



# Metacognition of agency and theory of mind in adults with high functioning autism



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## ABSTRACT

We investigated metacognition of agency in adults with high functioning autism or Asperger Syndrome (HFA/AS) using a computer task in which participants moved the mouse to get the cursor to touch the downward moving X's and avoid the O's. They were then asked to make judgments of performance and judgments of agency. Objective control was either undistorted, or distorted by adding turbulence (i.e., random noise) or a time Lag between the mouse and cursor movements. Participants with HFA/AS used sensorimotor cues available in the turbulence and lag conditions to a lesser extent than control participants in making their judgments of agency. Furthermore, the failure to use these internal diagnostic cues to their own agency was correlated with decrements in a theory of mind task. These findings suggest that a reduced sensitivity to veridical internal cues about the sense of agency is related to mentalizing impairments in autism.

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## 1. Introduction

This article addresses the question of whether people with autism spectrum disorders (ASDs) exhibit difficulties in distinguishing between self-controlled and externally-controlled action, that is, whether they may exhibit abnormalities in their metacognition of agency. The ability to reliably monitor whether one is, oneself, controlling an action, or whether the action is being controlled or interfered with by forces or circumstances that are external, seems to be fundamental in establishing self-other boundaries. Difficulties in establishing and maintaining such boundaries between self and non-self could have many consequences, including impairments in understanding the perspective of another and in knowing that the perspective of another is different from one's own perspective – difficulties that are prominent in people with ASDs.

Russell (1996) proposed that an impairment in agency monitoring processes in individuals with ASDs might emerge as early as the second year of life. He suggested, as well, that an agency detection breakdown could impact the acquisition of theory of mind (ToM, i.e., the ability to attribute mental states to oneself and to others) (Premack & Woodruff, 1978) in ASDs, because mentalizing abilities centrally depend upon possessing a form of pre-theoretical self-awareness that self-agency-monitoring makes possible. This ability underpins the most basic processes needed for ToM, and hence deficits in one's own sense of agency may be deeply linked with ToM impairments (Russell, 1996).

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This proposal is consistent with what is known about the developmental trajectory of agency monitoring in normal children. Human infants are not initially endowed with either a fully mature ToM, or sense of agency. An elementary sensitivity to one's own agency, which arises in infants around 9–18 months of age (Johnson, 2003), is thought to be a developmental precursor of the ability to assign intentions to others and to be capable of making metacognitive judgments about one's own agency. The experience of being the agent of one's own action, as compared to the experience of being an observer of an event caused by external sources, is constitutive of the self-other differentiation. Baldwin (1906) argued that for an infant to overcome adualism (the merging of objectivity and subjectivity), he or she must discover that data from the world are sometimes discrepant with his or her needs (i.e., that the nipple is not invariably there). It is the mismatch between the child's 'conative affective striving' and *what is there* that allows the child to begin to separate the self from the outside world, and that provides a precursor for the development of a self. Thus, the detection of discrepancy between one's own intentions and what happens (due to others or the world) allows the individual to begin to sort out the relation between the self and others as is needed for a formation of self-awareness at the most elementary level. Such discrepancy detection is at the core of a number of models concerned with people's sense of agency (described below). Any impairment in making a clear distinction between the self and others – i.e., partial perseveration of adualism – could result in (a) conflation of one's own perspective with that of the other including misattributions of agency, and in (b) difficulties in tasks, such as ToM tasks, in which it is necessary to appreciate that the other's beliefs or perspectives are different from one's own.

Pacherie (1997), too, has argued that agency monitoring and mentalizing deficits may be impaired, in tandem, in ASD. In her view, it is a specific aspect of agency monitoring that potentially gives rise to elementary self-knowledge and that is related to both metacognition of agency and mentalizing. It is not just the individual's prior intentions, per se, that are important, but rather their 'intention in action' (Searle, 1983) that allows the development of self-awareness. The 'intention in action' cue is the ongoing detection of potential discrepancy or lack of discrepancy between the outcome and the intention which indicates the effectiveness of the self's motor action during action performance and that conjoins self-awareness, agency judgments, and ToM. It is this cue that we tap – as the sensory motor discrepancy detection cue – in the present experiment.

Although the rationale for expecting a correspondence between an impaired sense of agency and diminished ToM in ASDs is clear, the empirical studies directed at this question – particularly at the agency question – are few and the results are mixed.

Considerable research points to a deficit in ToM among people with ASDs, including those with high functioning autism and Asperger Syndrome (HFA/AS). ASDs are neuro-developmental disorders that are characterized by qualitative impairments in communication, social interactions and stereotyped repetitive behavior (DSM-IV, American Psychological Association, 2000). Indeed, many researchers have regarded impairments in TOM, or in what is sometimes been called 'mentalizing', as the core deficit underlying ASDs (Baron-Cohen, 1989, 1995; Baron-Cohen, Leslie, & Frith, 1985; Frith, 1989; Leslie, 1987, 1991; Leslie & Roth, 1993). Adults with HFA/AS can pass first- and second-order mindreading tests (Dahlgren & Trillingsgaard, 1996), but they often may fail in more 'advanced' ToM tasks, based on the detection of sarcasm, irony or bluff (Happé, 1994). They also often fail to appreciate inappropriate or insensitive social comments, that is they do not understand Faux Pas (Baron-Cohen, O'Riordan, Stone, Jones, & Plaisted, 1999; Zalla, Stopin, Ahade, Sav, & Leboyer, 2009). The Faux Pas advanced ToM task will be used in the present study.

While a deficit in ToM is well established in studies of ASDs, the sense of agency has been less investigated. In the present study, we will first overview current ideas on how people are thought to be able to determine whether they are the agent controlling a phenomenon, and then turn to studies investigating this capability in participants with ASDs. The predominant theory explaining people's sense of agency is the Comparator Model (Frith, 2005; Frith, Blakemore, & Wolpert, 2000; Wolpert, Ghahramani, & Jordan, 1995) of motion control. One important component of this model is that people use an *effe-rence copy* that incorporates an intention or plan of the action to predict the sensory consequences of a given motor command. This expectation or plan is compared, in real time, to the so-called *afference*, that is, the actual sensory-motor outcome (Wolpert et al., 1995). The matching process between central motor plans and the multisensory feedback signals (visual, tactile and proprioceptive) arising during action execution, together with the associated motor intention, is the crucial mechanism thought to both underlie the kind of delicate motor control exhibited by humans and a signal that is the basis for people's sense of agency. This matching process is tantamount to what Searle (1983) calls 'intention in action'.

Recent theories directed at people's metacognition of agency offer support for the idea that people use a variety of cues to make conscious judgments of agency. One of these cues could be the match/mismatch cue from the comparator model. Such a cue allows control of motor or other behavior and it can affect behavior at a level prior to awareness (Fournier & Jeannerod, 1998; Georgieff & Jeannerod, 1998; Jeannerod, 1999; Sebanz, Bekkering, & Knoblich, 2006). However, the high-level metacognitive judgment process by which people are able to assess the extent of their control is thought to involve consciousness (Metcalfe, 2013; Metcalfe, Eich, & Miele, 2013; Synofzik, Vosgerau, & Newen, 2008), and to be reportable by the individual. Thus, there are two distinct components to agency: (1) an implicit 'feeling of agency' (FoA), mediated by lower-level, pre-reflective, sensori-motor processes that subserves action-processing, and which arises mainly from the match or mismatch between the efference copy and afference, and (2) an explicit or conscious 'judgment of agency', which is based, not only on a signal from this matching process but also on reflective or belief-like processes. These explicit metacognition of agency judgments can use but are not limited to using only the match/mismatch cue. Other cues can also contribute to these judgments. Importantly, some of the other cues that are utilized in the conscious judgments of agency are the perceived goodness of performance and the salience of reward (for example, see Metcalfe, 2013). These 'external' cues

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