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The relationship between autism traits and listening comprehension among Chinese preschool children with autism spectrum disorder

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Abstract

The purpose of the present study was to investigate the direct and indirect relationships between autism traits and listening comprehension among Chinese preschool children with autism, of varying verbal and non-verbal IQ. Ninety-eight (N = 98) children aged from 35 to 86 months participated in the study. Autism traits were measured with the Chinese version of the Autism Spectrum Quotient: Children's Version (AQ-Child) (Auyeung et al., J Autism Dev Disord 38:1230–1240. https://doi.org/10.1007/s10803-007-0504-z, 2008). We found that among all five autism traits, social skills and imagination deficits were closely associated with overall listening comprehension. Specifically, children's imagination, communication, and social skills had direct effects on their listening comprehension of literal statements. Attention switching had an indirect effect on listening comprehension of inferential statements. We discuss the findings in relation to previous research on listening comprehension from a situation model perspective. The research has practical implications concerning the improvement of listening comprehension skills among children with autism spectrum disorder.

Keywords Autism · Listening comprehension · Literal statements · Inferential statements · Autism traits

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Introduction

Autism is a neuro-developmental condition that involves deficits in social interaction, as well as communicative features such as impaired patterns of conversational initiation and response, stereotypical and repetitive use of language, and minimal spoken language. It has become one of the most common developmental disorders worldwide. Statistics from the US Centers for Disease Control and Prevention (2020) showed that, on average, 1 in 54 children in the United States was diagnosed as having autism spectrum disorder (ASD) and ASD is about 4.3 times more common among boys than among girls. In China, although no national statistics have been collected, evidence from regions and cities indicates that the prevalence rate of ASD in China is approximately 1% (Sun et al., 2019). Evidence from extant studies has consistently revealed that children with ASD have common deficits in language comprehension in both written and oral forms (Knight & Sartini, 2015; Nation et al., 2006).

Successful comprehension requires literal and inferential comprehension to construct a mental representation of the text (van Kleeck, 2008); however, children with ASD find it challenging to satisfy these requirements (Chevallier et al., 2010; Cronin, 2014). While most of the studies on comprehension have focused on reading comprehension, only a handful of studies have focused on listening comprehension (Henry & Solari, 2020; Whalon et al., 2019). However, listening comprehension difficulties pose enormous obstacles to children's academic achievement and social communication in school, home, and other environments. Their failure in oral literal comprehension might prevent them from acquiring factual knowledge. Also, their inadequacy in inferential comprehension makes it hard for them to process implicit information in different contexts (Dawes et al., 2019; Kim, 2016).

Studies on the factors that influence listening comprehension among children with ASD are scarce. The relationship between autism traits and listening comprehension among children with ASD remains relatively unexplored. Therefore, the present paper aims to examine oral literal and inferential comprehension in children with ASD by investigating their listening skills. This study also seeks to probe into the connection between their autism traits and their listening comprehension abilities, to offer their teachers and caregivers viable strategies to improve their listening comprehension.

Language comprehension and the situation model

Typically, language comprehension entails constructing and retrieving a representation of the state of affairs in a text (Zwaan & Radvansky, 1998). Van Dijk and Kintsch (1983) proposed the situation model to investigate mental representations of verbally stated situations. In the situation model, discourse comprehension concerns both "the representation of a textbase in episodic memory" and "the

cognitive representation of the events, actions, persons, and in general the situation" (pp. 11–12). In this sense, people construct situational representations on the basis of text-based representations while comprehending language (Zwaan & Radvansky, 1998). The contribution of this model to listening comprehension is that comprehension is achieved by an interaction between top-down and bottom-up processes. The top-down processes are driven by prior world knowledge and the bottom-up processes are driven by vocabulary knowledge (Perfetti & Stafura, 2014).

In the comprehension process, first, listeners and readers tend to focus on the wording to construct a mental representation of the surface structure. Then, they shift their focus to the explicit semantic meaning and textual information, which eventually activates their world knowledge related to the situation denoted in discourse (Wassenburg et al., 2015). In essence, the situation model amalgamates explicitly conveyed information, which helps comprehenders achieve comprehension by making appropriate inferences. During the process, the construction of the situation model is supported by imagination, which stimulates the mental representations of settings, situations, and background knowledge related to given texts (Quinlan & Mar, 2020). To sum up, successful language comprehension involves the understanding of the literal and inferential meaning of given sentences or texts in oral and written form, as well as an active imagination.

Listening comprehension: literal and inferential comprehension

Listening comprehension refers to the ability to analyze, integrate, and understand spoken input (Tighe et al., 2015). Effective listening comprehension involves literal interpretation and inferencing that help listeners obtain explicitly and implicitly stated information. Only by employing literal and inferential comprehension skills can comprehenders understand "what is said" and "what is meant" (Dawes et al., 2019). Among typically developing (TD) children, several studies have found that they performed better in comprehending literal statements than non-literal statements (e.g., Dawes et al., 2019; Florit et al., 2011). For example, Florit et al. (2011) examined listening comprehension among 221 typically developing preschoolers aged between 4 and 6 regarding how they understood and processed explicit and implicit information by using verbal and inferential skills. Findings revealed that they were better at comprehending explicit information than implicit information.

As for children with ASD, they performed worse in comprehending the literal meaning of oral statements, compared to age-matched TD groups. For instance, Cheung et al. (2020) reported the differences between 30 Cantonese-speaking children with high-functioning autism spectrum disorders (HFASD) and 36 Cantonese-speaking TD children that matched the HFASD group in chronological age and verbal mental age through a carefully designed utterance-picture matching task, pointing out that Cantonese-speaking children with ASD tended to make more mistakes while comprehending both literal statements and similes than TD children. In addition, Zhou et al. (2017) used utterance-to-picture matching tasks to investigate how children with HFASD and a high verbal IQ (measured

by Chinese-Wechsler Young Children Scale of Intelligence) processed literal statements characterized by different morphological markers. The study revealed that children with HFASD and a high verbal IQ were able to comprehend simple Subject-Verb-Object sentences but performed worse in comprehending morpho-syntactically more complicated sentences than their age-matched TD group. Furthermore, children with ASD demonstrated problems with comprehending inferential language, which might be attributable to their difficulty in understanding social conventions and their inadequacy in social skills, as suggested by Dennis et al. (2001). The researchers explored the ability to cope with inferential language tasks and make reasonable inferences among 32 children with HFASD and found that they were successful in some of the tasks such as word definition but were not successful in others such as understand mental state verbs in context and making inferences about social scripts.

Listening comprehension skills of children with ASD can be influenced by several factors. A study conducted by Zhao et al. (2019) examined listening comprehension in preschool children with ASD and IQ-matched TD children. Results showed that children with ASD performed significantly worse on this task than IQ-matched TD children. Listening comprehension was associated with working memory and morphological awareness among TD children, but it was not associated with these cognitive and linguistic skills among children with ASD.

Moreover, since the intellectual potential and abilities of individuals are highly predictive of their functional abilities, some studies attempt to probe the possible roles of intelligence, namely verbal and nonverbal intelligence, in literal and inferential listening comprehension among individuals with and without ASD. In terms of verbal intelligence, Florit et al. (2014) conducted a longitudinal study among 152 TD children to examine the relationship between semantic components and listening text comprehension of implicit and inferential information at Time 1 and Time 2 (mean age = 4;10 years/months and 5;5 years/months respectively). Results indicated a statistically significant correlation between verbal IQ measured with the Italian version of the Peabody Picture Vocabulary Test-Revised (PPVT-R) and literal and inferential listening comprehension at two time points. Similarly, Zhao et al. (2019) demonstrated that verbal IQ assessed by the Chinese version of PPVT-R was statistically significantly correlated with listening comprehension of literal and inferential statements among TD children. However, among children with ASD, they found no correlation between the two skills. While these two studies included both literal and inferential statements to evaluate listening comprehension, they only adopted a holistic score of listening comprehension without further considering how the understanding of literal and inferential statements might be differentially associated with children's verbal IQ. In contrast, Florit et al. (2011) separately examined listening text comprehension of explicit statements and listening text comprehension of implicit statements among 221 TD children. Results indicated that verbal IQ measured by the Italian version of PPVT-R was statistically significantly correlated with their listening comprehension of explicit statements and implicit information respectively. Still, there is a paucity of separate discussions on the relationship between verbal IQ and literal and inferential listening comprehension among children with ASD.

Catts et al. (2001) associated non-verbal IQ with reading comprehension. Additionally, Nation et al. (2010) pointed out that reading comprehension is closely related to listening comprehension. Therefore, it is reasonable to pay attention to the possible connection between non-verbal IQ and listening comprehension. In a 5-year longitudinal study, Alonzo et al. (2016) examined the association between non-verbal intelligence and listening comprehension in TD children progressing from prekindergarten to second grade. Results revealed that non-verbal IQ measured by the Kaufman Brief Intelligence Test-2 was a significant and positive predictor of prekindergarten and second grade listening comprehension of information explicitly and implicitly conveyed in narratives; however, little evidence has been found associating non-verbal IQ with literal and inferential listening comprehension among children with ASD.

The relationship between autism traits and language comprehension

It is generally recognized that individuals with ASD display behavioral traits that vary in scope and severity. More specifically, ASD is best characterized in terms of multiple associated traits rather than a single unitary deficiency (Murray et al., 2017). To gain a better understanding of autism traits, psychometric scales are frequently employed to examine the degree of ASD severity among individuals with ASD or to explore the prevalence of autistic-like behaviors among individuals without ASD (English et al., 2021). Autism Spectrum Quotient (AQ) is one of the widely used scales with a total of 50 questions assessing five dimensions of autism traits: social skills, attention switching, attention to detail, communication, and imagination (Baron-Cohen et al., 2001).

Previous studies have revealed possible relationships between autism traits (e.g., social skills, attention switching, attention to detail, communication, and imagination) and some aspects of language comprehension (e.g., reading comprehension and figurative language comprehension). Knight's (2016) study among children with ASD between pre-kindergarten and second grade showed that students with ASD who possessed stronger social skills measured with Social Skills Improvement System Rating Scales performed better in reading comprehension of literal and non-literal questions than those with poorer social skills. Furthermore, a meta-analysis of studies concerning figurative language comprehension among people with ASD by Kalandadze et al. (2018) indicated that the social communication problems of autistic individuals might covary with their poor comprehension of non-literal language. As well, a review by Vyshedskiy et al. (2020) highlighted some possible connections between voluntary imagination and language comprehension among children with ASD, pointing out that voluntary imagination was responsible for the "mental juxtaposition of objects into novel combinations" to process information in a given sentence.

However, whether listening comprehension skills are related to children's autistic traits has seldom been systematically examined. Nuske and Bavin (2011) reported the failure to employ contextual rules and world knowledge in comprehending spoken narratives among 4–7-year-old children with ASD, which was probably due to

the autistic trait of special attention to details. Collins et al. (2019) conducted a computer-aided listening comprehension intervention among students with ASD, who showed concurrent growth in listening comprehension and communication skills, implying a possible link between listening comprehension and the communication outcomes. Lee et al. (2019) explored the relationship between autism traits measured by an established autism scale, Social Responsiveness Scale, Second Edition (SRS-2), and performance on theory of mind (ToM) among 104 Chinese children with ASD. Results demonstrated that participants' autism traits predicted their ToM performance, which was reported to be directly related to listening comprehension in another study by Kim and Pilcher (2016). Nevertheless, Arutiunian et al. (2021) reported that language abilities, including listening comprehension at sentence and discourse levels, were independent from autism traits measured by AQ and that AQ failed to predict language performance in Russian children with ASD. Even though we should be cautious while interpreting and comparing results of these studies due to their different measurements and cultural backgrounds, these inconsistent findings make it necessary to probe the topic further (Murray et al., 2014).

Thus, to further investigate the relationship between autism traits and language comprehension, and more specifically, listening comprehension, this study aimed to look into Chinese preschool children with ASD in the Chinese context and their performance in literal and inferential listening comprehension. In this way, this paper contributes to the existing literature. Moreover, it may give teachers and caregivers of children with ASD hints about improving their listening comprehension based on different situations and creating more social opportunities for them.

Method

Participants

Ninety-eight (N = 98) Mandarin-speaking children with ASD participated in this study. They were recruited from two kindergartens[1] serving children with special needs in two northern cities in China. Their age ranged from 35 to 86 months (*SD* = 13.79), with an average of 58.14 months. The sample included 79 boys and 19 girls. The ratio of boys to girls was 4.16: 1.

[1] A kindergarten in mainland China is a pre-school institution. It is not part of compulsory education and it serves children from ages 3–6. There are government and non-government kindergartens. The government kindergartens are subsidized by the government but the parents still pay for their children to attend. The non-government kindergartens have to come up with their own funds and the operation mainly depends on tuition. In 2015 (Chinese Ministry of Education, MOE, 2015), there were a total of 146,376 non-governmental kindergartens in China serving 23 million children. The specific kindergarten in which our study took place is a non-government kindergarten. It was certified by the local educational bureau and also, because it enrolls children with special needs, it was contracted by the municipal branch of China's Disabled Person's Federation (DPF). Families with disabled children who have an annual household income lower than a certain amount qualify to receive government subsidies for special education until the child reaches 16 (the age cap varies from city to city). The subsidies can only be redeemed if the child attends a kindergarten or school that is contracted by the local branch of the DPF.

All children with ASD participating in our study were previously diagnosed by two experienced pediatric clinicians according to the diagnostic criteria for ASD in the DSM-IV-TR (American Psychiatric Association, 2000). As well, we confirmed the diagnosis of children by asking parents of the ASD group to fill in the Chinese version of the Autism Spectrum Quotient: Children's Version (AQ-Child; Auyeung et al., 2008). Children with full or partial hearing losses were excluded from the study. For all participants, their parents signed the written informed consent forms illustrating important information at the beginning of the research.

Assessment and measures

All participants were administered assessments of verbal and non-verbal IQ and listening comprehension with literal and inferential statements. Also, their parents were required to fill in the Chinese version of the Autism Spectrum Quotient: Children's Version (AQ-Child; Auyeung et al., 2008), which is commonly used to measure autism traits.

Peabody Picture Vocabulary Test-Revised (PPVT-R)

This adapted test is a measure of verbal IQ in Chinese (Sang & Miao, 1990). It was adapted by modifying some words and pictures of the Peabody Picture Vocabulary Test-Revised (Dunn & Dunn, 1981), conducting two pilot studies, and standardizing it using 600 Chinese children aged 3.5 to 9 years old in Shanghai. This test is the only standardized receptive vocabulary assessment in Chinese so far. The reliability coefficients were 0.98 (split-half) and 0.94 (test–retest). It has been used with many studies involving Chinese children with ASD (e.g., Li et al., 2016; Yi et al., 2013). Children were asked to look at a choice of four pictures and point to the picture that best matches the word the experimenter says. The test stops when the child makes six errors out of eight consecutive items.

Non-verbal IQ

The Raven's Standard Progressive Matrices was administered as a nonverbal test of intelligence. This is a standardized test that can be used with participants in all age groups (Raven, 2000; Raven et al., 1996), with Chinese norms established by Zhang and Wang (1989) through a series of standardized procedures. The test consists of five sets of 12 items each. Each item is made up of a target matrix with one missing component. Children were required to choose the part that best completed the matrix from six to eight options.

Literal and inferential listening comprehension

The listening comprehension task is a subscale from the Hong Kong Cantonese Oral Language Assessment Scale (HKCOLAS, Department of Health of Hong Kong SAR, 2006). The instruction and directions were translated into Mandarin Chinese.

The experimenter presented a sentence and the children were instructed to point to the picture that best matched the sentence. In this study, 20 literal statements with explicitly conveyed information and 11 non-literal statements with inferential meanings were used. More specifically, the literal listening comprehension task included items like "Dad is carrying a bag." After hearing the sentence, participants were supposed to choose the picture portraying a man with a bag in his hand. The inferential listening comprehension task included items like "Dad said, 'I should have brought an umbrella.' What was the situation like?" In this sense, participants should choose the picture depicting a man getting wet in the rain without an umbrella. Cronbach's alpha for scores of listening comprehension was 0.58.

Autism traits

Participants' autism traits were measured with the Chinese version of the Autism Spectrum Quotient: Children's Version (AQ-Child) completed by their parents. The AQ-Child is a 50-item parent-report questionnaire used to evaluate autism traits in children with and without ASD. It consists of five subscales assessing children in terms of social skills, attention switching, attention to detail, communication, and imagination. Each subscale is made up of 10 items that are answered in a 4-point Likert scale (definitely agree, slightly agree, slightly disagree, and definitely disagree). The social skills subscale measures children's ability to build up and continue interpersonal relationships (e.g., "S/he is drawn more strongly to people than to things."). The attention switching subscale examines children's ability to shift back and forth while coping with "multiple tasks, operations, or mental tests" (Miyake et al., 2000), which includes items like "S/he frequently gets so strongly absorbed in one thing that s/he loses sight of other things." The subscale associated with attention to detail assesses participants' ability to complete a task with thoroughness and precision (e.g., "S/he tends to notice details that others do not."). The communication subscale evaluates children's capacity to use language in social contexts (e.g., "S/he does not know how to keep a conversation going with her/his peers."). The imagination subscale investigates children's ability to form new ideas and mental images that are not present to their senses, which includes items like "If s/he tries to imagine something, s/he finds it very easy to create a picture in her/his mind." The scores of the AQ-Child range from 0 to 150, and higher scores indicate more "autistic-like" behavior. The AQ-Child is characterized by high sensitivity, specificity, statistical reliability, and internal consistency (Auyeung et al., 2008).

ToM performance

Participants' ToM performance was measured with the Chinese version of a highly scalable multi-component ToM understanding task battery developed by Wellman and Liu (2004). A study (Wu & Su, 2014) among 74 Chinese children using the battery reported the Cohen's Kappa value of 1.00, indicating a high inter-rater reliability. Involving six dimensions of ToM ability, the battery consists of six subtasks: the Diverse Desires task, the Diverse Beliefs task, the Knowledge Access task, the Contents False Belief task, the Belief—Emotion task, and the Real—Apparent Emotion

task. In the Diverse Desires task, the participant was required to tell the difference between him/herself and another person in their desires for the same things. In the Diverse Beliefs task, the participant was supposed to differentiate between his/her beliefs and another person's beliefs and make choices based on another person's beliefs. In the Knowledge Access task, the participant was allowed to see what was in a specific box and told that another person had never seen what was inside the box. Then, the participant needed to answer questions as to whether another person knew and had seen what was in it. In the Contents False Belief task, the participant was first shown what was in a clip box and told that another person had not seen what was inside the clip box. Then, the participant was required to make a judgment on another person's false belief about what was inside the distinctive clip box. For the Belief—Emotion task, the participant was asked to judge another person's emotion when the person's belief was misguided. In the Real—Apparent Emotion task, the participant was expected to understand that people would display emotions inconsistent with their true feelings. In this study, the participant got one point when he/she passed one task. Thus, the scores of the ToM understanding task battery ranged from 0 to 6.

Results

Descriptive statistics and intercorrelations

Table 1 shows the descriptive statistics and correlations among children's verbal IQ, nonverbal IQ, listening comprehension, ToM, and ASD traits. The distribution of the measures showed no significant derivation from normality. Children's mean score on the literal comprehension subscale was 7.27 out of 20 ($SD = 3.57$), and the mean score of inferential listening comprehension was 3.27 out of 11 ($SD = 2.18$). The mean standardized score of children's verbal IQ was 70.97 ($SD = 28.26$), and the mean raw score of children's nonverbal IQ was 14.39 ($SD = 9.52$). In the measure of ToM, children scored 1.15 ($SD = 1.11$) out of a total of 6 on average, suggesting deficits in ToM among children with ASD. Mean scores of ASD traits, including communication, attention to details, imagination, and social skills, were lower than the mean scores of the UK sample with autism aged between 4 and 11 (Auyeung et al., 2008), but the mean score of attention switching was slightly higher than the scores of UK samples. The mean total score of ASD traits in our current sample was 81.60 ($SD = 14.63$), comparable to the cutoff score of 76; scores above this level indicate a likelihood of children being diagnosed with ASD.

Bivariate Pearson correlation showed that children's literal listening comprehension score was positively correlated with their verbal IQ, $r = 0.26$, $p = 0.04$, and negatively correlated with scores of social skills, $r = -0.30$, $p = 0.02$, communication, $r = -0.26$, $p = 0.04$, and imagination, $r = -0.43$, $p = 0.00$. We also found negative correlations between children's comprehension skills of literal statements and the total score of AQ-Child, $r = -0.30$, $p = 0.02$. Children's inferential listening comprehension score was negatively correlated with nonverbal IQ, $r = -0.39$, $p = 0.01$, and attention-switching, $r = -0.28$, $p = 0.03$. Children's total score of listening

Table 1 Mean, standard derivation, and intercorrelation of listening comprehension skills, ASD traits, verbal IQ, and nonverbal IQ

Variable	*n*	*M*	*SD*	1	2	3	4	5	6	7	8	9	10	11	12
Literal Comp.	67	7.27	3.57	**											
Inferential Comp.	67	3.27	2.18	.25*	**										
Total Comp. Score	67	10.54	4.62	.89**	.66**	**									
Verbal IQ[a]	77	70.97	28.26	.26*	−.09	.16	**								
Nonverbal IQ[b]	54	14.39	9.52	.06	−.39*	−.14	.45**	**							
ToM	62	1.15	1.11	.10	.02	.08	.38*	.25	**						
Social Skills	92	17.17	5.40	−.30*	−.09	−.27*	−.07	.07	.06	**					
Attention Switching	92	14.49	4.29	−.05	−.28*	−.16	.09	.39**	−.17	.46**	**				
Attention to Details	92	11.90	4.87	.18	−.03	.12	.32*	.23*	.17	−.12	−.02	**			
Communication	92	19.22	4.83	−.26*	.12	−.14	−.13	−.09	.05	.53**	.15	−.12	**		
Imagination	92	18.82	4.94	−.43**	−.15	−.40**	−.36**	−.09	−.23*	.58**	.33**	−.32**	.50**	**	
AQ-Total	92	81.60	14.63	−.30*	−.14	−.29*	−.05	.17	−.02	.83**	.62**	.14	.70**	.70**	**

Literal Comp. = Literal Comprehension, Inferential Comp. = Inferential Comprehension, Total Comp. Score = Total Comprehension Score, ToM = Theory of Mind, Social Skill = Subscale of Social Skill from AQ-Child, Attention Switching = Subscale of Attention Switching from AQ-Child, Attention to Details = Subscale of Attention to Details from AQ-Child, Communication = Subscale of Communication from AQ-Child, Imagination = Subscale of Imagination from AQ-Child, AQ-Total = Total Score of AQ-Child

[a]We reported the standardized scores of verbal IQ measured with PPVT-R because a majority of the children in our study reached 39 months old (90%), the cutoff age to obtain standardized scores according to their raw score and age

[b]We reported the raw scores of nonverbal IQ measured with Raven's Standard Progressive Matrices because more than half of our participants were below the age of 5.5 years old (68%), which was the cutoff age level to obtain standardized scores (Zhang & Wang, 1989)

~$p < .1$; *$p < .05$; **$p < .01$

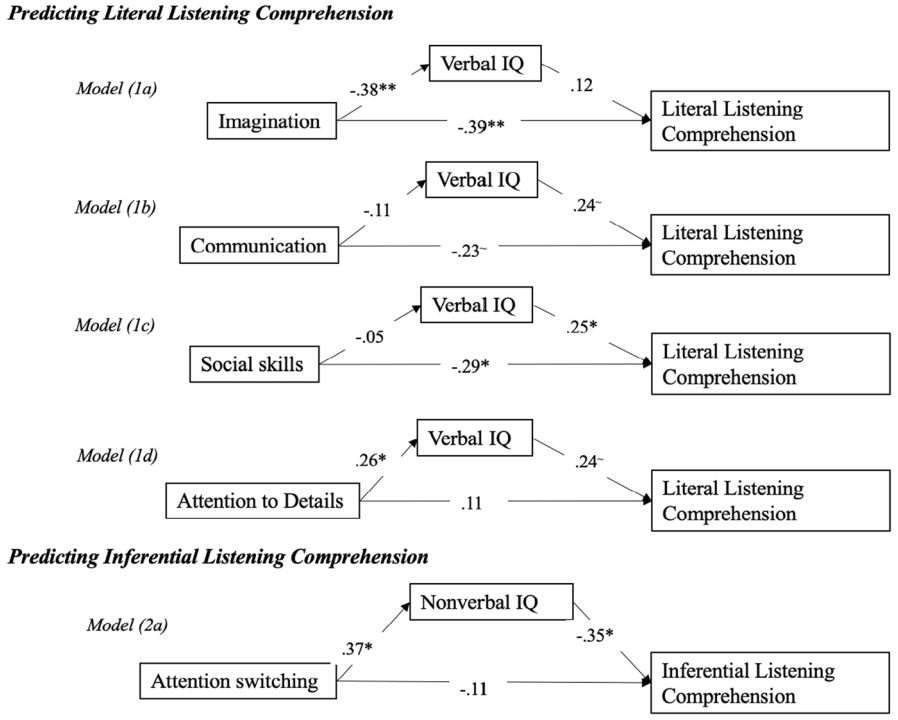

Fig. 1 Final path models from ASD traits to literal and inferential listening comprehension skills

comprehension was negatively correlated with social skills, $r=-0.27$, $p=0.03$, and imagination, $r=-0.40$, $p=0.00$, and the total score of AQ-Child, $r=-0.29$, $p=0.02$. We also found positive correlations between children's verbal IQ and attention to details, $r=0.32$, $p=0.01$, and negative correlations between children's verbal IQ and their imagination, $r=-0.36$, $p=0.00$. Nonverbal IQ was positively correlated with attention switching, $r=0.39$, $p=0.00$, and marginally correlated with attention to details, $r=0.23$, $p=0.09$. Children's ToM was positively correlated with verbal IQ, $r=0.38$, $p=0.01$, and marginally correlated with the AQ measure of imagination, $r=-0.23$, $p=0.08$.

The effect of ASD traits and IQ on literal and inferential listening comprehension

To further examine the effect of different ASD traits and IQ on children's literal and inferential listening comprehension, we conducted path analyses based on the literature and intercorrelations among variables. Path analysis was performed via PROCESS on SPSS, which is a computational tool that produces path estimates and mediation results of path models (Hayes, 2018). Figure 1 illustrates the path models with their standardized path coefficients. By examining the autistic traits predicting literal listening comprehension, we found that in Model (1a), imagination predicted

Table 2 Direct, indirect, and total effects of ASD traits on literal and inferential listening comprehension

Independent variable	Direct effect		Indirect effect (via verbal IQ)		Total effect	
	Estimate	95% CI	Estimate	95% CI	Estimate	95% CI
Literal listening comprehension						
Imagination	−0.28	[−0.46, −0.10]	−0.03	[−0.16, 0.04]	−0.32	[−0.48, −0.15]
Communication	−0.16	[−0.33, 0.01]	−0.02	[−0.12, 0.04]	−0.18	[−0.35, −0.01]
Social skills	−0.20	[−0.35, −0.04]	−0.01	[−0.09, 0.03]	−0.21	[−0.37, −0.04]
Attention to details	0.08	[−0.10, 0.26]	0.04	[−0.02, 0.13]	0.13	[−0.05, 0.31]
Inferential listening comprehension						
Attention switching	−0.06	[−0.21, 0.10]	−0.07	[−0.16, −0.01]	−0.13	[−0.27, 0.02]

both verbal IQ ($\beta = -0.38$, $p = 0.00$) and children's literal listening comprehension ($\beta = -0.39$, $p = 0.00$), but the path from verbal IQ to literal listening comprehension was statistically insignificant. Model (1a) explained 20% of variance in children's literal listening comprehension, $p = 0.00$. In Model (1b), communication ($\beta = -0.23$, $p = 0.06$) and verbal IQ ($\beta = 0.24$, $p = 0.05$) both predicted literal listening comprehension, but the path coefficients were statistically marginally significant. There was no statistically significant prediction from communication to verbal IQ. The variance of literal listening comprehension explained by Model (1b) was 12%, $p = 0.02$. In Model (1c), both social skills ($\beta = -0.29$, $p = 0.02$) and verbal IQ ($\beta = 0.25$, $p = 0.04$) statistically significantly predicted literal listening comprehension, but verbal IQ did not statistically significantly predict literal listening comprehension. The R^2 of Model (1c) was 16%, $p = 0.01$. Model (1d) achieved marginal statistical significance predicting literal listening comprehension, $R^2 = 0.09$, $p = 0.07$. Attention to details statistically significantly predicted verbal IQ ($\beta = 0.26$, $p = 0.04$), which predicted children's understanding of literal statements with marginal statistical significance ($\beta = 0.24$, $p = 0.07$). Attention to details did not statistically significantly predict children's comprehension of literal statements. Findings on Model (2a) suggested that children's attention switching statistically predicted nonverbal IQ ($\beta = 0.37$, $p = 0.01$), which further statistically significantly predicted children's inferential listening comprehension ($\beta = -0.35$, $p = 0.02$). This model explained 17% of variance in inferential listening comprehension, $p = 0.02$.

Table 2 shows the direct effect, indirect effect, and total effect of ASD traits on children's literal and inferential listening comprehension skills. Standard error of indirect effect was estimated with biased-corrected bootstrap method, with 95% confidence interval (CI). For Models (1a), (1b), (1c), and (1d), results showed only direct effects from children's imagination and social skills on children's listening comprehension of literal statements, with no statistically significant mediation of verbal IQ. For Model (2a), the effect of attention switching on children's inferential listening comprehension was fully mediated by nonverbal IQ, 95% CI [−0.16, −0.01], with no statistically significant direct effect from attention switching on inferential listening comprehension.

Discussion

The present study investigated the direct and indirect relationships between autism traits and listening comprehension among Chinese preschool children with autism, of varying verbal and non-verbal IQ. We found that the total scores of AQ-Child and total scores of listening comprehension were statistically significantly correlated ($r = -0.29$, $p < 0.05$). Since these traits exist before any impairment of language and other behavioral issues can be observed, the relationships deserve more attention from researchers and practitioners. This finding, however, is different from the findings of Arutiunian et al. (2021) that AQ failed to be a predictor of listening comprehension after age and non-verbal IQ were controlled for among Russian children with ASD. This inconsistency might be due to the age range of the participants and the precise nature of the measurements. In the study of Arutiunian et al. (2021), the participants were primary school students and the score of listening comprehension of sentences was focused on word order and sentence complexity. However, our study involved preschool children who were much younger and the listening comprehension task we used had a different focus, which was on literal and inferential meaning.

We found that literal and inferential comprehension abilities were significantly correlated with each other among preschool children with ASD. In addition, the participants performed better at literal comprehension than inferential comprehension. Although there was considerable variability in both listening comprehension tasks, the variability in inferential comprehension was higher. Kim (2020) pointed out the prevalent use of the literal and inferential taxonomy in evaluating and instructing comprehension. Generally, literal comprehension is considered to be easier and more basic than inferential comprehension. In essence, literal comprehension of the explicitly stated information and inferential comprehension of the implicitly stated information are necessary for the construction of a situation model. Given children's failure in making appropriate inferences, some scholars contended that children's situation models may be primarily composed of explicitly stated information, implying that children can perform better in understanding the surface structure of given statements and constructing the textbase representation than in constructing the situation model. When it comes to inferential comprehension, the process involves constructing both the textbase and the situation model (Dawes et al., 2019); however, it can be challenging for children to construct a situation model because of the need for more complex inferencing, conversational logic analysis, sensitivity to pragmatic information, and background knowledge. Several previous studies (e.g., Cheung et al., 2020; Dennis et al., 2001) have highlighted problems in understanding inferential language in children with ASD and the issue has been connected to certain autistic traits.

When we decompose general traits into specific traits, we did find that specific traits have a specific influence on different listening comprehension skills among children with ASD. In the present study, we found that among the five autism traits, imagination and social skills were associated with overall listening comprehension. Specifically, imagination, communication, and social skills

were directly associated with children's listening comprehension of literal statements. The model involving imagination explained 20% of the variance in literal listening comprehension. In our study, the imagination subscale of the AQ-Child questionnaire includes items like "If s/he tries to imagine something, s/he finds it very easy to create a picture in her/his mind," "When s/he is reading a story, s/he can easily imagine what the characters might look like," "When s/he is reading a story, s/he finds it difficult to work out the characters' intentions or feelings," and "S/he finds it very easy to play games with children that involve pretending," which examined participants' ability to generate mental images and conjure up others' not-presently-perceived ideas and intentions to reconstruct events. Similarly, the listening comprehension task of literal statements used in this study consists of items like "The brother dressed up the sister like the mom," "She drew an apple on the left side of the paper," and "There were some patches on the skin of the horse chasing the dog," which require participants to form mental images of situations and objects that are not actually present to their senses. Imagination is central to listening comprehension in that it enables people to "imagine characters, settings, objects, and situations, as well as the complex relationships among all these elements" (Quinlan & Mar, 2020, p. 467–468) to understand the text.

Dysfunction in communication and social skills explained 12% and 16% of the variance in literal listening comprehension. These findings are not surprising because listening comprehension is an important part of communication and social skills. Deficits in communicating and in interacting with others would reduce children's opportunity to practice their comprehension skills (Naigles, 2021). It is not clear why autism traits such as impaired imagination, communication, and social skills do not predict inferential listening comprehension in our study. We propose that autism traits measured by AQ are only a representation of the severity of symptoms, and do not represent the complex cognitive processes that might be relevant in understanding inferential statements. These cognitive processes include but are not limited to working memory, shifting attention, and inhibitory control. In addition, inferential listening comprehension is a higher-order skill than literal listening comprehension, which might not have fully developed in young children between 3 and 6 years old. In our study we asked a child to choose a pictured situation after he or she heard an inferential statement such as "Dad said, 'I should have brought an umbrella. What was the situation like?" The correct choice should be a picture of Dad walking in the rain without an umbrella. To be able to make the correct choice, the child will need to suppress the idea of what is considered a regular situation—Dad stayed indoors without an umbrella or an alternative that Dad walked in the rain with an umbrella. They will need to hold these ideas in their mind at the same time and switch their attention to conjure a representation of an unexpected situation, which is that Dad was outside in the rain without an umbrella. Thus, the autistic traits such as dysfunction in imagination, communication, social skills, and attention to detail captured in our study might not be sufficient to differentiate the ability to comprehend inferential statements (with the exception of attention switching).

Attention switching was correlated with listening comprehension of inferential statements. Attention switching in AQ-child assesses children's ability to organize things with flexibility and to switch attention from one task to another. The

inferential listening comprehension task in our study included items to test children's understanding of words for mental state (e.g., "The brother said: 'I thought you would bring the dog.'"), making inferences about social scripts (e.g., "Mom hid the candies. Some said candies maybe are in the box. Others said candies are in the bag. Where would you go first to find the candies?") and drawing implications from a certain context (e.g., "The less water this plant gets, the more flowers it has. Which plant got the most water?"). Some general executive functions are believed to account for dysfunction of attention switching in children with ASD. More specifically, the deficit in inhibitory control and attention switching is present in high function children with autism but not in children with Asperger's disorder (Rinehart, et al., 2001). In our study, attention switching has an indirect effect on listening comprehension of inferential statements through the mediation of non-verbal IQ. Children who have difficulty in attention switching are more likely to have a higher non-verbal IQ ($r = 0.39$, $p < 0.001$). We speculated that children with a lower nonverbal IQ might have difficulty in maintaining attention in the first place. Inference and reasoning abilities have been shown to be positive predictors of listening comprehension among TD children both concurrently and longitudinally (e.g., Kim, 2016; Tighe et al., 2015). However, among children with ASD, the pattern might be different.

Our finding suggests that with attention switching statistically controlled for, children who have higher nonverbal IQ would have more difficulty in understanding inferential statements. We attribute this to the differences between visual pattern and logic inferencing abilities revealed by the Raven progressive matrix and social meaning inferencing abilities revealed by our inferential listening comprehension task. More specifically, this might be because that non-verbal IQ measured by Raven reveals the ability to recognize visual sequences, figure out the relationship between visual concepts and make visual analogies. It does not involve reasoning in language, especially language with social meaning. Also, inferential comprehension is a higher-order skill and children who are between 3 and 6 years old might not have developed this skill fully yet. Therefore, although our study shows a negative correlation between non-verbal IQ and inferential listening comprehension, this result must be interpreted with caution. It is still not clear whether this link is driven by attentional processing or conversation logic processing, or social skills. Future studies are needed to unpack this relationship.

Implications

Some studies have highlighted the possibility of improving listening comprehension skills and verbal participation among children with ASD through story-book based interventions that emphasize communication and social skills (Akemoglu & Tomeny, 2021; Fleury & Schwartz, 2017; Solari et al., 2020). Information, tools, and strategy training should be provided to families and kindergartens serving children with ASD. Our findings suggest that caregivers and practitioners should take into consideration more aspects of the inherent abilities of children with ASD to improve the effect of shared book reading on children's listening comprehension.

For example, in daily communication and story-reading time with children with ASD, we suggest that teachers and caregivers help children imagine the characters and plot during story-book reading. Besides, more open-ended questions should be asked, especially questions making conjectures about the character of the story, and situations should be posed to facilitate children's identifying of causal or intentional factors and to manipulate a mental representation of reality and create an alternative to it. Meanwhile, caregivers and practitioners should consistently wait to allow sufficient time for the child to process visual and/or verbal information, ask children to predict what happens next by using their imagination, and help children initiate a conversational turn when they find something they are particularly interested in. Specifically, literal comprehension should come before inferential comprehension, and caregivers should try to make utterances explicit and simple to help children build their listening comprehension skills at an early age.

Limitations and future directions

There are some limitations of this study. First, our results only generalize to Mandarin-speaking Chinese preschool children with Autism. They might be different for children who speak a dialect or children from bilingual or multilingual homes. A second limitation lies in the measure for assessing listening comprehension. The current measure contains both literal statements and inferential statements, but they are developed for typically developing children and some items had low internal consistency for children with ASD. Future research should consider developing a listening comprehension task that could generate scores of better reliability. Future listening comprehension measures should consider the balance of literal statements and inferential statements, simple and complex sentences, and sentences of varying lengths. The final limitations involve the fact that we were not able to examine home language environment and support of listening comprehension that children receive from their immediate environment. Future studies should take into consideration a more comprehensive battery of cognitive and linguistic tests such as working memory, inhibitory control, phonological awareness, and morphological awareness that tap into the underlying mechanisms of listening comprehension.

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