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Knowing your heart and your mind: The relationships between metamemory and interoception

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ABSTRACT

Humans experience a unified self that integrates our mental lives and physical bodies, but many studies focus on isolated domains of self-knowledge. We tested the hypothesis that knowledge of one's mind and body are related by examining metamemory and interoception. We evaluated two dimensions of metamemory and interoception: subjective beliefs and the accuracy of those beliefs compared to objective criteria. We first demonstrated, in two studies, that metamemory beliefs were positively correlated with interoceptive beliefs, and this was not due to domain-general confidence. Finally, we showed that individuals with better metamemory accuracy also had better interoceptive accuracy. Taken together, these findings suggest a common mechanism subserving knowledge of our cognitive and bodily states.

1. Introduction

"Know thyself," says the ancient Greek maxim, not "Know thy thinking self" or "Know thy feeling self." However, studies of self-knowledge have, for the most part, been limited by domain. There are studies of how one knows thy thinking self (e.g., Fleming, Weil, Nagy, Dolan, & Rees, 2010; Kelemen, Frost, & Weaver, 2000) and studies of how one knows thy feeling self (e.g., Brackett, Rivers, Shiffman, Lerner, & Salovey, 2006; Robinson & Clore, 2002; Spain, Eaton, & Funder, 2000), but the current literature leaves open the question of whether and how these forms of self-knowledge are related (e.g., Fleming, Ryu, Golfinos, & Blackmon, 2014; Kelemen et al., 2000; Schraw, 1998; Song et al., 2011). That is, is the knowing when we recognize an acquaintance in a crowd, or that we've forgotten an item on the grocery list, supported by the same psychological and biological processes as knowing when we feel our hearts are beating rapidly as we wait at the arrivals gate for a long absent lover, or knowing that we sense impending doom as a deadline approaches for which we have not completed the work? As a first step to answer this question, we examined the relationship between knowledge about one's cognitive and bodily states using measures of metamemory and interoception.

1.1. Knowledge about cognitive states: metamemory

Metamemory, a type of metacognition, is knowledge about the contents and accuracy of one's own memory (Nelson & Narens, 1990). Metamemory is typically assessed by asking individuals to reflect on, or introspect about, their own memory

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(e.g., Chua, Schacter, & Sperling, 2009b; Ghetti, Mirandola, Angelini, Cornoldi, & Ciaramelli, 2011). Because introspections are fallible, we refer to self-reports about perceived memory ability as *metamemory beliefs*, and do not assume that these beliefs reflect accurate knowledge about memory. These beliefs can pertain to how good or bad their own memory is (e.g., "I am good at remembering names") and can also be more broad and include general beliefs about how memory works (e.g., "studying longer will help me remember") (Bennett-Levy & Powell, 1980; Dixon, Hultsch, & Hertzog, 1988; Gilewski, Zelinski, & Schaie, 1990). Metamemory beliefs can be assessed via questionnaires in which individuals report their overall beliefs about their own memory. Alternatively, they can also be assessed on a trial-by-trial basis by asking people to rate how confident, or certain, they are about specific memories, with high confidence ratings indicating they believe that they have retrieved correct information (e.g., Chua, Hannula, & Ranganath, 2012; Simons, Peers, Mazuz, Berryhill, & Olson, 2010). Comparing these metamemory beliefs to objective tests of memory yields information about the accuracy of these introspections, which is referred to as *metamemory accuracy*. In other words, metamemory accuracy provides an index of how well subjective beliefs correspond with actual memory performance. For example, an individual who is more likely to have a correct memory when he has higher confidence, and incorrect memory when he has lower confidence would have high *metamemory accuracy* because his confidence in his memory tracks his actual memory. In contrast, an individual who is equally likely to have a correct memory when she has high or low confidence would have low *metamemory accuracy* because her confidence would be a meaningless indicator of her actual memory performance. Metamemory accuracy is typically calculated using measures such as calibration, gamma, and d_a; these indices of metamemory accuracy include measures of confidence in combination with memory accuracy (Benjamin & Diaz, 2008; Masson & Rotello, 2009). While calibration, gamma, and d_a all index metamemory accuracy, their calculations are different and they tap into slightly different ways confidence can be meaningfully related to accuracy (see Section 3.1.2.1). In examining metamemory, it is critical to evaluate and understand both of these dimensions (Table 1): (1) the *metamemory beliefs*, which encompass both the confidence in one's memory for a single memory and declarative statements about one's memory and how it works and (2) *metamemory accuracy*, which is the comparison of the metamemory beliefs to actual memory performance (Chua, Pergolizzi, & Weintraub, 2014).

1.2. Knowledge about bodily states: interoception

Just like we have knowledge of cognitive states (e.g., metamemory), we also have knowledge of our bodily or physiological states, referred to as interoception (Craig, 2003). Like metamemory, interoception can broadly refer to both subjective beliefs about physiological states and the accuracy of those beliefs (Table 1) (Ceunen, Van Diest, & Vlaeyen, 2013; Garfinkel & Critchley, 2013). Parallel with metamemory measures, *interoceptive beliefs* can be indexed via retrospective self-report measures (e.g., Body Awareness Questionnaire (*BAQ*); Shields, Mallory, & Simon, 1989) and when they are, typically reflect general beliefs about capacity (for review, see Mehling et al., 2009). To measure the accuracy of interoceptive beliefs about the body, participants are generally asked to report on their physiological states in the moment (Garfinkel, Seth, Barrett, Suzuki, & Critchley, 2015). As is true of metamemory accuracy, computing *interoceptive accuracy* involves mathematically comparing people's beliefs about their bodies to some objective criteria about what their bodies are doing. The most common interoceptive tasks ask participants to count or monitor their heartbeats (Pollatos, Gramann, & Schandry, 2007; Schandry, 1981; Whitehead & Drescher, 1980; Whitehead, Drescher, Heiman, & Blackwell, 1977). It is important to note that less attention has been paid to the relationship between subjective beliefs and accuracy of interoception, compared to metamemory. Investigating the relationship between interoceptive beliefs and interoceptive accuracy is an active area of research (Garfinkel et al., 2015).

Table 1
Dimensions of metamemory and interoception in terms of beliefs and accuracy, and how they relate to Studies 1–3. Modeled off of Garfinkel et al. (2015).

	Metamemory Beliefs	Metamemory Accuracy	Interoceptive Beliefs	Interoceptive Accuracy
Definition	Self-perceived knowledge of one's own memory	Accuracy of self-perceived knowledge of one's own memory	Self-perceived ability to detect bodily sensations	Accuracy of self-perceived bodily sensations
Example	Do you think you are good at remembering names? Will studying in spaced intervals help you remember?	When you are highly confident in a memory, is it an accurate memory?	Do you think that you detect internal bodily sensations?	Can you accurately report the number of heart beats during a specific interval?
Mode of Assessment	Self-report about perceived memory ability	Relationship between objective performance and self-reported beliefs	Self-report about perceived ability to detect bodily sensations	Relationship between objective bodily sensation and perceived bodily sensation
Example	Questionnaires, such as the Metamemory in Adulthood Questionnaire; Confidence in specific memories, or average confidence in memory ability	Assessing the confidence-accuracy relationship via calibration, the gamma correlation, d_a, and meta d′	Questionnaires, such as the Body Awareness Questionnaire	Accuracy during heartbeat counting or detection tasks