Spontaneous mentalizing in neurotypicals scoring high versus low on symptomatology of autism spectrum disorder

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ABSTRACT

Spontaneous mentalizing ability has been linked to symptoms severity in individuals with autism spectrum disorder (ASD). Here we investigated whether in neurotypicals, higher levels of ASD symptomatology could also be linked to lower levels of spontaneous mentalizing, by comparing neurotypicals scoring high with those scoring low on the short Autism Spectrum Quotient. Participants watched movies during which they, and another agent, formed beliefs about the location of an object. These beliefs could influence reaction times (RT) to that object in the outcome phase. We expected participants with more ASD symptoms to show less spontaneous mentalizing, as reflected by a smaller effect of the other agent's beliefs on RT patterns (the ToM index). In contrast, the effect of own beliefs on RTs, reflecting an egocentric bias, was expected to be larger in the high-scoring group. Results showed that groups differed in the effect of the agent's beliefs; the ToM index was highly significant in the low-scoring group, while being absent in the high-scoring group. No difference in egocentric bias was observed. These findings suggest that the relationship between levels of ASD symptomatology and spontaneous mentalizing is not only present in individuals with ASD, but also in the neurotypical population.

1. Introduction

Theory-of-Mind (ToM), also referred to as mentalizing, is defined as the ability to attribute mental states (such as desires, beliefs or intentions) to oneself or others (Premack and Woodruff, 1978; Wimmer and Perner, 1983). This ability is thought to underlie successful communication and social interaction. Because individuals with autism spectrum disorder (ASD) show deficits in exactly these capacities as a crucial part of their symptomatology (American Psychiatric Association, 2013), researchers have argued that ASD is characterized by a specific ToM deficit (Baron-Cohen et al., 1985; Rajendran and Mitchell, 2007). ToM ability has been investigated mostly with ‘false-belief tasks’: tasks in which an agent holds a false belief about the location of an object, because it was moved outside of the agent’s awareness. Participants are asked where the agent will search for this object, and when they correctly take into account the agent’s false belief, this is seen as successful ToM.

Based on studies with these false-belief tasks, for a long time ToM was thought to develop around the age of four years (Wellman et al., 2001). However, more recently, when using different measures of mentalizing, such as eye-tracking, that do not require language or other higher cognitive skills, evidence for mentalizing was found in children much younger than 4 years (Onishi and Baillargeon, 2005; Senju et al., 2011; Southgate et al., 2007; Surian et al., 2007), for one study even as young as only seven months old (Kovács et al., 2010). For this reason, Apperly and Butterfill proposed the ‘two-systems account of mentalizing’ (Apperly and Butterfill, 2009). They hypothesized that there are two mentalizing systems: one system entails an implicit or spontaneous form of mentalizing that develops early, and which is fast and inflexible; the other is a more explicit form of mentalizing developing at a later age, which is more cognitively demanding and slow, but also more flexible. It has been debated whether there are really two separate systems, or whether there is one core mentalizing system, which can either operate spontaneously or, under more controlled conditions, in combination with additional domain-general resources such as executive functioning and working memory (Carruthers, 2015). This latter view is supported by the recent finding that the brain regions underlying both forms of mentalizing overlap to a great extent (Bardi et al., 2016; Van Overwalle and Vandekerckhove, 2013). Bardi et al. (2016) directly compared a spontaneous and an explicit version of a ToM task, which is the same task that we will apply in the current study. During this task, both spontaneous and explicit belief processing activated the medial prefrontal cortex and right temporoparietal junction, two regions that have consistently shown to activate during explicit mentalizing (Decety and Lamm, 2007; Schurz et al., 2014; Van Overwalle, 2009).

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In any case, the existence of a spontaneous form of mentalizing might help to resolve the controversies surrounding the ToM theory of ASD. Soon after Baron-Cohen introduced the theory of a specific ToM deficit in ASD (Baron-Cohen et al., 1985), it was already criticized because a relatively large amount of children and adults with ASD, especially high-functioning individuals, passed ToM tests (Bowler, 1992; Frith and Happé, 1994; Ozono et al., 1991). Since then, studies have shown that individuals with ASD can even succeed on more advanced ToM tasks (Scheeren et al., 2013; Spek et al., 2010). Still, they do show profound difficulties with everyday social communication and interaction. The argument would be that these individuals have a deficit in spontaneous mentalizing, but use compensatory strategies on explicit mentalizing tasks: in order to solve these tasks, they apply learnt rules and, if intact, their executive functioning skills, thus masking their reduced ability to mentalize spontaneously (Frith, 2004; Ozono et al., 1991; Pellicano, 2010).

Several studies to date have indeed found support for impaired spontaneous mentalizing in people with ASD (Callenmark et al., 2013; Deschrijver et al., 2015; Schneider et al., 2013; Schuwerk et al., 2015; Senju, 2013; Senju et al., 2009). However, all of these studies have taken a categorical approach to ASD, comparing individuals with a diagnosis to neurotypical controls. More and more, researchers are taking a dimensional approach to developmental psychopathology (Hudziak et al., 2007), arguing that individuals with a diagnosis are at the end of a continuum of traits existing in the general population, and that creating a categorical dichotomy will inevitably lead to the loss of potentially interesting information. Additionally, studying the non-clinical population has the advantage of reducing the influence of comorbidities present in the clinical population, such as attention-deficit hyperactivity disorder, anxiety and depression in the case of ASD (Joshi et al., 2013; Mannion and Leader, 2013). These arguments have been recognized in the field of ASD specifically, where researchers acknowledge the importance of taking into account the presence of ASD-related behavior and personality traits in relatives of individuals with ASD (the broader autism phenotype or BAP) (Losh et al., 2011; Parr and Le Couteur, 2013), as well as in the neurotypical population more generally (Constantino, 2011; Constantino and Todd, 2003; Robertson and Simmons, 2013; Robinson et al., 2011).

In this light, it would be interesting to investigate whether the link between spontaneous mentalizing ability and ASD symptomatology is also present in the neurotypical population. Therefore, with the current study we wanted to see if we would find differences in spontaneous mentalizing between people scoring high versus low on ASD symptomatology in the neurotypical population. In order to measure spontaneous mentalizing, we used the ‘Buzz Lightyear task’, a simple ball detection task based on the study by Kovács et al. (2010). Within this task, both the participants themselves and another agent (Buzz) form a belief about the location of a ball, but they are never asked about these beliefs explicitly. By recording reaction times to ball presence, which reflects knowledge the importance of taking into account the presence of ASD-centric bias.

2. Methods

2.1. Participants

Participants were contacted through Experimetrix, the online system of Ghent University used to recruit students for experimental research. As part of this system, participants already filled out a large battery of short screening questionnaires, including the AQ-10 (Allison et al., 2012), a screener for autism symptomatology which consists of the 10 items with highest sensitivity and specificity of the 50-item Autism Spectrum Quotient (AQ; Baron-Cohen et al., 2001). Based on the online database of all AQ-10 scores (N = 427), a cut-off for the highest and lowest 20% of scores was set. Students with a score lower than 2 fell in the bottom 20% range and were recruited for the low-scoring group, while students with a score of 5 or higher were recruited for the high-scoring group. This resulted in a group of 31 participants in the high-AQ-10 range, and 29 participants in the group scoring low on the AQ-10. None of the participants in either group reported any history of neurological or psychiatric disorders (including an ASD diagnosis). All participants gave informed consent prior to the study, which was approved by the local ethics committee of the Faculty of Psychology and Educational Sciences of Ghent University, and received a financial reward for their participation.

Data of one participant in the low-scoring group were not saved correctly, so as a result, our final sample consisted of 31 participants in the ‘high-AQ’ group (7 male, 5 left-handed), and 28 participants in the ‘low-AQ’ group (2 male, 2 left-handed). Mean group characteristics (including between-group comparisons) are displayed in Table 1.

To check for the reliability of the AQ-10 score, during the experimental session participants also filled out the full AQ and the Social Responsiveness Scale for adults (SRS-A; Constantino and Gruber, 2002), which is another self-report screening questionnaire of ASD symptomatology, primarily addressing social responsiveness. The mean full AQ score across the two groups was 15.0 (SD = 8.6), in line with previous findings in neurotypical populations (Ruzich et al., 2015). Mean SRS-A
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