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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 temporo-parietal 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; Ozonoff 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; Ozonoff 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 can be expected or unexpected for the participant and/or the other agent, one can measure the extent to which participants spontaneously tracked their own and other's beliefs. A crucial measure in this task is the so-called 'ToM index': the difference between the condition in which neither participant nor Buzz expect the ball and that in which only the agent expects it: if RTs are faster only on the basis of what the other agent was expecting, this can be taken as evidence for spontaneous mentalizing.

Recently, the Buzz Lightyear task has been validated both in neurotypical and ASD samples (Deschrijver et al., 2015; Nijhof et al., 2016), and in the fMRI study mentioned previously (Bardi et al., 2016). Deschrijver et al. (2015), who applied the task in ASD, found that adults with high-functioning autism (HFA) had a significantly larger egocentric bias in spontaneous belief processing, reflecting an increased adherence to their own beliefs/expectations, as has also been reported in literature on explicit ToM (Begeer et al., 2012; Fisher et al., 2005; Williams and Happé, 2009). In addition, the effect of the other agent's belief, as reflected in the ToM index, was found to be correlated negatively with ASD symptomatology within the HFA group, indicating less spontaneous mentalizing with higher levels of symptomatology. This latter finding supports the hypothesis that the relationship between spontaneous mentalizing and ASD traits may be seen as a continuum rather than as a categorical distinction between people with and without an ASD diagnosis.

In a recent study, we compared performance on an explicit and implicit spontaneous version of the Buzz Lightyear task in a neurotypical sample (Nijhof et al., 2016). RT patterns were similar for both versions, and the presence of the ToM index showed that participants indeed calculated the belief of another agent spontaneously (i.e., without being instructed to do so). In contrast to the study of Deschrijver et al. (2015), measures of ASD symptomatology in this study did not correlate with the size of the ToM index. This may, however, have been due to restricted variation in ASD symptoms within the neurotypicals included in the study. To address this, in the current study, we compared neurotypical participants with high and low extremes of ASD traits. This allows us to investigate whether the inverse relationship between spontaneous mentalizing and ASD traits is specific to the ASD population, or can be observed more broadly. The hypothesis would be that individuals scoring high on ASD symptoms show less spontaneous mentalizing than those scoring low, which would be indicative of a specific relationship between ASD traits and the ability to mentalize spontaneously. In other words, we expected the ToM index to be present in the low-scoring group, and it to be decreased or absent in the high-scoring group. In addition, in line with the findings of Deschrijver et al. (2015), we expected to find a larger effect of own belief in our group scoring high on ASD measures, reflecting an egocentric 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