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# Interaction effect of brooding rumination and interoceptive awareness on depression and anxiety symptoms

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ABSTRACT

Awareness of the body (i.e., interoceptive awareness) and self-referential thought represent two distinct, yet habitually integrated aspects of self. A recent neuroanatomical and processing model for depression and anxiety incorporates the connections between increased but low fidelity afferent interoceptive input with self-referential and belief-based states. A deeper understanding of how self-referential processes are integrated with interoceptive processes may ultimately aid in our understanding of altered, maladaptive views of the self – a shared experience of individuals with mood and anxiety disorders. Thus, the purpose of the current study was to examine how negative self-referential processing (i.e., brooding rumination) relates to interoception in the context of affective psychopathology. Undergraduate students (N = 82) completed an interoception task (heartbeat counting) in addition to self-reported measures of rumination and depression and anxiety symptoms. Results indicated an interaction effect of brooding rumination and interoceptive awareness on depression and anxiety-related distress. Specifically, high levels of brooding rumination coupled with low levels of interoceptive awareness were associated with the highest levels of depression and anxiety-related distress, whereas low levels of brooding rumination coupled with high levels of interoceptive awareness were associated with lower levels of depression and anxiety-related distress. The findings provide further support for the conceptualization of anxiety and depression as conditions involving the integration of interoceptive processes and negative self-referential processes.



## 1. Introduction

Two of the most commonly occurring emotional disorders, major depressive disorder (MDD) and generalized anxiety disorder (GAD), represent an enormous public health burden. Both disorders are similar in that impairment occurs within cognitive, affective, and somatic domains of functioning. Although significant progress in treating these disorders has been made, less than half of patients receiving a combination of medication and psychotherapy for MDD achieve remission (Casacalenda, Perry, & Looper, 2002). Similarly, only 50–60% of patients seeking treatment for GAD demonstrate clinically meaningful change (Borkovec & Ruscio, 2001). Thus, further integrative research is needed to identify aberrant mechanisms that can be targeted for more efficient treatment interventions (Sanislow et al., 2010).

The capacity to reflect on one's self (i.e., self-referential processing) is a defining characteristic of human beings and may represent the default state of the brain (Raichle et al., 2001). The neuroanatomy of self-referential processing has been linked primarily to activity in the medial prefrontal cortex (mPFC; Buckner, Andrews-Hanna, & Schacter, 2008), an area of the brain that is also implicated in the detection of emotionally salient stimuli (Morris et al., 1998; Phillips, Drevets, Rauch, & Lane, 2003) as well as determining whether beliefs are “acceptable” or “unacceptable” (Paulus & Stein, 2010). Activation in medial prefrontal regions has been observed in association with subjective reports and behavioral measures of mind wandering (Buckner et al., 2008; Christoff et al., 2009) which is akin to activity typically associated with the “default mode network” involved in self-regulation and monitoring of the internal milieu (Farb et al., 2007; Paulus & Stein, 2010). Indeed, the mPFC is often found active during conditions in which attention is internally directed, processing self-relevant thoughts and beliefs (Paulus & Stein, 2010). Thus, in the absence of task demands, neural activation tends to reflect an automatic tendency

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to engage in narrative, or evaluative cognitive processing (Mason et al., 2007; McKiernan, D'Angelo, Kaufman, & Binder, 2006). In its healthy forms, self-referential processing is critical for self-regulation, adaptive social cognition, and planning of personally relevant goals (Mennin & Fresco, 2013).

However, the human capacity for such higher-level self-consciousness may also be associated with dysfunction (Olatunji, Naragon-Gainey, & Wolitzky-Taylor, 2013), as a shared aspect of both anxiety and depression is the altered experience of the individual with respect to self (Paulus & Stein, 2010). Both affective psychopathologies exhibit the feature of negative self-referential processing (Northoff, 2007), though the content and temporal orientation of the negative thoughts may vary between depression and anxiety (Beckwé, Deroost, Koster, De Lissnyder, & De Raedt, 2014). Negative self-referential thought in depression characteristically takes on the form of rumination, which describes a focus on negative past events along with a tendency to respond to sad mood by passively and repetitively focusing on the causes and consequences of negative emotions (Nolen-Hoeksema & Morrow, 1993). Worry, a core feature of anxiety, focuses on possible negative events in the future and strategies to prevent such events from occurring (Borkovec & Inz, 1990). Though distinct, recent literature suggests that rumination and worry are transdiagnostic processes that cut across MDD, GAD, and comorbid patients (Kircanski, Thompson, Sorenson, Sherdell, & Gotlib, 2015). Thus, both rumination and worry represent dysfunctional forms of self-referential processing (Farb et al., 2015) and reflect cognitive processing that is temporally oriented toward the past or future – that is, away from present moment experience (Kircanski et al., 2015). Importantly, research has found that easily triggered self-evaluative processes to negative emotion may result in maladaptive cognitive reactivity, suggesting that the inability to disengage from such self-evaluative processes may ultimately be a hallmark of relapse risk (Farb, Anderson, Bloch, & Segal, 2011). It is this endemic reliance upon networks supporting temporally extended processing that may obscure the recruitment of networks implicated in more immediate, perceptual self-reflection (Farb et al., 2007).

Another important aspect of self is corporeal awareness (Berlucchi & Aglioti, 2010) or the "material self" (Craig, 2002). Research is beginning to uncover the importance of receiving, accessing, and appraising internal visceral signals, as such processing is critical for an organism's maintenance of desired physiological states, self-regulation, homeostasis, and in turn, survival (Craig, 2013; Farb et al., 2015; Paulus, 2007). The term "interoception" has been variously employed to reference the awareness of body signals (Mussgay, Klinkenberg, & Rüddel, 1999), physiological feedback from the whole body (Wiens, 2005), and afferent information that arises from anywhere and everywhere within the body (Cameron, 2001). Neuroanatomical evidence supports such broad definitions as research has indicated that a class of afferent fibers that monitor the physiological state of all internal organs of the body converge in the insular cortex (Craig, 2002; Paulus & Stein, 2006). The insula, a candidate brain area implicated in interoception (Critchley, Wiens, Rotshtein, Öhman, & Dolan, 2004), is critical for evaluating the potential impact of stimuli on the body (Paulus & Stein, 2006), including generation and regulation of affective responses and detection of emotionally salient stimuli (Paulus & Stein, 2010). However, other evidence suggests that the insula may not be solely necessary for interoception (Khalsa, Rudrauf, Feinstein, & Tranel, 2009), and that other body sensitive brain regions are engaged by interoceptive processing, including the somatosensory cortex and cerebellum (Cameron & Minoshima, 2002; Rapps, Van Oudenhove, Enck, & Aziz, 2008).

Various techniques have been developed to quantify interoceptive awareness in research settings. Efforts have focused on cardiovascular perception primarily because heartbeats are distinct autonomic events that are easily measured via non-invasive methods, and clearly associated with emotion (Barrett, Quigley, Bliss-Moreau, & Aronson, 2004; Herbert, Pollatos, Flor, Enck, & Schandry, 2010; Wiens, Mezzacappa, & Katkin, 2000). The most widely used method is heartbeat counting (Ehlers & Breuer, 1992; Schandry, 1981), which requires participants to silently count their heartbeats during various intervals of time. Performance is captured by an error score, which reflects the difference between the number of heartbeats reported by the individual compared to the actual number of heartbeats that occurred in a given time period as recorded by physiological monitoring equipment. "Good perceivers" on these tasks are individuals whose subjective reports align with their objective number of recorded heartbeats. Other non-invasive approaches to assessing interoception include various forms of respiratory load discrimination tasks (Zechman, Hall, & Hull, 1957), water load tasks (Herbert, Muth, Pollatos, & Herbert, 2012), and tasks that involve simply paying attention to interoceptive sensations of the heartbeat or breath (Farb, Segal, & Anderson, 2013; Simmons et al., 2013).

A growing body of research has shown that interoceptive awareness is implicated in decision making (Dunn, Evans, Makarova, White, & Clark, 2012; Dunn, Galton et al. 2010; Kirk, Downar, & Montague, 2011; Werner, Jung, Duschek, & Schandry, 2009), affect regulation (Füstös, Gramann, Herbert, & Pollatos, 2013; Sze, Gyurak, Yuan, & Levenson, 2010), and in other domains of cognitive and behavioral functioning (Herbert et al., 2010; Pollatos & Schandry, 2008; Pollatos, Schandry, Auer, & Kaufmann, 2007; Werner, Mannhart, Reyes Del Paso, & Duschek, 2014; Werner, Peres, Duschek, & Schandry, 2010). Specifically, Kirk et al. (2011) found that interoception drives increased rational decision-making while playing the ultimatum game, a two-person monetary exchange task. Füstös et al. (2013) provided electrophysiological evidence for the relevance of interoceptive awareness in emotion regulation; specifically, interoceptive awareness facilitated downregulation of affect-related arousal during a cognitive reappraisal task, suggesting that the more aware a person is of ongoing bodily processes, the more successful this person will be in regulating emotions in response to negative affect. However, another study found that individuals who demonstrated superior interoceptive awareness revealed greater arousal (i.e. greater P300 amplitudes) in response to a set of emotional stimuli (Pollatos, Kirsch, & Schandry, 2005). The finding that interoceptive awareness was associated with down-regulation of emotional arousal (Füstös et al., 2013), yet associated with enhanced arousal (Pollatos et al., 2005) suggests that individuals with greater interoceptive awareness may be able to respond more flexibly to task demands. Finally, previous work has also found that individuals who show greater interoceptive sensitivity spend less physical effort due to their better perception of bodily feedback coming from their cardiac system (Herbert, Ulbrich, & Schandry, 2007).

Previous research also suggests that the focus of attention on directly experienced sensations (i.e., visceral signals) may represent a critical aspect of well-being (Davidson, 2004; Watkins & Moulds, 2005). Evidence has shown that localized attention to body sensations enables subsequent gains in emotional and cognitive regulation by enhancing sensory information processing in the brain (Kerr, Sacchet, Lazar, Moore, & Jones, 2013). The notion that more experiential forms of attention are important for well-being is shared by previous theories which distinguish maladaptive verses adaptive modes of mind, or self-focus (Teasdale, 1999; Watkins & Teasdale, 2004). For example, Interacting Cognitive Subsystems (ICS) theory (Teasdale, 1999) proposes that direct experience of one's sensations (i.e., mindful experiencing-being mode) allows the integration of multiple elements of