



## Research paper

# Worry amplifies theory-of-mind reasoning for negatively valenced social stimuli in generalized anxiety disorder

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## ABSTRACT

**Background:** Theory-of-mind (ToM) is the ability to accurately infer others' thoughts and feelings. In generalized anxiety disorder (GAD), cognitive and emotion regulation theories allude to the plausibility that ToM is conditional on the degree of individuals' state worry, a hallmark symptom. GAD and state worry may interact to predict ToM constructs. However, no experiments have directly tested such interactional hypotheses, and used ToM as a framework to advance understanding of social cognition in GAD. This study therefore aimed to address this gap.

**Methods:** 171 participants (69 GAD, 102 Controls) were randomly assigned to either a Worry or Relaxation induction and completed well-validated ToM decoding (Reading the Mind in the Eyes Test) and reasoning (Movie for the Assessment of Social Cognition) tasks.

**Results:** GAD status significantly interacted with state worry to predict accuracy of overall reasoning, cognitive-reasoning, positive-reasoning, and negative-reasoning ToM. Worry, as opposed to relaxation, led sufferers of GAD to display more accurate overall reasoning and cognitive-reasoning ToM than controls, especially for negative signals. Participants with GAD who worried, but not relaxed, were also significantly better than the norm at interpreting *negative* signals. These findings remained after controlling for gender, executive function, social anxiety, and depressive symptoms. For other ToM abilities, mean scores of persons with and without GAD who either worried or relaxed were normative.

**Limitations:** The ToM reasoning measure lacked self-reference, and these preliminary findings warrant replication.

**Conclusions:** Theoretical implications, such as the state worry-contingent nature of ToM in GAD, and clinical implications are discussed.

## 1. Introduction

Theory-of-mind (ToM) refers to the ability to accurately infer others' internal states such as intentions and emotions that drive observable behaviors (Premack and Woodruff, 1978). Two components, decoding (social perceptual) and reasoning (social cognitive), are embodied within ToM (Sabbagh, 2004). *Decoding* involves deciphering others' tangible social information (e.g., eye gaze; Samson, 2009). *Reasoning* ToM is subdivided into affective and cognitive components. Whereas *Affective-reasoning* ToM is the ability to identify and draw accurate inferences of others' feeling states, *Cognitive-reasoning* ToM is the capacity to precisely deduce others' intentions and beliefs. This includes predicting characters' actions based on inferences about their false beliefs, or discerning jokes from sarcasm. Lesion and neuroimaging studies have supported the decoding and reasoning components of ToM, showing that they entail distinct neural networks.

Whereas static tasks such as reading the mind in the eyes test (RMET; Baron-Cohen et al., 2001) assess ToM decoding, ecologically valid paradigms such as the movie for assessment of social cognition (MASC; Dziobek et al., 2006) measure ToM reasoning. Importantly, ToM decoding focuses on merely one aspect of social cognition (e.g., visual emotion detection using only the eyes) to detect emotion whereas ToM reasoning integrates multiple channels of interpersonal data (i.e., video unfolding with auditory, visual, and interactive facial and body movement) to understand others' emotions, intentions, and behaviors. Thus, although decoding and reasoning take into account some overlapping information, ToM reasoning, a higher-order cognitive process, builds on basic ToM decoding skills and combines both bottom-up mind-reading of information from dynamic environmental changes, as well as top-down schema-driven processing based on knowledge of a person's experiences and belief systems.

With respect to psychopathology, ToM deficits manifest in the form

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of either *over-attributing* mental states (e.g., excessive ToM in social anxiety disorder; Hezel and McNally, 2014) or making *inadequate* mental state inferences (e.g., autism spectrum disorders; Baron-Cohen et al., 2001). To our knowledge, no studies have explicitly investigated ToM in generalized anxiety disorder (GAD), a condition where excessive and uncontrollable worry is the hallmark symptom. Nonetheless, some indirect evidence may speak to this. Interpersonal problems have been linked to its etiology and maintenance (Newman and Erickson, 2010). For example, persons with GAD were more likely than controls to either under- or over-estimate their impact and hostile behaviors on others (Erickson and Newman, 2007). In addition, although trait worry was associated with self-reported affiliative tendencies, it predicted impacting significant others in unaffiliative ways (Erickson et al., 2016). However, support for no ToM impairment includes evidence that those with GAD were similar to controls in social competence, and involvement (Scharfstein et al., 2011). Similarly, a meta-analysis found unimpaired emotion recognition in GAD (Plana et al., 2014). Thus, there is broad evidence for and against persons with GAD having intact ToM reasoning and decoding capacities.

At the same time, indirect evidence alludes to inferior ToM decoding relative to affective-reasoning capacities in those with GAD. For instance, across cultures, trait anxiety showed no significant link to comprehension of an array of emotional faces on static photographs, which mimics ToM decoding measures (Baron-Cohen et al., 2001; Cooper et al., 2008; Surcinelli et al., 2006; Yoon et al., 2016). Likewise, individuals with GAD (vs. healthy controls) were similar on attentional processing of facial emotions in response to stationary spatial cueing tasks (Yiend et al., 2015) akin to ToM decoding measures. On the other hand, meta-analytical evidence highlighted that those with GAD had the highest attention toward visual social stimuli when such stimuli were presented in a verbal-linguistic, dynamic, and ecological manner (comparable to ToM reasoning tasks) as opposed to static images (Goodwin et al., 2017). Other evidence of enhanced affective-reasoning in GAD is that compared to non-anxious persons, GAD analogues reported enhanced empathy for others' pain (Peasley et al., 1994). Such empathy was also illustrated in Erickson and Newman (2007), when persons with GAD showed stronger sad responses than controls to sad emotional disclosures by confederates. Empathy refers to the propensity to reflexively emulate and synchronize postures, expressions, or vocalizations, and thus, connect emotionally and viscerally with others' experiences (Hatfield et al., 1993). Elevated empathy could signify heightened affective-reasoning ToM accuracy (Tibi-Elhanany and Shamay-Tsoory, 2011). Affective-reasoning ToM may thus be stronger in individuals with GAD than controls (Shamay-Tsoory et al., 2009).

Moreover, evidence demonstrates that cognitive-reasoning ToM may be unique in GAD. Compared to controls, those with GAD showed enhanced amygdala-precuneus (Strawn et al., 2012) and amygdala-PFC (Makovac et al., 2016) connectivity. Importantly, these neural linkages were associated with ToM reasoning relative to decoding (Sabbagh, 2004). Persons with GAD also had elevated bilateral connectivity between the amygdala and executive control networks (e.g., ventromedial prefrontal cortex [vm-PFC]) which was not observed in controls (Etkin et al., 2009). Such tight amygdala-frontoparietal network coupling may indicate a habit of recruiting the cognitive control system as a form of vigilance for comprehending others' motives and intentions, similar to cognitive-reasoning ToM.

Nonetheless, people with GAD worry more chronically than their less severe counterparts. Thus, when simply comparing those with and without GAD, it is difficult to know whether differences found within and across studies were due to inherently present processes regardless of participants' worried versus relaxed state or were instead due to current elevated levels of state worry enhancing their tendency toward vigilance. It is possible that state worry versus relaxation among persons with GAD could heighten attunement to various emotions and other more complex cues related to ToM reasoning abilities. In fact, several theorists have postulated that worry in GAD may function to

understand and respond to others' interpersonal needs and vulnerabilities (Borkovec and Newman, 1998; Erickson et al., 2016). Moreover, the hypervigilance model of anxiety (Eysenck et al., 2007) assumes that worry in GAD enhances motivation to assuage anxiety, particularly in response to socially relevant material. Worry in GAD is also a cognitive-elaborative process (Borkovec and Inz, 1990), which could heighten the ability to be attuned to others' thought processes (Brothers and Ring, 1992). Worry in GAD may thus facilitate precise reading of emotions and intentions underlying others' observable actions. However, this conjecture has not been tested directly.

Indirect evidence for this speculation is derived from accounts of chronic worriers showing more rapid detection of emotional expressions following priming of a fearful image, as opposed to benign stimuli (Olatunji et al., 2011). Fear resembles state worry. If these assumptions are true, attunement of persons with GAD to their social environment and ToM reasoning skills may be sharpened when they engage in an acute state of worry. In addition, worry in GAD was correlated with the notion that one cares deeply about others' affairs (Hebert et al., 2014), and may thus motivate accurate comprehension of others' motives. This is consistent with heightened attention to ambiguous aspects of their social environment as a result of state worry in persons with GAD (Hirsch et al., 2009). Taken together, compared to relaxation, state worry may intensify cognitive and affective reasoning ToM in those with GAD more strongly than non-anxious controls. Thus, we conjecture that persons with GAD may have keen ToM reasoning skills when engaged in worry.

Negative versus positive context may also influence ToM reasoning. Indeed, the cognitive model (Hirsch and Mathews, 2012) asserts that pathological worry in GAD is intrinsically linked to the proclivity to attend to and difficulty disengaging from negative social material. A predilection to process environmental threats is theorized to be evolutionarily adaptive (Öhman, 2007) and is thus relevant to all people, but is more pronounced in individuals with GAD when worried (Bar-Haim et al., 2007). Across a diversity of paradigms, worry led individuals with GAD to show vigilance toward social threats (Bar-Haim et al., 2007). However, lower state worry was linked to the propensity to naturally attend to positive social features and interpret ambiguous social signals in a positive light (Frewen et al., 2008). Moreover, relaxation training successfully led to reduction in worry severity, vigilance to social threat (Fonzo et al., 2014), and construing incoming data in negative ways (Hayes et al., 2010). Thus, relaxation, may foster the ability of individuals with GAD to access both positive and negative meanings of the social environment. Taken together, degree of engagement in state worry and relaxation may interact with GAD status to determine ToM reasoning accuracy for negative social signals in particular.

In summary, the foregoing theories and data suggest that effects based solely on GAD status may not reflect the complex reality of ToM processes. Plausible hypotheses of how GAD moderates ToM capacities are likely to be conditional on participants' degree of state worry, which may be controlled by inducing either worry or relaxation in a laboratory setting. To address a knowledge gap, the goal of this experimental study was to test the interactional link between state worry and GAD on ToM reasoning and decoding. Persons with GAD have heightened sensitivity to a diversity of context-specific social cues when worried (Olatunji et al., 2011). As such, we hypothesized that GAD and state worry would interact to facilitate greater awareness of social cues, resulting in higher *global ToM reasoning*. However, we predicted no effects of GAD or worry on *decoding* accuracy, as studies that used static context-absent ToM-like tasks (e.g., Yoon et al., 2016) found no link with GAD diagnostic status. Although hypothesizing null effects poses certain risks (e.g., biased results; Bloeser et al., 2015, p. 335), we based our hypotheses on both theory and data. Second, we predicted based on research on worry and empathy that persons with GAD would demonstrate heightened ToM *affective-reasoning* accuracy when worried compared to relaxation and compared to controls. Third, we predicted

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