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ORIGINAL PAPER

Theory of Mind and Executive Function in Preschoolers with Typical Development Versus Intellectually Able Preschoolers with Autism Spectrum Disorder

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Abstract Children with autism spectrum disorder (ASD) have difficulties in theory of mind (ToM) and executive function (EF), which may be linked because one domain (EF) affects the other (ToM). Group differences (ASD vs. typical development) were examined in both cognitive domains, as well as EF's associations and regressions with ToM. Participants included 29 intellectually able preschoolers with ASD and 30 typical preschoolers, aged 3–6 years. EF tasks included planning and cognitive shifting measures. ToM tasks included predicting and explaining affective and location false-belief tasks. The novelty of this study lies in its in-depth examination of ToM explanation abilities in ASD alongside the role of verbal abilities (VIQ). Significant group differences emerged on most EF and ToM measures, in favor of typically developing children. Overall in the study group, EF-planning skills, EF-cognitive shifting and VIQ significantly contributed to the explained variance of ToM measures. Implications are discussed regarding the social-cognitive deficit in ASD.

Keywords ASD · Theory of mind · Executive functions · Preschool

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Introduction

Autism spectrum disorder (ASD) is a neurobiological disorder that significantly impairs children's social interactions, verbal and nonverbal communications, and behaviors (*Diagnostic and Statistical Manual of Mental Disorder—DSM-5*, American Psychiatric Association 2013). Theory of mind (ToM) and executive function (EF) comprise two important functions for the understanding of social-cognitive development in ASD. ToM is the ability to infer to others' minds a range of mental states (beliefs, desires, intentions, imagination, emotions, etc.) that cause different behaviors (Wellman and Liu 2004). EF skills refer to higher order cognitive functions like working memory, cognitive shifting, planning, and inhibition, which aid in developing goal-directed behaviors (Hill 2004; Zelazo et al. 2004). Children with ASD reveal documented difficulties in both ToM and EF capabilities (Hill 2004; Isquith et al. 2005; Joseph et al. 2005; Kleinhans et al. 2005). These difficulties underscore cognitive atypicalities that may be considered independent of one another; yet, researchers have established links between ToM and EF among typically developing preschoolers (Hughes and Ensor 2007; Hughes and Graham 2002; Flynn 2007; Flynn et al. 2004; Perner et al. 2002). Nonetheless, such links in intellectually able preschoolers with ASD were explored in only two studies to date (Pellicano 2007, 2010). These two studies showed that EF abilities underlie ToM capabilities even when controlling for factors such as age and verbal ability, and that EF abilities influence the development of ToM.

EF and ToM in Typical Development and in ASD

The present study aimed to shed light on how specific EF mechanisms may be linked with specific ToM mechanisms at the preschool age in ASD. In particular, we focused on EF planning abilities and cognitive shifting because most studies on children with ASD show deficits in these fields (Hill 2004; Ozonoff et al. 1991; Pennington and Ozonoff 1996). To grasp the full scope of ToM abilities, we focused on the ToM mechanisms of prediction and explanation. According to Bartsch and Wellman (1989), children with typical development are able to give correct explanations of false belief before they make correct predictions; yet, data are lacking about explanations of false belief in intellectually able preschoolers with ASD. Research elucidating EF's relations with ToM in general, and with explanation abilities in particular, may advance the conceptualization and therefore the facilitation of social-cognitive development in ASD.

EF Capabilities

Children's EF abilities refer to higher order control processes that include cognitive shifting (the ability to shift one's attention from one stimulus to another), planning (the ability to monitor and evaluate relevant actions), working memory (the ability to store and manage information required to carry out cognitive tasks), and inhibition (the ability to suppress irrelevant or interfering information or impulses) (Hill 2004; Robinson et al. 2009). EF has been widely investigated among school-age children and adults with ASD, and research has pinpointed this population's difficulties alongside preserved abilities (Hill and Bird 2006; Kleinhans et al. 2005; Robinson et al. 2009). Data on adult, adolescent, and school-age samples have, for the most part, shown significant EF deficits in ASD relative to typically developing control groups, mainly regarding cognitive shifting and planning (Hill 2004; Pennington and Ozonoff 1996; Verte et al. 2005). Some ASD studies also found deficits in working memory (Geurts et al. 2004; Landa and Goldberg 2005) and inhibitory response (Christ et al. 2007; Verte et al. 2005). Only a few studies did not find such differences (e.g., Russell and Hill 2001), perhaps due to the measures selected for those studies (Hill 2004).

Interestingly, the few existing studies concerning EF in very young preschool-age children with ASD (age 33 months and up), which examined mostly preschoolers with lower intellectual functioning, generally yielded no significant differences between the ASD group and peers with typical development or peers with developmental delay (Griffith et al. 1999; Rutherford and Rogers 2003; Yerys et al. 2007). One study of older preschoolers with ASD [chronological age (CA) = 64.6 months] who had low cognitive functioning [receptive language mental age (MA) = 30.4 months] found a significant delay on EF tasks (rule learning ability, working memory, and inhibition) in comparison to peers with down syndrome (CA = 65.3; receptive language MA = 27.3 months) and to typical peers (CA = 30.9; receptive language MA = 32.4 months) (Dawson et al. 1998). A possible reason for this discrepancy could be the older age range of the children in this study (CA = 64.6 months) in comparison to the younger age in the aforementioned studies (CA = 33 months and up), thereby leading to the conclusion that various EF impairments may appear at different ages throughout the preschool age period (Pellicano 2007).

With regard to EF abilities in intellectually able children with ASD at preschool ages, Pellicano (2007) compared 30 preschoolers with ASD (CA = 67.6 months) and 40 preschoolers with typical development (CA = 65.7 months). The EF abilities included planning skills [mazes and Tower of London (TOL) tasks], cognitive shifting abilities (the set shifting task—a simplified version of the Wisconsin Card Sorting Test), and inhibitory control (Luria's hand game). The typically developing group significantly outperformed the intellectually able ASD group on all measures except the mazes task. To date, no EF studies have been conducted on intellectually able preschoolers with ASD younger than 67.6 months (mean CA).

ToM Capabilities

ToM abilities are commonly measured using false-belief paradigms, in which children are requested to show their knowledge that people can have different thoughts (including false thoughts) about the same situation. Young typical children develop the ability to explain others' behavior before the ability to predict it (Bartsch and Wellman 1989; Perner et al. 2002). Between 3 and 4 years of age, children can explain other people's actions in terms of false beliefs, thus showing an understanding that belief is separate from desire (Bartsch and Wellman 1989; Wimmer and Perner 1983). In most cases, by age 5, children can predict what action would follow a false belief (Rieffe et al. 2001). By school age (6–7 years), children can successfully predict a protagonist's feelings after receiving a nice or unpleasant surprise (Harris et al. 1989).

Although the ability to explain protagonists' actions is evident at an early age, few ToM false-belief tasks elicit such explanations or analyze their types. Children as young as 3 years can furnish an explanation for a protagonist's actions; yet, at this age preschoolers tend to explain the protagonist's desire ("he wants an apple") rather than the psychological reason underlying that desire ("he wants an apple *because* he is hungry") (Colonnesi et al. 2008). When explaining an affective ToM (false-belief) task, older typical children at school ages tend to supply mentalistic justifications that explain the protagonist's mental state, rather than situational justifications that provide informational facts to support their answer (Parker et al. 2007).

Research that examined ToM abilities in intellectually able preschoolers with ASD found that their performance on false-belief prediction tasks was significantly lower than that of control groups, whether in comparison to preschoolers with typical development (Pellicano 2007) or to preschoolers with specific language impairment (Colle et al. 2007). No study to date has examined the ability of preschoolers with ASD to explain false belief.

Links between EF and ToM

Findings from preschool studies have shown causal relations between EF and ToM both in typical development (Carlson et al. 2004; Hughes and Ensor 2007; Perner et al. 2002; Sabbagh et al. 2007) and in ASD (Pellicano 2007, 2010). EF measures of inhibition, working memory, cognitive shifting, and planning showed significant correlations with ToM prediction tasks in preschool-age children with typical development (McAlister and Peterson 2006). The mental functions connecting EF and ToM prediction abilities involve, amongst others (Sabbagh et al. 2007): (a) the cognitive inhibition (EF ability) required to disengage oneself from real-world, salient situations and focus on abstract representations of the mind (ToM); and (b) working memory and cognitive shifting (EF abilities) required while debating between two contrasting representations—one's own representation of reality and the "other's" representation (ToM). Previous research outcomes showed that children's EF abilities provide an important platform that enables them to develop ToM capabilities (Hughes 1996; Hughes and Ensor 2007; Pellicano 2007).

Moreover, it is important to examine false-belief explanation tasks separately from prediction (Hughes 1998) in order to comprehend which executive demands are needed for each of the separate tasks (Perner et al. 2002). Only a few studies examined the links between ToM false-belief explanation abilities and EF in preschoolers with typical development. Hughes (1998) found a significant association between inhibition (EF) and false-belief explanation (ToM), and Perner et al. (2002) found correlations between the explanation of false belief (ToM) and card sorting that required executive control of cognitive shifting and inhibition (EF abilities). According to these authors, a single component of inhibitory control cannot account for the ability to explain false belief; however, the executive demand of inhibition and additional cognitive load (such as cognitive shifting) can account for such explanations.

Only a few studies have examined the relations between ToM and EF in intellectually able preschoolers with ASD. As described above, Pellicano (2007) investigated the ToM and EF abilities of 30 intellectually able preschoolers with ASD ($M = 67.6$ months) in comparison to 40 same-age peers with typical development who were matched on nonverbal ability and verbal ability. Correlations between EF and ToM were significant and of high magnitude within the intellectually able ASD group, although most correlations' magnitude dropped after partialling out the effects of age, verbal ability, and nonverbal ability. Yet, ToM scores' correlations with the EF composite score and cognitive-shifting score remained significant. Within the typically developing group, ToM scores were initially significantly correlated with scores on the EF composite score, inhibitory control, and one of the planning tasks (TOL), but after adjusting for age, verbal ability, and nonverbal ability, no significant links emerged. Pellicano highlighted EF as an important factor in the development of ToM and of understanding others' minds.

In a later study, Pellicano (2010) examined the longitudinal relationships between ToM, EF, and central coherence (i.e., local vs. global processing) at two different age periods: at 4–7 years and then 3 years later at age 7–10 years. One of the most important findings arising from this study was that individual differences in EF at the first age period predicted the change in children's ToM skills at the second age period, over and above the variance that was accounted for by other factors (i.e., age, verbal ability, nonverbal ability, and children's initial ToM abilities). Furthermore, no links emerged between children's early ToM skills and their later EF abilities, leading to the same conclusion as in Pellicano's earlier (2007) study: Indeed, EF appears to be an important and also predictive factor for ToM abilities in intellectually able preschool children with ASD.

In sum, knowledge concerning ToM and EF relations is far from complete, although substantial progress has been made. It is clear that links and predictive relations do exist between the two cognitive domains, and most studies to date have pinpointed relations between various EF components and ToM.

Current Study Objectives

This study's unique contribution is twofold. First, it offers an in-depth examination of EF and ToM abilities and their links in young preschoolers with ASD. We chose to limit our examination of EF measures to cognitive shifting and planning, because prior research mainly identified significant inter-group differences (ASD vs. typical controls) for these two measures (Hill 2004; Pennington and Ozonoff 1996; Verte et al. 2005). To date, only ToM prediction abilities were assessed in young, intellectually able preschoolers with ASD, not ToM explanation abilities. The current study aimed to expand understanding of ToM capabilities by employing an assessment of false-belief explanation skills. In accordance with previous studies indicating significantly lower scores on ToM prediction tasks among intellectually able children with ASD than their typical counterparts (school ages: Peterson 2005; Slaughter et al. 2007; preschool ages: Pellicano 2007), we hypothesized the same group differences for our participants' predictions as well as their explanations on false-belief tasks. In line with Colonnesi et al. (2008), we examined the children's explanation types (psychological or informative) in the affective false-belief task. Hence, we compared intellectually able preschoolers with ASD versus preschoolers with typical development on two EF abilities (cognitive shifting and planning) and on two major ToM capabilities (explanation and prediction) using first-order false-belief tasks (an unexpected-location task and an affective false-belief task). We also tested the links between EF and ToM.

Inasmuch as ToM tasks in general, and explanation tasks in particular, place a significant demand on children's verbal abilities, we also examined the function of verbal IQ (VIQ). In accordance with Pellicano's (2007) findings that executive abilities and VIQ made independent contributions to ToM scores, we studied VIQ's contribution to the relations between EF and ToM. A further contribution of the current study lies in the specific age group of choice, with a mean of 59.4 months, thus closing the existing gap in the literature concerning EF and ToM capabilities in relation to intellectually able ASD preschoolers. The only other studies we found involving intellectually able preschoolers examined a group of 30 older children with a mean CA of 67.6 months (Pellicano 2007, 2010).

In summary, this study aimed to examine:

1. Group differences (ASD/typical) in ToM and EF. We hypothesized that preschoolers with typical development would outperform preschoolers with ASD.
2. Correlations between ToM (explanation and prediction) and EF (cognitive shifting and planning). We hypothesized positive links between EF and ToM in both study groups.
3. The possible contribution of EF (cognitive shifting and planning) to preschoolers' ToM explanation and prediction abilities. We hypothesized that EF components would predict ToM capabilities in both study groups.
4. The possible contribution of verbal functioning (VIQ) to the explanation of the link between ToM and EF. We hypothesized positive links between VIQ and ToM and EF measures.

Method

Participants

Participants consisted of 59 preschoolers from central Israel: 29 intellectually able children with ASD (4 girls, 25 boys) and 30 with typical development (4 girls, 26 boys).

Table 1 Sample characteristics for intellectually able preschoolers with ASD and preschoolers with typical development

	ASD		Typical		F (1, 58)
	($n = 29$)		($n = 30$)		
	M	SD	M	SD	
CA (in months)	59.45	11.06	55.30	10.97	1.45
Verbal MA[a]	59.41	11.30	58.68	10.53	.25
Nonverbal MA[a]	60.63	11.16	55.87	11.66	1.59
MA[a]	60.05	10.90	57.27	10.83	.97
IQ	103.52	17.21	107.60	14.13	.99
Mother's education[b]	4.90	1.01	5.23	.94	1.33

[a] Based on the Mullen Scales of Early Learning (1995); *WISC-R95* (Wechsler 1998); Wechsler Preschool and Primary Scale of Intelligence (WPPSI-III; Wechsler 2002)

[b] Calculated on a 6-point scale: 1 = less than 8th grade; 2 = some high school; 3 = high school with diploma; 4 = some college; 5 = college degree (e.g., B.A.); 6 = graduate degree (e.g., master's or above)

The two groups were matched for sex, CA, MA, verbal MA (including receptive and expressive language), nonverbal MA (including visual perception and fine motor skills), and IQ (Mullen Scales of Early Learning—AGS Edition, Mullen 1995), as well as mother's level of education. Analyses of variance (ANOVAs) revealed no significant differences between the two groups on these criteria (see Table 1).

All participants with ASD were previously diagnosed by licensed psychologists unassociated with the current study, based on the *DSM-IV-TR* (American Psychiatric Association 2000). Clinical diagnoses were as follows: PDD-NOS (6.9 %, $n = 2$), autism disorder (34.5 %, $n = 10$), and Asperger syndrome (58.6 %, $n = 17$). In addition, all 29 children met full criteria for autism on the Autism Diagnostic Interview–Revised (ADI-R; Lord et al. 1994), which parents completed for the current study to verify diagnosis (ADI-Social: $M = 15.14$, $SD = 4.18$; ADI-Communication: $M = 13.03$, $SD = 4.53$; ADI-Behavior: $M = 5.33$, $SD = 2.07$). Other inclusion criteria included an IQ of 75 or above to assure a high level of cognitive functioning for the participants with ASD.

To assess children's IQ scores, the Mullen Scales of Early Learning (Mullen 1995) were administered to all target children, except for 5 children with ASD who came to the study with prior IQ scores based on recent testing from less than 1 year earlier using the Wechsler Intelligence Scale for Children-Revised (*WISC-R95*; Wechsler 1998) or the Wechsler Preschool and Primary Scale of Intelligence (WPPSI-III; Wechsler 2002). Standard scores of all IQ tests share a comparable mean of 100, with a standard deviation of 15.

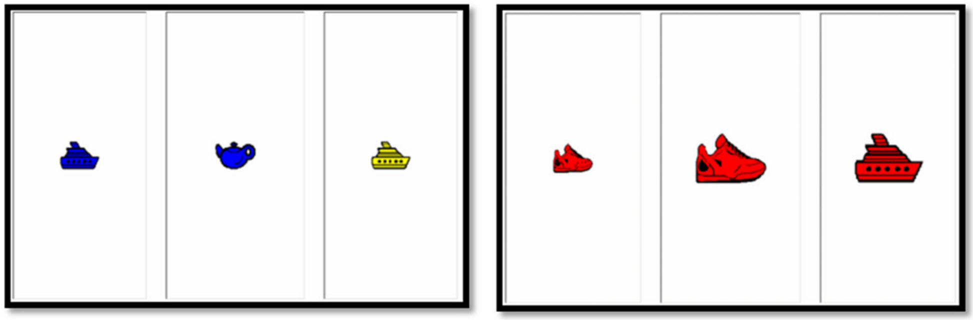

Fig. 1 Two sample card sets from the FIST

Measures

Four measures were administered, two for EF and two for ToM.

EF Flexible Item Selection Task (FIST)

Children's cognitive shifting ability was assessed using the FIST procedure developed by Jacques and Zelazo (2001). As seen in Fig. 1, the task included 15 cards (A4 size) that each contained a set of 3 printed pictures of objects (teapot, ship, or shoe) of a particular color (red, blue, or yellow) and size (small, medium, or large). In each of the 15 trials of the task, children were: (a) shown a card with 3 pictures; (b) asked to select 2 of the pictures that matched each other on one category (object, color, or size)—a categorization task; and then (c) asked to select a different pair of pictures on that same card that matched each other on a different category—a cognitive shifting flexibility task. The categories were unspecified and were to be determined by the child. Children first completed two practice runs, and then, upon succeeding in the practice stage, they proceeded to the task. Two types of errors were scored: categorization error (i.e., failing to correctly identify the category in the first pair selected) and shifting error (i.e., failing to correctly select a second different pair). For each of these two error types, children obtained a global score of either 0 or 1. A score of 0 indicated a mistake on any of the 15 trials or a failure to pass the practice stage, and a score of 1 indicated no errors on any of the 15 trials.

EF Tower of London (TOL)

Children's' planning ability was assessed using the TOL procedure developed by Shallice (1982). Children were presented with a prearranged sequence of three differently colored balls (blue, green, and red) on three pegs of different lengths. For each of 12 trials, children were required to move the balls to match a goal state shown on a parallel board of pegs, in a specified amount of moves and in accordance with pre-specified rules (moving more than one ball concurrently, holding the ball, or putting the ball on the table). Trials' complexity differed in terms of the number of moves required for solution (ranging from 2 to 5) and in the moves' complexity (a direct move in which the child just moved the balls to the correct peg, or indirect moves in which the child first must move a ball off of a peg in order to place the correct ball on that specific peg).

Children were given two attempts to solve each of the 12 trials. After three consecutively failed trials, the task was halted. Each trial was scored between 0 and 4 points as follows: 4 = solved at first attempt with the correct number of moves; 3 = solved at first attempt with an excess number of moves; 2 = solved at second attempt with the correct number of moves; 1 = solved at second attempt with an excess number of moves; 0 = failed to solve at either attempt. Scores for children's general planning ability were computed by summing the correct tasks performed out of the 12 trials given. Thus, the total score for the TOL task ranged from 0 to 48.

ToM Unexpected-Location Task

This first-order false-belief task included four unexpected-location stories with dolls, following Bartsch and Wellman's (1989) procedure. Two stories required *predictions* of the doll's actions, and two stories required *explanations* of the doll's actions. Each of the four stories involved one empty archetypal brand-labeled box (cookies/plastic brick construction set/crayons/adhesive bandages) and a plain box containing the actual brand-name object. The task also included a filler story (a candy box) with non-deceptive contents to prevent children from guessing that the archetypical box would be empty. The filler story was told after the first two stories.

In the two prediction stories (cookies, bricks), children were asked to predict in which of the two boxes the doll would look for the stated object, based on the doll's recognition of the logo, thereby suppressing their own knowledge concerning the real location of the brand-name contents in the plain box. The doll was made to start looking for the cookie in the predicted location, and then the children were asked a reality control question, “Will he find the cookie?” The reality control question was not scored. Children received 1 point for a correct prediction and 0 points for an incorrect one. The total score for the two prediction stories ranged from 0 to 2.

In the two explanation stories (adhesive bandages, crayons), children were asked to explain why the doll was looking in a specific box. In these explanation tasks, the children were introduced to the doll and watched as the doll started to look in an empty brand-labeled box. Then the experimenter asked the children to explain the doll’s action. If the children failed to respond or mentioned something other than the puppet’s beliefs, the experimenter prompted with: “What does Tom think?” In addition, if children gave an incorrect explanation, they were given a prompt (i.e. “Where does the doll think the adhesive bandages/crayons are?”). In each story, children were asked a reality control question (i.e., “Which box really has the contents inside?”). The reality control question was not scored. Correct answers were explanations that attributed a false belief to the character such as “…because he thinks there are bandages in the box.” Children received 2 points for a correct explanation without aid of the prompt, 1 point for a correct explanation following the prompt, and 0 points for an incorrect explanation. Explanation scores thus ranged from 0 to 2 for each separate story, and from 0 to 4 for the total of both explanation stories.

ToM Affective False-Belief Task

In this first-order false-belief task (Harris et al. 1989), children were shown two puppet stories that placed the false-belief scenario in a realistic context, involving an unpleasant surprise and a pleasant surprise. The unpleasant surprise story depicted a puppet who exchanged a friend’s favorite peanut snack for the friend’s disliked snack (candy), while the friend was away. When the peanut-favoring puppet left the room, the prank-playing puppet emptied the clearly labeled bag of the favored snack and filled it with the disliked snack. In the pleasant surprise, the prank-playing puppet exchanged a friend’s disliked food (waffles) for a liked food (honey snack), emptying the clearly labeled waffle bag and filling it with a jar of the favored honey snack, again in the friend’s absence. In both stories, the puppet returned wanting a snack.

Children were asked two prediction questions regarding the puppet’s emotions: before opening the closed snack bag and after opening the bag. Two cartoon faces depicting a happy and a sad expression were presented to allow for pointing responses. Children received 1 point for each correct prediction (before and after opening the closed bag), and 0 points for each incorrect prediction. Prediction scores thus ranged from 0 to 2 for each separate story, and from 0 to 4 for the total of both prediction stories.

After each of the four predictions of puppets’ feelings (before and after opening the bag in each story), children were also asked to explain why the puppet felt that way. Explanations were coded for informative and psychological aspects. Content analysis of children’s explanations was performed by two separate coders, who arrived at 100 % agreement. Children received 1 point for each informative explanation, referring to the relevant informative details of the story (e.g., “the peanut snack isn’t in the bag”), and 0 points if no informative explanation was given. Children also received 1 point for each psychological explanation, referring to the puppet’s preferences (e.g., “because the puppet doesn’t like the candy in the bag”), and 0 points if no psychological explanation was given. Thus, each explanation type (informative and psychological) was coded on a 0–1 scale, and the total score for both stories ranged from 0 to 4 for each explanation type in the affective false-belief task.

Procedure

This study was part of a large project investigating social-emotional aspects of intellectually able preschoolers with ASD and preschoolers with typical development. Parents were contacted through their children’s preschool teachers, after receiving permission from the Israeli Ministry of Education. After the children were found eligible for the study, we arranged three meetings for the children with ASD and two meetings for the children with typical development. The first meeting for children with ASD comprised the ADI-R interview (Lord et al. 1994) of at least one parent. In the second meeting (the first meeting for children with typical development), the Mullen Scales were administered for all participants but 5 children with ASD who had taken IQ tests within the past year. Finally, in the third meeting for ASD (second for typical development), the ToM and EF tasks were administered individually in counterbalanced order in a quiet room in the target children’s preschools.

Results

Group Differences

EF: Cognitive Shifting

We computed Chi square analyses to examine group differences on the two EF–FIST error types (i.e., categorization and shifting), which yielded a significant group difference only on shifting errors. A significantly greater

Table 2 Group (ASD/typical) differences for ToM measures

ToM measures	Group				F (1, 58)	η^2
	ASD		Typical development		Group	
	($n = 29$)		($n = 30$)			
	M	SD	M	SD		
Unexpected-location task						
Prediction	.41	.73	.83	.87	3.98*	.10
Explanation	1.79	1.32	3.10	1.37	13.87***	.20
Affective false-belief task						
Prediction	2.31	1.17	3.07	1.17	6.16*	.10
Informative explanation	1.17	1.31	2.10	1.18	8.14**	.12
Psychological explanation	.93	1.25	.97	1.19	.01	.00

ASD = intellectually able children with autism spectrum disorder

* $p < .05$, ** $p < .01$, *** $p < .001$

number of children in the ASD group ($n = 27$, 93.1 %) made shifting errors than in the typical group ($n = 21$; 70 %), $\chi^2(1, 59) = 5.26$, $p < .05$. No significant group differences (ASD: 58.1 %; Typical: 46.7 %) emerged on the EF-FIST categorization error measure, $\chi^2(1, 59) = .84$, $p > .05$.

EF: Planning Ability

ANOVA was performed to examine group differences on planning ability, which revealed a significant group effect, $F(1,57) = 4.32$, $p < .05$, $\eta^2 = .07$. The ASD group's planning abilities ($M = 15.00$, $SD = 13.41$) were significantly lower than those of their typical peers ($M = 22.27$, $SD = 13.43$).

ToM: Predictions and Explanations

Multivariate analysis of variance (MANOVA) was computed to examine group differences in preschoolers' ToM abilities for their predictions and explanations in the unexpected-location and affective false-belief tasks. The MANOVA revealed a significant group difference, $F(5, 53) = 3.41$, $p < .01$, $\eta^2 = .24$.

Results of the follow-up ANOVAs revealed group differences in both preschoolers' predictions and explanations for the unexpected-location task (see Table 2 for means, standard deviations, and F values). Due to the larger standard deviations than means for the prediction question in both groups, a non-parametric Mann–Whitney computation was conducted, which mirrored the ANOVA results, $U = 318.00$, $p < .05$. As seen in Table 2, the effect size for the explanation task was larger than for the prediction task; hence, the difference between the two groups was greater on the explanation task.

With regard to the affective false-belief task, as seen in Table 2, children with ASD also revealed significantly lower ToM prediction scores compared to children with typical development, as expected. Regarding the ToM explanation types (psychological or informative) in the affective false-belief task, a significant group difference emerged only for preschoolers' informative explanations, not for psychological explanations. Children with typical development were able to provide a significantly greater number of informative explanations for the puppets' feelings in comparison to the ASD group. All ToM variables were found in the normal distribution range according to tests of skewness and kurtosis (less than ± 1.96), despite large standard deviations compared to the mean.

Correlations Between ToM and EF

In line with our second hypothesis, we conducted correlation analysis to examine associations between ToM categories (prediction and explanation in the unexpected-location task and prediction and type of explanation in the affective false-belief task) and EF categories (error type in the cognitive shifting FIST task and the general score in the TOL planning task) for both groups. Findings showed, as expected, that EF and ToM scores were significantly correlated in both groups, with similar directions of correlations in the two groups.

As seen in Table 3, EF planning skills (TOL) correlated positively with prediction abilities on both ToM tasks (unexpected-location and affective false-belief) in the ASD group but only on the affective false-belief task in the typical development group. Regarding EF planning skills' links with ToM explanation skills, correlations were more robust for the typical group, where children who showed better planning on the tower task were more likely to provide correct explanations on the three ToM explanation measures. Children with ASD who had better EF planning skills showed a better ability to provide ToM psychological explanations on the affective false-belief task.

EF cognitive shifting ability (FIST) was significantly correlated with ToM measures in both groups (see Table 3). In the ASD group, fewer categorization errors correlated with better ToM psychological explanations on the affective false-belief task. Also, fewer shifting errors were linked with better prediction abilities on the unexpected-location task. In the group of typically developing children, fewer categorization errors were linked with better explanation abilities on the unexpected-location task, and fewer shifting errors were linked with better ToM prediction and explanation abilities on the unexpected-location task.

Table 3 Pearson correlation coefficients between EF and theory of mind (ToM) abilities in each group

EF task	ToM task									
	Unexpected-location				Affective false-belief					
	Prediction		Explanation		Prediction		Informative explanation		Psychological explanation	
	ASD	Typical	ASD	Typical	ASD	Typical	ASD	Typical	ASD	Typical
Planning (Tower of London)										
General score	.40*	−.02	.23	.47**	.30[a]	.36*	.00	.27[a]	.42*	.34*
Cognitive shifting (flexible item selection task)										
Categorization error	.00	.05	.19	.42**	.02	.23	−.17	.19	.33*	.20
Shifting error	.41**	.30	.25	.44**	.04	.15	-.25	.26	.24	.02

ASD = intellectually able children with autism spectrum disorder

* $p < .05$, ** $p < .01$

The Role of VIQ

To examine the role of verbal capabilities in the links between ToM and EF, we repeated the correlation analyses while partialling out the effects of VIQ. This did not significantly affect the results.

Hierarchical Regressions

Hierarchical regression analyses were performed to test the third hypothesis with regards to the contribution of EF planning and cognitive shifting skills to the ToM prediction and explanation abilities, with the following five dependent variables: (a) predictions and explanations on the unexpected-location task, and (b) predictions, informative explanations, and psychological explanations on the affective false-belief task. The regression series included the predictors in the same order, as follows: The first step introduced group (ASD/typical), the second step included VIQ, and the third step included the EF dimensions of cognitive shifting (categorization error, shifting error) and planning (TOL general score).

Results of regression analysis are shown in Table 4. Independent variables best contributed to children's ToM explanation ability on the unexpected-location task ($R^2 = .43$). Next, these variables contributed similarly to children's psychological explanations on the affective false-belief test ($R^2 = .22$); prediction ability on the affective false-belief ($R^2 = .21$); and prediction ability on the unexpected-location task ($R^2 = .19$). The independent variables did not contribute to children's ability to provide informative explanations on the affective false-belief test.

As seen in Table 4, group status (entered as the first step) significantly contributed to three out of the five ToM variables (explanation of actions on the unexpected-location task, and prediction and informative explanation of feelings on the affective false-belief task). The difference between the groups contributed 18 % to the explanation of the variance in children's ability to explain the doll's actions in the unexpected-location task, 14 % of the ability to supply an informative explanation of the puppet's feelings in the affective false-belief task, and an even lower percentage (10 %) of the ability to predict the puppet's feelings. As expected, for each of these variables, children with typical development showed higher ToM skills than children with ASD. The inclusion of VIQ in the second step contributed to two out of the three explanation tasks, adding10 % to the unexpected-location task and adding 7 % to psychological explanations on the affective false-belief task, but it did not contribute to children's prediction skills. Thus, higher VIQ significantly contributed specifically to children's better explanation capabilities. EF scores (both cognitive shifting and planning abilities) were entered in the third step, contributing a significant increase in explained variance beyond group and VIQ across four of the ToM capabilities: prediction (adding 13 %) and explanations on the unexpected-location task (adding 15 %), predictions on the affective false-belief task (adding 9 %), and psychological explanations on the affective false-belief task (adding 15 %). Among the different EF variables, TOL planning ability was predictive of the three aforementioned ToM capabilities, with higher planning skills contributing to better ToM task performance. Cognitive shifting capabilities were predictive of prediction and explanation on the unexpected-location task, with higher shifting abilities contributing to better ToM task performance.

Discussion

The main findings of the current study showed that intellectually able children with ASD demonstrated difficulties on EF (cognitive shifting and planning) abilities and on most ToM prediction and explanation abilities, relative to matched typically developing preschool age children.

Table 4 Hierarchical regression analysis for ToM by group, VIQ, and EF variables

Predictors	ToM variables									
	Unexpected-location task				Affective false-belief task					
	Prediction		Explanation		Prediction		Informative explanation		Psychological explanation	
	β	ΔR^2	β	ΔR^2	β	ΔR^2	B	ΔR^2	β	ΔR^2
Step 1		.06		.18***		.10*		.14**		.00
Group	.24		.43***		.32*		.38**		.01	
Step 2		.00		.10**		.02		.00		.07*
VIQ[a]	−.07		.32**		.11		−.06		.27*	
Step 3—EF		.13*		.15**		.09*		.03		.15*
Categorization error[b]	−.12		.08		.06		.00		.20	
Shifting error[b]	.36**		.26*		.03		.05		−.05	
Planning[c]	.14		.23*		.31*		.15		.34**	
R^2		.19*		.43***		.21*		.17		.22*
F test		2.52*		7.84***		2.80*		2.14		2.93*

[a] VIQ-verbal IQ based on the Mullen Scales of Early Learning (1995); *WISC-R95;* Wechsler 1998); Wechsler Preschool and Primary Scale of Intelligence (WPPSI-III; Wechsler 2002)

[b] Cognitive shifting measure—flexible item selection task

[c] Planning measure—TOL task

* $p < .05$, ** $p < .01$,*** $p < .001$

However, in both groups, EF planning and cognitive shifting as well as VIQ contributed to better ToM explanation and prediction abilities, supporting and expanding former findings (Pellicano 2007), as will be detailed below.

Group Differences and Similarities in EF and ToM Abilities

In line with our first hypothesis, the typically developing children significantly outperformed the intellectually able children with ASD in the current study on both EF tasks, planning and cognitive shifting, although the preschoolers revealed no group differences in their ability to successfully categorize 2 out of 3 given pictures by an unspecified category. Interestingly, some prior studies on very young, low cognitively functioning preschoolers with ASD (mean age of 33 months and up) showed no deficits on EF measures of inhibition, cognitive shifting, and working memory (Griffith et al. 1999; Rutherford and Rogers 2003; Yerys et al. 2007); yet, by 6 years of age, the majority of studies concerning EF in ASD reported deficits, in both high and low intellectually functioning samples (Corbett et al. 2009; Shu et al. 2001; Pellicano 2007; Yerys et al. 2009). In the current study of cognitively able preschoolers, we did find significant differences from 36 months onwards, both on planning and cognitive shifting tasks, thus underscoring the need to examine the age when children with ASD actually "grow into" an EF deficit (Pellicano 2007). It seems that the age of onset for EF deficits in ASD may possibly appear during the later preschool years. Another possible explanation for this discrepancy may be the existence of distinct subgroups of children with greater or lesser executive dysfunction, as found by White et al. (2009). In White et al.'s study, intellectually able school-age children with ASD showed a wide range of abilities on EF tasks that varied from below to above the control range, showing that some children with ASD had more intact EF capabilities. Further examination is required to tease out this issue.

Ability to Predict Mental States

According to Wellman and Liu's (2004) sequential stage model of ToM prediction development in typically developing children (1-diverse desires, 2-diverse beliefs, 3-perceptual access to knowledge, 4-false-belief [of location], and 5-hidden emotion), the current study's ToM unexpected-location task tested the study participants' prediction abilities at the third and fourth stages, whereas the affective false-belief task coincided to some degree with the fifth (hidden emotion) stage. In the third stage, children are tested on their ability to predict knowledge access (i.e., correctly predicting the response of a character concerning an item inside a container, by setting aside one's own knowledge). In the fourth stage, children are tested on their ability to suppress their own knowledge concerning the real location of the contents. Thus, the current study's findings suggest that intellectually able preschoolers with ASD showed difficulty from the third stage of the model onwards. (Note that the test used by Wellman and Liu to assess the fourth stage derived from the same Bartsch and Wellman 1989 unexpected-location prediction task used in our study.)

Ability to Explain Mental States

A major point of interest in our study was the examination of ToM explanation tasks in ASD. Children with typical development first acquire the ability to explain false belief and then to predict it (Bartsch and Wellman 1989). When comparing effect sizes for the various ToM measures in the current study, the largest effect size emerged for explanation of false belief in the unexpected-location task, which may imply that the provision of explanations for others' behaviors based on mental states is specifically challenging for the ASD group in comparison to the typical group. This finding raises questions as to the cognitive demands required to succeed in explanation tasks for the ASD group. Explanations may involve more complex cognitive abilities, including higher verbal skills, apparently making it a more complex task within ASD.

The false-belief task that examined the pleasant and unpleasant surprise scenarios (Harris et al. 1989) tested children's understanding that emotions can be caused by mental states such as desires and beliefs. The ability to explain actions in such terms is fundamental to understanding people and to interacting effectively in social situations. When asked to explain puppets' emotions, children with ASD gave fewer informative explanations than the children with typical development but, surprisingly, a similar number of psychological explanations. The ASD group's seemingly intact ability to provide psychological explanations for puppets' happy and sad emotions seems to contradict what is known concerning ToM in children with ASD because psychological explanations might be considered an explicit means by which children show their understanding of the social world (Colonnesi et al. 2008). However, the emotion recognition deficit in cognitively able children with ASD may not become apparent until they are required to recognize complex emotions and mental states (Golan et al. 2007; Harris 1989) or atypical emotions (Rieffe et al. 2000). The current study merely requested recognition and explanation of clear-cut basic emotions—happy/sad—which are not overtly complex. Indeed, in previous studies children with ASD were shown to have a good understanding of typical emotional scenarios (Capps et al. 1995). These findings may add to the accumulating research (e.g., Rieffe et al. 2000) that challenges the "mindblindness" theory stating that children with ASD do not refer to others' mental states to explain their behavior. Nonetheless, such speculation must be stated with caution because the number of psychological explanations supplied by both groups was low overall.

ToM and EF Links in ASD and Typical Development

The current findings demonstrated links between EF and ToM in both groups, especially between preschoolers' planning abilities and their capacity to predict and explain false beliefs, and also between their cognitive shifting and prediction abilities. The present findings support previous outcomes concerning links between EF and ToM prediction abilities in young children with ASD (Pellicano 2007) and uniquely extend those prior outcomes in relation to ToM explanation abilities.

Links Between EF Planning Ability and ToM Skills

Planning is a multidimensional concept, and according to Frye (2000), in order to be able to plan appropriate responses to a given problem, children need conditional reasoning ability (if–if–then reasoning). This same ability is required for success in understanding false-belief tasks where respondents must analyze protagonists' actions. Based on the link found between EF-planning and ToM-prediction, deficits in planning abilities as seen in the ASD group could reflect a difficulty in producing or comprehending intentional action plans.

With regard to explanations of mental states, planning skills were also significantly related to the ability to produce explanations on all false-belief tasks among typical preschoolers, and to the ability to provide psychological explanations among preschoolers with ASD. Planning encompasses the ability to mentally visualize the strategic steps needed for constant monitoring, evaluation, and updating of actions. The ability to explain false belief increases in preschool, as children gain more opportunities to witness what other people like and dislike and can then draw on these experiences for future reference (Atance et al. 2010). Through such experiences, preschoolers monitor and evaluate the knowledge they accumulate, highlighting that high-order cognitive planning is crucial for appropriate explanations in false-belief tasks. To further elucidate preschoolers' ability to supply psychological explanations in the ASD group and informative explanations in the typical group, future research should systematically examine the components of planning and explanation.

Links Between EF Cognitive Shifting and ToM Skills

False-belief tasks require shifting from one's own perspective to another's, thus facilitating the ability to conceive alternative models of reality (Kissine 2012). Children with ASD have difficulties shifting between their model of reality and others'. The links found between cognitive shifting and prediction abilities in ASD follow the pattern found in prior research. For example, Zelazo et al. (2002) found that although most correlations between false-belief prediction and cognitive flexibility (based on raw scores) dropped to nonsignificance in the typical group, the correlations remained significant for the group of mildly cognitively impaired school-age children with ASD. Likewise, false-belief predictions by intellectually able preschoolers with ASD remained significantly correlated with cognitive shifting skills (as measured by an adapted version of the Wisconsin Card Sorting Test), even after partialling out for individual differences (Pellicano 2007). In another study, robust correlations persisted between preschoolers' cognitive shifting (as measured by a two-dimensional change card-sorting test) and ToM prediction and explanation tasks, even after partialling out age, verbal intelligence, and performance intelligence (Perner et al. 2002). Interestingly, our findings showed that cognitive shifting was significantly related to explanation ability in the typical group, like the typically developing preschoolers in Perner et al. (2002), but this correlation did not emerge for the ASD group.

The Contribution of EF to ToM Abilities

Causal and predictive relations between EF and ToM have been established both in typical development and in ASD (Carlson et al. 2004; Hughes and Ensor 2007; Pellicano 2007, 2010; Perner et al. 2002; Sabbagh et al. 2007). The regression analyses in the current study revealed that the EF abilities of shifting and planning contributed significantly to ToM in both study groups. Cognitive shifting predicted children's capacity to switch between modes of thought; moreover, simultaneously thinking about multiple concepts enabled the children to shift between their own belief and the presented false belief, both predicting and explaining it. Planning first and foremost predicted children's explanation abilities. In the unexpected-location task, children who had better planning skills could disengage from their own beliefs and verbally explain another's misconception regarding the location of an object. Higher planning skills also predicted children's ability to supply a verbal psychological explanation for another's emotions on the affective false-belief task. Furthermore, planning also played a role in preschoolers' ability to predict others' emotions on the affective task.

These findings underscore the importance of developing preschoolers' EF skills to facilitate their success on verbal tasks such as the current explanation tasks. In a study that examined the relations between EF and verbal ability in intellectually able school-age children with ASD, Joseph et al. (2005) found that executive ability was unrelated to language ability in their ASD group but was linked in their typically developing control group. Joseph et al. suggested that children with ASD do not use their language skills to facilitate their performance on the various EF tasks, in contrast to children with typical development. This assumption that children may not use their language skills to improve EF abilities deserves further examination in light of the current findings that highlight the importance of EF abilities for generating relevant verbal explanations in ToM tasks.

The Role of VIQ

Language plays a causal role in the development of ToM abilities in both typically developing children and children with ASD (Steele et al. 2003; Tager-Flusberg and Sullivan 1994). Inclusion of VIQ in the regression added to the explained variance for two out of the three ToM explanation tasks: for children's explanations of the doll's actions in the unexpected-location task and for their psychological explanations in the affective task. Interestingly, VIQ did not add to the explained variance of the prediction tasks. Notwithstanding, verbal ability clearly plays an important role in the relations between ToM and EF skills in ASD (Biro and Russell 2001; Russell 1996), and it plays an important role in facilitating ToM abilities (Pellicano 2010). This relationship demonstrates the need to deliver treatments for executive dysfunction in general among children with ASD, and for planning abilities in particular. Altogether, these findings are consistent with the literature stating that EF is crucial for the development of ToM (Pellicano 2010; Russell 1996), irrespective of verbal ability.

Conclusions and Limitations

The present study contributed to the body of research addressing the role of EF and verbal abilities vis-à-vis ToM abilities in ASD. We found that higher order cognitive functions (EF planning skills) and language skills are indeed important abilities for preschoolers' ToM in general and ToM explanation abilities specifically. Notwithstanding, the current study has several limitations. First, the statistical analysis in this study revealed some cases of standard deviations higher than the mean. Although we tested the normality of the distribution and conducted nonparametric analyses in all such cases, it remains unclear whether this distribution could have affected the results, and future studies would do well to further examine this point. Second, we selected our ASD participants because of their high cognitive functioning, thereby possibly limiting the findings' generalizability to the larger group of preschoolers with lower intellectual ability. Furthermore, although the sample studied here is considered appropriate in size for research in clinical subgroups such as intellectually able children with ASD, its small size may have limited the power of our analyses to detect associations and predictors. Therefore, caution must be taken in interpreting the results, and replication studies are needed to verify the current findings.

Despite these limitations, this study's outcomes hold important clinical and theoretical implications. There is a clear need for future research on the relations between other EF components and the specific components of ToM prediction and explanation, including false (hidden) emotions and not only affective false beliefs as investigated here. Inasmuch as explication abilities are a crucial skill for everyday life, it is important to examine this skill further for children with ASD at all ages, and not only in preschool. In addition, the current study involved the use of only two EF tasks. Future research should assess whether these findings generalize across different EF assessments, including computerized ones, as well as across different EF components like inhibitory control and working memory.

Furthermore, based on the success of Fisher and Happe's (2005) study, which identified significant improvements on ToM task performance in intellectually able school-age children with ASD who underwent training in EF, we recommend expanding such interventions to lower ages and other EF skills. Appropriate interventions may be designed for preschoolers with ASD to target EF planning abilities, not only cognitive shifting and inhibition as targeted in Fisher and Happe's training study. If indeed better planning skills and verbal skills can facilitate ToM explanation abilities in children with ASD, then appropriate interventions could directly promote their social abilities both for understanding and for explaining other persons' intentions, beliefs, and behaviors. The possibility that EF facilitates children's ToM abilities in general, and in young preschoolers with ASD in particular, should be further studied and pursued at both the theoretical and operative levels.

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