emotions (ps<.01). As such, although I did not fully explore the roles of interoceptive focus and interoceptive knowledge within this dissertation, future work with this dataset and beyond could begin to disentangle how these two constructs might matter for affective and somatic processes.

CHAPTER FIVE: THE AFFECTIVE POWER OF THE BODY AND BELIEFS

Broadly, this dissertation reveals that physiological reactivity, interoceptive ability, and interoceptive beliefs (specifically, evaluative beliefs about the value vs. danger of interoceptive sensations) all matter for the kinds of emotions that people commonly report experiencing during an acute stressor (i.e., negative, high arousal emotions). However, consistent with the notion that people's expectations and beliefs can powerfully shape downstream experiences and outcomes (Adler et al., 2000; Beecher, 1955; Cohen et al., 2008; Enck & Zipfel, 2019; Hawkley & Cacioppo, 2010; Reicherts et al., 2016), interoceptive beliefs emerged as the most reliable predictor of subjective stress. Importantly, the only significant and consistent interactions observed were with interoceptive beliefs. Individuals with low interoceptive ability and more negative beliefs about the value of their bodily sensations were significantly more likely to report experiencing greater negative, high arousal emotion during the stressor. Alternatively, holding more positive interoceptive beliefs was protective, even when interoceptive ability was poor. Similarly, interoceptive beliefs served as a buffer against negative, high arousal emotions when physiological reactivity was high (specifically, pre-ejection period, often used as an index of sympathetic nervous system reactivity).

These two patterns of interactions may suggest different mechanisms or pathways by which interoceptive beliefs matter. On the one hand, interoceptive beliefs did not appear to matter when physiological reactivity was low, perhaps suggesting that interoceptive beliefs only become relevant once physiological signals have crossed a certain intensity threshold (even when accounting for differences in interoceptive ability). On the other hand, individuals with poor interoceptive ability likely have less access to what is actually going on inside of their bodies. As such, this lack of accurate or sufficient interoceptive insight could make interoceptive beliefs far weightier and more important, leading the brain to rely more on predictions in the absence of clear or reliable afferent signals. One surprising null effect was that interoceptive ability never interacted with physiological reactivity in any model. Instead, it was interoceptive beliefs that mattered for subjective stress experiences in interaction with both physiological reactivity and interoceptive ability.

Interestingly, these observed main effects and interactions further held for reported somatic intensity. Although somatic intensity was of secondary interest in this dissertation, it serves as a valuable contrast against emotion in terms of identifying the replicability and specificity of effects for emotion vs. other subjective features of the stress experience. When controlling for physiological reactivity and other interoceptive factors, interoceptive ability only mattered for emotional experiences but was unrelated to subjective somatic experiences. Instead, physiological reactivity (i.e., heart rate) showed a larger effect size for somatic intensity compared to emotion. Together, these patterns suggest that although physiological reactivity does matter for emotion, it may matter more for the intensity of somatic sensations we experience; alternatively, objective interoceptive ability appears more relevant in translating that physiology and sensation into emotional experiences. It may be surprising that there was no relation between interoceptive ability and somatic intensity. However, similar findings have been observed previously, including by Whitehead and colleagues (1976). Finally, interoceptive beliefs remained significant across all models for somatic intensity, suggesting that individuals with more positive interoceptive beliefs were less likely to report experiencing more intense somatic sensations like their heart racing, sweat increasing, or faster breathing.

In terms of interactive effects, there was again a significant interaction of physiological reactivity (specifically, pre-ejection period) and interoceptive beliefs on somatic intensity, replicating what I found for the *pre-ejection period reactivity x interoceptive beliefs* interaction on negative, high arousal emotion. Similarly, I observed parallel, albeit weaker, interaction effects of *interoceptive ability x beliefs* on somatic intensity, replicating what I observed for emotion outcomes. These effects with interoceptive beliefs, consistent across negative, high arousal emotion and somatic intensity, ultimately point to the conclusion that our beliefs and expectations about interoceptive signals matter for subjective experience—for the kinds and intensity of emotions we feel and even for how much we experience sensations like our heart racing.

Another consistent finding across all models was the effect of gender on subjective reports.

Females consistently reported more intense subjective stress experiences (both in terms of negative, high arousal emotions and somatic sensations) compared to males. This finding is consistent with previous literature on gender differences in emotion reports and somatization tendencies (Fujita, Diener, & Sandvik, 1991; Hiller, Rief, & Brähler, 2006; Kelly, Tyrka, Anderson, Price, & Carpenter, 2008; Nakao et al., 2001). However, after observing how much gender mattered, I ran follow-up exploratory analyses to test whether gender interacted with physiological reactivity or any of the interoceptive measures. There were no significant interactions of gender in any model, only a main effect. These findings point to the interpretation that females may report more intense negative emotions, for example, even if their physiological reactivity to stress is not greater. It is unclear whether this effect is a product of internalized stereotypes that women are more emotional than men (e.g., Barrett, Robin, Pietromonaco, & Eyssell, 1998) or some other reporting bias. It is also unclear the extent to which women may be over-reporting vs. men are under-reporting subjective stress. Nonetheless, this observed main effect suggests that gender is an important confound that future studies should account for when examining both physiological reactivity and interoception.

In sum, findings are consistent with hypotheses from active inference models on interoception and constructionist theories of emotion (e.g., Barrett & Simmons, 2015; Friston & Kiebel, 2009; Lindquist, 2013; Parr & Friston, 2019). Although physiological reactivity and interoceptive ability mattered for emotions and the subjective stress experience, I found evidence that people's interoceptive priors also mattered and perhaps mattered more than physiological changes or objective access to said physiology. The term "interoceptive priors" is used primarily in active inference or computational neuroscience approaches, where "priors" are cascading neural signals about previous and ongoing sensory information (e.g., Allen, Levy, Parr, & Friston, 2019; Barrett & Simmons, 2015; Parr & Friston, 2019). In this dissertation, I wanted to take a *psychological* rather than neuroscientific approach to "interoceptive priors" to identify what people think and believe about their bodies and whether these psychological beliefs or meta-cognitive frameworks could also predict emotional experience relative to physiological reactivity or interoceptive ability.

Herein, I examined both interoceptive sensibility and more evaluative interoceptive beliefs as two different classes or kinds of psychological interoceptive priors. However, only interoceptive beliefs about the value vs. danger of bodily sensations emerged as significant. Measures of interoceptive sensibility were consistently non-significant in relation to *in vivo* subjective stress experiences, especially negative, high arousal emotion. Furthermore, although most studies on interoceptive ability have found a positive relation between interoceptive ability and emotional intensity (often with the Schandry task), this study surprisingly found a negative relation with the Whitehead task. In light of these findings, I next discuss important construct and measurement implications that these results may hold for the nature of interoception.

The Nature of Interoception: Measurement Implications

One broader goal of this study was to clarify the nature of interoceptive constructs—especially in the context of *in vivo* emotional experience. The field of interoceptive science has exploded over the past decade, with hundreds of studies seeking to correlate diverse interoceptive constructs with emotional processes (i.e., experience, awareness, perception, regulation), empathy, social skills, intuitive decision-making, risk-taking, health behaviors, mood disorders, addiction, autism, schizophrenia, and more (Tsakiris & De Preester, 2018). This explosion has also coincided with a proliferation of constructs that presumably tap into different aspects of interoception, as researchers investigate a range of constructs such as interoceptive ability (sensitivity or accuracy), awareness, sensibility, focus, attention, etc.—but often measure even the same construct in very different ways. As such, the broader constructs underpinning interoception remain inconsistently defined and operationalized, making it difficult to interpret and integrate findings. Several leaders in the field have begun building a taxonomy of constructs and definitions (Khalsa et al., 2018). Yet this is only a first step.

It is vital that we also perform measurement validation and replication across interoceptive constructs and with larger samples. For example, most studies on interoception and emotion have often relied upon smaller sample sizes (*Ns*<50), focused on only one interoceptive measure (e.g., the Schandry task), or did not parse apart potential shared variance between psychophysiology and interoception. As such, this study is one of the first of its kind to integrate multiple measures of physiological reactivity, facets of interoception, and emotion together in the context of acute stress while also capitalizing on a larger-than-typical sample size. Similarly, this study is to my knowledge the largest sample collected to date with the Whitehead heartbeat detection task—let alone the first study to examine physiological reactivity, interoceptive ability, interoceptive sensibility, and interoceptive beliefs in parallel together during *in vivo* emotion. Other study strengths are that this is a high-quality healthy young adult sample in terms of physical and mental health prescreening requirements and has a fairly balanced gender distribution. As such, I hope that the present data can provide some much-needed clarity on the nature of interoception in the context of emotion and stress. Below, I summarize some key take-aways on the nature and measurement of interoceptive ability, sensibility, and beliefs.

Interoceptive Ability

I found that interoceptive ability, as measured via the Whitehead heartbeat detection task, was inversely associated with negative, high arousal emotion during the stressor. This negative relation stands in direct contradiction to the narrative for interoceptive ability and emotion in the broader interoceptive literature, where most researchers would expect to observe a significant positive association between greater interoceptive ability and *in vivo* negative, high arousal emotion. One possible reason for this divergence in findings could be that the link between interoceptive ability and emotion is likely a small effect. In this dissertation, the effect of the heartbeat detection was indeed small (~.20). Yet almost all studies with the Schandry/Whitehead tasks and emotional experience tend to have *Ns*< 50 (with a few notable exceptions). As such, almost definitely, previous studies on interoceptive ability and emotion are underpowered to detect smaller effects, and these literatures may be subject to false positives or perhaps even publication biases (e.g., everyone assumes that greater interoceptive ability = greater emotional intensity due to older underpowered findings).

Thus, this present study's data are important because we doubled even the largest of previous sample sizes obtained for the Whitehead task and, as such, can provide more reliable and robust effect estimates on the link between interoceptive ability (as measured by the Whitehead task) and emotion during an acute stress induction. Relatedly, another historical problem is that many of the foundational studies on interoceptive ability and emotion dichotomized their sample into good vs. poor heartbeat perceivers or detectors. These "extreme sample" and dichotomization approaches are problematic both for theoretical and (especially) statistical reasons (e.g., do not disentangle response tendencies, lead to biases in parameter estimates; MacCallum, Zhang, Preacher, & Rucker, 2002; Preacher, Rucker, MacCallum, & Nicewander, 2005), and thus make it more difficult to identify the true effect of interoceptive ability measures in relation to emotion variables. More work is clearly needed to further verify the relation between interoceptive ability and emotion.

Finally, given that the positive association for interoceptive ability and emotion is consistent across at least some studies, a more charitable and reasonable interpretation (than explaining away all contradictory findings as false positives) is that past studies do indeed capture true effects with the specific measures or contexts assessed, but that there may be several other key features at play leading to heterogenous findings. For example, studies may differ in terms of the *kinds of measures used* (e.g., Schandry vs. Whitehead tasks; trait anxiety vs. state emotions), *the situational context* (whether emotions were measured at rest or after a specific kind of affect induction), *the physiological context* (e.g., whether or not the autonomic and cardiovascular systems are more robustly active such as during a stressor), or perhaps *other uncaptured factors* such as differences in attention, cognitive load, and executive function across individuals or across studies. For example, most studies that have reported a positive relation between interoceptive ability and emotion used the Schandry task—although it is worth noting that), in a sample of over 500 individuals, Zamariola, Luminet, and colleagues (2019 found no association for interoceptive ability using the Schandry task with mood measures following social exclusion and negative feedback affect inductions. Alternatively, publications that used the Whitehead task seem more likely to report a negative or null association for interoceptive ability and emotion.

Divergence in findings could also be due to the different kinds of affect inductions used. For example, positive associations (greater interoceptive ability and greater emotional intensity) have largely been found in studies with affect inductions that used images or film clips (e.g., Eichler, Katkin, Blascovich, & Kelsey, 1987; Ferguson & Katkin, 1996; Hantas, Katkin, & Blascovich, 1982; Herbert, Pollatos et al., 2007; Pollatos, Gramann, & Schandry, 2007; Pollatos, Herbert et al., 2007; Pollatos, Kirsch, & Schandry, 2005; Pollatos, Schandry, Auer, & Kaufmann, 2007; Pollatos, Traut-Mattausch, Schroeder, & Schandry, 2007). Overall, these studies found that greater interoceptive ability was associated with more intense emotion reports, especially arousal reports during negative affective images or clips. However, as discussed in the first chapter, several other studies (both with affective image paradigms and with other more stressor-based affect inductions) have found either no relation or a negative relation, i.e., where higher interoceptive ability was associated with *less* intense emotion reports (e.g., Blascovich et al., 1992; Mikkelsen et al., 2019). For example, Werner et al. (2009) found that better performance on the Schandry task was associated with less trait anxiety overall and less state anxiety before and after the TSST, in parallel with the present study's findings using the Whitehead task and TSST.

Picture and film induction techniques are effective and widely used in affective science and can successfully induce physiological changes but may elicit weaker physiological changes for high arousal states like anger and anxiety compared to stressor and performance tasks (e.g., the TSST; see the Lench, Flores, & Bench, 2011 meta-analysis for high arousal effects by induction method; see discussion in the Siegel et al., 2018 meta-analysis for points about active vs. more passive induction technique effects on psychophysiology). As such, it may be that interoceptive ability relates to emotional experience differently during conditions of weak vs. robust physiological activity. Little to no work has yet explicitly tested whether trait interoceptive ability varies in its relation to emotion depending on whether the affect induction is accompanied by stronger or weaker physiological activation, but this would be an important next step in clarifying how interoceptive ability relates to emotional experience.

Altogether, what we know about the nature of interoceptive ability in relation to emotional experience remains unclear. Prior studies were foundational in establishing that interoceptive ability likely does indeed impact our emotional experiences, pioneering a new wave of research questions and ideas on the body's role in emotion. However, several caveats and issues remain unaddressed. Future studies assessing interoceptive ability should strive to use larger sample sizes (at least N>100 but ideally N>200-300 for correlational studies), should avoid dichotomizing their samples into high vs. low interoceptive ability groups, and should more explicitly examine how heterogeneity in situational, physiological, and attentional factors may shape the extent to which interoceptive ability relates to emotional experiences. Ideally, future studies should also include both the Schandry and

Whitehead tasks in the same study so that the field can more fully grapple with how consistent vs. divergent these measures are for emotion outcomes. One limitation of this dissertation is that I only included the Whitehead heartbeat detection task, thus restricting inferences about interoceptive ability to this task rather than across interoceptive tasks in general.

Interoceptive Sensibility

Another surprise from this study was that interoceptive sensibility (measured with the BAQ and MAIA) was unrelated to *in vivo* stress experiences, at least when controlling for other important factors like physiological reactivity, interoceptive ability, beliefs, and gender (see **Appendix** for simple bivariate correlations). There are a couple possible reasons for this. First, sensibility is about how much individuals *think* they notice or pay attention to their interoceptive signals. This does not imply anything about actual accuracy or ability. High sensibility likely encompasses both self-characterizations that one is interoceptively “in touch” as well as the belief that it is important to pay attention to or notice interoceptive signals. Yet people could believe it is important to pay attention to their bodies for many reasons.

For example, some individuals may be hyper-vigilant and see their interoceptive signals as dangerous or problematic. Other individuals may instead relish or indulge in positive focus on their bodily sensations, such as for the purposes of emotion regulation (e.g., physiological modulation by exercising, taking a hot bath or shower, savoring certain kinds of comfort foods, etc.). Thus, sensibility does not fully distinguish between these different kinds of attentional motivations (e.g., threatened vigilance vs. body/self-care)[5]. On the other hand, interoceptive beliefs as measured in this dissertation help parse apart the underlying reasons motivating *why* individuals might want to notice and manage their sensations in the first place.

[5] The MAIA was originally developed in focus groups with practitioners of mindfulness meditation, yoga teachers, etc. As such, it makes sense that MAIA items focus on people’s willingness to engage with and experience interoceptive sensations (whether pleasant or unpleasant). The MAIA may also use items that reflect a tendency to focus on interoceptive signals even under conditions of low-level physiological changes (e.g., such as during meditation or when relaxed), helping orient attention towards the body. Thus, the MAIA may be more relevant for the experience of positive, low arousal emotions and pleasurable somatic sensations as well as the regulation of negative or unpleasant emotions and somatic sensations. Thus, situational and physiological factors may determine for whether or not trait sensibility measures such as the MAIA are predictive of emotion, somatic, and health outcomes. These are questions that should be explored in future work, but see **Appendix** for supplementary bivariate correlations with positive and low arousal emotions.

Second, it is possible that sensibility as measured with questionnaires is more about broad trait self-construals and less relevant to in-the-moment state construction. Previous work has mostly examined sensibility as a trait in the context of psychopathology and mental wellbeing, health behaviors, etc. Very little work has investigated whether sensibility matters in the context of real-time emotions. Similar to interoceptive ability, the degree of low-level vs. robust current physiological activity may make a difference in whether and how much interoceptive sensibility relates to emotion. For example, interoceptive sensibility may be useful during conditions of low-level physiological changes, helping orient attention more towards interoceptive signals (regardless of how clear or accurate those perceptions are). However, in the context of robust physiological changes, interoceptive sensibility may be unnecessary, because physiology is already more intense and noticeable. Future work could test this hypothesis that interoceptive sensibility matters more for emotions at rest and during low-level physiological conditions relative to high intensity-high reactivity physiological conditions. Future work is also needed to clarify what interoceptive sensibility is truly measuring. Current measures like the BAQ and MAIA conflate self-construals about interoceptive attention or access with interoceptive beliefs about the value and use of sensations. This dissertation suggests that it is vital we disentangle sensibility from evaluative beliefs and move beyond predictive validity with trait outcomes (e.g., trait anxiety, somatization tendencies) into real-world experiences (e.g., emotional and somatic states).

Finally, another plausible interpretation is that people's beliefs about their interoceptive performance or abilities simply do not map well onto actual performance-based measures. Within affective science, there is a long history of findings demonstrating inconsistencies between beliefs and performance-based measures (see discussions in Barrett, 2004; Lindquist & Barrett, 2008; Robinson & Clore, 2002). Psychology has long recognized limitations to self-insight (Nisbett & Wilson, 1977). Questionnaires—especially about people's general behavioral or experiential tendencies—ask participants to make summary judgments that could be problematic in two ways. First, summary judgments are likely subject to retrospective memory biases (Robinson & Clore, 2002; Van den Bergh & Walentynowicz, 2016). Retrospective memory biases occur in part because what people are more likely to encode into memory and what they most easily recall are based upon socially proscribed schemas (e.g., social norms, stereotypes). Ultimately, this means that self-reports may conform more to schemas rather than actual idiographic experience.

Second, these sorts of summary judgments likely require individuals to make social comparisons that may be unrepresentative of the broader population distribution of traits (Hoorens & Damme, 2012; Suls, Martin, & Wheeler, 2002); for example, if you come from a highly interoceptive family, your judgments about how in touch you are with your sensations may be skewed. Thus, sensibility reports ("How much do I tend to notice my body?") may not match objective interoceptive ability for many reasons. However, it is still useful to measure sensibility because it represents people's schemas about whether they are someone who is "in touch" with their bodily changes vs. not. Similarly, with more evaluative interoceptive beliefs ("Bodily sensations are misleading"), the whole point is to identify people's negative vs. positive schemas about their interoceptive sensations in the first place. I discuss interoceptive beliefs next.

Interoceptive Beliefs

Finally, the present work highlights that people's evaluative beliefs about the nature and value of their interoceptive sensations matter for subjective experiences—both emotional and somatic. Although these ideas have been explored somewhat in literatures on anxiety sensitivity and panic disorders, this construct has been less explored within healthy, non-clinical samples nor has this construct been formally integrated into the broader interoceptive literature. The BSBQ was a measure I created especially for this study to help address this issue. As a measure, further psychometric validation is necessary in a larger, more diverse sample beyond the 250 healthy young adults represented herein. Additionally, there are likely other existing measures or parts of measures that tap into interoceptive beliefs—whether within the interoceptive literature or in other literatures on psychopathology, disease beliefs, or health behavior change. For example, beliefs about the hedonic enjoyment of certain sensations or beliefs around the regulation and manageability of sensations—these too may be important facets of interoceptive beliefs. An important next step is to identify and unify these literatures together into an interdisciplinary understanding of interoceptive beliefs and to begin testing the convergent vs. discriminant validity of related interoceptive belief measures. Towards this goal, I close this dissertation by identifying new research directions and outlining the implications of interoceptive beliefs for social affective processes and beyond.

Minding the Body: Implications for Social Affective Processes and Beyond

Above and beyond implications for the measurement and nature of interoception, this dissertation's findings reveal several important implications for social affective processes, physical and mental health, and development. At a broad level, results affirm what has long been known—that both actual and perceived ongoing physiological activity are relevant for emotional experiences. Although this study did manipulate physiological reactivity within-subjects (assessing TSST change from baseline), this study was more broadly correlational and cannot speak to the claim that physiological systems and interoception are causally contributing to emotion. Nevertheless, this study was a critical step in clarifying how physiology might interact with different facets of interoception in the context of emotion. I found that physiological reactivity did not interact with interoceptive ability—but instead, both physiological reactivity and interoceptive ability interacted with interoceptive beliefs to predict the subjective stress experience. With these findings in mind, future experiments could manipulate both physiological reactivity and interoceptive beliefs to investigate causal influences on emotional experience and even other outcomes that rely on affect such as affective forecasts, risk-taking, or social and moral judgments.

Arousal Re-Appraisal

Manipulating interoceptive beliefs would also be consistent with existing work in the stress literature on arousal re-appraisal (Jamieson, Hangen, Lee, & Yeager, 2018; Jamieson, Mendes, & Nock, 2013). For example, participants who are taught to re-appraise their stress-related physiological arousal as facilitative or helpful during times of pressure (e.g., a TSST performance, a standardized exam, a sports game, etc.) tend to exhibit more challenge-oriented (rather than threat-oriented) physiological changes, report less negative and more adaptive emotional responses and appraisals, and sometimes even perform better during stressors (Jacquart, Papini, Freeman, Bartholomew, & Smits, 2020; Jamieson et al., 2010; Jamieson, Nock, & Mendes, 2012; Jamieson, Peters, Greenwood, & Altose, 2016; Sammy et al., 2017). These effects are in contrast to effects for participants asked to re-appraise their physiological arousal as a hindrance or in contrast to participants undertaking the stressor normally (i.e., the control group). In parallel with arousal reappraisals, interoceptive beliefs as measured herein target whether individuals believe that their bodily sensations are valuable and insightful vs. misleading and difficult to manage. Ultimately, this study illustrates that there is variation between (even young, healthy) individuals in views about whether bodily sensations are helpful vs. problematic. Arousal re-appraisal could be one mechanism for targeting negative interoceptive beliefs that are exacerbating stress.

Clinical Approaches

Interoceptive beliefs may also be more likely to shift after negative life events of adversity or trauma and thus could be critical pathways by which anxiety, panic, and post-traumatic stress disorders are propagated. However, existing anxiety sensitivity and panic disorder interventions already provide insight into how negative interoceptive beliefs can be targeted and changed. For example, some individuals, including those with anxiety sensitivity find uncomfortable or more intense physical sensations especially difficult or intolerable, known as *discomfort intolerance* (Schmidt, Richey, & Fitzpatrick, 2006). In addition to discomfort intolerance, the catastrophizing of pain, physiological arousal, etc. are also more likely to occur in anxiety and panic disorders (De Cort et al., 2013; McHugh, Kneeland, Edwards, Jamison, & Weiss, 2019; Olthuis, Stewart, Watt, Sabourin, & Keogh, 2012; Richards & Bertram, 2000). Current anxiety and panic disorder treatments include techniques that directly and indirectly target both discomfort intolerance and catastrophizing, including psychoeducation about the different components of anxiety or panic (e.g., the interoceptive sensations that occur with anxiety), cognitive behavioral therapy to identify and target maladaptive beliefs or cognitions (including those about interoceptive sensations), interoceptive exposure treatments where individuals are exposed to painful or anxiety-provoking sensations, and teachings on stress management and coping, which include techniques to target the physiological dimensions of stress (e.g., Norr, Allan, Macatee, Keough, & Schmidt, 2014; Stewart & Watt, 2009). All of these treatments arguably address negative interoceptive beliefs and teach both cognitive and behavioral strategies to help individuals shift their beliefs and in-the-moment reactions to interoceptive sensations.

Altogether, social psychological work on arousal re-appraisal during stress and clinical science on anxiety and panic disorder provide parallel external evidence in line with the present findings that interoceptive beliefs can play a powerful role in affective processes. However, the construct of interoceptive beliefs may also hold promise beyond emotion, stress, and anxiety/panic disorders—for other psychopathologies, social processes, and health perceptions and behaviors. One of the most promising things about interoceptive beliefs is their potential malleability. Malleability suggests that interoceptive beliefs may be especially suitable treatment targets. Thus, we need to understand how such beliefs develop and change over the lifespan (e.g., due to early familial environment and one's culture, due to traumatic events as noted above, or due to aging processes), and we also need to test how much interoceptive beliefs can shift for better or worse with lifestyle changes and health experiences (e.g., a stroke or heart attack). In line with these considerations, I close by outlining possible roles for interoceptive beliefs in development and health.

Developmental Perspectives

First, a limitation of this study is that it was conducted in healthy young adults. It remains unclear how findings might translate to childhood, adolescence, or later stages of adulthood. Interoceptive beliefs are likely accumulated and can change via both idiographic experience and cultural transmission (e.g., garnered from upbringing, body metaphors in one's native language, folk wisdom about the body). One area of future research could be to understand how interoceptive beliefs develop in the first place and what implications this has for downstream social affective functioning and physical health. Recent work shows that what mothers know about the link between interoceptive sensations and emotional experience is related to their children's social skills and emotion regulation in the classroom, as rated by children's third-grade teachers (MacCormack, Castro, Halberstadt, & Rogers, 2019). Furthermore, this maternal interoceptive knowledge was more predictive of children's social affective skills than other classic parent emotion socialization measures, such as supportive vs. non-supportive parenting behaviors. Although this work is in its early stages, it hints that caregivers' knowledge and beliefs about interoceptive sensations are likely important avenues of socialization that remain underexplored in developmental literature.

How children learn to understand their interoceptive sensations—including whether they believe such sensations are comfortable, trustworthy, and manageable vs. upsetting, misleading, and difficult—could have long-term implications for social affective development and, more broadly, the etiology of mood and behavioral problems, including issues surrounding arousal management (e.g., hyperactivity, externalization problems). Similarly, parental interoceptive beliefs could be especially important in the context of children suffering with pain and acute or chronic illnesses. For example, children suffering from abdominal pain issues can learn to attend to, interpret, and accept their interoceptive sensations, in turn helping to reduce both the pain itself and the children's pain distress (Zucker et al., 2017). In this way, parents and caregivers can model positive interoceptive mindsets and talk children through the experience and meaning of interoceptive sensations, including distressing arousal, pain, or illness, which could ultimately improve children's outcomes.

In addition to early life, interoceptive beliefs in later life may also be extremely important. Late life is often accompanied by increased illness, pain, and somatic complaints. Yet also, older adulthood is characterized by greater emotional stability, fewer negative and more positive emotions, and less distress during conflict (Birditt, 2014; Birditt, Fingerman, & Almeida, 2005; Brose, Scheibe, & Schmiedek, 2013; Charles, Piazza, Luong, & Almeida, 2009; Mather & Carstensen, 2005; Neupert, Almeida, & Charles, 2007). One possible reconciliation between biological and emotional aging effects are that the peripheral nervous system and interoception are also aging, resulting in a weakened link between physiology and emotion (MacCormack, Henry, Davis, Oosterwijk, & Lindquist, 2019; Mendes, 2010; Mikkelsen et al., 2019). For example, the peripheral nervous system becomes increasingly demyelinated and less efficient with age (Palve & Palve, 2018; Verdú, Ceballos, Vilches, & Navarro, 2000). Other studies demonstrate that older adults perform worse on measures of interoceptive ability than younger adults (Khalsa et al., 2009; Murphy, Geary, et al., 2018) and that age moderates the link between interoceptive ability and emotional reactivity (Mikkelsen et al., 2019).

Taken together, these data suggest that ascending interoceptive signals may become noisier and less reliable or meaningful in the brain's predictions in late life. Rather than construct an experience of anxiety, for example, older adults may be more prone to somaticize or interpret physiological arousal and discomfort as physical symptoms. Indeed, older adults appear to be more prone to somatization than younger adults, including in the context of depression (Fiske, Wetherell, & Gatz, 2009; Henderson, 1999; Wongpakaran & Wongpakaran, 2014). Similarly, older adults associate interoceptive sensations less with emotion categories than younger adults do and this age-related decrement in interoceptive associations is related to shifts in older adults' reported arousal during emotion in daily life (MacCormack, Henry, et al., 2019). But what about interoceptive beliefs? Based on this dissertation's findings, I would expect interoceptive beliefs to become increasingly important in late life, as interoceptive signals become less clear or reliable. For example, I found that negative interoceptive beliefs were most detrimental when interoceptive ability was low. Similarly, given that interoceptive ability may decline with age, so too might negative interoceptive beliefs exacerbate detrimental social affective and health outcomes for older adults.

Health Consequences

Finally, interoceptive beliefs may have important consequences for health beyond social affective development and functioning. For example, starting to exercise regularly or diet for the first time may lead to new insights and beliefs about interoceptive sensations (e.g., "The burn is actually good for me" or "Ignoring my hunger is a win"). This shift in interoceptive beliefs could ultimately be key for whether health behavior change persists vs. fails. Studies on exercise interventions, smoking cessation, dieting, and eating disorder interventions suggest that this is likely true. For example, beliefs that interoceptive side effects are too painful, unpleasant, uncontrollable, or difficult to manage can serve as cognitive barriers to weight loss and smoking cessation (Dalle Grave, Calugi, Centis, El Ghoch, & Marchesini, 2010; Husebø, Karlsen, Allan, Søreide, & Bru, 2015; Nosen & Woody, 2014; Reese & Veilleux, 2015). On the other hand, some individuals with eating disorders like anorexia nervosa believe that hunger is a sensation that needs to be conquered and may learn to associate feelings of gastrointestinal fullness with aversion and feelings of hunger with self-control and positive affect (Gregertsen, Mandy, & Serpell, 2017; Zucker & Bulik, 2020). Altogether, these findings suggest that interoceptive beliefs may change over time as health behaviors change—and may be an important pathway to self-efficacy in the health domains as well as lasting health behavior change.

In a similar vein, major adverse health events such as a stroke, myocardial infarction, cancer, or chronic pain could negatively alter people's interoceptive beliefs, with repercussions for illness recovery and reoccurrence as well as downstream emotion, stress coping, and the etiology of mood disorders like depression and anxiety. In line with these ideas, a fascinating literature on "illness beliefs" has begun to examine exactly this. For example, the Illness Perception Questionnaire (Moss-

Morris et al., 2002; Weinman et al., 1996) assesses how many different somatic complaints people report, how much individuals believe that these somatic complaints are indicative of their diagnosed illness, as well as a variety of items on beliefs around personal control and consequences of symptoms, treatment efficacy, illness timeline and reoccurrence, emotional reactions to the illness, and how much the illness is due to random chance, risk factors, or psychosocial problems like stress, overwork, or conflict. Across studies on chronic pain, cancer, stroke, and adverse cardiac events, individuals with more negative illness beliefs were less responsive to rehabilitation, reported higher and longer lasting pain, and were more likely to develop depression or find the illness event distressing (Dickens et al., 2008; French, Cooper, & Weinman, 2006; Glattacker, Heyduck, & Meffert, 2013; Järemo, Arman, Gerdle, Larsson, & Gottberg, 2017; Thuné-Boyle, Myers, & Newman, 2006; Twiddy, House, & Jones, 2012; van der Kloot et al., 2016). Although illness beliefs are not the same as interoceptive beliefs, they are likely intertwined. Negative health events could serve as vulnerable periods when individuals are more likely to develop negative interoceptive beliefs or to intensify already-existing negative beliefs, perhaps even potentiating a downward spiral between negative health outcomes and social affective functioning.

Conclusion

In sum—both physiological reactivity and interoceptive ability matter for emotional experience, especially during an acute stressor. However, this dissertation suggests that interoceptive beliefs also play an important role in subjective stress and may even matter more than objective physiological changes and access to those changes. These findings are consistent with constructionist approaches to emotion which argue that people's predictions and conceptualizations of both context and interoceptive sensations are important ingredients in the construction of emotional experiences and perceptions (Barrett, 2017, 2018; Doyle & Lindquist, 2018; Hoemann & Barrett, 2019; Lindquist, 2013; MacCormack & Lindquist, 2017, 2018; Wilson-Mendenhall, Barrett, & Barsalou, 2013). More broadly, interoceptive beliefs provide a measurable psychological parallel to neuroscientific work on "interoceptive priors" in the brain's active inferences during cognition, emotion, and sensory perception (Allen et al., 2019; Barrett & Simmons, 2015; Hesp et al., 2019; Seth, 2013). The present work capitalized on a larger-than-average sample size, careful recruitment procedures, and an acute stress paradigm to provide important insights into the nature and measurement of interoceptive ability, sensibility, and beliefs during acute stress. More generally, this work highlights that the construct of interoceptive beliefs opens up new opportunities to bridge affective science, psychopathology, development, and health. In the years to come, it is critical that we begin to disentangle how heterogeneity in interoceptive processes, including beliefs, develops over time and what impact this may have on individuals' functioning and resilience vs. risk across all domains of life.

APPENDIX 1: TABLES

Table 1. Sample characteristics.

Demographics	Total
Self-identified gender	
N Female	144 (57.6%)
N Male	106 (42.4%)
Self-identified ethnicity	
N African descent	34 (13.6%)
N Asian descent	34 (13.6%)
N European descent	144 (57.6%)
N Latinx descent	16 (6.4%)
N Bi- or multi-racial	15 (6.0%)
N Other	7 (2.8%)
Other demographics	
Mean Age	19.20 ± 1.29
Mean BMI (self-report)	22.76 ± 2.86
Mean Subjective SES [a]	4.62 ± 1.32
Somatization [b]	
Mean Symptom reports	1.49 ± .39
Mean Hypochondriasis	1.53 ± .67

[a] Rather than asking students to report their family income, which they might not know, I instead assessed subjective SES with a 6-item scale about relative wealth in childhood and at college (Likert ratings ranged 1-7). [b] Somatization tendencies were assessed using the Common Mental Disorders somatization and hypochondriasis subscales (Likert ratings ranged 1-5; Søgaard & Bech, 2009). Note that I did not assess depressive or anxious tendencies, given that these were conditions screened against during intake.

Table 2. Exploratory factor analysis loadings using promax rotation.

Factor loadings	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6
Proposed physio loadings						
Heart rate reactivity				**1.00**		
Respiratory sinus arrhythmia reactivity				**-.57**		
Respiratory reactivity	.11		.11			-.14
Pre-ejection period reactivity				**-.41**		
Proposed intero ability loadings						
HBD fraction correct			**.96**			
HBD dprime			**.71**			.11
HBD mean confidence			**.33**			
HBD log reaction time		.19		.17	.15	
Session 1 HR baseline					-.18	
Proposed intero sensibility loadings						
BAQ mean	**.58**					.17
MAIA Notice subscale	**.72**					.10
MAIA Non-distract subscale						-.22
MAIA Attention regulation subscale	**.72**				-.39	-.10
MAIA Emotion awareness subscale	**.73**				.31	.13
Free-reported sum of physio words		**.78**			-.30	
Free-reported intero focus mean		**.99**				
Proposed intero belief loadings						
MAIA Non-worry subscale	-.11		.12		**.67**	
MAIA Self-regulation subscale	**.78**				.12	-.23
MAIA Body listen subscale	**.78**				-.10	
MAIA Body trust subscale	**.50**				.29	
BSBQ (reversed) mean			-.21		**.37**	
EAT Interoceptive likert mean						**.62**
EAT Interoceptive likert variance					.17	**.58**
Total						
SS loadings	3.42	1.66	1.63	1.59	1.16	.97
Proportion of variance	.15	.07	.07	.07	.05	.04
Cumulative variance	.15	.22	.29	.36	.41	.45

Note: χ^2= 145.52 (*df*=130), *p*=.153, suggesting that six factors are sufficient. This factor analysis by necessity excludes any rows with partial missing data, leaving *N*=187 full rows of data.

Table 3. Exploratory factor analysis focused on the BAQ, MAIA, and BSBQ.

Factor loadings	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5
BSBQ items					
Body is unpredictable - reversed	.13	**.63**			
Body is difficult to handle - reversed		**.62**			
Body is too intense - reversed	-.20	**.45**		.15	
Bodily urges hard to control - reversed		**.66**			
Afraid of bodily sensations - reversed	-.11	**.29**			**.49**
Body is misleading - reversed		**.59**			
Listening to body is bad - reversed		**.49**	-.23		.19
BAQ and MAIA subscales					
BAQ mean	**.60**				-.11
MAIA Notice subscale	**.74**				-.14
MAIA Non-distract subscale				-.11	-.14
MAIA Non-worry subscale	**-.25**		.18	-.21	.15
MAIA Attention regulation subscale	**.49**		**.79**		
MAIA Emotion awareness subscale	**.80**		-.14		
MAIA Self-regulation subscale	**.57**		.28		.14
MAIA Body listen subscale	**.76**			.18	.22
MAIA Body trust subscale	**.33**			-.16	**.58**
Total					
SS loadings	2.94	2.09	.83	.79	.76
Proportion of variance	.18	.13	.05	.05	.05
Cumulative variance	.18	.31	.37	.42	.46

Note: For this 5-factor solution, χ^2= 67.46 (*df*=50), *p*=.051, suggesting that five factors may be sufficient. There were no missing data here, *N*=250.

Table 4. Latent structural equation regressions for negative, high arousal emotion.

Model	β	*SE*	*p*
Model 1			
Physio latent factor	.00	.117	.982
Intero ability latent factor	**-.20**	**.078**	**.011**
Intero sensibility latent factor	-.05	.075	.481
Intero beliefs latent factor	**-.16**	**.080**	**.042**
Model 2			
Physio latent factor	.00	.117	.970
Intero ability latent factor	**-.19**	**.077**	**.012**
Intero sensibility latent factor	-.04	.075	.562
Intero beliefs (BSBQ)	**-.15**	**.070**	**.031**

Table 5. HR reactivity and interoceptive predictors on negative, high arousal emotion.

Predictors	R^2	*b*	*SE*	*β*	*p*	*Lower 95% CI*	*Upper 95% CI*
Step 1: *F*(1,206)= 2.10	.005						
Intercept		2.12	.091		<.0001	1.94	2.30
HR reactivity		.13	.090	.10	.149	-.05	.31
Step 2: *F*(2,206)= 3.29*	.022*						
Intercept		2.12	.090		<.0001	1.94	2.29
HR reactivity		.15	.090	.11	.108	-.03	.32
Intero ability factor		**-.20**	**.097**	**-.15**	**.036**	**-.40**	**-.01**
Step 3: *F*(3,206)= 2.45†	.021						
Intercept		2.12	.090		<.0001	1.94	2.29
HR reactivity		.14	.090	.11	.128	-.03	.33
Intero ability factor		**-.20**	**.097**	**-.14**	**.040**	**-.39**	**-.01**
Intero sensibility factor		-.09	.098	-.06	.382	-.28	.11
Step 4: *F*(4,206)= 3.04*	.038*						
Intercept		2.12	.089		<.0001	1.94	2.29
HR reactivity		.15	.090	.12	.092	-.03	.33
Intero ability factor		**-.23**	**.097**	**-.16**	**.020**	**-.42**	**-.04**
Intero sensibility factor		-.08	.098	-.06	.425	-.27	.11
Intero beliefs (BSBQ)		**-.19**	**.088**	**-.15**	**.032**	**-.37**	**-.02**
Step 5: *F*(10,206)= 2.02*	.047						
Intercept		2.16	.091		<.0001	1.98	2.33
HR reactivity		.18	.094	.14	.065	-.01	.36
Intero ability factor		**-.21**	**.098**	**-.15**	**.030**	**-.41**	**-.02**
Intero sensibility factor		-.08	.100	-.06	.432	-.28	.12
Intero beliefs (BSBQ)		**-.20**	**.088**	**-.15**	**.029**	**-.37**	**-.02**
HR x Intero ability		-.02	.101	-.10	.866	-.22	.18
HR x Intero sensibility		.07	.104	.05	.506	-.14	.27
HR x Intero beliefs		-.15	.098	-.11	.139	-.34	.05
Intero ability x sensibility		-.04	.112	-.03	.725	-.26	.18
Intero ability x beliefs		.19	.097	.14	.051	.00	.38
Intero sensibility x beliefs		.08	.100	.05	.453	-.12	.27
Step 6: *F*(12,206)= 2.91**	.100**						
Intercept		2.25	.686		.001	.90	3.60
HR reactivity		**.18**	**.092**	**.14**	**.047**	**.00**	**.37**
Intero ability factor		-.17	.096	-.12	.077	-.36	.02
Intero sensibility factor		-.11	.097	-.08	.245	-.31	.08
Intero beliefs (BSBQ)		**-.22**	**.086**	**-.17**	**.011**	**-.39**	**-.05**
HR x Intero ability		.01	.099	.01	.946	-.19	.20
HR x Intero sensibility		.08	.101	.06	.419	-.12	.28
HR x Intero beliefs		-.14	.095	-.10	.139	-.33	.05
Intero ability x sensibility		-.01	.110	-.01	.096	-.23	.20
Intero ability x beliefs		**.22**	**.095**	**.16**	**.021**	**.03**	**.41**
Intero sensibility x beliefs		.04	.098	.03	.659	-.15	.24
Gender		**-.66**	**.180**	**-.25**	**<.0001**	**-1.02**	**-.31**
BMI		.01	.030	.02	.774	-.05	.07

Note: HR= Heart rate. Adjusted R^2 is reported. Significance reported for R^2 represents whether there was a significant ΔR^2. Bolded lines indicate significant effects. Standard errors and confidence intervals are for the unstandardized betas. Gender is coded 0=Female, 1=Male. † p<.10, * p<.05, ** p<.01.

Table 6. PEP reactivity and interoceptive predictors on negative, high arousal emotion.

Predictors	R^2	*b*	*SE*	*β*	*p*	*Lower 95% CI*	*Upper 95% CI*
Step 1: *F*(1,189)= .78	-.001						
Intercept		2.04	.092		<.0001	1.86	2.22
PEP reactivity		-.08	.092	-.06	.380	-.26	.10
Step 2: *F*(2,189)= 3.17*	.022*						
Intercept		2.03	.091		<.0001	1.85	2.21
PEP reactivity		-.09	.091	-.07	.327	-.27	.09
Intero ability factor		**-.24**	**.101**	**-.17**	**.020**	**-.44**	**-.04**
Step 3: *F*(3,189)= 2.36†	.021						
Intercept		2.04	.091		<.0001	1.86	2.22
PEP reactivity		-.10	.092	-.08	.299	-.28	.09
Intero ability factor		**-.23**	**.101**	**-.17**	**.022**	**-.43**	**-.03**
Intero sensibility factor		-.09	.100	-.06	.384	-.28	.11
Step 4: *F*(4,189)= 2.69*	.034†						
Intercept		2.04	.091		<.0001	1.86	2.22
PEP reactivity		-.08	.091	-.06	.384	-.26	.10
Intero ability factor		**-.26**	**.102**	**-.19**	**.010**	**-.46**	**-.06**
Intero sensibility factor		-.07	.099	-.05	.456	-.27	.12
Intero beliefs (BSBQ)		-.17	.092	-.14	.061	-.35	.01
Step 5: *F*(10,189)= 2.35*	.067†						
Intercept		2.07	.092		<.0001	1.89	2.25
PEP reactivity		-.09	.092	-.07	.346	-.27	.10
Intero ability factor		**-.25**	**.102**	**-.18**	**.017**	**-.45**	**-.05**
Intero sensibility factor		-.07	.101	-.05	.476	-.27	.13
Intero beliefs (BSBQ)		-.18	.091	-.14	.056	-.36	.01
PEP x Intero ability		-.10	.112	-.07	.384	-.32	.12
PEP x Intero sensibility		-.19	.116	-.12	.111	-.41	.04
PEP x Intero beliefs		**-.25**	**.096**	**-.19**	**.011**	**-.43**	**-.06**
Intero ability x sensibility		-.04	.124	-.02	.774	-.28	.21
Intero ability x beliefs		.16	.100	.12	.103	-.03	.36
Intero sensibility x beliefs		.11	.099	.08	.281	-.09	.30
Step 6: *F*(12,189)= 3.41***	.133**						
Intercept		1.93	.688		.006	.57	3.28
PEP reactivity		-.14	.090	-.11	.127	-.32	.04
Intero ability factor		**-.21**	**.099**	**-.15**	**.033**	**-.41**	**-.02**
Intero sensibility factor		-.12	.098	-.09	.227	-.31	.08
Intero beliefs (BSBQ)		**-.19**	**.088**	**-.15**	**.030**	**-.37**	**-.02**
PEP x Intero ability		-.11	.108	-.08	.294	-.33	.10
PEP x Intero sensibility		-.19	.113	-.12	.090	-.42	.03
PEP x Intero beliefs		**-.20**	**.093**	**-.16**	**.031**	**-.39**	**-.02**
Intero ability x sensibility		-.01	.120	-.01	.939	-.25	.23
Intero ability x beliefs		.19	.097	.13	.055	-.01	.38
Intero sensibility x beliefs		.10	.096	.07	.313	-.09	.29
Gender		**-.72**	**.181**	**-.28**	**<.0001**	**-1.07**	**-.36**
BMI		.02	.030	.05	.522	-.04	.08

Note: PEP= Pre-ejection period. Adjusted R^2 is reported. Significance reported for R^2 represents whether there was a significant ΔR^2. Bolded lines indicate significant effects. Standard errors and confidence intervals are for the unstandardized betas. Gender is coded 0=Female, 1=Male. † *p*<.10, * *p*<.05, ** *p*<.01, *** *p*<.0001.

Table 7. RSA reactivity and interoceptive predictors on negative, high arousal emotion.

Predictors	R^2	*b*	*SE*	*β*	*p*	*Lower 95% CI*	*Upper 95% CI*
Step 1: *F*(1,206)= .36	-.003						
Intercept		2.12	.091			1.94	2.30
RSA reactivity		-.06	.092	-0.04	.551	-.24	.13
Step 2: *F*(2,206)= 1.10	.001						
Intercept		2.12	.091		<.0001	1.94	2.30
RSA reactivity		.04	.114	0.03	.738	-.19	.26
HR reactivity		.15	.113	0.12	.176	-.07	.38
Step 3: *F*(3,206)= 2.24†	.018*						
Intercept		2.12	.090		<.0001	1.94	2.29
RSA reactivity		.05	.113	.04	.687	-.18	.27
HR reactivity		.17	.113	.13	.127	-.05	.39
Intero ability factor		**-.21**	**.097**	**-.15**	**.035**	**-.40**	**-.01**
Step 4: *F*(4,206)= 1.87	.017						
Intercept		2.12	.090		<.0001	1.94	2.30
RSA reactivity		.05	.114	.04	.688	-.18	.27
HR reactivity		.17	.113	.13	.145	-.06	.39
Intero ability factor		**-.20**	**.097**	**-.14**	**.039**	**-.39**	**-.01**
Intero sensibility factor		-.09	.099	-.06	.383	-.28	.11
Step 5: *F*(5,206)= 2.45*	.034*						
Intercept		2.12	.089		<.0001	1.94	2.29
RSA reactivity		.05	.113	.04	.681	-.18	.27
HR reactivity		.18	.112	.14	.111	-.04	.40
Intero ability factor		**-.23**	**.097**	**-.16**	**.019**	**-.42**	**-.05**
Intero sensibility factor		-.08	.098	-.06	.426	-.27	.12
Intero beliefs (BSBQ)		**-.19**	**.088**	**-.15**	**.032**	**-.37**	**-.02**
Step 6: *F*(11,206)= 1.87*	.044						
Intercept		2.15	.090		<.0001	1.97	2.33
RSA reactivity		.03	.114	.02	.827	-.20	.25
HR reactivity		.18	.113	.14	.107	-.04	.41
Intero ability factor		**-.22**	**.099**	**-.16**	**.029**	**-.41**	**-.02**
Intero sensibility factor		-.07	.101	-.05	.490	-.27	.13
Intero beliefs (BSBQ)		**-.19**	**.089**	**-.15**	**.031**	**-.37**	**-.02**
RSA x Intero ability		-.01	.099	-.01	.928	-.21	.19
RSA x Intero sensibility		-.10	.110	-.07	.362	-.32	.12
RSA x Intero beliefs		.13	.101	.10	.205	-.07	.33
Intero ability x sensibility		-.03	.111	-.02	.819	-.24	.19
Intero ability x beliefs		**.21**	**.100**	**.15**	**.036**	**.01**	**.41**
Intero sensibility x beliefs		.07	.100	.05	.465	-.12	.27
Step 7: *F*(13,206)= 2.76***	.100***						
Intercept		2.16	.690		.002	.79	3.52
RSA reactivity		.01	.111	.01	.956	-.21	.23
HR reactivity		.19	.110	.15	.078	-.02	.41
Intero ability factor		-.18	.096	-.13	.071	-.37	.02
Intero sensibility factor		-.11	.098	-.07	.284	-.30	.09
Intero beliefs (BSBQ)		**-.23**	**.087**	**-.18**	**.010**	**-.40**	**-.06**
RSA x Intero ability		.01	.097	.01	.886	-.18	.20
RSA x Intero sensibility		-.12	.107	-.08	.259	-.33	.09
RSA x Intero beliefs		.15	.099	.11	.142	-.05	.34
Intero ability x sensibility		-.01	.108	-.00	.988	-.21	.21
Intero ability x beliefs		**.24**	**.097**	**.17**	**.013**	**.05**	**.44**
Intero sensibility x beliefs		.04	.098	.03	.652	-.15	.24
Gender		**-.68**	**.180**	**-.26**	**<.0001**	**-1.03**	**-.32**
BMI		.01	.030	.03	.666	-.05	.07

Note: RSA= Respiratory sinus arrhythmia, HR= Heart rate. Adjusted R^2 is reported. Significance reported for R^2 represents whether there was a significant ΔR^2. Bolded lines indicate significant effects. Standard errors and confidence intervals are for the unstandardized betas. Gender is coded 0=Female, 1=Male. † *p*<.10, * *p*<.05, ** *p*<.01, *** *p*<.0001.

APPENDIX 2: FIGURES

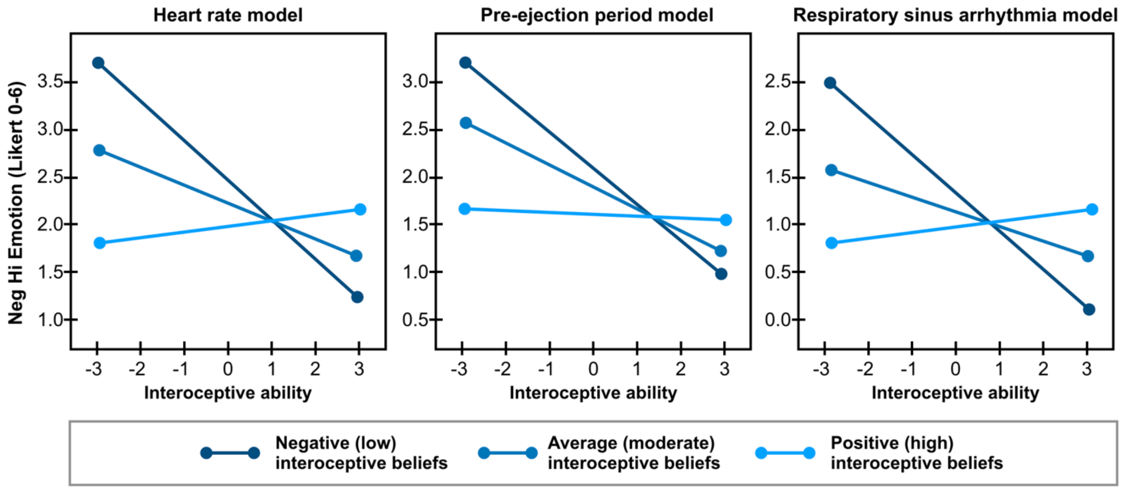

Figure 1. Interaction models testing moderation of interoceptive ability x beliefs. Lines depict the moderating role of low (negative), moderate, and high (positive) interoceptive beliefs on the effect of interoceptive ability predicting negative, high arousal emotion during an acute stressor. Interoceptive ability and beliefs are standardized. When both interoceptive ability and positive interoceptive beliefs are low, individuals report the most intense negative, high arousal emotions from the acute stressor. On the other hand, greater positive interoceptive beliefs appear to buffer against negative, high arousal emotions, even at lower interoceptive ability.

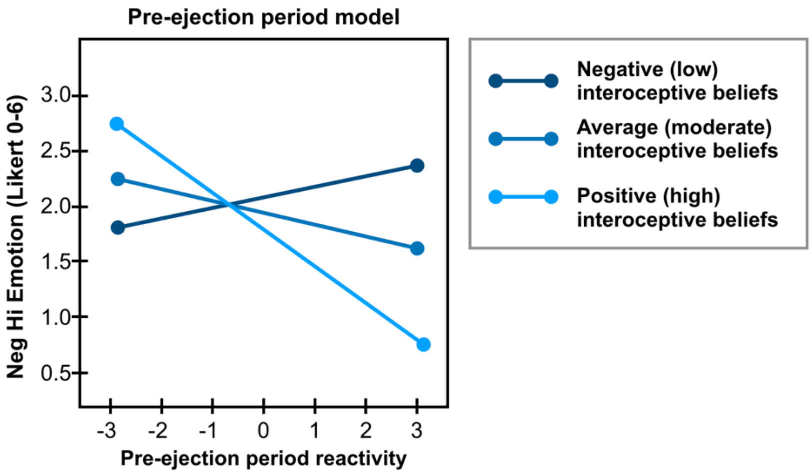

Figure 2. Interaction model testing moderation of PEP reactivity x interoceptive beliefs. Lines depict the moderating role of low (negative), moderate, and high (positive) interoceptive beliefs on the effect of pre-ejection period reactivity predicting negative, high arousal emotion during an acute stressor. Pre-ejection period reactivity and interoceptive beliefs are standardized.

APPENDIX 3: SECONDARY AND EXPLORATORY RESULTS

Table S1. Physio factor score and interoceptive predictors on negative, high arousal emotion.

Predictors	R^2	*b*	*SE*	*β*	*p*	*Lower 95% CI*	*Upper 95% CI*
Step 1: *F*(1,187)= .02	-.005						
Intercept		2.05	.093		<.0001	1.87	2.24
Physio reactivity factor		.02	.153	.01	.885	-.28	.32
Step 2: *F*(2,187)= 2.72 †	.018*						
Intercept		2.05	.092		<.0001	1.87	2.23
Physio reactivity factor		-.00	.152	-.00	.983	-.30	.30
Intero ability factor		**-.24**	**.101**	**-.17**	**.021**	**-.44**	**-.04**
Step 3: *F*(3,187)= 1.96	.015						
Intercept		2.05	.092		<.0001	1.87	2.23
Physio reactivity factor		-.01	.152	-.00	.972	-.31	.30
Intero ability factor		**-.23**	**.102**	**-.17**	**.023**	**-.43**	**-.03**
Intero sensibility factor		-.07	.101	-.05	.493	-.27	.13
Step 4: *F*(4,187)= 2.61*	.033*						
Intercept		2.06	.091		<.0001	1.88	2.24
Physio reactivity factor		-.02	.151	-.01	.911	-.31	.28
Intero ability factor		**-.27**	**.102**	**-.19**	**.010**	**-.47**	**-.07**
Intero sensibility factor		-.06	.100	-.04	.574	-.25	.14
Intero beliefs (BSBQ)		**-.19**	**.092**	**-.15**	**.037**	**-.38**	**-.01**
Step 5: *F*(10,187)= 1.74 †	.038						
Intercept		2.05	.093		<.0001	1.87	2.23
Physio reactivity factor		-.04	.155	-.02	.817	-.34	.27
Intero ability factor		**-.25**	**.103**	**-.18**	**.016**	**-.45**	**-.05**
Intero sensibility factor		-.06	.103	-.04	.561	-.26	.14
Intero beliefs (BSBQ)		-.17	.093	-.13	.069	-.35	.01
Physio x Intero ability		-.25	.186	-.12	.139	-.57	.08
Physio x Intero sensibility		-.10	.183	-.04	.596	-.46	.26
Physio x Intero beliefs		-.23	.170	-.11	.179	-.57	.11
Intero ability x sensibility		.02	.124	.01	.853	-.22	.27
Intero ability x beliefs		.11	.105	.08	.299	-.10	.32
Intero sensibility x beliefs		.11	.101	.08	.279	-.10	.31
Step 6: *F*(12,187)= 2.88**	.108**						
Intercept		2.29	.700		.001	.91	3.67
Physio reactivity factor		-.13	.154	-.06	.400	-.43	.17
Intero ability factor		**-.22**	**.100**	**-.16**	**.031**	**-.42**	**-.02**
Intero sensibility factor		-.10	.100	-.07	.336	-.29	.10
Intero beliefs (BSBQ)		**-.20**	**.089**	**-.16**	**.026**	**-.38**	**-.02**
Physio x Intero ability		-.20	.160	-.09	.221	-.51	.12
Physio x Intero sensibility		-.13	.177	-.05	.469	-.48	.22
Physio x Intero beliefs		-.19	.164	-.09	.256	-.51	.14
Intero ability x sensibility		.05	.120	.03	.699	-.19	.28
Intero ability x beliefs		.15	.102	.11	.148	-.05	.35
Intero sensibility x beliefs		.08	.098	.06	.395	-.11	.28
Gender		**-.73**	**.185**	**-.29**	**<.0001**	**-1.10**	**-.37**
BMI		.00	.031	.01	.918	-.06	.06

Note: Adjusted R^2 is reported. Significance reported for R^2 represents whether there was a significant ΔR^2. Bolded lines indicate significant effects. Standard errors and confidence intervals are for the unstandardized betas. Gender is coded 0=Female, 1=Male. † $p<.10$, * $p<.05$, ** $p<.01$, *** $p<.0001$.

Table S2. Physio factor score and interoceptive predictors on somatic intensity.

Predictors	R^2	*b*	*SE*	*β*	*p*	*Lower 95% CI*	*Upper 95% CI*
Step 1: *F*(1,187)= .04	-.005						
Intercept		.95	.050		<.0001	.85	1.05
Physio reactivity factor		-.02	.082	-.02.	.834	-.18	.15
Step 2: *F*(2,187)= .68	-.003						
Intercept		.95	.050		<.0001	.85	1.05
Physio reactivity factor		-.02	.083	-.02	.770	-.19	.14
Intero ability factor		-.06	.055	-.09	.251	-.17	.05
Step 3: *F*(3,187)= .63	-.006						
Intercept		.95	.050		<.0001	.85	1.04
Physio reactivity factor		-.02	.038	-.02	.781	-.19	.14
Intero ability factor		-.07	.055	-.09	.238	-.18	.04
Intero sensibility factor		.04	.055	.05	.476	-.07	.15
Step 4: *F*(4,187)= 3.30*	.047**						
Intercept		.95	.049		<.0001	.85	1.05
Physio reactivity factor		-.03	.081	-.03	.684	-.19	.13
Intero ability factor		-.10	.055	-.13	.083	-.20	.01
Intero sensibility factor		.05	.053	.07	.350	-.06	.16
Intero beliefs (BSBQ)		**-.16**	**.049**	**-.24**	**.001**	**-.26**	**-.07**
Step 5: *F*(10,187)= 1.81†	.041						
Intercept		.95	.050		<.0001	.85	1.05
Physio reactivity factor		-.05	.084	-.05	.526	-.22	.11
Intero ability factor		-.08	.055	-.11	.131	-.19	.03
Intero sensibility factor		.04	.056	.06	.464	-.07	.15
Intero beliefs (BSBQ)		**-.16**	**.050**	**-.24**	**.002**	**-.26**	**-.06**
Physio x Intero ability		-.06	.089	-.05	.495	-.24	.12
Physio x Intero sensibility		-.04	.098	-.03	.715	-.23	.16
Physio x Intero beliefs		-.11	.092	-.10	.234	-.29	.07
Intero ability x sensibility		.09	.067	.10	.191	-.04	.22
Intero ability x beliefs		.04	.056	.06	.468	-.07	.15
Intero sensibility x beliefs		.02	.054	.02	.777	-.09	.12
Step 6: *F*(12,187)= 2.32**	.078*						
Intercept		1.21	.383		.002	.45	1.96
Physio reactivity factor		-.09	.084	-.08	.313	-.25	.08
Intero ability factor		-.07	.055	-.10	.187	-.18	.04
Intero sensibility factor		.03	.055	.04	.621	-.08	.14
Intero beliefs (BSBQ)		**-.17**	**.049**	**-.26**	**.001**	**-.27**	**-.08**
Physio x Intero ability		-.04	.088	-.04	.640	-.21	.13
Physio x Intero sensibility		-.05	.097	-.03	.639	-.24	.15
Physio x Intero beliefs		-.09	.090	-.08	.311	-.27	.09
Intero ability x sensibility		.10	.066	.11	.142	-.03	.23
Intero ability x beliefs		.06	.056	.08	.312	-.05	.17
Intero sensibility x beliefs		.00	.054	.00	.967	-.10	.11
Gender		**-.30**	**.101**	**-.21**	**.004**	**-.50**	**-.10**
BMI		-.01	.017	-.03	.735	-.04	.03

Note: Adjusted R^2 is reported. Significance reported for R^2 represents whether there was a significant ΔR^2. Bolded lines indicate significant effects. Standard errors and confidence intervals are for the unstandardized betas. Gender is coded 0=Female, 1=Male. † *p*<.10, * *p*<.05, ** *p*<.01, *** *p*<.0001.

Table S3. HR reactivity and interoceptive predictors on somatic intensity.

Predictors	R^2	*b*	*SE*	*β*	*p*	*Lower 95% CI*	*Upper 95% CI*
Step 1: *F*(1,206)= 3.63†	.013†						
Intercept		.99	.050		<.0001	.89	1.09
HR reactivity		.10	.050	.13	.058	-.00	.20
Step 2: *F*(2 206)= 1.85	.008						
Intercept		.99	.051		<.0001	.89	1.09
HR reactivity		.10	.050	.13	.057	-.00	.20
Intero ability factor		-.02	.054	-.02	.781	-.12	.09
Step 3: *F*(3,206)= 1.29	.004						
Intercept		.99	.051		<.0001	.89	1.09
HR reactivity		.10	.051	.14	.053	-.00	.20
Intero ability factor		-.02	.055	-.02	.767	-.12	.09
Intero sensibility factor		.02	.055	.03	.663	-.09	.13
Step 4: *F*(4,206)= 2.83*	.034**						
Intercept		.99	.050		<.0001	.89	1.09
HR reactivity		**.11**	**.050**	**.15**	**.032**	**.01**	**.21**
Intero ability factor		-.04	.054	-.05	.517	-.14	.07
Intero sensibility factor		.03	.055	.04	.584	-.08	.14
Intero beliefs (BSBQ)		**-.13**	**.049**	**-.19**	**.007**	**-.23**	**-.04**
Step 5: *F*(10,206)= 1.88*	.041						
Intercept		1.01	.051		<.0001	.91	1.11
HR reactivity		**.14**	**.053**	**.20**	**.008**	**.04**	**.25**
Intero ability factor		-.03	.055	-.04	.583	-.14	.08
Intero sensibility factor		.03	.056	.03	.631	-.08	.14
Intero beliefs (BSBQ)		**-.14**	**.049**	**-.20**	**.005**	**-.24**	**-.05**
HR x Intero ability		-.07	.057	-.09	.215	-.18	.04
HR x Intero sensibility		.03	.058	.04	.614	-.09	.14
HR x Intero beliefs		-.10	.055	-.13	.075	-.21	.01
Intero ability x sensibility		.01	.063	.01	.878	-.11	.13
Intero ability x beliefs		.09	.054	.12	.093	-.02	.20
Intero sensibility x beliefs		-.01	.056	-.01	.869	-.12	.10
Step 6: *F*(12,206)= 2.11*	.061*						
Intercept		1.08	.391		.006	.31	1.85
HR reactivity		**.14**	**.052**	**.20**	**.006**	**.04**	**.25**
Intero ability factor		-.01	.055	-.02	.797	-.12	.09
Intero sensibility factor		.01	.056	.02	.807	-.10	.12
Intero beliefs (BSBQ)		**-.15**	**.049**	**-.21**	**.002**	**-.25**	**-.06**
HR x Intero ability		-.06	.056	-.08	.278	-.17	.05
HR x Intero sensibility		.03	.058	.04	.555	-.08	.15
HR x Intero beliefs		-.10	.054	-.13	.076	-.20	.00
Intero ability x sensibility		.02	.062	.02	.748	-.10	.14
Intero ability x beliefs		.10	.054	.13	.057	-.00	.21
Intero sensibility x beliefs		-.02	.056	-.03	.696	-.13	.09
Gender		**-.25**	**.103**	**-.17**	**.014**	**-.46**	**-.05**
BMI		.00	.017	.00	.912	-.03	.04

Note: HR=Heart rate. Adjusted R^2 is reported. Significance reported for R^2 represents whether there was a significant ΔR^2. Bolded lines indicate significant effects. Standard errors and confidence intervals are for the unstandardized betas. Gender is coded 0=Female, 1=Male. † p<.10, * p<.05, ** p<.01, *** p<.0001.

Table S4. PEP reactivity and interoceptive predictors on somatic intensity.

Predictors	R^2	*b*	*SE*	*β*	*p*	*Lower 95% CI*	*Upper 95% CI*
Step 1: *F*(1,189)= 1.78	.004						
Intercept		.94	.049		<.0001	.85	1.04
PEP reactivity		-.07	.049	-.10	.183	-.16	.03
Step 2: *F*(2,189)= 1.59	.006						
Intercept		.94	.049		<.0001	.84	1.04
PEP reactivity		-.07	.049	-.10	.169	-.17	.03
Intero ability factor		-.06	.055	-.09	.239	-.17	.04
Step 3: *F*(3,189)= 1.16	.002						
Intercept		.94	.050		<.0001	.84	1.04
PEP reactivity		-.07	.050	-.10	.183	-.16	.03
Intero ability factor		-.07	.055	-.09	.231	-.17	.04
Intero sensibility factor		.03	.054	.04	.587	-.08	.14
Step 4: *F*(4,189)= 3.40**	.048**						
Intercept		.94	.048		<.0001	.85	1.04
PEP reactivity		-.05	.049	-.08	.284	-.15	.04
Intero ability factor		-.09	.054	-.12	.089	-.20	.01
Intero sensibility factor		.04	.053	.06	.441	-.06	.15
Intero beliefs (BSBQ)		**-.15**	**.049**	**-.23**	**.002**	**-.25**	**-.06**
Step 5: *F*(10,189)= 2.40*	.069						
Intercept		.96	.049		<.0001	.86	-1.06
PEP reactivity		-.05	.050	-.08	.275	-.15	.04
Intero ability factor		-.09	.055	-.11	.117	-.19	.02
Intero sensibility factor		.04	.054	.05	.489	-.07	.14
Intero beliefs (BSBQ)		**-.16**	**.049**	**-.24**	**.001**	**-.26**	**-.07**
PEP x Intero ability		-.05	.050	-.06	.424	-.17	.07
PEP x Intero sensibility		-.03	.062	-.04	.616	-.15	.09
PEP x Intero beliefs		**-.13**	**.051**	**-.10**	**.014**	**-.23**	**-.03**
Intero ability x sensibility		.07	.067	.08	.287	-.06	.20
Intero ability x beliefs		.07	.054	.09	.207	-.04	.17
Intero sensibility x beliefs		.01	.053	.02	.837	-.09	.12
Step 6: *F*(12,189)= 2.73**	.099*						
Intercept		1.10	.376		.004	.36	1.84
PEP reactivity		-.07	.049	-.11	.145	-.17	.03
Intero ability factor		-.08	.054	-.10	.167	-.18	.03
Intero sensibility factor		.02	.054	.03	.705	-.09	.13
Intero beliefs (BSBQ)		**-.17**	**.048**	**-.25**	**.001**	**-.27**	**-.08**
PEP x Intero ability		-.05	.059	-.07	.367	-.17	.06
PEP x Intero sensibility		-.03	.062	-.03	.643	-.15	.09
PEP x Intero beliefs		**-.11**	**.051**	**-.16**	**.035**	**-.21**	**-.01**
Intero ability x sensibility		-.08	.066	.09	.211	-.05	.21
Intero ability x beliefs		-.8	.053	.10	.149	-.03	.18
Intero sensibility x beliefs		.00	.053	.01	.938	-.10	.11
Gender		**-.28**	**.099**	**-.20**	**.006**	**-.47**	**-.08**
BMI		-.00	.016	-.01	.948	-.03	.03

Note: PEP= Pre-ejection period. Adjusted R^2 is reported. Significance reported for R^2 represents whether there was a significant ΔR^2. Bolded lines indicate significant effects. Standard errors and confidence intervals are for the unstandardized betas. Gender is coded 0=Female, 1=Male. † *p*<.10, * *p*<.05, ** *p*<.01, *** *p*<.0001.

Table S5. RSA reactivity and interoceptive predictors on somatic intensity.

Predictors	R^2	*b*	*SE*	*β*	*p*	*Lower 95% CI*	*Upper 95% CI*
Step 1: *F*(1,206)= .23	-.004						
Intercept		.99	.051		<.0001	.89	1.09
RSA reactivity		-.03	.051	-.03	.630	-.13	.08
Step 2: *F*(2,206)= 2.15	.011*						
Intercept		.99	.050		<.0001	.89	1.09
RSA reactivity		.05	.064	.07	.414	-.07	.18
HR reactivity		**.13**	**.063**	**.17**	**.045**	**.00**	**.25**
Step 3: *F*(3,206)= 1.46	.007						
Intercept		.99	.051		<.0001	.89	1.09
RSA reactivity		.05	.064	.07	.410	-.07	.18
HR reactivity		**.13**	**.063**	**.18**	**.044**	**.00**	**.25**
Intero ability factor		-.02	.054	-.02	.762	-.12	.09
Step 4: *F*(4,206)= 1.14	.003						
Intercept		.99	.051		<.0001	.89	1.09
RSA reactivity		.05	.064	.07	.411	-.07	.18
HR reactivity		**.13**	**.063**	**.18**	**.042**	**.00**	**.26**
Intero ability factor		-.02	.055	-.02	.748	-.13	.09
Intero sensibility factor		.02	.055	.03	.663	-.09	.13
Step 5: *F*(5,206)= 2.40*	.033**						
Intercept		.99	.050		<.0001	.89	1.09
RSA reactivity		.05	.063	.07	.400	-.07	.18
HR reactivity		**.14**	**.063**	**.19**	**.026**	**.02**	**.26**
Intero ability factor		-.04	.054	-.05	.500	-.14	.07
Intero sensibility factor		.03	.055	.04	.584	-.08	.14
Intero beliefs (BSBQ)		**-.13**	**.049**	**-.19**	**.007**	**-.23**	**-.04**
Step 6: *F*(11,206)= 1.94*	.048						
Intercept		1.01	.050		<.0001	.91	1.11
RSA reactivity		.03	.064	.05	.606	-.09	.16
HR reactivity		**.16**	**.063**	**.22**	**.013**	**.03**	**.28**
Intero ability factor		-.03	.055	-.04	.599	-.14	.08
Intero sensibility factor		.04	.056	.06	.434	-.07	.16
Intero beliefs (BSBQ)		**-.14**	**.050**	**-.20**	**.004**	**-.24**	**-.05**
RSA x Intero ability		.05	.055	.07	.341	-.06	.16
RSA x Intero sensibility		-.12	.061	-.14	.054	-.24	.00
RSA x Intero beliefs		.07	.057	.09	.247	-.05	.18
Intero ability x sensibility		.02	.062	.02	.806	-.11	.14
Intero ability x beliefs		.09	.056	.12	.104	-.02	.20
Intero sensibility x beliefs		-.02	.056	-.02	.755	-.13	.09
Step 7: *F*(13,206)= 2.26**	.074*						
Intercept		1.01	.391		.010	.24	1.78
RSA reactivity		.03	.063	.03	.690	-.10	.15
HR reactivity		**.16**	**.062**	**.22**	**.010**	**.04**	**.29**
Intero ability factor		-.01	.055	-.02	.831	-.12	.10
Intero sensibility factor		.03	.056	.04	.599	-.08	.14
Intero beliefs (BSBQ)		**-.16**	**.049**	**-.22**	**.002**	**-.25**	**-.06**
RSA x Intero ability		.06	.055	.09	.257	-.05	.17
RSA x Intero sensibility		**-.13**	**.061**	**-.15**	**.037**	**-.25**	**-.01**
RSA x Intero beliefs		.07	.056	.10	.196	-.04	.18
Intero ability x sensibility		.03	.061	.03	.682	-.10	.15
Intero ability x beliefs		.10	.055	.13	.060	-.00	.21
Intero sensibility x beliefs		-.03	.055	-.04	.596	-.14	.08
Gender		**-.28**	**.102**	**-.19**	**.007**	**-.48**	**-.08**
BMI		.01	.017	.02	.761	-.03	.04

Note: RSA= Respiratory sinus arrhythmia, HR= Heart rate. Adjusted R^2 is reported. Significance reported for R^2 represents whether there was a significant ΔR^2. Standard errors and confidence intervals are for the unstandardized betas. † *p*<.10, * *p*<.05, ** *p*<.01, *** *p*<.0001.

Table S6. HR reactivity and interoceptive predictors on positive emotion.

Predictors	R^2	*b*	*SE*	*β*	*p*	*Lower 95% CI*	*Upper 95% CI*
Step 1: *F*(1,206)= 1.72	.003						
Intercept		1.19	.074		<.0001	1.05	1.34
HR reactivity		-.10	.073	-.09	.191	-.24	.05
Step 2: *F*(2 206)= .86	-.001						
Intercept		1.19	.074		<.0001	1.05	1.34
HR reactivity		-.10	.074	-.09	.190	-.24	.05
Intero ability factor		.01	.079	.01	.915	-.15	.17
Step 3: *F*(3,206)= 1.98	.001						
Intercept		1.19	.074		<.0001	1.04	1.33
HR reactivity		-.09	.074	-.09	.233	-.23	.06
Intero ability factor		.01	.079	.00	.959	-.15	.16
Intero sensibility factor		.10	.081	.09	.215	-.06	.26
Step 4: *F*(4,206)= 1.01	.000						
Intercept		1.19	.074		<.0001	1.04	1.33
HR reactivity		-.08	.074	-.08	.260	-.23	.06
Intero ability factor		-.01	.080	-.00	.951	-.16	.15
Intero sensibility factor		.10	.081	.09	.204	-.06	.26
Intero beliefs (BSBQ)		-.06	.073	-.06	.388	-.21	.08
Step 5: *F*(10,206)= .82	-.009						
Intercept		1.18	.076		<.0001	1.03	1.33
HR reactivity		-.07	.079	-.07	.357	-.23	.08
Intero ability factor		-.01	.082	-.01	.898	-.17	.15
Intero sensibility factor		.11	.083	.09	.195	-.06	.27
Intero beliefs (BSBQ)		-.07	.074	-.07	.361	-.21	.08
HR x Intero ability		-.04	.085	-.04	.619	-.21	.13
HR x Intero sensibility		-.03	.087	-.03	.714	-.20	.14
HR x Intero beliefs		.03	.082	.02	.738	-.13	.19
Intero ability x sensibility		.04	.094	.03	.677	-.15	.22
Intero ability x beliefs		-.06	.081	-.05	.468	-.22	.10
Intero sensibility x beliefs		-.13	.084	-.11	.133	-.29	.04
Step 6: *F*(12,206)= 2.38**	.074***						
Intercept		.93	.564		.101	-.18	2.04
HR reactivity		-.08	.076	-.08	.294	-.23	.07
Intero ability factor		-.05	.079	-.05	.518	-.21	.11
Intero sensibility factor		.14	.080	.12	.078	-.02	.30
Intero beliefs (BSBQ)		-.04	.071	-.04	.571	-.18	.10
HR x Intero ability		-.07	.081	-.06	.415	-.23	.09
HR x Intero sensibility		-.04	.083	-.04	.601	-.21	.12
HR x Intero beliefs		.02	.078	.02	.763	-.13	.18
Intero ability x sensibility		.01	.090	.01	.896	-.17	.19
Intero ability x beliefs		-.09	.078	-.08	.254	-.24	.07
Intero sensibility x beliefs		-.09	.081	-.08	.255	-.25	.07
Gender		**.65**	**.148**	**.31**	**<.0001**	**.36**	**.95**
BMI		-.02	.025	-.01	.946	-.05	.05

Note: HR=Heart rate. Adjusted R^2 is reported. Significance reported for R^2 represents whether there was a significant ΔR^2. Bolded lines indicate significant effects. Standard errors and confidence intervals are for the unstandardized betas. Gender is coded 0=Female, 1=Male. † p<.10, * p<.05, ** p<.01, *** p<.0001.

Table S7. PEP reactivity and interoceptive predictors on positive emotion.

Predictors	R^2	*b*	*SE*	*β*	*p*	*Lower 95% CI*	*Upper 95% CI*
Step 1: *F*(1,189)= .48	-.003						
Intercept		1.20	.078		<.0001	1.05	1.35
PEP reactivity		-.05	.078	-.05	.483	-.21	.10
Step 2: *F*(2,189)= .62	-.006						
Intercept		1.20	.078		<.0001	1.05	1.35
PEP reactivity		-.05	.078	-.05	.501	-.21	.10
Intero ability factor		.06	.086	.05	.500	-.11	.23
Step 3: *F*(3,189)= .47	-.002						
Intercept		1.20	.078		<.0001	1.04	1.35
PEP reactivity		-.05	.078	-.04	.560	-.20	.11
Intero ability factor		.05	.086	.05	.537	-.12	.22
Intero sensibility factor		.11	.085	.09	.211	-.06	.27
Step 4: *F*(4,189)= .89	-.003						
Intercept		1.20	.078		<.0001	1.05	1.35
PEP reactivity		-.04	.078	-.04	.623	-.19	.12
Intero ability factor		.04	.087	.03	.647	-.13	.21
Intero sensibility factor		.11	.085	.10	.189	-.06	.28
Intero beliefs (BSBQ)		-.08	.078	-.07	.334	-.23	.08
Step 5: *F*(10,189)= 1.04	.002						
Intercept		1.19	.080		<.0001	1.03	1.34
PEP reactivity		-.02	.080	-.02	.812	-.18	.14
Intero ability factor		.04	.088	.04	.629	-.13	.22
Intero sensibility factor		.11	.088	.10	.207	-.06	.28
Intero beliefs (BSBQ)		-.08	.079	-.08	.305	-.24	.08
PEP x Intero ability		.12	.097	.10	.202	-.07	.32
PEP x Intero sensibility		.08	.100	.06	.411	-.12	.28
PEP x Intero beliefs		.13	.083	.12	.130	-.04	.29
Intero ability x sensibility		.08	.108	.05	.491	-.14	.28
Intero ability x beliefs		-.10	.087	-.08	.270	-.27	.07
Intero sensibility x beliefs		-.11	.086	-.10	.191	-.28	.06
Step 6: *F*(12,189)= 2.76**	.100***						
Intercept		1.33	.588		.025	.17	2.49
PEP reactivity		.03	.077	.03	.677	-.12	.18
Intero ability factor		.01	.084	.01	.919	-.16	.18
Intero sensibility factor		.16	.084	.14	.061	-.01	.32
Intero beliefs (BSBQ)		-.07	.075	-.06	.391	-.21	.08
PEP x Intero ability		.14	.092	.11	.130	-.04	.32
PEP x Intero sensibility		.09	.097	.07	.353	-.10	.28
PEP x Intero beliefs		.08	.080	.08	.295	-.07	.24
Intero ability x sensibility		.05	.103	.03	.641	-.16	.25
Intero ability x beliefs		-.12	.083	-.10	.150	-.28	.04
Intero sensibility x beliefs		-.10	.082	-.09	.211	-.27	.06
Gender		**.72**	**.155**	**.33**	**<.0001**	**.41**	**1.02**
BMI		-.02	.026	-.05	.450	-.07	.03

Note: PEP= Pre-ejection period. Adjusted R^2 is reported. Significance reported for R^2 represents whether there was a significant ΔR^2. Bolded lines indicate significant effects. Standard errors and confidence intervals are for the unstandardized betas. Gender is coded 0=Female, 1=Male. † p<.10, * p<.05, ** p<.01, *** p<.0001.

Table S8. RSA reactivity and interoceptive predictors on positive emotion.

Predictors	R^2	*b*	*SE*	*β*	*p*	*Lower 95% CI*	*Upper 95% CI*
Step 1: *F*(1,206)= .63	-.002						
Intercept		1.19	.074		<.0001	1.05	1.34
RSA reactivity		.06	.074	.06	.430	-.09	.21
Step 2: *F*(2,206)= .86	-.001						
Intercept		1.19	.074		<.0001	1.05	1.34
RSA reactivity		.00	.093	.00	.994	-.18	.18
HR reactivity		-.10	.092	-.09	.298	-.28	.09
Step 3: *F*(3,206)= .57	-.006						
Intercept		1.19	.074		<.0001	1.04	1.34
RSA reactivity		.00	.093	.00	.996	-.18	.18
HR reactivity		-.10	.092	-.09	.297	-.28	.09
Intero ability factor		.01	.080	.01	.916	-.15	.17
Step 4: *F*(4,206)= .81	-.004						
Intercept		1.19	.074		<.0001	1.04	1.33
RSA reactivity		.00	.093	.00	.996	-.18	.18
HR reactivity		-.09	.093	-.08	.342	-.27	.09
Intero ability factor		.00	.080	.00	.960	-.15	.16
Intero sensibility factor		.10	.081	.09	.217	-.06	.26
Step 5: *F*(5,206)= .80	-.005						
Intercept		1.19	.074		<.0001	1.04	1.33
RSA reactivity		.00	.093	.00	.994	-.18	.18
HR reactivity		-.08	.093	-.08	.370	-.27	.10
Intero ability factor		-.01	.080	-.00	.951	-.16	.15
Intero sensibility factor		.10	.081	.09	.205	-.06	.26
Intero beliefs (BSBQ)		-.06	.073	-.06	.389	-.21	.08
Step 6: *F*(11,206)= .96	-.002						
Intercept		1.18	.075		<.0001	1.03	1.33
RSA reactivity		-.01	.095	-.01	.923	-.20	.18
HR reactivity		-.07	.094	-.06	.473	-.25	.12
Intero ability factor		-.02	.082	-.02	.798	-.18	.14
Intero sensibility factor		.10	.084	.08	.246	-.07	.26
Intero beliefs (BSBQ)		-.08	.074	-.08	.297	-.22	.07
RSA x Intero ability		.10	.082	.10	.220	-.06	.26
RSA x Intero sensibility		.10	.091	.08	.258	-.08	.28
RSA x Intero beliefs		.02	.084	.02	.813	-.15	.17
Intero ability x sensibility		.02	.092	.02	.801	-.16	.21
Intero ability x beliefs		-.06	.083	-.05	.498	-.22	.11
Intero sensibility x beliefs		-.12	.083	-.10	.153	-.28	.05
Step 7: *F*(13,206)= 2.36**	.079***						
Intercept		1.01	.566		.077	-.11	2.13
RSA reactivity		.01	.091	.01	.944	-.17	.19
HR reactivity		-.08	.090	-.07	.389	-.26	.10
Intero ability factor		-.06	.079	-.05	.454	-.22	.10
Intero sensibility factor		.13	.081	.11	.106	-.03	.29
Intero beliefs (BSBQ)		-.05	.071	-.04	.525	-.19	.10
RSA x Intero ability		.08	.079	.08	.312	-.08	.24
RSA x Intero sensibility		.12	.088	.10	.170	-.05	.30
RSA x Intero beliefs		.01	.081	.00	.954	-.16	.16
Intero ability x sensibility		.00	.089	.00	.998	-.18	.17
Intero ability x beliefs		-.09	.080	-.08	.270	-.25	.07
Intero sensibility x beliefs		-.09	.080	-.08	.269	-.25	.07
Gender		**.65**	**.148**	**.30**	**<.0001**	**.36**	**.94**
BMI		-.01	.025	-.01	.837	-.05	.04

Note: RSA= Respiratory sinus arrhythmia, HR= Heart rate. Adjusted R^2 is reported. Significance reported for R^2 represents whether there was a significant ΔR^2. Standard errors and confidence intervals are for the unstandardized betas. † $p<.10$, * $p<.05$, ** $p<.01$, *** $p<.0001$.

Table S9. HR reactivity and interoceptive predictors on low arousal emotion.

Predictors	R^2	*b*	*SE*	*β*	*p*	*Lower 95% CI*	*Upper 95% CI*
Step 1: *F*(1,206)= 1.09	.000						
Intercept		1.21	.046		<.0001	1.12	1.30
HR reactivity		-.05	.046	-.07	.297	-.14	.04
Step 2: *F*(2 206)= 2.02	.010†						
Intercept		1.21	.046		<.0001	1.12	1.30
HR reactivity		-.04	.046	-.06	.359	-.13	.05
Intero ability factor		-.09	.049	-.12	.088	-.18	.01
Step 3: *F*(3,206)= 1.37	.005						
Intercept		1.21	.046		<.0001	1.12	1.30
HR reactivity		-.04	.046	-.06	.377	-.13	.05
Intero ability factor		-.09	.050	-.12	.086	-.18	.01
Intero sensibility factor		.02	.050	.02	.763	-.08	.11
Step 4: *F*(4,206)= 2.78*	.033**						
Intercept		1.21	.045		<.0001	1.12	1.30
HR reactivity		-.03	.046	-.05	.480	-.12	.06
Intero ability factor		**-.10**	**.049**	**-.14**	**.039**	**-.20**	**-.01**
Intero sensibility factor		.02	.050	.03	.684	-.08	.12
Intero beliefs (BSBQ)		**-.12**	**.045**	**-.18**	**.009**	**-.21**	**-.03**
Step 5: *F*(10,206)= 1.62	.029						
Intercept		1.21	.046		.000	1.12	1.30
HR reactivity		-.01	.048	-.02	.782	-.11	.08
Intero ability factor		**-.11**	**.050**	**-.15**	**.035**	**-.21**	**-.01**
Intero sensibility factor		.01	.051	.01	.892	-.09	.10
Intero beliefs (BSBQ)		**-.12**	**.045**	**-.19**	**.008**	**-.21**	**-.03**
HR x Intero ability		-.04	.052	-.06	.426	-.14	.06
HR x Intero sensibility		-.02	.053	-.02	.737	-.12	.09
HR x Intero beliefs		-.07	.050	-.09	.192	-.16	.03
Intero ability x sensibility		.10	.058	.12	.091	-.02	.21
Intero ability x beliefs		-.01	.050	-.02	.808	-.11	.09
Intero sensibility x beliefs		-.02	.051	-.03	.677	-.12	.08
Step 6: *F*(12,206)= 1.51	.029						
Intercept		1.42	.361		<.0001	.71	2.14
HR reactivity		-.02	.048	-.03	.726	-.11	.08
Intero ability factor		**-.12**	**.051**	**-.16**	**.023**	**-.22**	**-.02**
Intero sensibility factor		.01	.051	.02	.779	-.09	.12
Intero beliefs (BSBQ)		**-.12**	**.045**	**-.18**	**.011**	**-.21**	**-.03**
HR x Intero ability		-.04	.052	-.07	.395	-.15	.06
HR x Intero sensibility		-.02	.053	-.03	.689	-.13	.08
HR x Intero beliefs		-.07	.050	-.10	.186	-.17	.03
Intero ability x sensibility		.09	.058	.12	.104	-.02	.21
Intero ability x beliefs		-.02	.050	-.02	.744	-.12	.08
Intero sensibility x beliefs		-.02	.052	-.03	.711	-.12	.08
Gender		.12	.095	.09	.210	-.07	.31
BMI		-.01	.016	-.05	.462	-.04	.02

Note: HR=Heart rate. Adjusted R^2 is reported. Significance reported for R^2 represents whether there was a significant ΔR^2. Bolded lines indicate significant effects. Standard errors and confidence intervals are for the unstandardized betas. Gender is coded 0=Female, 1=Male. † p<.10, * p<.05, ** p<.01, *** p<.0001.

Table S10. PEP reactivity and interoceptive predictors on low arousal emotion.

Predictors	R^2	*b*	*SE*	*β*	*p*	*Lower 95% CI*	*Upper 95% CI*
Step 1: *F*(1,189)= 1.95	.005						
Intercept		1.18	.047		<.0001	1.09	1.27
PEP reactivity		.07	.047	.10	.165	-.03	.16
Step 2: *F*(2,189)= 1.09	.001						
Intercept		1.18	.047		<.0001	1.09	1.27
PEP reactivity		.06	.047	.10	.172	-.03	.16
Intero ability factor		-.03	.052	-.04	.622	-.13	.08
Step 3: *F*(3,189)= .73	-.004						
Intercept		1.18	.047		<.0001	1.09	1.27
PEP reactivity		.07	.047	.10	.171	-.03	.16
Intero ability factor		-.04	.052	-.04	.620	-.13	.08
Intero sensibility factor		.02	.051	.01	.902	-.10	.11
Step 4: *F*(4,189)= 2.53*	.031**						
Intercept		1.18	.046		<.0001	1.09	1.27
PEP reactivity		.08	.046	.12	.101	-.02	.17
Intero ability factor		-.06	.052	-.07	.349	-.15	.05
Intero sensibility factor		.02	.051	.02	.751	-.08	.12
Intero beliefs (BSBQ)		**-.13**	**.047**	**-.21**	**.006**	**-.22**	**-.04**
Step 5: *F*(10,189)= 1.47	.024						
Intercept		1.17	.048		<.0001	1.07	1.26
PEP reactivity		.08	.048	.13	.094	-.01	.18
Intero ability factor		-.05	.053	-.07	.330	-.16	.05
Intero sensibility factor		.01	.052	.01	.900	-.10	.11
Intero beliefs (BSBQ)		**-.13**	**.047**	**-.21**	**.006**	**-.23**	**-.04**
PEP x Intero ability		.02	.058	.03	.683	-.09	.14
PEP x Intero sensibility		.00	.060	.00	.990	-.12	.12
PEP x Intero beliefs		.02	.050	.04	.644	-.08	.12
Intero ability x sensibility		.10	.065	.11	.140	-.03	.22
Intero ability x beliefs		-.09	.052	-.12	.103	-.19	.02
Intero sensibility x beliefs		-.02	.051	-.03	.725	-.12	.08
Step 6: *F*(12,189)= 1.67†	.041†						
Intercept		1.74	.367		<.0001	1.02	2.47
PEP reactivity		**.10**	**.048**	**.15**	**.046**	**.00**	**.19**
Intero ability factor		-.07	.053	-.09	.219	-.17	.04
Intero sensibility factor		.02	.052	.03	.711	-.08	.12
Intero beliefs (BSBQ)		**-.13**	**.047**	**-.21**	**.006**	**-.22**	**-.04**
PEP x Intero ability		.03	.057	.04	.606	-.08	.14
PEP x Intero sensibility		.02	.060	.02	.780	-.10	.14
PEP x Intero beliefs		.02	.050	.04	.653	-.08	.12
Intero ability x sensibility		.09	.064	.11	.150	-.03	.22
Intero ability x beliefs		-.09	.052	-.13	.080	-.19	.01
Intero sensibility x beliefs		-.03	.051	-.04	.632	-.13	.08
Gender		.15	.097	.12	.124	-.04	.34
BMI		-.03	.016	-.13	.082	-.06	.00

Note: PEP= Pre-ejection period. Adjusted R^2 is reported. Significance reported for R^2 represents whether there was a significant ΔR^2. Bolded lines indicate significant effects. Standard errors and confidence intervals are for the unstandardized betas. Gender is coded 0=Female, 1=Male. † p<.10, * p<.05, ** p<.01, *** p<.0001.

Table S11. RSA reactivity and interoceptive predictors on low arousal emotion.

Predictors	R^2	*b*	*SE*	*β*	*p*	*Lower 95% CI*	*Upper 95% CI*
Step 1: *F*(1,206)= .16	-.004						
Intercept		1.21	.046		<.0001	1.12	1.30
RSA reactivity		.02	.047	.03	.692	-.07	.11
Step 2: *F*(2,206)= .58	-.004						
Intercept		1.21	.046		<.0001	1.12	1.30
RSA reactivity		-.02	.058	-.03	.776	-.13	.10
HR reactivity		-.06	.057	-.09	.316	-.17	.06
Step 3: *F*(3,206)= 1.36	.005†						
Intercept		1.21	.046		<.0001	1.12	1.30
RSA reactivity		-.01	.058	-.02	.815	-.13	.10
HR reactivity		-.05	.057	-.08	.383	-.16	.06
Intero ability factor		-.08	.049	-.12	.090	-.18	.01
Step 4: *F*(4,206)= 1.04	.001						
Intercept		1.21	.046		<.0001	1.12	1.30
RSA reactivity		-.01	.058	-.02	.816	-.13	.10
HR reactivity		-.05	.058	-.07	.398	-.16	.07
Intero ability factor		-.09	.050	-.12	.088	-.18	.01
Intero sensibility factor		.02	.050	.02	.764	-.08	.11
Step 5: *F*(5,206)= 2.23†	.029**						
Intercept		1.21	.045		<.0001	1.12	1.30
RSA reactivity		-.01	.057	-.02	.818	-.13	.10
HR reactivity		-.04	.057	-.06	.483	-.15	.07
Intero ability factor		**-.10**	**.049**	**-.14**	**.041**	**-.20**	**-.00**
Intero sensibility factor		.02	.050	.03	.685	-.08	.12
Intero beliefs (BSBQ)		**-.12**	**.045**	**-.18**	**.009**	**-.21**	**-.03**
Step 6: *F*(11,206)= 2.00*	.051						
Intercept		1.21	.046		<.0001	1.12	1.30
RSA reactivity		-.02	.058	-.03	.706	-.14	.09
HR reactivity		-.03	.057	-.05	.605	-.14	.08
Intero ability factor		**-.12**	**.050**	**-.16**	**.022**	**-.21**	**-.02**
Intero sensibility factor		-.01	.051	-.01	.838	-.11	.09
Intero beliefs (BSBQ)		**-.13**	**.045**	**-.20**	**.006**	**-.22**	**-.04**
RSA x Intero ability		.06	.050	.09	.246	-.04	.16
RSA x Intero sensibility		**.13**	**.056**	**.17**	**.020**	**.02**	**.24**
RSA x Intero beliefs		.08	.051	.11	.140	-.03	.18
Intero ability x sensibility		.09	.056	.11	.131	-.03	.20
Intero ability x beliefs		.01	.050	.01	.884	-.09	.11
Intero sensibility x beliefs		-.01	.051	-.01	.844	-.11	.09
Step 7: *F*(13,206)= 1.86*	.051						
Intercept		1.48	.359		<.0001	.77	2.10
RSA reactivity		-.02	.058	-.02	.800	-.13	.19
HR reactivity		-.03	.057	-.05	.578	-.14	.08
Intero ability factor		**-.13**	**.050**	**-.18**	**.014**	**-.22**	**-.03**
Intero sensibility factor		-.00	.051	-.01	.947	-.10	.10
Intero beliefs (BSBQ)		**-.12**	**.045**	**-.19**	**.008**	**-.21**	**-.03**
RSA x Intero ability		.05	.050	.08	.292	-.05	.15
RSA x Intero sensibility		**.14**	**.056**	**.18**	**.014**	**.03**	**.25**
RSA x Intero beliefs		.07	.051	.11	.160	-.03	.17
Intero ability x sensibility		.08	.056	.10	.145	-.03	.19
Intero ability x beliefs		.00	.051	.00	.955	-.10	.10
Intero sensibility x beliefs		-.01	.051	-.01	.861	-.11	.09
Gender		.12	.094	.09	.216	-.07	.30
BMI		-.01	.016	-.06	.368	-.05	.02

Note: RSA= Respiratory sinus arrhythmia, HR= Heart rate. Adjusted R^2 is reported. Significance reported for R^2 represents whether there was a significant ΔR^2. Standard errors and confidence intervals are for the unstandardized betas. † p<.10, * p<.05, ** p<.01, *** p<.0001.

Table S12. HR reactivity and BAQ/MAIA on negative high arousal emotion.

Predictors	R^2	*b*	*SE*	*β*	*p*	*Lower 95% CI*	*Upper 95% CI*
Step 1: *F*(1,206)= 2.10	.005						
Intercept		2.12	.091		<.0001	1.94	2.30
HR reactivity factor		.13	.090	.10	.149	-.05	.31
Step 2: *F*(2,206)= 3.29*	.022*						
Intercept		2.12	.090		<.0001	1.94	2.29
HR reactivity factor		.15	.090	.11	.108	-.03	.32
Intero ability factor		**-.20**	**.097**	**-.15**	**.036**	**-.40**	**-.01**
Step 3: *F*(4,206)= 2.34 †	.026						
Intercept		2.12	.090		<.0001	1.94	2.30
HR reactivity factor		.14	.090	.11	.131	-.04	.31
Intero ability factor		**-.19**	**.097**	**-.14**	**.049**	**-.38**	**.00**
Intero sensibility (BAQ)		-.06	.110	-.04	.607	-.27	.16
Intero sensibility (MAIA)		-.12	.106	-.09	.263	-.33	.09
Step 4: *F*(5,206)= 2.80*	.042*						
Intercept		2.12	.089		<.0001	1.95	2.30
HR reactivity factor		.15	.089	.12	.094	-.03	.33
Intero ability factor		**-.22**	**.097**	**-.16**	**.026**	**-.41**	**-.03**
Intero sensibility (BAQ)		-.10	.111	-.08	.365	-.32	.12
Intero sensibility (MAIA)		-.06	.109	-.05	.570	-.28	.15
Intero beliefs (BSBQ)		**-.19**	**.091**	**-.15**	**.040**	**-.37**	**-.01**
Step 5: *F*(7,206)= 3.92***	.090**						
Intercept		2.14	.685		.002	.78	3.49
HR reactivity factor		.16	.087	.13	.065	-.01	.33
Intero ability factor		-.18	.095	-.13	.059	-.37	.01
Intero sensibility (BAQ)		-.16	.110	-.12	.155	-.37	.06
Intero sensibility (MAIA)		-.03	.106	-.02	.799	-.24	.18
Intero beliefs (BSBQ)		**-.23**	**.090**	**-.18**	**.012**	**-.40**	**-.05**
Gender		**-.64**	**.180**	**-.24**	**<.0001**	**-.99**	**-.29**
BMI		.01	.030	.03	.697	-.05	.07

Note: HR=Heart rate. Adjusted R^2 is reported. Significance reported for R^2 represents whether there was a significant ΔR^2. Bolded lines indicate significant effects. Standard errors and confidence intervals are for the unstandardized betas. Gender is coded 0=Female, 1=Male. † p<.10, * p<.05, ** p<.01, *** p<.0001.

Table S13. PEP reactivity and BAQ/MAIA on negative high arousal emotion.

Predictors	R^2	*b*	*SE*	*β*	*p*	*Lower 95% CI*	*Upper 95% CI*
Step 1: *F*(1,189)= .78	-.001						
Intercept		2.04	.092		<.0001	1.86	2.22
PEP reactivity factor		-.08	.092	-.06	.380	-.26	.10
Step 2: *F*(2,189)= 3.17*	.022*						
Intercept		2.03	.091		<.0001	1.86	2.22
PEP reactivity factor		-.09	.091	-.07	.327	-.27	.09
Intero ability factor		**-.24**	**.101**	**-.17**	**.020**	**-.44**	**-.04**
Step 3: *F*(4,189)= 2.66*	.034						
Intercept		2.04	.091		<.0001	1.87	2.22
PEP reactivity factor		-.11	.091	-.09	.226	-.29	.07
Intero ability factor		**-.22**	**.101**	**-.16**	**.028**	**-.42**	**-.02**
Intero sensibility (BAQ)		-.16	.110	-.12	.153	-.38	.06
Intero sensibility (MAIA)		-.05	.106	-.04	.617	-.26	.16
Step 4: *F*(5,189)= 2.93*	.048†						
Intercept		2.05	.090		<.0001	1.87	2.22
PEP reactivity factor		-.10	.091	-.08	.296	-.28	.08
Intero ability factor		**-.26**	**.101**	**-.18**	**.013**	**-.46**	**-.06**
Intero sensibility (BAQ)		-.19	.111	-.15	.082	-.41	.03
Intero sensibility (MAIA)		.00	.109	.00	.985	-.21	.22
Intero beliefs (BSBQ)		-.18	.094	-.15	.052	-.37	.00
Step 5: *F*(7,189)= 4.96***	.128***						
Intercept		2.22	.673		.001	.89	3.54
PEP reactivity factor		-.14	.088	-.11	.116	-.31	.04
Intero ability factor		**-.22**	**.098**	**-.16**	**.024**	**-.41**	**-.03**
Intero sensibility (BAQ)		**-.27**	**.108**	**-.21**	**.013**	**-.49**	**-.06**
Intero sensibility (MAIA)		.05	.105	.04	.612	-.15	.26
Intero beliefs (BSBQ)		**-.23**	**.090**	**-.18**	**.014**	**-.40**	**-.05**
Gender		**-.78**	**.181**	**-.30**	**<.0001**	**-1.14**	**-.42**
BMI		.01	.030	.02	.812	-.05	.07

Note: PEP=Pre-ejection period. Adjusted R^2 is reported. Significance reported for R^2 represents whether there was a significant ΔR^2. Bolded lines indicate significant effects. Standard errors and confidence intervals are for the unstandardized betas. Gender is coded 0=Female, 1=Male. † $p<.10$, * $p<.05$, ** $p<.01$, *** $p<.0001$.

Table S14. RSA reactivity and BAQ/MAIA on negative high arousal emotion.

Predictors	R^2	*b*	*SE*	*β*	*p*	*Lower 95% CI*	*Upper 95% CI*
Step 1: *F*(1,206)= .23	-.004						
Intercept		2.12	.091		<.0001	1.94	2.30
RSA reactivity		-.06	.092	-.04	.551	-.24	.13
Step 2: *F*(2,206)= 2.15	.011*						
Intercept		2.12	.091		<.0001	1.94	2.30
RSA reactivity		.04	.114	.03	.738	-.19	.26
HR reactivity		.15	.113	.12	.176	-.07	.38
Step 3: *F*(3,206)= 1.46	.007						
Intercept		2.12	.090		<.0001	1.94	2.29
RSA reactivity		.05	.113	.04	.687	-.18	.27
HR reactivity		.17	.113	.13	.127	-.05	.39
Intero ability factor		**-.21**	**.097**	**-.15**	**.035**	**-.40**	**-.01**
Step 4: *F*(5,206)= .89	-.003						
Intercept		2.12	.090		<.0001	1.94	2.30
RSA reactivity		.05	.110	.03	.69	-.18	.27
HR reactivity		.16	.112	.13	.148	-.06	.39
Intero ability factor		**-.19**	**.097**	**-.14**	**.049**	**-.38**	**-.00**
Intero sensibility (BAQ)		-.06	.110	-.04	.604	-.28	.16
Intero sensibility (MAIA)		-.12	.106	-.09	.267	-.33	.09
Step 5: *F*(6,206)= 1.97†	.027**						
Intercept		2.12	.089		<.0001	1.94	2.30
RSA reactivity		.05	.112	.04	.677	-.18	.27
HR reactivity		.18	.112	.14	.113	-.04	.40
Intero ability factor		**-.22**	**.097**	**-.16**	**.026**	**-.41**	**-.03**
Intero sensibility (BAQ)		-.10	.112	-.08	.363	-.32	.12
Intero sensibility (MAIA)		-.06	.109	-.05	.575	-.28	.15
Intero beliefs (BSBQ)		**-.19**	**.091**	**-.15**	**.040**	**-.37**	**-.01**
Step 6: *F*(8,206)= 2.22*	.045†						
Intercept		2.15	.689		.002	.80	3.51
RSA reactivity		.04	.110	.03	.732	-.18	.25
HR reactivity		.18	.109	.14	.092	-.03	.40
Intero ability factor		-.18	.096	-.13	.058	-.37	.01
Intero sensibility (BAQ)		-.16	.110	-.12	.156	-.38	.06
Intero sensibility (MAIA)		-.03	.107	-.02	.803	-.24	.18
Intero beliefs (BSBQ)		**-.23**	**.090**	**-.18**	**.012**	**-.40**	**-.05**
Gender		**-.64**	**.180**	**-.24**	**<.0001**	**-.99**	**-.28**
BMI		.01	.030	.02	.720	-.05	.07

Note: RSA= Respiratory sinus arrhythmia. Adjusted R^2 is reported. Significance reported for R^2 represents whether there was a significant ΔR^2. Bolded lines indicate significant effects. Standard errors and confidence intervals are for the unstandardized betas. Gender is coded 0=Female, 1=Male. † p<.10, * p<.05, ** p<.01, *** p<.0001.

Table S15. HR reactivity and EAT/IF measures on negative high arousal emotion.

Predictors	R^2	*b*	*SE*	*β*	*p*	*Lower 95% CI*	*Upper 95% CI*
Step 1: *F*(4,205)= 3.25*	.042*						
Intercept		.88	.482		.071	-.08	1.83
EAT intero likert mean		**.51**	**.151**	**.25**	**.001**	**.22**	**.81**
EAT intero likert variance		-.11	.100	-.08	.275	-.31	.09
Free-reported physio words		.04	.040	.10	.331	-.04	.12
Free-reported intero focus		-.18	.161	-.12	.269	-.50	.14
Step 2: *F*(8,205)= 3.18**	.078*						
Intercept		.77	.485		.114	-.19	1.73
EAT intero likert mean		**.52**	**.152**	**.26**	**.001**	**.22**	**.82**
EAT intero likert variance		-.09	.098	-.07	.356	-.29	.10
Free-reported physio words		.04	.039	.11	.287	-.04	.12
Free-reported intero focus		-.17	.160	-.12	.244	-.50	.13
HR reactivity		**.18**	**.089**	**.14**	**.041**	**.01**	**.36**
Intero ability factor		**-.21**	**.096**	**-.15**	**.027**	**-.40**	**-.02**
Intero sensibility factor		-.12	.097	-.08	.225	-.31	.07
Intero beliefs (BSBQ)		-.13	.089	-.10	.155	-.30	.05
Step 3: *F*(9,205)= 3.97***	.115**						
Intercept		1.41	.519		.007	.38	2.43
EAT intero likert mean		**.45**	**.151**	**.22**	**.004**	**.15**	**.74**
EAT intero likert variance		-.15	.098	-.11	.138	-.34	.05
Free-reported physio words		.05	.039	.12	.249	-.03	.12
Free-reported intero focus		-.15	.157	-.10	.351	-.46	.16
HR reactivity		**.19**	**.087**	**.14**	**.035**	**.01**	**.36**
Intero ability factor		-.18	.094	-.13	.058	-.37	.01
Intero sensibility factor		-.14	.095	-.10	.151	-.32	.05
Intero beliefs (BSBQ)		-.16	.088	-.12	.073	-.33	.12
Gender		**-.57**	**.186**	**-.22**	**.003**	**-.94**	**-.20**

Note: EAT=Emotion Association Task, IF=Interoceptive Focus. HR=Heart rate. Adjusted R^2 is reported. Significance reported for R^2 represents whether there was a significant ΔR^2. Bolded lines indicate significant effects. Standard errors and confidence intervals are for the unstandardized betas. Gender is coded 0=Female, 1=Male. † *p*<.10, * *p*<.05, ** *p*<.01, *** *p*<.0001.

Table S16. PEP reactivity and EAT/IF measures on negative high arousal emotion.

Predictors	R^2	*b*	*SE*	*β*	*p*	*Lower 95% CI*	*Upper 95% CI*
Step 1: *F*(4,188)= 3.51**	.051**						
Intercept		.60	.520		.254	-.43	1.62
EAT intero likert mean		**.55**	**.161**	**.26**	**.001**	**.23**	**.87**
EAT intero likert variance		-.09	.102	-.07	.383	-.29	.11
Free-reported physio words		.05	.040	.15	.184	-.03	.13
Free-reported intero focus		-.24	.164	-.16	.148	-.56	.09
Step 2: *F*(8,188)= 3.11**	.081*						
Intercept		.50	.519		.334	-.52	1.53
EAT intero likert mean		**.54**	**.161**	**.26**	**.001**	**.26**	**.86**
EAT intero likert variance		-.06	.100	-.04	.559	-.26	.14
Free-reported physio words		.06	.040	.16	.151	-.02	.14
Free-reported intero focus		-.26	.164	-.18	.111	-.59	.06
PEP reactivity		-.09	.089	-.07	.318	-.27	.09
Intero ability factor		**-.27**	**.100**	**-.19**	**.008**	**-.47**	**-.07**
Intero sensibility factor		-.12	.098	-.09	.235	-.31	.08
Intero beliefs (BSBQ)		-.10	.092	-.08	.273	-.28	.08
Step 3: *F*(9,188)= 4.32***	.137**						
Intercept		1.32	.554		.018	.23	2.41
EAT intero likert mean		**.43**	**.160**	**.20**	**.009**	**.11**	**.74**
EAT intero likert variance		-.12	.099	-.09	.216	-.32	.07
Free-reported physio words		.07	.039	.19	.088	-.01	.14
Free-reported intero focus		-.25	.159	-.17	.124	-.56	.07
PEP reactivity		-.12	.087	-.09	.180	-.29	.05
Intero ability factor		**-.23**	**.097**	**-.17**	**.018**	**-.43**	**-.04**
Intero sensibility factor		-.14	.095	-.10	.143	-.33	.05
Intero beliefs (BSBQ)		-.13	.090	-.10	.155	-.31	.05
Gender		**-.67**	**.190**	**-.26**	**.001**	**-1.04**	**-.29**

Note: EAT=Emotion Association Task, IF=Interoceptive Focus. PEP=Pre-ejection period. Adjusted R^2 is reported. Significance reported for R^2 represents whether there was a significant ΔR^2. Bolded lines indicate significant effects. Standard errors and confidence intervals are for the unstandardized betas. Gender is coded 0=Female, 1=Male. † $p<.10$, * $p<.05$, ** $p<.01$, *** $p<.0001$.

Table S17. RSA reactivity and EAT/IF measures on negative high arousal emotion.

Predictors	R^2	*b*	*SE*	*β*	*p*	*Lower 95% CI*	*Upper 95% CI*
Step 1: *F*(4,205)= 3.25*	.042						
Intercept		.88	.482		.071	-.08	1.83
EAT intero likert mean		**.51**	**.151**	**.25**	**.001**	**.22**	**.81**
EAT intero likert variance		-.11	.100	-.08	.275	-.31	.09
Free-reported physio words		.04	.040	.10	.331	-.04	.12
Free-reported intero focus		-.18	.161	-.12	.269	-.50	.14
Step 2: *F*(9,205)= 2.83**	.115*						
Intercept		.78	.486		.113	-.19	1.73
EAT intero likert mean		**.53**	**.152**	**.26**	**.001**	**.22**	**.83**
EAT intero likert variance		-.09	.099	-.07	.347	-.29	.10
Free-reported physio words		.04	.040	.11	.302	-.04	.12
Free-reported intero focus		-.18	.160	-.12	.256	-.50	.13
RSA reactivity		.04	.111	.03	.715	-.18	.26
HR reactivity		.21	.111	.16	.065	-.01	.43
Intero ability factor		**-.21**	**.096**	**-.15**	**.027**	**-.40**	**-.03**
Intero sensibility factor		-.12	.097	-.08	.226	-.31	.07
Intero beliefs (BSBQ)		-.13	.089	-.10	.154	-.30	.05
Step 3: *F*(10,205)= 3.57***	.111**						
Intercept		1.41	.521		.007	.38	2.45
EAT intero likert mean		**.45**	**.151**	**.22**	**.004**	**.15**	**.75**
EAT intero likert variance		-.15	.098	-.11	.134	-.34	.05
Free-reported physio words		.04	.039	.12	.262	-.03	.12
Free-reported intero focus		-.14	.158	-.10	.364	-.45	.17
RSA reactivity		.04	.109	.03	.746	-.18	.25
HR reactivity		.21	.109	.16	.060	-.01	.42
Intero ability factor		-.18	.095	-.13	.058	-.37	.01
Intero sensibility factor		-.14	.095	-.10	.152	-.32	.05
Intero beliefs (BSBQ)		-.16	.088	-.12	.073	-.33	.02
Gender		**-.57**	**.187**	**-.22**	**.003**	**-.94**	**-.20**

Note: EAT=Emotion Association Task, IF=Interoceptive Focus. RSA=Respiratory sinus arrhythmia, HR=Heart rate. Adjusted R^2 is reported. Significance reported for R^2 represents whether there was a significant ΔR^2. Bolded lines indicate significant effects. Standard errors and confidence intervals are for the unstandardized betas. Gender is coded 0=Female, 1=Male. † p<.10, * p<.05, ** p<.01, *** p<.0001.

Table S18. Correlations between interoceptive ability, sensibility, and beliefs.

	HBD d’	Confidence	BAQ	MAIA	BSBQ	Gender
Ability						
HBD Hit Rate	**.66*** **	**.34*** **	.06	.02	-.11†	.10
HBD *d’*	-	**.28*** **	-.00	-.05	-.10	.08
Confidence		-	.10	.05	.03	.00
Sensibility						
BAQ Mean			-	**.51*** **	-.12†	-.03
MAIA Mean				-	**.14***	.02
Beliefs						
BSBQ Mean					-	-.12†

Note: Intero=Interoceptive, HBD=Whitehead heartbeat detection task, BAQ=Body Awareness Questionnaire, MAIA=Multidimensional Assessment of Interoceptive Awareness, BSBQ= reverse score of Body Signal Beliefs Questionnaire. Gender is coded 0=Female, 1=Male. † p<.10, * p<.05, ** p<.01, *** p<.0001.

Table S19. Correlations for interoceptive predictors with reported stress experience.

	Reported Subjective Stress Experience					
	NegHi Emotion	**Neg Emotion**	**Hi Emotion**	**Pos Emotion**	**Lo Emotion**	**Somatic Intensity**
Ability						
HBD Hit Rate	-.08	**-.14***	-.10	.02	-.11	-.06
HBD *d'*	-.08	-.11	-.13†	-.02	-.72	-.07
Confidence	-.03	-.05	-.00	-.04	**-.19****	-.09
Sensibility						
BAQ Mean	-.12†	-.10	-.08	.05	.01	**.15***
MAIA Mean	-.12†	**-.15***	-.08	**.16***	-.02	.11†
Beliefs						
BSBQ Mean	-.08	**-.14***	**-.15***	-.07	**-.17***	-.04
Gender	**-.18****	**-.21****	**-.14***	**-.28*****	.08	-.01

Note: HBD=Whitehead heartbeat detection task, BAQ=Body Awareness Questionnaire, MAIA=Multidimensional Assessment of Interoceptive Awareness, BSBQ= reverse score of Body Signal Beliefs Questionnaire, Neg= Negative, Hi= High Arousal, Pos= Positive, Lo= Low Arousal. Gender is coded 0=Female, 1=Male. † p<.10, * p<.05, ** p<.01, *** p<.0001.

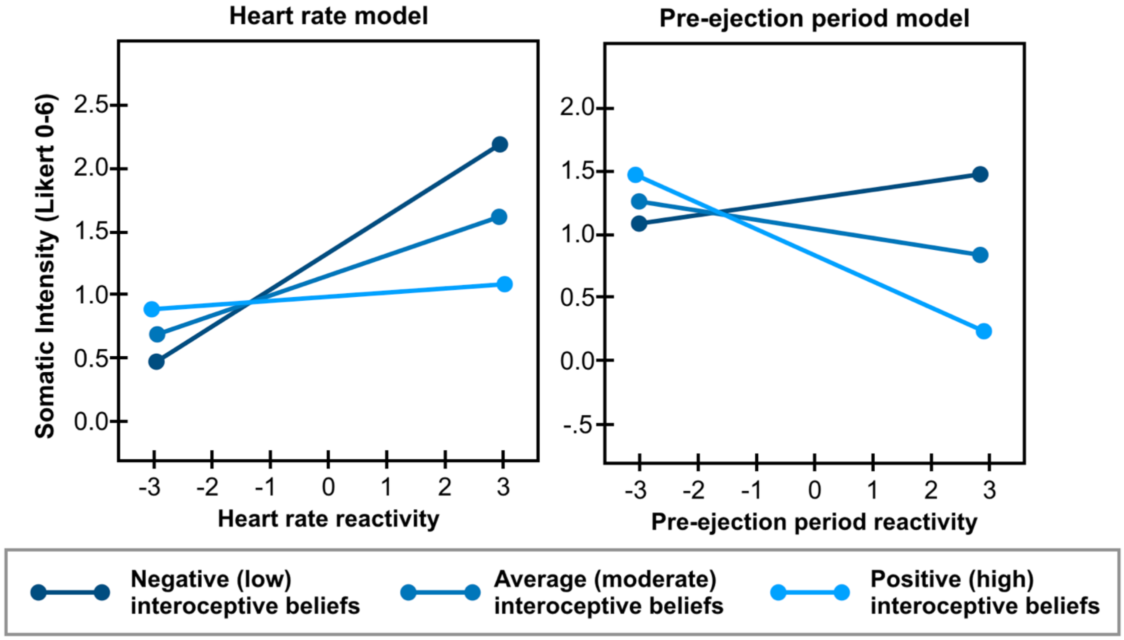

Figure S1. Interaction models testing moderation of physiological reactivity x interoceptive beliefs on somatic intensity. Lines depict the moderating role of low (negative), moderate, and high (positive) interoceptive beliefs on the effect of heart rate reactivity or pre-ejection period reactivity predicting somatic intensity during an acute stressor. Heart rate reactivity, pre-ejection period reactivity, and interoceptive beliefs are standardized.

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