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Authors

Santini, Anysa
Bullen, Jennifer C
Zajic, Matthew C
et al.

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BRIEF REPORT

Brief Report: The Factors Associated with Social Cognition in Children with Autism Spectrum Disorder

Anysa Santini[1] · Jennifer C. Bullen[2] · Matthew C. Zajic[3,5] · Nancy McIntyre[4,5] · Peter Mundy[5,6]

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Abstract

This study examined whether school-aged autistic children without co-occurring intellectual disabilities (autistic$_{WoID}$) show similar difficulty on Theory of Mind (ToM) tasks as young autistic$_{WoID}$ children and if these difficulties are related to problems in domain-general aspects of cognition. Eighty-one autistic$_{WoID}$ and 44 neurotypical (NT) children between the ages of 8–16 years participated in this study and were matched on verbal IQ. ToM performance significantly and independently differentiated many, but not all, autistic$_{WoID}$ and NT participants above and beyond the effects of working memory and inferential thinking. However, these cognitive variables did not fully explain difficulties with social cognition in autistic$_{WoID}$ children. These findings have implications for understanding autism, the factors that may impact intervention for social cognition in autism, and the factors that impact the education of autistic children who may struggle in general education classrooms.

Keywords Autism spectrum disorder · Social cognition · Theory of mind

Autism spectrum disorder is a neurodevelopmental disorder that affects social development in around 1 in every 44 children in the United States. Of these children identified with autism, approximately two-thirds are not affected by co-occurring intellectual disability diagnosis (Maenner et al., 2021). Social symptoms for children with autism without intellectual disability (autism$_{WoID}$) remain prominent, and despite the increasing prevalence of autism, the social symptoms are not fully understood.

As noted by Alkire et al. (2020), many psychological processes may be involved in the development of the social symptoms in autism. In this regard, research suggests that performance on Theory of Mind (ToM) measures may be associated with measuring the social symptoms of autism. However, the degree to which problems with social cognition in autism are associated with or explained by domain-general (i.e., non-social) cognitive processes, such as working memory, inferential thinking, and verbal IQ (VIQ) remains unclear. For example, some research has suggested that better working memory correlates with better performance on ToM tasks (Gordon & Olson, 1998) possibly because working memory is often involved in the processing of social information (Meyer & Lieberman, 2012; Phillips et al., 2008). The ability to hold different social perspectives in one's mind is inherent to ToM tasks, as individuals must simultaneously process their own and other's viewpoints to correctly answer questions (Kouklari et al., 2018; Moses & Carlson, 2004). Autistic children often display memory difficulties (Boucher et al., 2012; Williams et al., 2006), particularly in response to emotion- or person-related stimuli (Boucher et al., 2012).

Research has also found that autistic children show difficulties in making inferences, especially those relating to

✉ Jennifer C. Bullen
jcbullen@ucdavis.edu

1 Department of Neurobiology, Physiology, and Behavior, University of California Davis, Davis, CA, USA

2 Department of Human Ecology, Human Development, University of California Davis, One Shields Ave, 1315 Hart Hall, Davis, CA, USA

3 Present Address: Intellectual Disability/Autism Program, Department of Health and Behavior Studies, Teachers College, Columbia University, New York, NY, USA

4 Present Address: School of Communication Sciences and Disorders, College of Health Professions and Sciences, University of Central Florida, Orlando, FL, USA

5 School of Education, University of California Davis, Davis, CA, USA

6 MIND Institute, University of California Davis, Sacramento, CA, USA

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implied social information (Kaland et al., 2005, 2011; Le Sourn-Bissaoui et al., 2009). Typical ToM tasks often recruit the ability to use background information to make inferences about the causes of character behavior in stories or vignettes (Le Sourn-Bissaoui et al., 2009). This raises the hypothesis that inferential thinking may be related to ToM performance. Consequently, difficulties with inferences may mediate difficulties with ToM performance in autism. However, research on this relationship is limited, so the present study seeks to explore it further.

Finally, it is also possible that VIQ is related to individuals' ability to correctly complete ToM tasks. A significant association between ToM and language development has been observed in autistic children (Astington & Baird, 2005). Moreover, those who have higher VIQs may compensate for impairments in social cognition with better language ability. Children with autism with higher VIQs perform better on ToM tasks than children with ASD-WoID who have lower VIQs (Bauminger & Kasari, 1999; Happé, 1995; Kaland et al., 2005; Livingston et al., 2019). Thus, it is possible that autistic children rely on general cognitive abilities such as language to complete ToM tasks as opposed to relying on social cognitive mentalizing (Tager-Flusberg, 2007).

Because of these observations, it remains unclear if autistic children's difficulties on ToM measures are (a) due to impairments in social cognitive processes, (b) due to general cognitive difficulties, or (c) due to both social and domain-general cognitive differences. The current study was designed to test these alternatives by examining the degree to which the ToM problems associated with autism may be explained by impairments in domain-general aspects of cognition, such as working memory, inferential thinking, and VIQ or whether social cognition and general cognition have unique but additive impacts on ToM performance. If the former were true, we would expect that domain-general cognitive measures would fully account for the social cognitive diagnostic differentiation of autistic and NT children. On the other hand, ToM tasks often differentiate autistic children from their neurotypical (NT) peers (Baron-Cohen et al., 2000). Therefore, if social cognition and general cognition have unique but additive effects, we would expect ToM performance to significantly discriminate between the samples even when the effects of domain-general cognitive variables are considered.

Method

Participants

The data for the study were obtained from a previous longitudinal study that examined academic development in children identified with attention-deficit/hyperactivity disorder or autistic children without intellectual disabilities (autistic$_{WoID}$) alongside their NT peers. For the purposes of this study, only autistic$_{WoID}$ and NT participants were included. Participants consisted of 125 children (94 males, 31 females) between the ages of 8–16 years: 81 in the autistic$_{WoID}$ group ($M = 11.29$ years, $SD = 2.13$), and 44 in the NT group ($M = 11.59$ years, $SD = 2.25$).

Children from participating families were volunteers from several school districts in a Northern California metropolitan area. Autistic$_{WoID}$ children entered the study with a community diagnosis of autism and had to meet criteria on the Autism Diagnostic Observation Scale-2 (ADOS-2; Lord et al., 2012) Module 3 or 4 administered by a research-reliable research team member. Parents filled out the Social Communication Questionnaire-Lifetime Version (SCQ; Rutter et al., 2003), the Autism Spectrum Screening Questionnaire for children (ASSQ; Ehlers et al., 1999), and the Social Responsiveness Scale (SRS; Constantino & Gruber, 2005) to report ASD symptoms. The NT group required no history or symptoms of neurodevelopmental disorders according to parent report data. Parent consent and child assent were obtained for each participant in this study. Approval from the university Institutional Review Board was obtained prior to the implementation of this study. Table 1 provides demographic information for the autistic$_{WoID}$ and NT groups.

Procedure

Participants in this study were part of a 30-month longitudinal study to assess academic, social, and cognitive development in children with ASD, ADHD, or neurotypical development. Participants were assessed at three time points separated by 15 months (± 3 weeks). Data was collected by trained members of a research group at a university laboratory during 2.5 h sessions conducted within two weeks. Data for these analyses are primarily from Time Point 2 of the longitudinal study, except for the symptomatology, demographic, and IQ variables, which were collected at Time Point 1.

Measures

IQ

Full-scale IQ (FIQ) and VIQ were assessed using scores obtained from the Wechsler Abbreviated Scale of Intelligence, 2nd Edition (WASI-2; Wechsler, 2011). The WASI-2 contains the following four subtests: Vocabulary, Block Design, Similarities, and Matrix Reasoning. FIQs were used to screen for participants without ID (i.e., FIQ ≥ 74). Because we were particularly interested in the impact of verbal abilities, the autistic$_{WoID}$ and NT samples were matched

Table 1 Demographic information for the $autistic_{WoID}$ and NT groups

	$Autistic_{WoID}$ (N = 81)	NT (N = 44)	Statistic	P-Value
Age (in years)	11.29 (2.13)	11.59 (2.25)	$t(123) = -0.72$	0.47
Grade	5.58 (2.17)	6.03 (2.19)	$t(123) = -1.09$	0.28
Sex			$\chi^2(1) = 3.96$	0.05
Male	66 (81%)	28 (64%)		
Female	15 (19%)	16 (36%)		
Percent time in general education			$\chi^2(4) = 9.27$	0.06
81–100%	53 (65%)	38 (86%)		
61–80%	6 (7%)	2 (5%)		
41–60%	4 (5%)	1 (2%)		
< 40%	8 (10%)	1 (2%)		
0%	8 (10%)	0 (0%)		
Missing	2 (3%)	2 (5%)		
Learning disability endorsed			$\chi^2(1) = 1.86$	0.17
Yes[a]	9 (11%)	1 (2%)		
No	72 (89%)	42 (95%)		
Missing	0 (0%)	1 (2%)		
Ethnicity			$\chi^2(16) = 28.58$	0.05
Hispanic/Latino	8 (10%)	1 (2%)		
Asian	4 (5%)	1 (2%)		
Black/African American	1 (1%)	0 (0%)		
Native Hawaiian/Pacific Islander	0 (0%)	1 (2%)		
White	53 (65%)	31 (70%)		
Hispanic/Latino + Asian	0 (0%)	3 (7%)		
Hispanic/Latino + White	3 (4%)	2 (5%)		
Asian + White	1 (1%)	2 (5%)		
Black/African American + White	2 (3%)	0 (0%)		
Native Hawaiian/Pacific Islander + White	1 (1%)	0 (0%)		
Multi-Ethnic (3 or more identities reported)	3 (4%)	0 (0%)		
Decline to State	2 (3%)	0 (0%)		
Other	3 (4%)	0 (0%)		
Missing	0 (0%)	3 (7%)		
Mother education level			$\chi^2(6) = 4.74$	0.58
Some High School	1 (1%)	1 (2%)		
Completed High School	2 (3%)	0 (0%)		
Some College	20 (25%)	9 (20%)		
College	29 (36%)	17 (39%)		
Some Grad	6 (7%)	1 (2%)		
Graduate School	22 (27%)	12 (27%)		
Missing	1 (1%)	4 (9%)		
Father education level			$\chi^2(6) = 7.05$	0.32
Some High School	1 (1%)	0 (0%)		
Completed High School	6 (7%)	1 (2%)		
Some College	24 (30%)	8 (18%)		
College	29 (36%)	14 (32%)		
Some Grad	4 (5%)	2 (5%)		
Graduate School	16 (20%)	14 (32%)		
Missing	1 (1%)	5 (11%)		

$Autistic_{WoID}$ autistic children without intellectual disabilities, *NT* neurotypical

[a]Of the 10 learning disabilities reported, 2 were auditory processing disabilities, 2 were sensory processing disabilities, two were writing disabilities (includes the 1 NT participant) and 4 were unspecified learning disabilities

in "higher VIQ" and "lower VIQ" subgroups based on a sample median VIQ split at 101.5. See Table 2. Internal consistency for the VIQ and FIQ subtests are .94 and .93, respectively (Wechsler, 2011).

Working Memory

Working memory was assessed using the Story Memory subtest from the Wide Range Assessment of Memory and Learning, Second Edition (WRAML2; Sheslow & Adams, 2003). In this Story Memory assessment, participants were asked to recall information from two orally presented short stories. Performance on this subtest can be evaluated based on the child's ability to remember and recall the exact story information (i.e., "Verbatim") or the general idea of the story information (i.e., "Gist"). Recall of prose is thought to measure working memory skills such as the central executive, episodic buffer, and phonological loop (Baddeley, 1992; Baddeley & Wilson, 2002). Internal consistency for the Story Memory subtest ranges from .91–.95 in children ages 8 to 16 (Sheslow & Adams, 2003).

Inferential Thinking

Inferential thinking was assessed using the Qualitative Reading Inventory-5 (QRI-5; Leslie & Caldwell, 2011). In this test, participants read passages aloud or silently and were then asked first to retell the passage from memory. They were then asked both text-explicit (i.e., answers are stated directly) and text-implicit (i.e., answers must be inferred) questions based on information in the passage. The passage topic and number varied by grade level. For two passages of the same readability, consistency in comprehension scores was above .80, with 75% being above .90 (Leslie & Caldwell, 2011). Reliability coefficients were .50 for second through sixth grade and .37 for middle school and high school passages. These coefficients were likely low due to the QRI having a low overall number of items (McIntyre et al., 2017). Dyslexia was not reported for any of the participants in this study (See Table 1). However, previous research on this dataset indicated that many participants struggled with reading comprehension (see McIntyre et al., 2017 for details).

Theory of Mind

ToM was assessed using the average of individual scores received on Strange Stories Task (Happé, 1994) and the Silent Films Task (Devine & Hughes, 2016). In the Strange Stories and Silent Films tasks, participants were asked to describe the mental states related to the actions of characters in both 3 to 5 sentence stories and brief clips from a silent comedy film, respectively. The Strange Stories task is a verbal task while the Silent Films task is a non-verbal task. The reliability coefficient for this task battery ranges from .68 to .72 (Devine & Hughes, 2016). The Silent Films and Strange Stories tasks both had good inter-rater reliability, with Cohen's kappa values of .85 and .97, respectively (McIntyre et al., 2018).

Results

All statistical analyses were conducted in R version 4.1.3. Prior to conducting MANOVA analyses, dependent variables were checked for violations of statistical assumptions. The analyses indicated our data met the statistical assumptions required to conduct MANOVA analyses. To confirm previous findings that diagnostic group differences in performance on the domain-general and domain-specific social cognitive measures exist, a 2 (diagnostic group) by 2 (VIQ subgroup) by 3 (ToM, inferential thinking, working

Table 2 Dependent variable statistics by group

Variable	$Autistic_{WoID}$ (n = 81)		NT (n = 44)	
	VIQ low	VIQ high	VIQ low	VIQ high
VIQ	87.5 (10.3)	111.8 (7.9)	91.6 (8.9)	117.2 (9.8)
Social cognitive and domain-general cognitive scores[a]				
ToM total	5.1 (2.7)	7.4 (1.3)	7.5 (1.5)	8.4 (1.5)
Strange stories	4.7 (2.7)	7.5 (1.3)	7.1 (2.0)	8.5 (1.9)
Silent films	5.8 (2.6)	7.3 (1.7)	7.6 (1.8)	8.6 (1.8)
QRI-5 inferences	32.4% (26%)	41.5% (29%)	57.8% (28%)	54.2% (29%)
WRAML2 story memory	7.8 (1.8)	9.5 (3.3)	11.5 (1.6)	12.5 (2.2)

$Autistic_{WoID}$ autistic children without intellectual disabilities; *NT* neurotypical; *ToM* Theory of Mind; *QRI-5* Qualitative Reading Inventory, 5th Edition; *WRAML2* Wide Range Assessment of Memory and Learning, 2nd Edition

[a]All data for social cognitive and domain-general cognitive measures are standard scores exceptive for percent correct scores for inferences

memory) multivariate analysis of variance (MANOVA) was conducted. The MANOVA revealed that there was a significant diagnostic group effect, F (3,100) = 11.18, $p < .001$, $\eta_p^2 = .25$, and a significant VIQ subgroup effect, F (3,100) = 7.62, $p < .001$, $\eta_p^2 = .19$, group differences across the measures. There was no interaction of diagnostic group and VIQ subgroup, F (3,100) = .84, $p = .47$, $\eta_p^2 = .02$, observed in the MANOVA. Follow-up univariate analyses indicated that the NT group outperformed the autistic$_{WoID}$ group on all the cognitive variables in comparisons of both the lower and high VIQ subgroups (see Table 2).

Despite a nonsignificant interaction between VIQ group and ToM, descriptive statistics for each of the groups are presented to examine the impact of VIQ subgroups on social cognitive ToM performance within autistic$_{WoID}$ and NT groups. This is of interest due to the nature of differing cognitive phenotypes in autistic individuals with varying IQs. Within the autistic$_{WoID}$ group, children with higher VIQs ($M = 7.40$, $SD = 1.30$) had higher ToM scores than children with lower VIQs ($M = 5.10$, $SD = 2.70$). However, in the NT group, ToM scores were similar between the higher ($M = 8.40$, $SD = 1.50$) and lower ($M = 7.50$, $SD = 1.50$) VIQ subgroups.

The next step in the analyses was to examine the capability of the cognitive measures to discriminate the diagnostic groups. First, Pearson correlations were conducted to examine the relations between the ToM, inferential thinking, and working memory measures in each diagnostic group. In the NT group, no significant relationships were found among the variables. In the autistic$_{WoID}$ group, ToM positively correlated with inferential thinking ($r = .44$, $p < .001$) and working memory ($r = .27$, $p = .03$, See Table 3).

Next, a stepwise logistic regression analysis examined the degree to which ToM performance discriminated the diagnostic groups when variance in inferential thinking and working memory were also considered. This analysis indicated that performance on ToM measures correctly identified 82% of the autistic$_{WoID}$ sample but only 49% of the NT sample (Wald = 16.0, $p < .001$). The addition of the working memory measure significantly contributed to diagnostic group identification (Wald = 15.1, $p < .001$), improving the identification of autism$_{WoID}$ slightly to 83.6% and substantially improving NT identification to 69.2%. The inferential thinking measure did not contribute significantly on the 3rd step of the regression (Wald = 2.17, $p = .14$). Thus, ToM performance significantly and independently differentiated many but not all autistic$_{WoID}$ and NT participants above and beyond the effects of working memory and inferential thinking. However, working memory contributed to the differentiation of the diagnostic groups as well.

Table 3 Correlations between domain-general and domain-specific cognitive variables for diagnostic groups

Variable	1	2	3
1. ToM Total	–	.11	.16
2. QRI-5 Inferences	.44***	–	.17
3. WRAML2 Story Memory	.27*	.03	–

Autistic$_{WoID}$ group data shown below the diagonal and NT group shown above the diagonal

Autistic$_{WoID}$ autistic children without intellectual disabilities; *ToM* Theory of Mind; *QRI-5* Qualitative Reading Inventory, 5th Edition; *WRAML2* Wide Range Assessment of Memory and Learning, 2nd Edition

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

Discussion

Several observations from this study contribute to a clearer understanding of the role of ToM for autistic$_{WoID}$ and NT children. First, the results indicated that autistic$_{WoID}$ children performed below their NT peers on all tasks. This is consistent with previous findings in the literature (Baron-Cohen et al., 2000) that show that autistic children often demonstrate group-level differences on working memory (Boucher et al., 2012; Williams et al., 2006), inferential thinking (Kaland et al., 2005, 2011; Le Sourn-Bissaoui et al., 2009), and ToM tasks (Baron-Cohen, 1988; Happé, 1994; Tager-Flusberg, 1999) compared to their same-age NT peers.

The results also indicated that there were significant associations between social cognitive task performance (ToM scores) and domain-general task performance in the autistic$_{WoID}$ group but not the NT group. In the autistic$_{WoID}$ group, ToM performance had significant positive relations with the VIQ subgroups and both working memory and inferential thinking task scores. These findings are consistent with the hypothesis that ToM performance is associated with the domain-general cognitive abilities in autism (Bauminger & Kasari, 1999; Gordon & Olson, 1998; Kaland et al., 2005; Le Sourn-Bissaoui et al., 2009). Moreover, the difference in the patterns of association across diagnostic groups is consistent with the compensation hypothesis that autistic children rely on general cognitive abilities to complete ToM tasks in a manner that is different from NT children (Livingston & Happe, 2017; Tager-Flusberg, 2007). Some individuals with autism may utilize intellectual and general cognitive abilities to circumvent rather than overcome their social cognitive difficulties (Livingston & Happe, 2017; Livingston et al., 2019). The results of the logistic analysis were consistent with this conclusion. They indicated that social cognitive difficulties assessed with ToM measures remain an important phenotypic characteristic of school-aged autistic children even after considering variance associated with aspects of social cognition (i.e., working memory and inferential thinking). Indeed, a stepwise

logistic regression analysis suggested that difficulty with ToM performance was the most powerful cognitive correlate of diagnostic group differences in this study's sample. It distinguished 82% of the autistic$_{WoID}$ sample from peers in the NT sample relative to the effects associated with working memory and inferential thinking. This was consistent with the hypothesis that ToM measures the social symptoms of autism and cannot be explained by domain-general cognitive processes. The heterogeneity of autism is such that no single set of measures may be expected to fully distinguish all autistic children from their NT peers (Happé et al., 2006). Nevertheless, it is important to continue attempts to identify the most powerful set of variables that distinguish autism. The results of this study suggest that social cognition is one of these variables even among school-aged autistic children without intellectual disability.

Implications

These findings have important implications for our understanding of social cognition in autistic individuals and the education of autistic students. The results indicate that domain-general cognitive abilities may be important for autistic individuals to complete ToM tasks, which has not been observed in their NT peers. Ongoing research needs to take into consideration these additional cognitive abilities when investigation social cognitive abilities to further our understanding of how autistic individuals approach social tasks and which additional cognitive abilities may be taxed in the process. Additionally, many of these students are placed in general education settings alongside their NT peers (Irwin et al., 2021). For these children, trying to navigate a classroom tailored to a neurotypical population full of ambiguous social cues may rightly be a challenge. The results of this study indicate that similarities in VIQ may not be enough for autistic children to match all the cognitive abilities of their NT peers needed for classroom learning. Therefore, there is a need to inform general education settings about the details of cognitive development of autistic students to support neurodiverse populations in classrooms.

Limitations and Future Directions

This study had at least three notable limitations. One limitation was the sample size. For example, examination of the descriptive analyses suggests that VIQ may have had a stronger association with ToM in the autistic$_{WoID}$ sample than in the NT sample. However, the sample size may have limited the ability of the MANOVA to detect a significant interaction of diagnostic group and VIQ subgroup in this study. Thus, future research with larger samples that examines the association between VIQ and ToM would be warranted.

Secondly, the Story Memory task from the WRAML may require the use of additional skills, such as language comprehension, in addition to working memory. Thus, it is possible that working memory measures that do not rely on verbal comprehension, such as the nonverbal Block Design task, may yield different results. More information is needed to understand the roles of working memory versus language in ToM tasks.

Finally, there are likely a combination of factors including variables not explored in this study such as joint attention (Mundy, 2003, 2018) and executive function (Kimhi et al., 2014) that have the potential to influence ToM performance in autistic children. Additionally, it is possible that an inferential thinking measure with higher reliability would have yielded different results. A further understanding of these factors would be beneficial in designing methods of intervention to address these differences and provide support for neurodiversity within a general education setting.

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Declarations

Conflict of interest Authors declare no conflict of interest.

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