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Equal egocentric bias in school-aged children with and without autism spectrum disorders



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ABSTRACT

Egocentric bias is a core feature of autism. This phenomenon has been studied using the false belief task. However, typically developing children who pass categorical (pass or fail) false belief tasks may still show subtle egocentric bias. We examined 7- to 13-year-old children with autism spectrum disorder (ASD; $n = 76$) or typical development ($n = 113$) using tasks with a continuous response scale: a modified false belief task and a visual hindsight bias task. All children showed robust egocentric bias on both tasks, but no group effects were found. Our large sample size, coupled with our sensitive tasks and resoundingly null group effects, indicate that children with and without ASD possess more similar egocentric tendencies than previously reported.

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Introduction

The term *autism* stems from the Greek *autos*, meaning “self.” An extreme orientation toward the self, usually referred to as “egocentrism,” is one of the defining features of an autism spectrum disorder (ASD). Over the past 30 years, egocentrism in ASD has been widely studied using the theory of

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mind (ToM) concept (Baron Cohen, Leslie, & Frith, 1985). Theory of mind refers to the ability to understand people as experiencing subjective mental states. Limited ToM of individuals with ASD can be conceptualized as an egocentric bias—a tendency to overestimate how similar other people's experiences are to one's own (Frith & de Vignemont, 2005; Goldman & Sebanz, 2005). This bias is typically assessed by asking children to reflect on a naive story character that holds an objectively false belief. The false belief paradigm has been highly successful in identifying egocentric bias in young children with ASD (Yirmiya, Erel, Shaked, & Solomonica-Levi, 1998), but its sensitivity to potential egocentric bias is limited when used with older and cognitively able children with ASD (Fisher, Happé, & Dunn, 2005; Scheeren, de Rosnay, Koot, & Begeer, 2013). The current study highlights two new tasks to assess egocentric bias in school-aged children with ASD.

Conventional false belief tasks often have limited value for assessing ToM in older children with ASD and those with normal intelligence. The first article on false belief in autism acknowledged this point (Baron Cohen et al., 1985). The usual solution to this problem is to use advanced versions of ToM tasks (e.g., Baron Cohen, Jolliffe, Mortimore, & Robertson, 1997), which require complex forms of reasoning, including double bluff and faux pas. However, even with advanced tasks, the performance of school-aged children and adolescents with ASD and normal intelligence has not consistently indicated a stronger egocentric bias when compared with their typically developing (TD) counterparts (e.g., Scheeren et al., 2013). More important, daily interactions may require advanced ToM reasoning only on relatively rare occasions (e.g., double bluff might be used during a poker game). Much more frequently, daily interactions require the elementary ability to orient oneself toward the inner world of other people. Such interactions do not involve complex recursive thinking but require basic perspective taking. Failing to orient oneself toward the inner world of other people can be referred to as "elementary egocentric bias." Thus, rather than developing complex measures targeting skills that are required infrequently, we need to develop sensitive but simple measures to examine frequently used, basic perspective-taking skills that, despite their elementary nature, remain a problem for individuals with ASD. The problem is to find ways to develop measures for these skills that are sensitive enough to tap individual differences beyond the preschool age.

A recent innovation in the study of elementary egocentric bias is the use of continuous response scales. These allow for a more sensitive measure of egocentric bias, in contrast to the categorical nature of the standard approach, which may be insensitive to perspective-taking deficits in school-age children and beyond. To explain this, consider the standard change-of-location task (Wimmer & Perner, 1983). In this task, participants predict the behavior of a story character who is looking for an object but is unaware that the object has been relocated. Participants must choose between two locations: the object's initial location or its new location. Because the story character is unaware that the object has been relocated, it would be correct to predict that this character would look in the initial location. However, providing participants with a choice *only* between the initial and new locations prompts the initial location as one of the two possible options. This directs participants toward the perspective of the naive story character. In real-life situations, however, we generally do not make egocentric errors in this way. We do not explicitly compare our own perspective with that of another person. In fact, we rarely, if ever, really know another person's perspective (Camus, 1942; Nagel, 1974). However, in the standard change-of-location task, participants who are inclined to respond egocentrically may reconsider their answer after being presented with the two response options. Presenting the alternative correct choice as an explicit option highlights the other person's perspective and, thus, prompts an other-oriented response. This may lead to an underestimation of egocentric bias, which is relevant to individuals with autism but also to individuals with normal development, who may be more egocentrically biased than previously thought.

A first candidate alternative to the standard change-of-location task that uses a continuous response scale is the Sandbox task (Bernstein, Thornton, & Sommerville, 2011b). The Sandbox task is a modified change-of-location task (Wimmer & Perner, 1983) that includes an object that is first buried and then reburied in a sandbox. When participants predict the story character's response, they can pick any spot in the sandbox. Indeed, the continuous response scale that is used in the Sandbox task has been shown to reliably measure egocentric bias in typically developing children, young adults (Sommerville, Bernstein, & Meltzoff, 2013), and older adults (Bernstein et al., 2011b). A previous simpler version of the Sandbox task showed more egocentric bias in children and adolescents with

ASD compared with TD groups (Begeer, Bernstein, van Wijhe, Scheeren, & Koot, 2012). However, group differences in the latter study were relatively small ($\eta^2 = .04$). This could be attributed to the method used, which included only one story drawn on a piece of paper, whereas the previous studies in TD children and adults relied on a series of stories using actual sandbox-like containers and toy objects to be hidden, resulting in medium to large effects (η^2 values between .11 and .17) (Bernstein et al., 2011b; Sommerville et al., 2013).

A second task that measures egocentric bias on a continuum, the Hindsight task, examines reasoning about one's own previous naive state or another person's naive state. Hindsight bias refers to the phenomenon that, after learning an outcome, people find it difficult to judge a naive perspective that lacks this outcome knowledge (Fischhoff, 1975; Roese & Vohs, 2012). Despite the links between hindsight bias and false belief reasoning that have been reported for more than 25 years (Massaro, Castelli, Sanvito, & Marchetti, 2014; Nickerson, 1999) and the focus on hindsight bias in other clinical groups such as schizophrenia (Woodward et al., 2006), to date hindsight bias has not been studied in autism. Similar to the Sandbox task, the Hindsight task uses a continuous response domain and is able to measure subtle patterns of egocentric bias more accurately than all-or-nothing measures. In the visual hindsight task, a line drawing gradually clarifies from a blur into a clear image (see Fig. 1). After identifying the object depicted by the line drawing, participants must judge at what stage of blur another person would recognize the clarifying object. Most people attribute a more rapid recognition of the object to naive persons than they show themselves. Thus, people ignore the fact that, unlike themselves, naive persons do not know what the image will represent yet. Thus, the egocentric perspective distorts the inference of another person's perspective (Bernstein, Atance, Loftus, & Meltzoff, 2004; Bernstein, Atance, Meltzoff, & Loftus, 2007; Bernstein, Erdfelder, Meltzoff, Peria, & Loftus, 2011a; Harley, Carlsen, & Loftus, 2004).

The aim of the current study was to examine elementary egocentric bias in children with ASD compared with TD children using the continuous outcome scales in the Sandbox and Hindsight tasks. Although both tasks require participants to reason about the belief of a naive other, the nature of the beliefs in both tasks differs (Bernstein et al., 2007). In the Sandbox task beliefs refer to an explicit salient state of affairs in reality (i.e., the location of an object), whereas in the Hindsight task beliefs are more vaguely defined and might be better described as hunches or estimations rather than beliefs. We expected that children with and without ASD would show egocentric bias on both the Sandbox and Hindsight tasks but that, compared with their TD peers, children with ASD would show more egocentric bias.

In the current study we also collected response times for both tasks. Individuals with ASD, both children (Apperly, Back, Samson, & France, 2008) and adults (Epley, 2008), may need more time to solve tasks that require perspective taking (Perner & Lang, 1999). This suggests that they rely on their analytic cognitive abilities more than TD individuals, thereby cognitively compensating for their limited social understanding (Frith, Happé, & Siddons, 1994). Therefore, we expected greater response times in the ASD group compared with the TD group.



Fig. 1. The blurred to clear presentation of the object in the Autitouch table version of the visual Hindsight task. (Copyrights Freena Eijffinger/Autitouch).

Method

Participants

After obtaining written parental consent, we included an initial sample of 259 children (7–13 years): those diagnosed with ASD ($n = 119$), recruited via specialized schools for children with ASD throughout the Netherlands, and a typically developing group ($n = 140$), recruited via public primary schools (see Table 1 for participant details). The ASD diagnoses were based on assessments in accordance with DSM-IV (*Diagnostic and Statistical Manual of Mental Disorders*) criteria (American Psychiatric Association, 2000) by psychiatrists or certified psychologists who were working independently from the current research group and were blind to the hypothesis of this study. Children from the TD developing group were matched as closely as possible to those diagnosed with ASD on gender, chronological age, and receptive vocabulary. They had no known history of developmental lag or disorders.

Parents of both ASD and TD children completed the Social Responsiveness Scale (SRS, a parental observation scale; Constantino et al., 2003; Roeyers, Thys, Druart, De Schryver, & Schittekatte, 2011). Participants completed the Dutch version of the Peabody Picture Vocabulary Test-NL (PPVT; Schlichting, 2005; Dunn & Dunn, 1997), which is a receptive language test that correlates with overall

Table 1
Participant details.

	<i>n</i>	Sex Boys/Girls	Age (years)		Verbal ability ^a		SRS ^b	
			<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
ASD	76	68/8	10.61	1.23	102.80	14.17	99.15	20.12
TD	113	93/20	10.31	1.31	110.84	16.03	27.48	11.08

Note. ASD, autism spectrum disorder; TD, typically developing.

^a As measured by the Peabody Picture Vocabulary Test.

^b Score on the Social Responsiveness Scale.

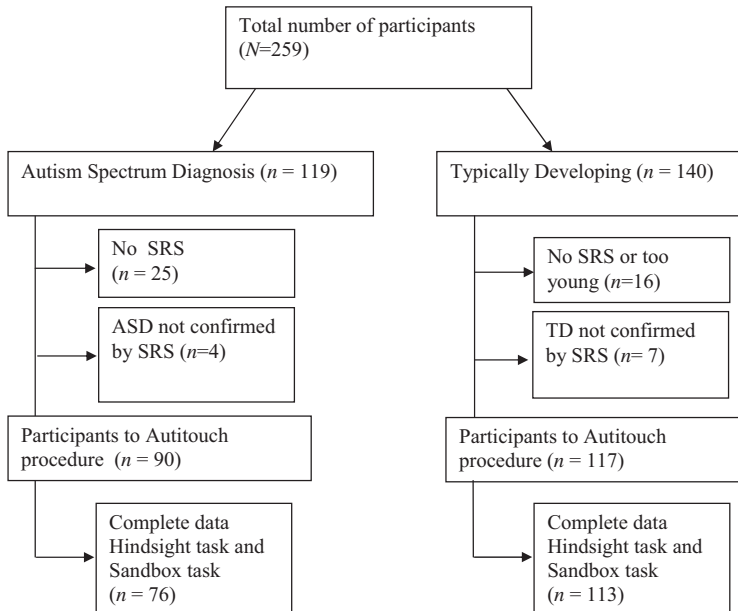


Fig. 2. Flow of participants.

intelligence (Bell, Lassiter, Matthews, & Hutchinson, 2001). We included only children with a raw score above the Dutch threshold for ASD on the SRS (≥ 60 for boys and ≥ 51 for girls). We excluded any TD children who scored above these thresholds. See Fig. 2 for an overview of the participant flow.

Materials

Both egocentric bias tasks were presented on a Microsoft Surface Touch Table, a large-screen touch-based computer. The touch table screen allows one or more people to select and share digital content simultaneously. The software for the current tasks was developed and programmed by Autitouch (copyright Freena Eijffinger/Autitouch).

Sandbox task

The Sandbox task used a prerecorded auditory text (see Fig. 3 for an example; the full text can be requested from the first author). The task was introduced as follows: “You will hear somebody tell a story and see some pictures on the table. After each story, you can move the figure of the story character on the table.” We used a computerized version of the Sandbox task (Bernstein et al., 2011b; Sommerville et al., 2013). For each story, an audio recording automatically conveyed the story content. The stories were illustrated in a 60×45 -cm area on the touch table screen in which two characters were first introduced (see Fig. 3A). In the story, one character (e.g., father) puts an object in an original location while another character (e.g., daughter) watches (Fig. 3B). While the father is away, the daughter moves the object to a second location (Fig. 3C). When the father returns (Fig. 3D), participants were asked to point to where in the box they expected him to look for the object (*false belief condition*) or where he put the object before he left (*memory control condition*). Participants indicated these locations by dragging a virtual picture of the story protagonist to a spot in the virtual sandbox.

Based on each participant’s response, the computer calculated the deviation (in pixels; one pixel is 0.6 mm) between the original hiding location of the object and the location where the participant indicated to look for the object. In all trials, the original and new hiding locations were 34 cm apart, but both locations were always different from those of all other trials. The computer presented mirrored versions of the task for all stories and placed the second hiding location equally often to the left or right of the first hiding location. All participants received the task in a fixed order of two false belief stories, two memory control stories, and again two false belief stories.

Sandbox Scenario

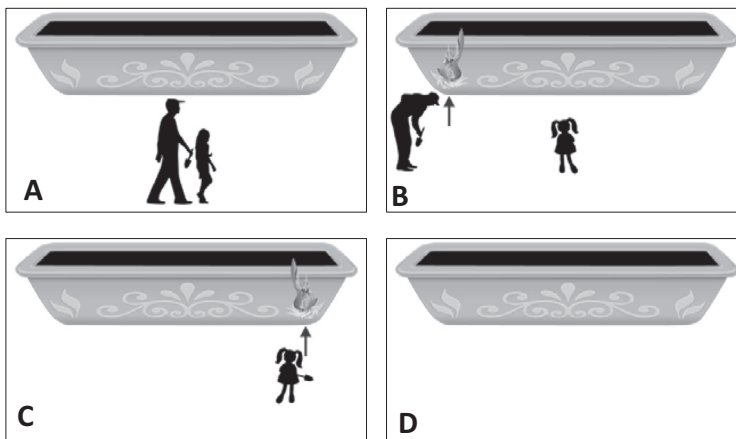


Fig. 3. Example of the surface display in the Autitouch table version of the Sandbox task. (Copyrights Freena Eijffinger/Autitouch).

In the Sandbox task, egocentric bias was conceptualized as responses away from the object's original hiding location (L1) toward its actual hiding location (L2). Biased responses in the memory control condition arguably reflect a lack of memory for L1, whereas biased responses in the false belief condition also reflect egocentric bias. We calculated an average bias score for the false belief condition and the memory control condition separately. We then calculated an egocentric bias score for each participant by subtracting the average bias score in the memory control condition from that in the false belief condition. For example, a child placing the story character on average 100 pixels away from L1 toward L2 in the false belief condition but only 50 pixels away from L1 toward L2 in the memory control condition would receive an egocentric bias score of 50. Thus, a larger positive score indicates a more egocentric response because the child here is more biased in the false belief condition than in the memory control condition.

Hindsight task

During the Hindsight task, children viewed blurred common objects (e.g., a tree) that became completely clear over the course of 10 s. Participants stopped the clarification as soon as they could identify the object (*Own condition*). After this, they were asked to indicate at what level of blur they thought a naïve other person would recognize the object (*Other condition*). Note that they saw each object clearly before estimating when a naïve peer would identify the object as it clarified from blurry to clear in the Other condition. The Hindsight task included five trials, each with a different object that began blurry and then became increasingly clear. Participants completed all five Own trials before completing the five Other trials. There were 100 levels of blur for each object, with a clarification rate of 10 levels of blur per second. Responses were scored on a scale from 100 to 0, where 100 = completely blurred and 0 = completely clear (Bernstein et al., 2011a). The Own condition of the Hindsight task was introduced as follows: "Now we will do a game that includes two tasks. For the first task, you will see a button, and above it you will see a picture. At the beginning the picture is very unclear. However, it will become clearer, a bit like a movie. If you recognize what the picture is, you can press the button and tell me what it is." After a practice trial, the task started. The Other condition of the Hindsight task was introduced as follows: "Now you will see the same picture, but instead of the button you see a scroll bar. Can you indicate when another child, just like you, will recognize the picture? This other child is of your age, also a boy [or girl], and equally bright. The other child has seen none of these pictures before."

The score in the Own condition was the level of clarification when the child named the object correctly. The score in the Other condition was the level of clarification when the child thought another child was able to identify the object. Critically, in the Other condition, the child knew the object's identity *before* estimating for the other child; in the Own condition, the child did not know the object's identity as the object clarified. As with the Sandbox task, we calculated an average Own score and an average Other score for each participant, and then we subtracted the average Own score from the average Other score to yield an egocentric bias score. For example, if the child stopped the clarification on average at 60 in the Other condition but stopped the clarification at 40 (less blurry) in the Own condition, the egocentric bias score was 20. Thus, a larger positive score indicates a more egocentric response because the child who knows the object's identity falsely infers that others should know the object's identity as well.

Peabody Picture Vocabulary Test

The Peabody Picture Vocabulary Test-III-NL (Dunn & Dunn, 1997) assesses receptive language and is highly correlated with more general measures of receptive vocabulary (Hodapp & Gerken, 1999). Participants need to select one of four pictures representing a given word. The test consists of 17 sets of 14 words that increase in difficulty. Based on the PPVT, participants received a receptive vocabulary score standardized for age. The validity of the PPVT is evidenced by strong correlations between PPVT scores and overall intelligence (Bell et al., 2001).

Social Responsiveness Scale

The Social Responsiveness Scale (Constantino & Gruber, 2005) is a 65-item parent questionnaire that examines autistic traits in children. The SRS consists of five scales: social awareness, social cognition, social communication, social motivation, and autistic mannerisms. A higher total score

indicates more autistic traits. Several studies found evidence for good test–retest reliability, interrater reliability, construct and convergent validity, and internal consistency of the SRS (Bolte, Poustka, & Constantino, 2008; Wigham, McConachie, Tandos, & Le Couteur, 2012).

Procedure

Trained assistants tested the children in a quiet room at the children's schools. Participants completed the PPVT and then learned how the touch table screen worked. To familiarize children with the touch table, the experimenter invited them to choose their own background pattern. Once children were comfortable with the touch table, they completed a total of four tasks. The presentation of the Sandbox and Hindsight tasks was counterbalanced and was separated by a third task, described elsewhere (Fink, De Rosnay, Wierda, Koot, & Begeer, 2014), and followed by a fourth task, described elsewhere (Backer van Ommeren, Koot, Scheeren, & Begeer, 2015). The whole procedure took approximately 45 min.

Results

Preliminary analyses

No significant correlation emerged between verbal ability and egocentric bias in the Sandbox task ($r = .09$, *ns*), although higher verbal ability correlated with lower response times in the false belief ($r = -.20$, $p = .007$) and memory control ($r = -.17$, $p = .02$) conditions. Verbal ability correlated significantly with egocentric bias scores in the Hindsight task ($r = -.17$, $p = .02$), indicating that higher verbal ability was associated with less bias. Correlations between verbal ability and response times within the TD and ASD groups were in the same direction but reached significance only in the TD group. Age did not correlate with egocentric bias or response times in the Sandbox task or the Hindsight task (r s between .05 and .14, *ns*). Egocentric bias scores between the Sandbox and Hindsight tasks did not correlate ($r = .06$, *ns*). Because ASD children showed lower receptive vocabulary scores than TD children, $F(1, 182) = 11.59$, $p < .01$, $\eta_p^2 = .06$, we used PPVT scores as a control measure in subsequent analyses. To control for the effect of PPVT covariation, we matched the 76 ASD children to 76 TD children, based on their PPVT scores, and reran all of the analyses without covarying for PPVT. This analysis yielded similar results to those reported below.

Sandbox task

Table 2 lists the mean bias scores for both groups in the Sandbox task. As expected, participants were more biased in the false belief condition than in the memory control condition, $F(1, 186) = 8.97$, $p = .003$, $\eta_p^2 = .05$. Unexpectedly, there was no group difference (ASD vs. TD) in the egocentric bias scores, $F < 1$, and no interaction between group and experimental condition (false belief vs. memory control) (see Table 2). Thus, participants with and without ASD showed signs of egocentric bias, failing to realize that the story character could hold a false belief that deviated from the participants' privileged knowledge. To test whether the null group difference could be attributed to low statistical power, we conducted power analyses with the program G*Power (Faul, Erdfelder, Lang, & Buchner, 2007) that indicated a satisfactory power of $> .99$ for a medium-sized effect ($f = 0.25$) given the sample size of this study ($N = 189$). No effects of group (ASD vs. TD), $F(1, 186) = 1.39$, $p = .24$, or experimental condition (false belief vs. memory control), $F(1, 186) = 1.05$, $p = .31$, were found for response times in the Sandbox task.

To clarify the mean responses and standard deviations on both tasks, Fig. 4 depicts the distribution of mean participant responses by group membership (ASD vs. TD) and experimental condition (false belief vs. memory control) relative to the first and second hiding locations (L1 and L2, respectively). It can be seen that more participants were drawn toward L2 in the false belief condition compared with the memory control condition, but it is also clear where the large standard deviations come from given that responses fall across the whole range between L1 and L2.

Table 2

Mean (SD) Sandbox and Hindsight task responses and response times by participant group and experimental condition.

	False belief	Memory control	Egocentric bias
<i>Sandbox task responses (number of pixels away from object's original hiding place)</i>			
ASD	205.74 (214.81)	98.69 (156.13)	107.04 (209.74)
TD	162.42 (191.55)	101.48 (135.41)	60.94 (205.97)
<i>Sandbox task response times (s)</i>			
ASD	6.70 (7.28)	7.14 (12.28)	
TD	5.41 (5.12)	5.87 (7.19)	
	Other	Own	Egocentric bias
<i>Hindsight task responses (level of clarification: 100 = blurred, 0 = clear)</i>			
ASD	43.08 (13.90)	28.94 (9.52)	14.03 (6.01)
TD	42.78 (11.43)	28.95 (6.67)	13.83 (11.84)
<i>Hindsight task response times (s)</i>			
ASD	2.97 (0.71)	7.11 (0.95)	
TD	3.11 (1.10)	7.10 (0.67)	

Note. Sandbox task scores were measured in pixels (one pixel is 0.6 mm) away from the object's original hiding location (L1) toward its actual hiding location (L2) (see Fig. 3). Hindsight task scores were based on clarification rate of the pictures, from 100 (completely blurred) to 0 (fully clear) (see Fig. 1). ASD, autism spectrum disorder; TD, typically developing.

Hindsight task

Table 2 lists the mean egocentric bias scores in the Hindsight task for participants with ASD and those with typical development. As expected, children showed egocentric bias by estimating that others would recognize the object earlier than they themselves did, $F(1, 186) = 115.66$, $p < .001$, $\eta_p^2 = .38$. Unexpectedly, there was no group difference (ASD vs. TD), $F < 1$, and no interaction between group (ASD vs. TD) and experimental condition (Own vs. Other), $F < 1$. Thus, participants with and without ASD erroneously predicted that another child would recognize a blurred picture before they recognized it themselves. No effect of group (ASD vs. TD) was found for response times in the Hindsight task (Other condition: $F(1, 187) = 1.10$, $p = .29$; Own condition: $F < 1$). Again, the lack of group difference could not be attributed to insufficient statistical power.

Discussion

We aimed to measure egocentric bias in the reasoning of children with autism compared with typically developing children. To do this, we used two recent measures of elementary egocentric bias: the Sandbox task and the Hindsight task. Both tasks include sensitive continuous outcome scales, which we administered to a large sample of children with and without autism. Drawing from one of the most replicated findings in child development, the limitations in ToM in children with autism (Yirmiya et al., 1998), our predictions were straightforward; we expected children with autism to show more egocentric bias on both tasks compared with their typically developing peers. Surprisingly, both tasks showed that children with and without autism were equally prone to be biased by their own knowledge when estimating others' responses. Moreover, response times in both groups were similar, providing little evidence for the suggestion that participants with autism require more time to solve social cognitive problems (cognitive compensation; Frith et al., 1994). Importantly, we can exclude low statistical power as an explanation for the lack of a group difference.

Why did the current outcomes on the Sandbox task fail to replicate previous findings using a similar task in autism (Begeer et al., 2012)? First, children in the current study were generally younger (7–13 years; average age = 10.5 years) than children in the 2012 study (6–20 years; average age = 13.0 years). Thus, it could be argued that the Sandbox task may be more sensitive to detecting group differences between ASD and TD groups in older participants. This may be related to atypical

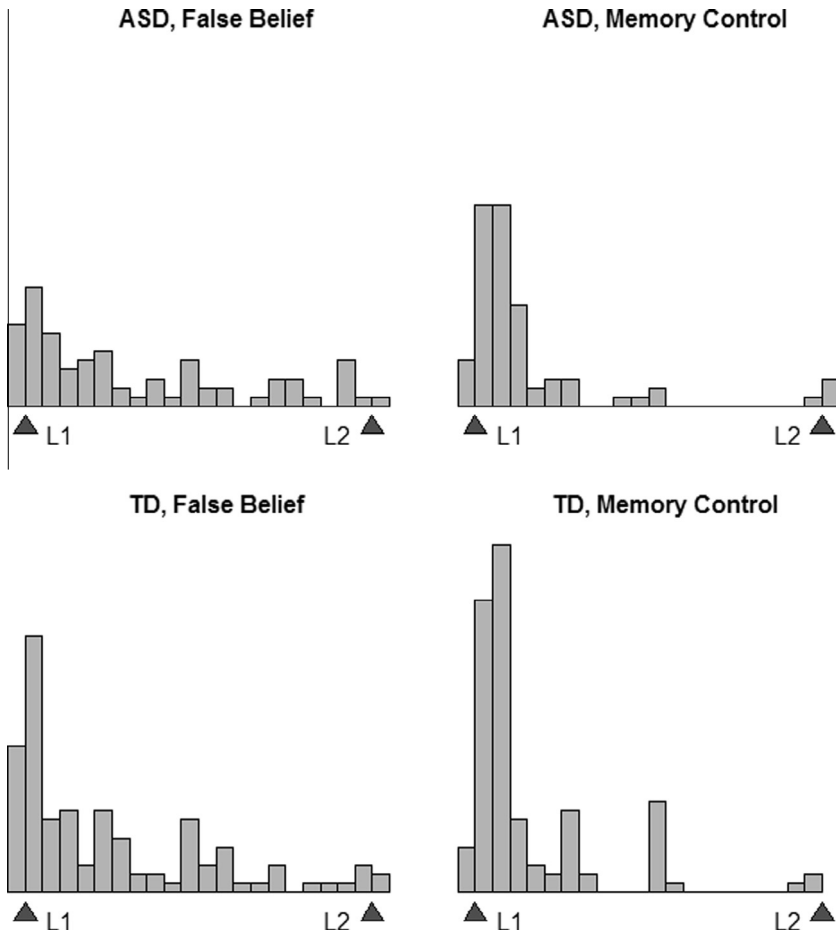


Fig. 4. Distribution of mean participant responses by group membership (ASD vs. TD) and experimental condition (false belief vs. memory control) relative to the first and second hiding locations (L1 and L2, respectively).

development of social cognitive skills in ASD (Schulte-Ruther et al., 2014). More important, in the current approach, responses in the false belief condition were compared with those in a memory control condition, whereas Begeer and colleagues (2012) used a “no false belief” comparison condition (where another object is placed in a second location). The latter approach controls only for participants’ attention to the second hiding location. The memory control condition, however, controls for participants’ ability to remember the first hiding location independent of their ability to acknowledge beliefs. In addition, the current study used six stories that were illustrated with pictures on the touch table screen, whereas the 2012 study used only two stories based on a paper drawing. Although the use of more engaging test procedures may have increased children’s motivation, a higher level of engagement in itself does not adequately explain the different results between the touch table and paper versions of the Sandbox task. Moreover, the classic false belief task has been administered using a variety of techniques, ranging from the paper-and-pencil approach to using dolls, real-life people, or videotaped footage. Overall, however, the mode of task administration does not seem to affect performance in the classic false belief tasks (both unexpected content and appearance-reality; Liu, Wellman, Tardif, & Sabbagh, 2008), although recent studies do highlight the advantage of using

dragging (as used on the touch table) versus pointing (as used in the paper version) techniques in related domains (Segal, Tversky, & Black, 2014).

It seems more likely that, as noted by Somerville and colleagues (2013), the use of a continuous response scale challenges children, both those with and without ASD, to distinguish between their own knowledge and the story character's belief. Similar pervasive egocentric biases were described by Taylor (1988) and subsequently occurred in various publications on both children and adults. Egocentric bias has been described under different headings, including realist bias (Mitchell, Robinson, Isaacs, & Nye, 1996), epistemic egocentrism (Royzman, Cassidy, & Baron, 2003), and the curse of knowledge (Birch & Bloom, 2003, 2007). A common element in these paradigms is that they all refer to general human reasoning and not just to a temporary egocentric state in child development. Integrating these approaches with the developmental psychology literature on ToM results in a fuller understanding of not only the development of social cognition but also the “fully formed” or optimal state of normal adult social cognition, which has received little attention (Barr & Keysar, 2005).

Previous findings in young children (3–5 years) indicated modest correlations between their scores on classic categorical false belief tasks and Hindsight tasks. However, developmental patterns on both tasks were dissimilar; Hindsight tasks remained difficult across all ages, whereas false belief tasks were mastered earlier (Bernstein et al., 2007). The absent correlation between egocentric bias scores in the Sandbox and Hindsight tasks of the current study suggests that in school-aged children (7–13 years) both measures may target different aspects of egocentric bias. Specifically, the low correlation between both egocentric bias measures could also be attributed to subtle differences on a conceptual level. The Sandbox task draws on attributing mental states about an explicit state of affairs (the location of an object), whereas the Hindsight task relies on retrospectively estimating or guessing a fleeting moment of recognizing an object. Thus, although both tasks highlight egocentric bias, the kinds of internal states that are attributed to others may differ fundamentally. This could explain the absent correlation. In addition, it should be highlighted that the nature of the control measures differed between the tasks. A memory control task was used in the Sandbox task, whereas a picture recognition task was used in the Hindsight task. This may have differentially affected the egocentric bias scores in both tasks, hence accounting for a lack of association between them. More specific studies are required to disentangle the differential nature of internal states and the variety of sources of information that can be used to make inferences about others' internal states (Achim, Guitton, Jackson, Boutin, & Monetta, 2013). This will inform future studies on the developmental patterns of ToM in normal and atypical development.

Although the current study included a large sample of children with ASD, who were diagnosed based on extensive procedures following DSM-IV criteria and whose diagnoses we confirmed by parent questionnaires (SRS), we did not have access to other standardized diagnostic measures to confirm their diagnoses such as the Autism Diagnostic Observation Scale (ADOS; Lord et al., 2000). In addition, the assessment of executive function skills and syntactic competence would have allowed for a wider focus on the role of working memory and inhibition in ToM tasks (Drayton, Turley-Ames, & Guajardo, 2011). Although our results were not affected by covarying for verbal ability scores, we should acknowledge that we had no data on full scale or nonverbal abilities. Using these data would have allowed for more in-depth analyses of the relation among language, intelligence, and egocentric bias.

Further replication is needed to shed light on several more abstract explanations of our findings. First, individuals with ASD may be unaffected by real-world problems with perspective taking. Although this is unlikely given the literature on ASD and classic ToM skills and their clinically significant impairments in social interaction, we do require a better definition of ASD-related real-world perspective-taking skills, including a detailed demarcation of what these individuals can and cannot do. Second, egocentrism as measured in this study might not be relevant to real-world problems with perspective taking in ASD. Future studies on correlations with ToM-specific real-life social skills (Fink, Begeer, Hunt, & De Rosnay, 2014) may shed light on the ecological validity of the Sandbox and Hindsight tasks.

The current study showed an overall inclination for egocentric biases that is (a) present in typically developing school-age children but (b) independent of an ASD diagnosis. These findings stand in stark contrast to the literature, which emphasizes egocentric bias as primarily reflected in early childhood

(Wellman, Cross, & Watson, 2001) or a deficit related to autism (Yirmiya et al., 1998). We argue that egocentric bias in TD children has been underestimated. This underestimation, in turn, has resulted in individuals with ASD appearing deficient in ToM reasoning relative to their TD peers. However, we do not claim that children with ASD have no limitations in their social-cognitive abilities. Rather, TD children may be better equipped than those with ASD to correct their intuitive egocentric inclinations, as suggested by Epley, Morewedge, and Keysar (2004). More research is needed to test whether TD children are, in fact, more egocentric than the literature would have us believe.

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