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## Brief Report

# Interoceptive ability and body awareness in autism spectrum disorder



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## ABSTRACT

Autism spectrum disorder (ASD) has been associated with various sensory atypicalities across multiple domains. Interoception, the ability to detect and attend to internal bodily sensations, has been found to moderate the experience of body ownership, a known difference in ASD that may affect social function. However, interoception has not been empirically examined in ASD. In the current study, 45 children (21 with ASD and 24 controls) ages 8 to 17 years completed a heartbeat perception paradigm as a measure of interoceptive ability. A subset of these children also completed the rubber hand illusion task, a multisensory paradigm probing the malleability of perceived body ownership. Although the heartbeat perception paradigm yielded comparable interoceptive awareness (IA) overall across both groups, children with ASD were superior at mentally tracking their heartbeats over longer intervals, suggesting increased sustained attention to internal cues in ASD. In addition, IA was negatively correlated with rubber hand illusion susceptibility in both groups, supporting a previously demonstrated inverse relationship between internal awareness and one's ability to incorporate external stimuli into one's perception of self. We propose a trade-off between attention to internal cues and attention to external cues, whereby attentional resources are disproportionately allocated to internal, rather than external, sensory cues in ASD.

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## Introduction

Autism spectrum disorder (ASD) is associated with atypical sensory processing across multiple sensory modalities. Much of this literature focuses on sensory processing as it is traditionally defined: the perception of, integration of, and response to physical energy from the external environment. Sensory stimuli can be categorized on a continuum of distance from the perceiver, whereby distal cues are emitted from some distance (e.g., light) and more proximal cues are perceived only through close or direct physical contact (e.g., heat). Proprioception and interoception lie on the extreme proximal end of the continuum because the physical source of stimulus energy is within the individual's body. Although there are some studies investigating proprioceptive ability in ASD (Blanche, Reinoso, Chang, & Bodison, 2012; Fuentes, Mostofsky, & Bastian, 2011; Izawa et al., 2012), there are no published studies of interoception in individuals with ASD.

Interoceptive awareness (IA) can be broadly defined as the conscious perception of internal bodily cues such as heartbeat and breathing (Craig, 2003) and is related to empathic abilities (Fukushima, Terasawa, & Umeda, 2011) and emotional experiences (Barrett, 2004; Wiens, 2005), both of which are affected in individuals with ASD (American Psychiatric Association, 2013). Interestingly, heightened IA has been identified in two disorders that often co-occur with ASD: depression and anxiety (Paulus & Stein, 2010), suggesting that IA may become maladaptive if excessive attention to interoceptive input is associated with negative affect (Arch & Craske, 2006; Cioffi, 1991; Flink, Nicholas, Boersma, & Linton, 2009; Spek, van Ham, & Nyklicek, 2013). To determine whether attention to interoceptive cues is "excessive," it is important to deconstruct the broad concept of IA into components of detection and attention.

Neurobiological evidence suggests that detection and attention are neurally separable (Sarter, Givens, & Bruno, 2001), with intervals of repeated sensory stimulation longer than 60 seconds representing sustained attention (Grahn & Manly, 2012). The ability to detect and accurately count one's heartbeats is one common measure of interoceptive ability (Schandry, 1981). By measuring accuracy over four temporal intervals of increasing duration and attentional demand, Schandry's (1981) heartbeat detection task allows separate measurement of interoceptive detection and attention in addition to IA as a whole, although prior studies have mainly addressed the holistic construct of IA.

Whereas IA is a measure of internal body awareness, the rubber hand illusion (RHI) paradigm (Botvinick & Cohen, 1998) has been used as a measure of external body awareness; the illusion reflects an ability to perceive a rubber hand as one's own by way of integrating visual, tactile, and proprioceptive information from the external environment and incorporating it into the sense of self. In adults, individuals with greater IA are more resistant to the RHI (Tsakiris, Tajadura-Jimenez, & Costantini, 2011). The authors suggest that IA modulates the experience of body ownership and that the RHI may result from a trade-off of attentional resources between internal and external cues. If this relationship between IA and RHI susceptibility holds true for children, it would be expected that those with ASD might have heightened interoceptive ability given the reduced susceptibility to the RHI in both children (Cascio, Foss-Feig, Burnette, Heacock, & Cosby, 2012) and adults (Paton, Hohwy, & Enticott, 2012) with ASD.

The goal of the current study was to (a) characterize interoceptive ability (detection, attention, and overall awareness) and (b) examine the relationship between IA and susceptibility to the RHI in children with and without ASD. This will help to clarify the relationship between perception of and attention to internal and external cues that affect body perception and how that relationship may differ in children with ASD. We hypothesized a group difference in IA given the well-established literature confirming sensory-perceptual abnormalities in ASD; however, the previous literature did not suggest a strong directional prediction. Importantly, because perception and attention are both psychologically and neurally distinguishable, and because the degree of attention seems to influence whether IA is adaptive versus maladaptive, we predicted potential group differences at the shortest and longest durations measured, with the longest interval requiring increased sustained attention (Grahn & Manly, 2012). Based on the established relationship between IA and susceptibility to the RHI in typical adults (Tsakiris et al., 2011), we

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