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Metacognitive monitoring and control processes in children with autism spectrum disorder: Diminished judgement of confidence accuracy

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ABSTRACT

Metacognition consists of monitoring processes (the ability to accurately represent one's own mental states) and control processes (the ability to control one's cognitive processes effectively). Both processes play vital roles in self-regulated learning. However, currently it is unclear whether these processes are impaired in individuals with autism spectrum disorders (ASDs). This study aimed to assess metacognition in thirty-two children with ASD, and 30 IQ-/age-matched neurotypical children, using a judgment of confidence task. It was found that children with ASD showed diminished accuracy in their judgments of confidence, indicating metacognitive monitoring impairments in ASD. Children with ASD also used monitoring to influence control processes significantly less than neurotypical children, despite little evidence of impairments in overall control ability.

1. Introduction

Metacognition refers to an individual's beliefs and knowledge about cognition (often referred to as *metacognitive knowledge*), as well as an individual's ability to monitor and control their own cognitive processes (often referred to as *metacognitive skill*). According to the standard definition, metacognition involves forming meta-representations (second order representations) of one's own mental states. Put more simply, metacognition involves "thinking *about* thinking" (Flavell, 2000). It is widely thought that accurate metacognitive skill is crucial for effective self-regulation of cognition and behaviour (e.g., Nelson & Narens, 1990). By accurately monitoring one's own mental states, one can gain a degree of control over those mental states and, by extension, control the behaviour elicited by those states (e.g., Perner, 1991). For example, whilst revising for an exam, if an individual is able to accurately assess what information they know/do not know, they can employ more effective revision techniques, thus ultimately improving their memory for the exam topic.

Whilst metacognition clearly plays an important role in self-regulation, meta-representation is also thought to play an important role in enhancing other aspects of cognition. For example, Perner (e.g., Perner, 2000) has suggested that the ability to distinguish one's thoughts from reality is a pre-requisite for episodic remembering (but see Williams, 2010). Additionally, there is evidence to suggest that such self-related processing is involved in imagining one's own future, and is involved in the processes of episodic *future* thinking (see for e.g. Wheeler, Stuss, & Tulving, 1997). In this latter respect, metacognition may

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play a role not only in controlling current behaviour, but also future behaviour by facilitating efficient planning for one's future.

However, the area of cognition most frequently discussed in relation to metacognition is mindreading (i.e., the ability to represent the mental states of other people; also known as "theory of mind"). There is a substantial debate that spans developmental, cognitive, and comparative psychology, as well as philosophy and cognitive science, about the relation between mindreading and metacognition. Whereas some argue that mindreading and metacognition rely on the same underlying (metarepresentational) mechanism/processing resources (e.g., Carruthers, 2009; Gopnik, 1993), henceforth termed "one mechanism" theories, others argue either that (a) metacognition and mindreading are unrelated (e.g., Nichols & Stich, 2003) or that (b) mindreading is dependent upon metacognition, but not vice versa (e.g., Goldman, 2006).

2. Metacognition, mindreading and autism spectrum disorder

One developmental disorder that is relevant to the study of all of the above issues is autism spectrum disorder (ASD). ASD is diagnosed on the basis of behavioural deficits in social-communication, and fixated interests and repetitive behaviours (American Psychiatric Association, 2013). There is substantial evidence that, at the cognitive level, individuals with ASD manifest impairments in episodic memory (see e.g., Crane & Goddard, 2008; Lind & Bowler, 2010; Lind, Williams, Bowler, & Peel, 2014; Losh & Capps, 2003), episodic future thinking (see Crane, Lind, & Bowler, 2013; Lind & Bowler, 2010; Lind, Bowler, & Raber, 2014; Terrett et al., 2013), cognitive flexibility (e.g., Ambery, Russell, Perry, Morris, & Murphy, 2006; Ozonoff, Pennington, & Rogers, 1991), and mindreading (see Yirmiya, Erel, Shaked, & Solomonica-Levi, 1998). However, despite the wealth of studies being conducted on these cognitive abilities (all of which are thought to be related to metacognition) in ASD, only a handful of studies have ever explored metacognitive skill in this disorder. This is surprising, given that the study of metacognition in ASD could have significant implications for both theory and practice. For example, there is almost universal agreement that mindreading ability is diminished in ASD. Therefore, if metacognitive monitoring was found to be quantitatively and qualitatively typical among people with this disorder, then this would rule out a one mechanism view of the relation between metacognition and mindreading (e.g., Carruthers, 2009).

To date, much of the evidence regarding metacognitive monitoring in ASD has come from studies that have employed "self-versions" of classic mindreading tasks, in which participants are required to explain their own behaviour on the basis of their mental states (see Williams, 2010, for a review). For example, in the classic unexpected contents false belief task, participants are asked what they believe is contained inside a familiar container (e.g., a Smarties tube). Having expressed their belief that the container contains its usual contents (e.g., Smarties) participants are then shown that it contains something unexpected (e.g., pencils). Participants are then often asked a critical *metacognitive test* question regarding what they thought was inside the box before they were shown. A correct answer to this question would, of course, be Smarties. However, in keeping with the suggestion that metacognition may be impaired in ASD, several studies have observed impairments on self-versions of such tasks, in children with ASD (see e.g., Baron-Cohen, 1992; Fisher, Happé, & Dunn, 2005; Russell, Hill, & Franco, 2001; Williams & Happé, 2009).

However, whilst such findings may be interpreted as evidence of impaired metacognitive abilities in ASD, some have argued that there is a critical limitation with these types of studies that prevents definitive conclusions being drawn (see Carruthers, 2009; Nichols & Stich, 2003). Namely, it has been argued that such tasks usually require participants to represent their *prior* mental states, rather than their *current* mental states. In the Smarties unexpected contents task, for example, participants believe that the box contains Smarties *before* they look inside (at time 1). Then the unexpected contents (pencils) are revealed to the participant, which results (at time 2) in a belief that the box contains pencils. Participants are then asked the critical test questions regarding what they believed was inside before they looked inside the box (i.e., what they believed at time 1). But the fact that participants no longer believe (at time 2) what they believed in the past (at time 1), the test question appears to be asking them to report on a prior belief, rather than a current belief. Yet metacognitive monitoring is, by definition, the ability to report on one's current, online mental states. Reporting one's prior, out-of-date beliefs requires *reconstruction of* one's earlier belief in memory. As such, many do not consider self-versions of standard ToM tasks to be tests of metacognitive monitoring (see e.g., Nichols & Stich, 2003). As such, the results from the above studies do not necessarily show that metacognition is impaired in ASD.

However, recently, studies of metacognition in ASD have begun to employ tasks that are considered more standard measures of metacognitive skill by researchers in that field and which, it is more widely agreed, require individuals to monitor their own *current* mental states. One classic paradigm that has been widely used to measure metacognitive ability in neurotypical individuals is a judgment of confidence (JOC) task. Studies assessing judgments of confidence typically involve participants answering questions about recently-studied material or stored semantic knowledge, and then reporting their confidence in the answers they provided. Importantly, is widely accepted that on such tasks participants monitor their *current* feelings of confidence in their answers. As such, this sort of paradigm overcomes the issue posed by self-versions of ToM tasks. If an individual's metacognitive monitoring ability is good, then their confidence judgements should accurately discriminate between correct and incorrect answers. Additionally, in some JOC paradigms participants are subsequently given the opportunity to exclude some of their answers, such that those answers will not contribute to the participant's final "score". This aspect of self-monitoring relies on metacognitive control (an individual's ability to regulate their cognition)