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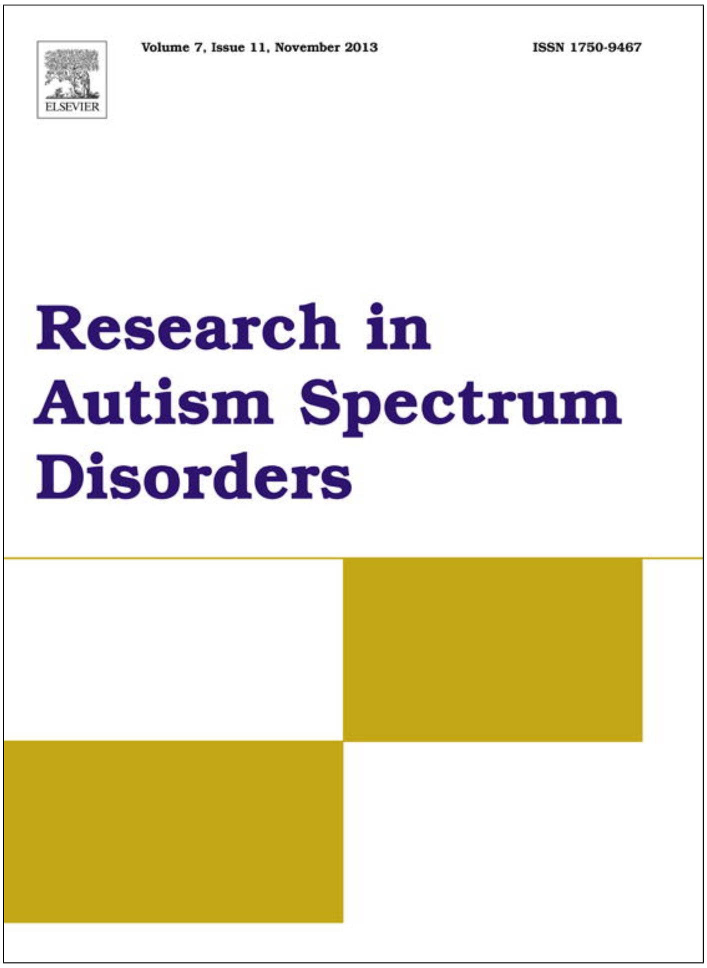

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Atypical understanding of mental terms in Chinese-speaking children with autism spectrum disorder

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ABSTRACT

The present study investigated how Chinese children with autism spectrum disorder (ASD) understand mental terms, especially their knowledge of verb factivity. We examined these children's ability to understand mental terms representing true belief (i.e., *zhi1dao4*, *know*) and false belief (i.e., *yi3wei2*, *thought*) and compared their ability with that of typically developing (TD) children matched with age, and TD children matched with verbal mental age (VMA). Children were asked to participate in a game to find a toy according to the experimenter's testimony, which involved these mental terms. Results showed that all children from these three groups understood *zhi1dao4* better than *yi3wei2*. Particularly, children with ASD performed statistically significantly worse in understanding mental terms than their age-matched TD children, but not differently from VMA-matched TD children. The understanding of mental verbs was correlated with the language ability of children with ASD, and with age, language ability and executive function of TD children. After controlling for the effects of age, general language ability, and executive functions, the group difference of mental verb understanding still existed.

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1. Introduction

Human languages provide tools for their speakers to communicate mental states. These tools, often referred to as mental terms, provide linguistic labels for the conceptual categories for mental experiences (e.g., Tardif & Wellman, 2000). Mental terms, in many languages, are often used to lead embedded propositions which represent the content of the mental states (de Villiers & Pyers, 2002). Therefore, the meaning of a mental term determines how the subsequent clause is interpreted. The verb factivity of mental terms, defined as the degree of the mental verbs presuppose the veracity of their clauses, and determines the interpretations of the clauses, that is, the likelihood of a belief being true (Cheung, Chen, & Yeung, 2009; Lee, Olson, & Torrance, 1999; Scoville & Gordon, 1980). Strong factive verbs affirm the following clause, and non-factive verbs negate their clauses (Cheung et al., 2009; Scoville & Gordon, 1980). For example, in the sentence "I know that there is a marble in the box," *know* has a high verb factivity, so the clause "there is a marble in the box" is more likely to be true; while in the sentence "I thought that there was a marble in the box", *thought* has a low verb factivity, so its clause is less likely to be true. Knowledge about verb factivity, especially the understanding of nonfactive verbs, uniquely correlates with children's understanding of people's false belief (Cheung et al., 2009; Lee et al., 1999; Papafragou, Cassidy, & Gleitman, 2007).

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1.1. Acquisition of mental terms

The acquisition of mental terms is relatively late compared to other semantic categories among typically developing (TD) children. From 2.5 years of age, mental-state terms such as *think*, *know* and *remember* start to appear in English-speaking children's spontaneous speech (Limber, 1973; Shatz, Wellman, & Silber, 1983). Two- and three-year-old children begin to acquire mental terms to firstly refer to perception, emotion, and desire (e.g., *see*, *hear*, *happy*, *love*, *want*), and then to knowledge and beliefs (e.g., *know*, *think*, *believe*; Bartsch & Wellman, 1995; Bretherton & Beeghly, 1982). Three- and four-year-old children can comprehend the subtle differences of implications of *think* and *know* by giving different answers to the questions, using *think* and *know* to ask about people's false belief (Johnson & Maratsos, 1977). By age 4, English-speaking children could distinguish *know* from *think* and *guess* in terms of their relative certainty (Moore, Bryant, & Furrow, 1989). Acquisition of these mental terms, as well as general language ability, reflects children's development of theory of mind (ToM) (e.g., Astington & Baird, 2005; Milligan, Astington, & Dack, 2007).

1.2. Understanding Chinese mental terms

A meta-analysis showed parallel developmental trajectories of ToM understanding for children in China and North America (Liu, Wellman, Tardif, & Sabbagh, 2008). Verb factivity is marked in the Chinese language through different mental terms (e.g., *xiang3* meaning *think*, *yi3wei2* meaning *thought*). Verb factivity plays an important role in Chinese-speaking children's false belief understanding (Cheung et al., 2009; Lee et al., 1999; Tardif, Wellman, & Cheung, 2004). Lee and colleagues (1999) investigated the effects of Chinese mental verbs (*xiang3*, *think*; *yi3wei2*, *thought*; and *dang4*, *falsely think*), on Chinese-speaking children's understanding of false belief. They found that children performed better in false belief questions using *yi3wei2*, or *dang4*, than those using *xiang3*. Linguistic representation of a belief has the potential to influence children's understanding of a statement being either true or false and this has been supported by evidence with children speaking English and other languages. For instance, studies have been conducted to explore the relations between understanding of false beliefs and mental verbs in Cantonese, a dialect used in South China (mainly in Guangdong and Hong Kong). Tardif and colleagues (2004) examined whether types of Cantonese verbs used in the verbal cues of the false belief task affected Cantonese-speaking children's performance. Cantonese represents beliefs in two ways: either neutral belief (i.e., *nam5*, *think*) or explicitly false (i.e., *ji5wai4*, *thought*). Results showed that children questioned with explicitly false belief words had an advantage in the performance of false belief tasks over children questioned with neutral belief words. This finding implied that children's ToM performance is partially mediated by their linguistic ToM. Cheung and colleagues (2009) further examined Cantonese-speaking children's understanding of some strong factive and non-factive Cantonese mental terms and their performance in false belief tasks. Results showed that understanding of mental terms, especially strong nonfactive Cantonese mental terms (i.e., *ji5wai4*, *thought*), predicted false belief understanding, after controlling for non-verbal IQ and general language ability.

1.3. Understanding mental terms in ASD

Although extensive research has suggested that children with autism spectrum disorder (ASD) are impaired in ToM understanding (e.g., Baron-Cohen, 2000; Baron-Cohen, Leslie, & Frith, 1985), little is known about their understanding of mental terms, a highly relevant ability to their ToM capacity (Ziatas, Durkin, & Pratt, 1998). Tager-Flusberg (1992) analyzed the spontaneous speech samples of children with ASD and Down syndrome by coding utterances including lexical terms for desire, perception, emotion and cognition. Results showed that children with ASD were as capable as children with Down syndrome of talking about desire, perception and emotion, but their speech included fewer utterances to call for attention and to refer to cognitive mental states. In a study by Ziatas et al. (1998), participants were asked to find a hidden candy according to a puppet's verbal cues involving mental terms *know*, *think* or *guess* ("I know/think/guess it is in the blue box"). Results showed that compared to TD children, children with ASD showed specific impairment understanding mental terms in this task.

1.4. The present study

Understanding verb factivity of Chinese mental terms is important for Chinese children to understand others' true or false beliefs. Studies on the Chinese mental terms in ASD not only contribute to our knowledge about the atypical language development in children with ASD, but also provide further evidence for the ToM deficits in children with ASD.

The objectives of this study were (1) to compare the understanding of Chinese (Mandarin) mental terms in Mandarin-speaking children with ASD and TD children matched with age and verbal mental age (VMA); (2) to examine whether the deficit in understanding Chinese mental terms in children with ASD was due to their limited general language ability or executive function. We sought to achieve these objectives through the following research questions:

(a) Could children with ASD tell the subtle differences between mental terms in terms of verb factivity like the TD children matched with age and VMA respectively?

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The present study used a similar paradigm adapted from Moore et al. (1989) and Ziatas et al. (1998), which asked children to find a hidden toy in one of the two locations according to the information provided by a puppet. The testimony of the puppet included a factive Mandarin mental verb *zhi1dao4* (*know*), or a non-factive Mandarin mental verb *yi3wei2* (*thought*), depending on different conditions. Based on the previous evidence on the deficit in understanding others' mental states in children with ASD (e.g. Baron-Cohen, 2000; Baron-Cohen et al., 1985), we expected to find the deficit of understanding mental terms in terms of verb factivity in children with ASD, compared to TD children.

(b) Are there any other confounding factors that influence understanding Chinese mental terms in children with ASD?

Previous evidence revealed that development of ToM was related to general language ability (e.g., Astington & Baird, 2005; de Villiers & de Villiers, 2000; Papafragou et al., 2007) and executive functions for both children with ASD (e.g., Pellicano, 2007) and TD children (e.g., Carlson, 2005; Carlson, Moses, & Claxton, 2004; Frye, Zelazo, & Palfai, 1995; Jacobson et al., 2006; Muller, Dick, Gela, Overton, & Zelazo, 2006; Sabbagh, Xu, Carlson, Moses, & Lee, 2006; Zelazo, 2006; Zelazo, Hongwanishkul, Happaney, & Lee, 2005; Zelazo, Muller, Frye, & Marcovitch, 2003). The understanding of mental terms is found to be related to VMA for children with ASD, but not for TD children (Kazak, Collis, & Lewis, 1997). Because children's general language ability and executive functions are correlates of understanding of mental terms, we hypothesized that general language ability and inhibitory control should also account for part of the group differences of understanding mental terms.

2. Method

2.1. Participants

Three groups of children participated in the present study: 18 Mandarin-speaking children with ASD in the ASD group ($M = 6.68$, $SD = 1.07$; 2 female), 25 age-matched Mandarin-speaking TD children in the age-matched TD group ($M = 6.58$, $SD = 1.15$; 2 female), and 18 VMA-matched TD children in the VMA-matched TD group ($M = 3.86$, $SD = 0.46$, 2 female). Table 1 shows characteristics of the participants. All TD children were recruited from kindergartens and primary schools in Guangzhou, China. All children with ASD were recruited from a special school for children with ASD in Guangzhou, China. They were previously diagnosed by clinicians, and satisfied the diagnostic criteria for ASD according to the DSM-IV (APA, 1994). Their diagnosis was confirmed by the Chinese version of the Autism Spectrum Quotient: Children's Version (AQ-Child) developed by Auyeung, Baron-Cohen, Wheelwright, and Allison (2008). The AQ scores of children with ASD ($M = 85.29$, $SD = 11.40$) were statistically significantly above the cut-off score (76), $t(17) = 3.46$, $p = .003$. Their VMA was tested using the Chinese version Peabody Picture Vocabulary Test-Revised (PPVT-R, Sang & Miao, 1990). An independent sample t test showed no age difference between ASD and age-matched TD children, $t(41) = 0.29$, $p = .78$. Compared to children with ASD, age-matched TD children scored statistically significantly higher on PPVT, $t(41) = 6.32$, $p < .001$. Children with ASD did not differ from the VMA-matched TD children on VMA, $t(34) = 0.79$, $p = .44$.

2.2. Material and procedure

Each child was tested individually in a room with an experimenter. The child was invited to play a hiding game to find a sticker hidden in one of the two closed boxes. The hiding game was adapted from the paradigms used by Moore et al. (1989) and Ziatas et al. (1998). In the training phase, the child was shown two identical boxes, with a sticker randomly placed in either box. The child was told that only one box had a sticker inside and the other one was empty, and asked to find the sticker by choosing one of the two boxes. Before the child made the decision, a puppet was introduced and described as the one who "could look into the boxes". The puppet, manipulated by the experimenter, opened one box with its lid masking the content from the child, and looked into the box. The experimenter confirmed with the child that the puppet had seen the contents of the boxes by asking "Did the puppet look into the boxes?" If the child disagreed, the puppet repeated the looking action until they agreed. Then the puppet pointed to one of the boxes it just looked into, and provided some verbal cues (i.e., "the sticker is here" in the first trial). Then the experimenter put the puppet aside and asked the child to choose one of the two boxes to find the sticker. The first box the child pointed to or touched was recorded. The two boxes were opened and the results were revealed. If the child guessed right, they would get the sticker as a reward.

Table 1
Participant characteristics in each group.

Group	ASD	Age-matched TD	VMA-matched TD
N	18	25	18
Age range	4;0–8;5[a]	5;2–8;10	3;2–4;8
Mean age	6.68 (1.07)	6.58 (1.15)	3.86 (0.46)
VMA (PPVT)	26.13 (18.11)	85.12 (32.85)	23.23 (17.54)
DCCS	1.56 (0.86)	2.56 (0.58)	1.67 (0.84)

Note. Standard deviations are shown in parentheses.
[a] There was only one child with ASD at 4 years old; others were older than 5;5.

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Table 2
Verbal cues used in the present study by condition.

Mental verb	Close reference	Distal reference
True belief	"I zhi1-dao4 (know) the sticker is here"	"I zhi1-dao4 (know) this box is empty"
False belief	"I yi3-wei2 (thought) the sticker is here"	"I yi3-wei2 (thought) this box is empty"

The second trial of the training repeated the procedures of the first trial with the exception that the puppet provided the verbal cue "this box is empty" for the child to exclude one box. Children who passed both trials would continue to participate in the following experiment. Those who failed either training trial were trained again until they passed both trails. Children who could not pass the training with sufficient repetition (i.e., being incorrect in either of the two trials) were excluded from the rest of the experiment. All 25 children in the age-matched TD group passed the training. There were 4 out of 22 children in the VMA-matched TD group and 6 out of 24 children in the ASD group that did not pass the training and thus did not proceed with the further experiment.

Children's general language ability was measured with the PPVT, as a measurement of VMA. Children's executive functions were measured using the Dimensional Change Card Sorting task (DCCS; Zelazo, 2006), a widely used measure of inhibitory control for children across a wide range of ages. In the DCCS task, we asked children to sort the cards according to a certain rule (e.g., color), and then after a certain amount of trials, to switch to another rule (e.g., shape). The task measures how flexible children switch between the two rules.

There were four conditions of the experiment using the same procedures as the two training trials but with different verbal cues (see Table 2 for verbal cues of each condition). To avoid the response tendency to always choose the pointed box with *zhi1dao4*, and the other box with *yi3wei2*, we used two types of direct object clauses following the mental terms. The direct object clause indicating (1) immediate reference (e.g., "the sticker is here") or (2) distal reference (e.g., "this box is empty"). The concept of immediate and distal references was first used in Snow (1977) to describe mother–child verbal interactions. Immediate reference focuses here and now and distal reference refers to abstract and intangible ideas. Table 2 shows the four types of verbal cues. After hearing the verbal cues from the puppet, the child was asked to find the sticker in one of the two boxes. The first box the child pointed to or touched was recorded as their choice. After the child made the decision in each trial, the chosen box was put aside, and the child was told to wait till the end to open all chosen boxes. At the end, all boxes were opened and the results were revealed. The order of the four conditions was randomized.

3. Results

The correct response of each experimental condition is to choose the pointed box for "I *yi3wei2 (thought)* this box is empty", and to choose the other box for "I *yi3wei2 (thought)* the sticker is here". Fig. 1 shows the correct rates of children with ASD, age-matched and VMA-matched and TD children in each condition.

We conducted a non-parametric repeated measures analysis of the effects of child group (ASD, age-matched TD, VMA-matched TD) and the four conditions (2 mental verbs × 2 clauses) on children's understanding of mental terms using the SAS CATMOD procedure. Child group and condition effects were statistically significant, $\chi^2(2, N = 61) = 9.00$, $p = .011$, $\chi^2(3, N = 61) = 237.71$, $p < .001$, respectively. The group × condition interaction was not statistically significant, $\chi^2(6, N = 61) = 7.58$, $p = .27$. A priori contrasts using the ASD group as the reference group showed that regardless of the conditions, the children with ASD performed statistically significantly worse than the age-matched TD children in the mental verb understanding task, $\chi^2(1, N = 43) = 8.68$, $p = .003$, but did not differ from VMA-matched TD children, $\chi^2(1, N = 36) = 0.68$, $p = .41$.

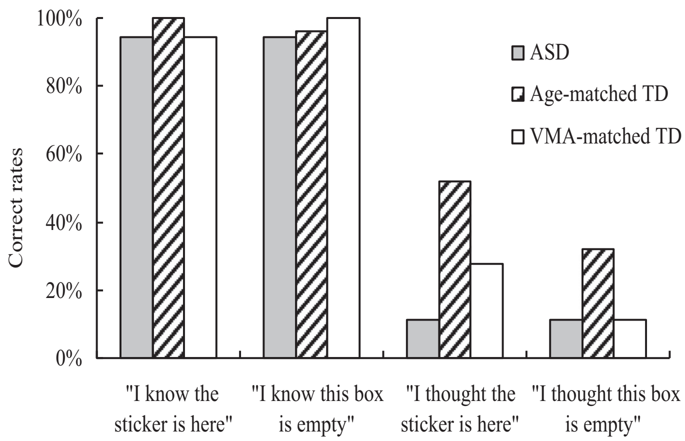

Figure 1. Percentage of children in the ASD ($n = 18$), age-matched TD ($n = 25$), and VMA-matched TD ($n = 18$) groups who correctly responded according to the understanding of different verbal cues.

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Table 3
Intercorrelations among age, general language ability (PPVT), executive functions (DCCS), and children's understanding of mental terms (combined scores), by group.

ASD	TD			
	1	2	3	4
1. Age	–	.90***	.44**	.31*
2. PPVT	.19	–	.47**	.30*
3. DCCS	−.11	.56*	–	.20
4. Combined scores	.24	.53*	.46	–

Notes. Intercorrelations for TD children ($n = 43$) are presented above the diagonal, and correlations for children with ASD ($n = 18$) are presented below the diagonal.
* $p < .05$.
** $p < .01$.
*** $p < .001$.

To further investigate the effect of mental verbs in understanding the verbal cues, Chi-square tests with Yates Correction indicated that ASD, age-matched TD and VMA-matched TD children all understood the verbal cues with *zhi1dao4* significantly better than the verbal cues with *yi3wei2*. $\chi^2(1, N = 72) = 46.87$, $p < .001$, $\chi^2(1, N = 100) = 34.71$, $p < .001$, $\chi^2(1, N = 72) = 41.66$, $p < .001$, respectively. Chi-square analyses were also conducted to test the effect of the clause. Results showed there were no statistically significant differences between understanding of immediate and distal references in ASD, age-matched TD and VMA-matched TD children, $\chi^2(1, N = 72) = 0.00$, $p = 1.00$, $\chi^2(1, N = 100) = 1.71$, $p = .79$, $\chi^2(1, N = 72) = 0.23$, $p = .63$, respectively.

A combined score was calculated by summing up scores in all four conditions. Pearson correlations were conducted to test whether children's performance in the present study (combined scores of all four conditions) was correlated with their age, general language ability and executive functions. As shown in Table 3, TD children's (combining two TD groups) combined scores of the current task were correlated with their age, $r(43) = .31$, $p = .042$, and general language ability, $r(43) = .30$, $p = .049$, but not correlated with their executive functions, $r(43) = .20$, $p = .20$. ASD children's combined scores were correlated with their general language ability, $r(18) = .53$, $p = .024$, and marginally correlated with their executive functions, $r(18) = .46$, $p = .056$, but not correlated with their ages, $r(18) = .24$, $p = .33$.

Hierarchical multiple regressions were conducted to examine the unique effects of general language ability and executive functions to the differences of understanding the mental terms between ASD and age-matched TD children. In the first regression model, the effects of age and group were examined; in the regression model 2, the effect of group were examined after controlling for the effects of age and general language ability, that is, whether there was any group differences of understanding mental terms assuming children with ASD and TD children obtained the same levels of general language ability; in the regression model 3, the effects of group was examined after controlling for the effect of age and executive functions, that is, whether there was any group differences of understanding mental terms after controlling for the executive functions; in the regression model 4, the group difference of understanding mental terms were examined after controlling for the age, general language ability and executive functions.

Results of the regression model 1 showed that after controlling for age, the group was significantly predictive of understanding mental terms, $F(1,41) = 5.98$, $p = .005$. After the effect of general language ability was controlled, 6% of the variance in the mental verb understanding was accounted for by the group of participants, $F(1, 41) = 4.00$, $p = .014$. In regression model 3, after the effect of executive functions was controlled, 5% of the variance in the mental verb understanding was accounted for by the group of participants, $F(1, 41) = 5.66$, $p < .001$. In regression model 4, after the effects of both general language ability and executive functions were controlled, 3% of the variance in the mental verb understanding was accounted for by the group of participants, $F(1, 41) = 3.44$, $p = .012$. Table 4 shows the regression models predicting children's understanding of mental terms as a function of children's age, language ability, and executive functions.

4. Discussion

The present study examined and compared children with ASD and TD children's understanding of Chinese mental verb factivity in true belief and false belief situations. Children with ASD performed worse than age-matched TD children in the four conditions of understanding of mental terms, but similarly to VMA-matched TD children. The correlation analysis further indicated that the understanding of mental terms for both TD children and children with ASD was correlated with the general language ability. This suggested that children with ASD had difficulty in understanding mental verb and the difficulty may be partially accounted for by their impaired general language ability. However, the regression analysis showed that, even after controlling for age and general language ability, children with ASD still show deficits in understanding mental terms. Regression analysis also showed that the deficit in understanding mental terms in children with ASD could not be explained by their impairments in executive functions alone. These findings suggested that, regardless of language and cognitive abilities, 5- to 8-year-old Chinese children with ASD have deficits in understanding mind-related concepts and their linguistic representations (i.e., mental terms).

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Table 4
Regression models predicting children's understanding of mental terms as a function of children's age, language ability (PPVT), and executive functions (DCCS).

Variables	R^2	R^2 change	F change	p value
Regression model 1:				
Step 1: age	.008	.008	0.31	.58
Step 2: group	.23	.22	5.98	.005
Regression model 2:				
Step 1: age	.008	.008	0.31	.58
Step 2: PPVT	.18	.17	4.40	.019
Step 3: group	.24	.06	4.00	.014
Step 4: PPVT × group	.30	.06	4.04	.008
Regression model 3:				
Step 1: age	.008	.008	0.31	.58
Step 2: DCCS	.25	.24	6.74	.0003
Step 3: group	.30	.05	5.66	.003
Step 4: DCCS × group	.31	.01	4.18	.007
Regression model 4:				
Step 1: age	.008	.008	0.31	.58
Step 2: PPVT, DCCS; PPVT × DCCS	.29	.28	3.82	.01
Step 3: group	.32	.03	3.44	.012
Step 4: PPVT × group; DCCS × group; PPVT × DCCS × group	.42	.10	3.11	.01

We also compared children's understanding of mental terms with different factivity values. Almost all children with ASD and TD children responded correctly to the verbal cues with *zhi1dao4* (*know*), but performed significantly worse to the verbal cues with *yi3wei2* (*thought*). Children did not respond to the immediate reference differently from distal reference. These findings suggested that children with ASD who passed the training could respond as well as TD children, that is, they could respond by picking the pointed box according to immediate reference and the other box according to the distal reference. However, all children with ASD and TD children had difficulty understanding false belief situations and responding correctly according to the non-factive verb *yi3ei2* (*thought*), compared to the true belief situation with the factive verb *zhi1dao4* (*know*). However, the lack of Group × Condition interaction showed that this difficulty in understanding false belief situation with non-factive mental verbs was not specific to children with ASD, but also for the two TD groups.

Previous studies also found deficits in understanding mental terms in children with ASD compared to TD children (e.g., Ziatas et al., 1998). However, it is unclear whether this deficit in children with ASD is due to the impaired general language ability or the difficulty in understanding mind concept per se. The present study found that regardless of their language ability and executive functions, children with ASD still have profound impairment in understanding mental terms, which may suggest their deficit in relevant mental concepts.

One limitation of the present study was that we did not investigate the relations between ASD children's deficits of mental verb understanding and their impaired ToM development. Previous research has focused on ASD children's difficulty in understanding others' mental states in traditional false belief tasks (e.g., Baron-Cohen et al., 1985). Acquiring mental terms facilitates understanding others' mind (Astington & Baird, 2005; de Villiers & de Villiers, 2000; Papafragou et al., 2007). Some researchers argued that language is an essential precursor of false-belief representation (Astington & Baird, 2005). In a strong version of "linguistic determinism", the development of ToM relies on the acquisition of the syntax of complementation, which provides the representational tools for understanding false belief (de Villiers & de Villiers, 2000; de Villiers & Pyers, 2002). On the other hand, other researchers argued that since these mental terms were hard to grasp their acquisition should await certain relevant conceptual development (*conceptual-growth hypothesis*, Papafragou et al., 2007). There is a growing body of evidence that children as young as infants may obtain pre-verbal ToM processes in implicit measures which suggested that understanding of other's mental state may precede acquisition of mental terms (e.g., Clements & Perner, 1994; Csibra & Southgate, 2006; Onishi & Baillargeon, 2005). The relations between acquisition of mental terms and ToM deficit in children with ASD should be further investigated in future studies with more sophisticated designs such as non-verbal false belief tasks.

5. Conclusions

The current study examined how Chinese-speaking children with ASD understand Chinese mental terms, especially the subtle differences in the verb factivity, compared to their age- or VMA-matched TD children. We found that children with ASD showed lower ability in understanding mental terms, compared to the age-matched TD children, even after controlling for the effects of age, general language ability and executive functions. However, both TD children and children with ASD could understand the factive mental verb in the true belief situation, but have difficulty in understanding the non-factive mental verb in the false belief situation.

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References

American Psychiatric Association. (1994). *Diagnostic and statistical manual of mental disorders* (4th ed.). Washington, DC: American Psychiatric Press.
Astington, J. W., & Baird, J. A. (2005). *Why language matters for theory of mind*. New York: Oxford University Press.
Auyeung, B., Baron-Cohen, S., Wheelwright, S., & Allison, C. (2008). The autism spectrum quotient: Children's version (AQ-Child). *Journal of Autism and Developmental Disorders, 38*, 1230–1240.
Baron-Cohen, S. (2000). Theory of mind and autism: A review. In L. M. Glidden (Ed.), *International review of research in mental retardation* (pp. 169–184). Academic Press.
Baron-Cohen, S., Leslie, A. M., & Frith, U. (1985). Does the autistic child have a "theory of mind"? *Cognition, 21*, 37–46.
Bartsch, K., & Wellman, H. M. (1995). *Children talk about the mind*. New York: Oxford University Press.
Bretherton, I., & Beeghly, M. (1982). Talking about internal states: The acquisition of an explicit theory of mind. *Developmental Psychology, 18*, 906–921.
Carlson, S. (2005). Developmentally sensitive measures of executive function in preschool children. *Developmental Neuropsychology, 28*, 595–616.
Carlson, S., Moses, L. J., & Claxton, L. J. (2004). Individual differences in executive functioning and theory of mind: An investigation of inhibitory control and planning ability. *Journal of Experimental Child Psychology, 87*, 299–319.
Cheung, H., Chen, H. C., & Yeung, W. (2009). Relations between mental verb and false belief understanding in Cantonese-speaking children. *Journal of Experimental Child Psychology, 104*, 141–155.
Clements, W., & Perner, J. (1994). Implicit understanding of belief. *Cognitive Development, 9*, 377–395.
Csibra, G., & Southgate, V. (2006). Evidence for infants' understanding of false beliefs should not be dismissed. *Trends in Cognitive Sciences, 10*, 4–5.
de Villiers, J. G., & de Villiers, P. A. (2000). Linguistic determinism and the understanding of false beliefs. In P. Mitchell & K. J. Riggs (Eds.), *Children's reasoning and the mind* (pp. 191–228). Hove, England: Psychology Press/Taylor & Francis (UK).
de Villiers, J. G., & Pyers, J. E. (2002). Complements to cognition: A longitudinal study of the relationship between complex syntax and false-belief-understanding. *Cognitive Development, 17*, 1037–1060.
Frye, D., Zelazo, P. D., & Palfai, T. (1995). Theory of mind and rule-based reasoning. *Cognitive Development, 10*, 483–527.
Jacobson, S. W., Molteno, C. D., Jacobson, J. L., Hay, A. M., Altken, L., Pienaar, M., et al. (2006). Deficits in number processing and executive function in fetal alcohol spectrum disorder in preschool children. *Alcoholism-Clinical and Experimental Research, 30*, 176a.
Johnson, C. N., & Maratsos, M. P. (1977). Early comprehension of mental verbs: Think and know. *Child Development, 48*, 1743–1747.
Kazak, S., Collis, G. M., & Lewis, V. (1997). Can young people with autism refer to knowledge states? Evidence from their understanding of "know" and "guess.". *The Journal of Child Psychology and Psychiatry and Allied Disciplines, 38*, 1001–1009.
Lee, Olson, & Torrance, N. (1999). Chinese children's understanding of false beliefs: The role of language. *Journal of Child Language, 26*, 1–21.
Limber, J. (1973). The genesis of complex sentences. In T. E. Moore (Ed.), *Cognitive development and the acquisition of language*. Oxford, England: Academic Press.
Liu, D., Wellman, H. M., Tardif, T., & Sabbagh, M. A. (2008). Theory of mind development in false-belief understanding Chinese children: A meta-analysis of across cultures and languages. *Developmental Psychology, 44*(2), 523–531.
Milligan, K., Astington, J. W., & Dack, L. A. (2007). Language and theory of mind: Meta-analysis of the relation between language ability and false-belief understanding. *Child Development, 78*, 622–646.
Moore, C., Bryant, D., & Furrow, D. (1989). Mental terms and the development of certainty. *Child Development, 60*, 167–171.
Muller, U., Dick, A. S., Gela, K., Overton, W. F., & Zelazo, P. D. (2006). The role of negative priming in preschoolers' flexible rule use on the dimensional change card sort task. *Child Development, 77*, 395–412.
Onishi, K., & Baillargeon, R. (2005). Do 15-month-old infants understand false beliefs? *Science, 308*, 255–258.
Papafragou, A., Cassidy, K., & Gleitman, L. (2007). When we think about thinking: The acquisition of belief verbs. *Cognition, 105*, 125–165.
Pellicano, E. (2007). Links between theory of mind and executive function in young children with autism: Clues to developmental primacy. *Developmental Psychology, 43*, 974–990.
Sabbagh, M. A., Xu, F., Carlson, S. M., Moses, L. J., & Lee, K. (2006). The development of executive functioning and theory of mind. A comparison of Chinese and U.S. preschoolers. *Psychological Science, 17*, 74–81.
Sang, B., & Miao, X. (1990). The revision of trail norm of Peabody picture vocabulary test revised (PPVT-R) in Shanghai proper. *Psychological Science, 5*, 20–25, (Chinese).
Scoville, R. P., & Gordon, A. M. (1980). Children's understanding of factive presuppositions: An experiment and a review. *Journal of Child Language, 7*, 381–399.
Shatz, M., Wellman, H. M., & Silber, S. (1983). The acquisition of mental verbs: A systematic investigation of the 1st reference to mental state. *Cognition, 14*, 301–321.
Snow, C. E. (1977). The development of conversation between mothers and babies. *Journal of Child Language, 4*, 1–22.
Tager-Flusberg, H. (1992). Autistic children's talk about psychological states: Deficits in the early acquisition of a theory of mind. *Child Development, 63*, 161–172.
Tardif, T., & Wellman, H. M. (2000). Acquisition of mental state language in Mandarin- and Cantonese-speaking children. *Developmental Psychology, 36*, 25–43.
Tardif, T., Wellman, H. M., & Cheung, K. M. (2004). False belief understanding in Cantonese-speaking children. *Journal of Child Language, 31*, 779–800.
Zelazo, P. D. (2006). The Dimensional Change Card Sort (DCCS): A method of assessing executive function in children. *Nature Protocols, 1*, 297–301.
Zelazo, P. D., Hongwanishkul, D., Happaney, K. R., & Lee, W. S. C. (2005). Assessment of hot and cool executive function in young children: Age-related changes and individual differences. *Developmental Neuropsychology, 28*, 617–644.
Zelazo, P. D., Muller, U., Frye, D., & Marcovitch, S. (2003). The development of executive function. *Monographs of the Society for Research in Child Development, 68*, vii-137.
Ziatas, K., Durkin, K., & Pratt, C. (1998). Belief term development in children with autism, Asperger syndrome, specific language impairment, and normal development: Links to theory of mind development. *Journal of Child Psychology and Psychiatry, 39*, 755–763.