

A Continuous False Belief Task Reveals Egocentric Biases in Children and Adolescents With Autism Spectrum Disorders

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What is This?

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Abstract

This study reports on a new false belief measure in a sample of 124 children and adolescents with or without high functioning autism (HFASD). In the classic paradigm, a participant predicts in which of two discrete locations a deceived protagonist will look for an object. In the current Sandbox task, the object is buried and reburied in a sandbox, thus creating a continuum between locations. Compared to typically developing individuals ($n=62$), those with HFASD ($n=62$) showed a larger egocentric bias on the Sandbox task. They failed to take the protagonist's false belief into account, despite their adequate ability to infer advanced mental states. This indicates that sensitive measures can reveal subtle first order Theory of Mind impairments in HFASD individuals.

Keywords

Autism Spectrum Disorders, Theory of Mind, Asperger's disorder, Egocentrism, Bias, Social Cognition

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Theory of Mind (ToM) is the ability to ascribe mental states to others or to oneself and to explain and predict behaviour in terms of underlying mental states (Baron-Cohen, et al., 2000). The false belief task is the most widely used test to reveal ToM. This task measures children's specific predictions of others' actions under conditions of limited information, which indicates the ability to appreciate others' mental states (Wimmer and Perner, 1983). Despite its many advantages, the classic false belief task is most appropriate for 3–6-year old children. This task is inappropriate for older children and adults due to ceiling effects in performance. Furthermore, the task's dichotomous nature is a limitation in that a participant either passes or fails. This categorical approach can miss the subtle variance in false belief reasoning at different ages, or across clinical groups (Bernstein, et al., 2007; Bernstein, et al., 2011). Indeed, increasing the number of response options results in a more sensitive measure in adults (Birch and Bloom, 2007). The current study highlights the use of a continuous false belief task. This task elicits subtle egocentric biases by measuring the extent to which participants can ignore or disregard their own beliefs in order to reason from an ignorant perspective on a continuous scale. We focus on children and adolescents with a diagnosis that impairs their false belief reasoning skills: Autism Spectrum Disorder.

A false belief task creates a situation in which participants find themselves more knowledgeable than another person. Consequently, researchers measure whether participants infer the mental state (e.g., a false belief about an object's location) of the other person, also referred to as 'first order false belief reasoning'. In the classic false belief task participants witness an object that is relocated in the absence of a protagonist. When the protagonist returns to the scene, participants indicate where the protagonist will look for the object. To predict the protagonist's behaviour correctly, participants must ignore their own privileged knowledge about the actual situation and reason from the protagonist's (false) perspective (Wimmer and Perner, 1983).

Typically developing children consistently fail false belief tasks until the age of four, while most six-year olds pass the task (Wellman, et al., 2001). This rapid shift in performance has led many developmental psychologists to hypothesise that children's ToM development undergoes a stage-like change in reasoning about mental states (Wimmer and Perner, 1983; Wellman, 1990). Before this conceptual change children do not appreciate the belief state of someone else, but explain the actions of someone else solely based on their own, egocentric knowledge of a situation (Moses and Flavell, 1990).

The term egocentrism is often used in its narrow sense, following Piaget, to refer to the ability to reconstruct the spatial perspective of another person. Here, we refer to the wider meaning of egocentrism, including the ability to take others' mental states into account, which is often problematic for individuals with Autism Spectrum Disorders (ASD; Begeer et al., 2010). ASD are characterized by impairments in verbal and nonverbal communication, which result in persistent social difficulties (APA, 2000). As opposed to young typically developing children who overcome their false belief failure, individuals with ASD fail false belief tasks well over the mental age of six years (Happé, 1995). They perform more poorly on false belief tasks than intellectually disabled individuals (Baron-Cohen, et al., 1985) or children with language impairment (Leslie and Frith, 1988). However, from around 12 years of age individuals with ASD and normal IQ (high functioning ASD, HFASD) often show levels of false belief performance that are similar to typically developing children (Happé, 1995). Whether their mentalizing abilities are also similar to typically developing children is unclear.

Researchers have developed various measures to study more advanced ToM skills of individuals that pass the classic false belief tasks, but these measures yield inconsistent results. While ToM has many facets, the tasks most closely linked to the false belief paradigm purport to measure advanced ToM. In these advanced ToM tasks, participants reflect on mental states of story

characters during complex social interactions. Such tasks may require the inference of advanced mental states, ironic remarks, double bluff or faux pas. Children and adults with HFASD perform at both impaired (Happé, 1995; Kaland, et al., 2002; Spek, et al., 2010; White, et al., 2009) and normal levels compared to comparison groups (Roeyers, et al., 2001; Ponnet, et al., 2004; Senju, et al., 2009). The inconsistent results may relate to the variety of measures included in advanced ToM batteries. Additionally, various instruments focus on the ability to identify complex emotions from facial expressions (e.g., the ‘reading the mind in the eyes’ task, Baron-Cohen, et al., 2001). However, again children and adults with HFASD do not consistently fail this task (see for instance: Spek, et al., 2010; Roeyers et al., 2001). Moreover, the extent to which the identification of facial expressions requires ToM understanding is unclear (Begeer, et al., 2008).

Implicit measures of false belief reasoning show specific problems in HFASD individuals. Adolescents with HFASD take more time to respond than typically developing adolescents (Kaland, et al., 2011). Moreover, adults with HFASD fail to attribute first order false beliefs spontaneously in their anticipatory looking behaviour (Senju, et al., 2009). Adults with HFASD also fail to employ their first order mindreading skills during a naturalistic interaction (Ponnet et al., 2004). However, they show these problems despite their adequate advanced conceptual reasoning skills on advanced ToM tasks.

While the above measures may capture the ToM impairments in HFASD individuals, these measures are of limited use in a clinical setting. Firstly, the results are inconsistent. Secondly, measures can be expensive and time-consuming, especially when responses must be filmed or analysed with eye-tracking technology. Consequently, there is a need for a simple measure that is sensitive enough to capture subtle false belief difficulties between individuals with HFASD or typical development who pass classic false belief tasks (see also Apperly, et al., 2011; Atance, et al., 2010; Cohen and German, 2010).

Previous research showed that a more complex false belief task, with several response options and variation of the target object, highlights subtle impairments in the false belief reasoning of typically developing adults (Birch and Bloom, 2007). Further extending response options, researchers recently developed a “Sandbox” task to measure false belief reasoning on a continuum (Bernstein, et al., 2011; Sommerville, et al., submitted). Where the classic false belief task forces participants to choose between the original and the actual location of the object, the Sandbox task permits participants to choose between those two locations in a large rectangular box filled with Styrofoam peanuts. Similar to the classic false belief task, a protagonist witnesses the object being buried in the first location. In the absence of the protagonist, the object itself (false belief condition), or an unrelated second object (no false belief condition) are relocated in the sandbox. In both conditions, the participant indicates where the protagonist will look for the object after his return. Importantly, participants can choose any location in the sandbox. The responses in the false belief and no false belief conditions depict the egocentric bias of the participant. Allowing participants to respond on a continuum permits us to capture more subtle egocentric biases. The dichotomous responses of the classic false belief task force the participant to choose between one of two alternatives. Thus the classic procedure may call to the participant’s attention the ignorant protagonist’s perspective. Using a continuous response option permits us to capture one’s unconscious egocentric bias, following social psychological approaches to adult egocentrism (e.g., Keysar, et al., 2003). Importantly, with these adaptations, the task can measure egocentric bias across the lifespan. To date, it has been used in typically developing preschoolers, adults, and the elderly (Bernstein, et al., 2011; Sommerville et al., submitted), but not in school-age children or individuals with autism.

In the current study we used the continuous false belief task in individuals with HFASD or typical development. We expected that the HFASD group would perform more poorly on the task than

Table 1. Descriptive data (Means and SDs) of children and adolescents with high functioning autism disorder and typically developing children and adults

	HFASD (n = 62)	TD (n = 62)
Age in years	13.1 (3.1)	13.1 (3.2)
Gender: male/female	50/12	51/11
Receptive language ability: Peabody Picture Vocabulary Test, PPVT	107.4 (13.1)	107.7 (12.0)
Social Responsiveness Scale: SRS ^a	82.9 (19.4)	31.1 (11.8)

HFASD high functioning autism spectrum disorder, TD typically developing, SD standard deviation.

^aSRS scores were obtained for 77% of the participants.

an age-matched comparison group. We also administered a short selection of five advanced ToM tasks to compare performance on the continuous false belief task and advanced ToM tasks.

Method

Participants

After obtaining written parental consent, we included 124 children and adolescents (6-20 years), diagnosed with HFASD (n=62) and a typically developing comparison group (n=62; see *Table 1* for participant details). We included children and adolescents to test false belief reasoning across a wide age range. The HFASD diagnoses were based on assessments by psychiatrists or certified psychologists in accordance with DSM-IV criteria (American Psychiatric Association, 2000). The HFASD participants came from the Berg en Bosch school, an institution in Bilthoven, The Netherlands, specialized in education for children with autism. Children from the comparison group were matched on gender, chronological age and verbal ability and recruited from primary and high schools near Amsterdam, The Netherlands. They had no known history of developmental lag or disorders.

For the HFASD group, we assessed all participants with the Autism Diagnostic Observation Schedule (ADOS, a play-based diagnostic measure that involves direct observation of the child; Lord, et al., 2000). Parents of both HFASD and comparison children completed the Social Responsiveness Scale (SRS, a parental observation scale; Constantino, et al., 2003; Roeyers, et al., 2009).

Participants completed the Dutch version of the Peabody Picture Vocabulary Test-NL (Schlichting, 2005; Dunn and Dunn, 2005), which is a receptive language test that correlates with overall intelligence (Bell, et al., 2001).

Materials & Procedure

Sandbox task. We used a scaled-down version of the Sandbox Task (Bernstein et al., 2011; Somerville, et al., submitted), originally based on Wimmer and Perner's (1983) classic false belief task. The interviewer, unaware of the experimental hypotheses, introduced the Sandbox task, using various pictures on a sheet of paper. Participants heard, "Here I have another task. It's about a father and a daughter planting flower bulbs in a Sandbox. Listen carefully while I tell the story and if you like you may read along from the paper" (see Figure 1 for the false belief condition and Figure 2 for the no false belief condition). After reading the first part (false belief- or no false belief condition) the interviewer asked whether the participant had a good look at the pictures, then turned the paper around and continued reading the second part of the story (see Figure 3).

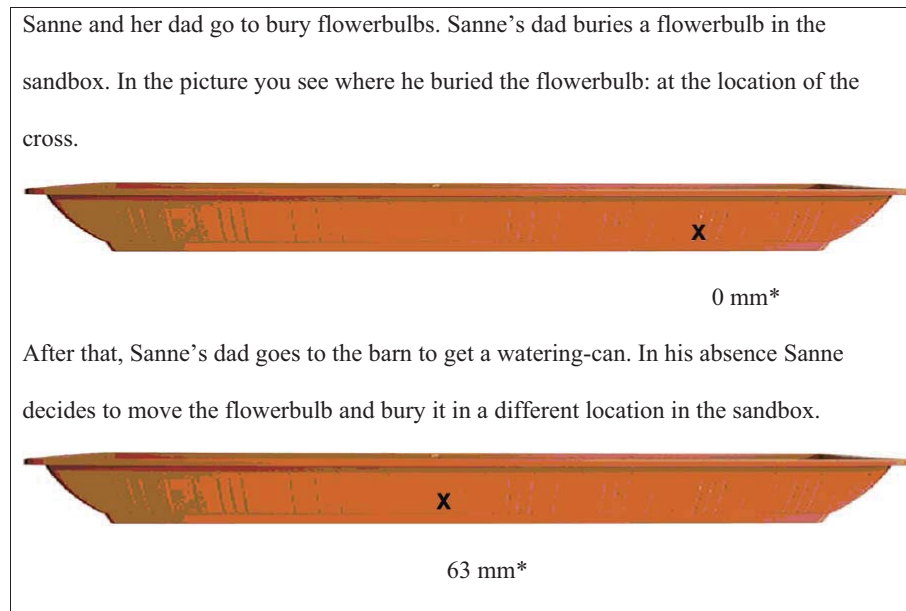


Figure 1. First part of story and images in the false belief condition, as shown to participants.

* Measurement indicators were not printed on the actual task.

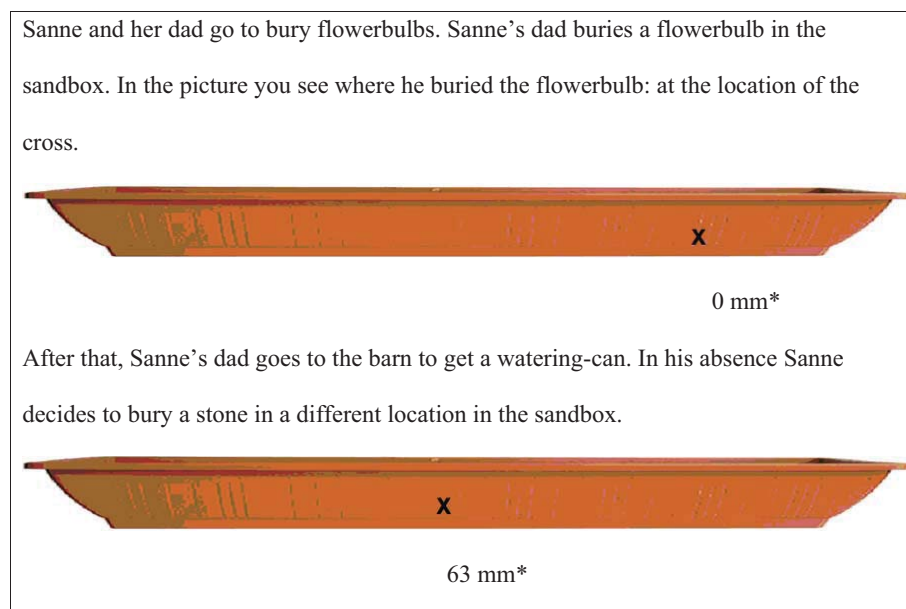


Figure 2. First part of story and images in the no false belief condition, as shown to participants.

* Measurement indicators were not printed on the actual task.

We measured (in millimetres) the difference between the original hiding location of the flower bulb (0 mm) and the location where the participant indicated to look for the flower bulb. When participants indicated a location in the direction of the second hiding location of the flower bulb (63 mm) in the false belief version, or the stone (63 mm) in the no false belief version, this received

When Sanne's dad returns with the watering-can, where will he give water to the flowerbulb? Draw a cross on that spot. You're allowed to draw only one cross.



Figure 3. Second part of story and images in the false belief and no false belief condition, as shown to participants.

a positive bias score. When participants indicated a location in the opposite direction of the flower bulb or the stone, to the right of the original hiding location, this received a negative bias score. In addition to the false belief and no false belief scores, we computed a specific egocentric bias score for each participant, we subtracted the no false belief condition score from the false belief condition score. We counterbalanced the order in which participants completed the false belief and no false belief conditions. Order did not affect performance.

Advanced ToM task. There were five mental state stories, including a advanced false belief story (Birthday Puppy; Sullivan, et al., 1994), an emotional display rule story (Rollercoaster; Begeer et al., 2011), and the Double Bluff, Social Blunder and Irony vignettes of the Stories of everyday life (Kaland, et al., 2002). We chose these stories based on their high sensitivity for detecting group differences between individuals with and without HFASD. The experimenter read stories aloud. All stories described characters with diverse beliefs, false beliefs or the intention to create false beliefs in others. Participants predicted the understanding, emotion or behaviour of story characters on the basis of the characters' mental states. In addition, participants inferred physical states from the story contexts of four of the stories. We counterbalanced physical and mental state questions, and combined these with various control and filler questions. All answers received pass or fail (1 or 0) scores. We summed correct responses on the mental state and physical stories, and then converted this to a proportion correct.

Results

First, we analysed the responses to the false belief and no false belief versions of the task separately, using a 2 (Group: HFASD and comparison) * 2 (Belief: false belief and no false belief) repeated measures ANOVA, with Group as a between-subject factor and Belief as a within-subject factor. Expected main effects emerged for Group, $F(1,122) = 4.00, p = .04, \eta^2 = .03$, and Belief, $F(1,122) = 20.99, p < .001$, partial $\eta^2 = .14$. These effects were qualified by a Group*Belief interaction, $F(1,122) = 4.84, p = .03$, partial $\eta^2 = .04$. Two separate post-hoc one-way ANOVAs indicated that the false belief bias score was larger in the HFASD than the comparison group, $F(1,122) = 5.06, p = .03$, partial $\eta^2 = .04$, while no group differences appeared in the no false belief bias score.

Second, to show the specific patterns of egocentric bias in both groups more explicitly, we analysed the egocentric bias scores for each participant separately. Both groups showed significant egocentric bias scores, which deviated from 0 (HFASD: $t(61) = 3.97, p < .001, \eta^2 = .45$; Comparison group: $t(61) = 2.29, p = .03, \eta^2 = .28$). Using ANOVA, we analyzed differences between the egocentric bias scores of individuals with HFASD or typical development. The HFASD group showed a larger egocentric bias than the comparison group, $F(1,122) = 4.84, p = .03, \eta^2 = .04$. Importantly, controlling for age and verbal ability showed the same results (main effect of Group, $F(1,120) =$

Table 2. Means (SD) of False Belief, No False Belief and egocentric bias scores in mm and of proportions of mental and physical state inferences for HFASD and typically developing participants

	False Belief	No False Belief	Egocentric Bias	Proportion correct mental state inferences	Proportion correct physical state inferences
HFASD (n=62)	11.00 (26.57)	-2.65 (10.00)	13.65 (27.05)	.70 (.22)	.79 (.23)
TD (n=62)	1.71 (18.75)	-3.08 (8.67)	4.79 (16.50)	.70 (.19)	.82 (.19)

HFASD high functioning autism spectrum disorder, TD typically developing, SD standard deviation.

4.79, $p = .03$, partial $\eta^2 = .04$; Table 2). An additional analysis, adjusting outliers (>2 SD), but maintaining their distal-most ranking in the distribution (Bernstein et al., 2011; Tabachnick & Fidell, 2007), showed similar group differences in the false belief condition, $F(1,122) = 4.09$, $p = .04$, $\eta^2 = .03$, but not in the no false belief condition, $F(1,122) = .00$, ns .

Third, to further analyse the number of children in both groups that showed the full egocentric error and pointed to the true location of the flower bulb in the false belief condition, we dichotomized the scores in the false belief condition into scores below or within 10 mm of the actual location of the flower bulb. Twelve participants with HFASD (19%) pointed to the true location in the false belief condition versus 3 participants from the control group (5%), $\chi^2 = 6.14$, $p = .01$, $\Phi = .55$. In the no false belief condition, no group differences were found, and only one participant with HFASD pointed to the location of the distracting object (stone) $\chi^2 = 1.00$, $p = .32$.

We analyzed the performance on the advanced ToM task with a 2 (Group: HFASD and comparison) $\times$ 2 (Inference: mental state and physical state) repeated measures analysis of variance. No effect of Group or interaction effects between Group and Inference were found (maximum $F = .84$, minimum $p = .36$; see Table 2). The egocentric bias score (based on the subtraction of no false belief scores from the false belief scores) correlated with advanced ToM mental state reasoning scores, $r(124) = -.18$, $p = .04$. This correlation remained marginally significant after partialing out age and language ability, $r(120) = -.15$, $p = .09$. No correlations emerged between egocentric bias and physical state reasoning scores, autism severity, as indicated by the Social Responsiveness Scale, or the ADOS total score. While the Advanced ToM mental state reasoning scores increased with age $r(124) = .26$, $p = .004$, and, marginally with receptive language ability $r(124) = .15$, $p = .09$, the egocentric bias scores on the Sandbox task showed no correspondence with age or language ability.

Discussion

The current study compared the extent to which children and adolescents with and without HFASD exhibit egocentric bias on a first-order false belief task that we measured on a continuous scale (the Sandbox task), compared to a standard advanced ToM task. The Sandbox task significantly discriminated between those with and without HFASD, but the advanced ToM task did not. In the Sandbox task, participants with HFASD more often showed an egocentric response than did individuals from the comparison group. All participants witnessed an object being buried and reburied in two locations in a sandbox, in the absence of a protagonist. Individuals with HFASD incorrectly attributed to the unknowing story protagonist their own privileged knowledge of the object's true location. This way they ignored the false belief of the protagonist, who was unaware of the true location.

The current study is the first to use a continuous measure of false belief reasoning in HFASD individuals. Although we found group differences, the effect sizes were relatively small compared

to other studies using the Sandbox to delineate age differences in ToM development (Bernstein et al., 2011; Sommerville et al., submitted). One reason for this difference is that the two other studies included multiple trials and an actual container and toys. Children with HFASD might relate better to the real-life container, because it does not require them to imagine their response based on the drawing of a hypothetical Sandbox. Furthermore, the two previous Sandbox studies used a larger distance between the two hiding locations, and counterbalanced the hiding locations, possibly increasing the effect sizes obtained. Thus, while the current group differences indicate that the present task, which only takes 2 minutes, can be a promising instrument targeting first order ToM in adolescents and adults, we need to develop the current methodology in a more elaborate and sensitive tool that can be used in clinical practice.

Earlier studies on ASD reported correlations between IQ and ToM skills (see Begeer et al., 2010 for an overview). The current results did not confirm this. This may be due to the nature of the current sample, which included high functioning children and adolescents, which often report fewer symptoms on the ADOS and SRS. It would be worthwhile to repeat the current study using younger or cognitively delayed children with ASD.

A shortcoming of the classic false belief task is its dichotomous nature. In this task, participants either pass or fail the task. Consequently, the researcher concludes that some individuals understand false belief and others do not, respectively. By extension, this conclusion indicates that false belief understanding follows stage-like development. In the current study, we found an age-related increase in advanced ToM performance in both HFASD and typically developing groups. This indicates that advanced ToM reasoning continues to develop through late childhood and adolescence, irrespective of an autism diagnosis. In contrast, we found no age-related increase in performance on the Sandbox task, a first-order false belief task, in either the HFASD or the typically developing groups. This shows the value of the Sandbox task in the assessment of subtle ToM skills in adolescents. Their performance does not increase with age, indicating that they also show subtle egocentric responses during adolescence, and possibly as adults. The age-related increase in conceptual, advanced ToM reasoning can be linked with an understanding of other minds that improves with age, independently from natural mindreading skills. Some additional evidence for a cognitive mediation of advanced ToM skills was found in the near significant correlation between language ability and advanced ToM mental state reasoning score.

Because even typically developing adolescents and adults appear to have difficulties with false beliefs (Keysar, et al., 2003; Birch and Bloom, 2007), some maintain that there is a more generic egocentric bias in all human beings (Epley, et al., 2004; Nickerson, 1999). Conversely, it is possible that individuals with HFASD do have a concept of mental representations. However, compared to typically developing individuals, their relatively stronger egocentric bias hampers their perspective taking performance. This means that the perspective taking problems of individuals with HFASD do not reflect a lack of ToM but rather a weakness inhibiting an egocentric perspective (Epley, et al., 2004). An executive failure in top-down processing likely prevents those with HFASD from benefitting from their intact understanding of mental state concepts.

As suggested by our findings, the capacity to reason correctly about false beliefs continues to develop in both HFASD and typically developing individuals. However, different developmental trajectories of underlying executive competence may be an important driving force behind the ToM problems that HFASD individuals encounter in real life interactions, despite their adequate conceptual skills (Apperly et al., 2011). Further investigations should delineate these developmental trajectories in children with ASD.

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