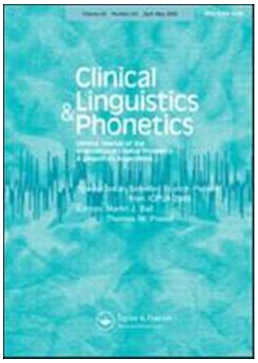

Comprehension of presuppositions in school-age Cantonese-speaking children with and without autism spectrum disorders

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Comprehension of presuppositions in school-age Cantonese-speaking children with and without autism spectrum disorders

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ABSTRACT

While an enormous amount of research has been done on the deficient conversation skills in individuals with autism spectrum disorders (ASD), little is known about their performance on presuppositions, a domain of knowledge that is crucial for successful communication. This study investigated the comprehension of four types of presupposition, namely existential, factive, lexical, and structural presuppositions, in school-age Cantonese-speaking children with and without ASD. A group of children with ASD (n = 21), mean age 8.8, was compared to a group of typically developing children (n = 106). Knowledge of presuppositions was evaluated based on children's ability to judge whether a given utterance was a correct

presupposition of a preceding utterance. Children with ASD were found to show a deficit in the comprehension of presuppositions, even after controlling for differences in general language ability and nonverbal intelligence. The relative difficulty of the four types of presupposition did not differ between the two groups of children. The present findings provide new empirical evidence that children with ASD have a deficit in the comprehension of presuppositions. Future research should explore whether the deficit in the comprehension of presuppositions is related to the development of theory of mind skills in children with ASD.

KEYWORDS

Autism spectrum disorders, Cantonese-speaking children, Cantonese, presuppositions

Introduction

One of the key features of individuals with autism spectrum disorders (ASD) is that they show deficits in communication. This is reflected by the fact that individuals with ASD often show delays and deficits in the acquisition of language, and they show difficulties in understanding, responding to, and sharing others' feelings and perspectives in conversations (Howlin, 2004). Even high-functioning individuals with ASD who have adequate linguistic

knowledge and started talking early in life may still find social communication challenging (Volkmar et al., 1996). For these reasons, autism is often considered to involve primary deficits in pragmatic aspects of language or in the ability to use language to communicate effectively in a range of social contexts (Lord & Paul, 1997; Tager-Flusberg, 1981, 1996; Wilkinson, 1998). In fact, a huge body of research has examined the difficulties children with ASD exhibit in conversational contexts, such as turn taking (e.g. Dobbinson, Perkins, & Boucher, 1998; García-Pérez, Lee, & Hobson, 2006), topic management (e.g. Dobbinson, Perkins, & Boucher, 1998; Hale & Tager-Flusberg, 2005; Rutter & Schopler, 1987), and conversational repair (e.g. Volden, 2004). While these studies suggested individuals with ASD have communication difficulties, one aspect that can contribute to our understanding of their deficits in social communication remains unexplored—namely whether individuals with ASD are able to distinguish presupposed and nonpresupposed information in conversations. The ability to differentiate presupposed and nonpresupposed information in an utterance is important for successful conversational exchanges, since interlocutors need to be able to distinguish between information that is taken for granted (i.e. presupposed or backgrounded information) and new or nonpresupposed information in order to respond appropriately. This paper investigates the comprehension of presuppositions by children with and without ASD, seeking to determine whether children with ASD display a deficit in this domain of knowledge. Importantly, children with ASD are known to have deficits in other aspects of

cognition that could also influence their comprehension of presuppositions (e.g. deficits in general language ability); the present study uses [generalised mixed-effects] multiple regression to examine whether their deficit (if any) in the comprehension of presuppositions is due to the disorder in particular or to deficits in, for example, general language ability or nonverbal intelligence.

Presuppositions

Presuppositions are backgrounded information that interlocutors mutually assume to be taken for granted, and they typically do not convey any new information (Karttunen, 1974; Stalnaker, 1973, 1974, 1998, 2002). For example, in (1), the fact that France has a Prime Minister is backgrounded information shared by the interlocutors in the conversation, and is triggered by the definite description *The Prime Minister of France*.

(1) The Prime Minister of France gave a speech this morning.

Note that if the presupposed proposition (i.e. the existence of a Prime Minister of France) is not mutually known to the interlocutors as backgrounded information, the utterance in (1) will become infelicitous or will trigger presupposition accommodation (Karttunen, 1974;

Stalnaker, 1974; von Fintel, 2008). The backgrounded information (i.e. France has a Prime Minister) is regarded as the "presupposed content", whereas the rest of the sentence is regarded as new information about the Prime Minister of France and is regarded as the "asserted content". Since the felicity of (1) relies on the mutual assumption made by the interlocutors that France has a Prime Minister, it is likely that successful identification of the presupposed content (which is crucial for successful conversational exchanges) relies, at least in part, on taking the speaker's perspective.

While presuppositions are well studied in the theoretical literature on semantics and pragmatics (Chierchia & McConnell-Ginet, 1990; Horn, 1969; Karttunen, 1973, 2016; Langendoen & Savin, 1971; Levinson, 1983; Morgan, 1969; Stalnaker, 1973, 1974, 1998, 2002), experimental studies on presuppositions primarily focused on adults' performance with respect to a specific presupposition trigger (Destruel et al., 2015; Kim, 2015; Schwarz & Tiemann, in press) or a specific set of presupposition triggers (Amaral & Cummins, 2015; Jayez, Mongelli, Reboul, and van der Henst, 2015). To our knowledge, no studies have been conducted on presuppositions in typically developing children. Particularly, there is no research on whether different types of presupposition (see below) develop differently in children, and no study on whether deficits seen in ASD children affect some types of presupposition more than others. The present study seeks to fill this gap by investigating both typically developing and ASD Cantonese-speaking children's performance on four types of

presupposition: existential, factive, lexical, and structural presuppositions. Specifically, this study aims to investigate (a) whether ASD children show a deficit in the comprehension of presuppositions relative to typically developing children of comparable age, general language ability, and nonverbal intelligence; and (b) whether the relative difficulty of different types of presuppositions (see below) differs between children with and without ASD.

Four types of presupposition

Based on the theoretical literature, we distinguish four types of presupposition for the purposes of this study: existential, factive, lexical, and structural.

In English, existential presuppositions can be triggered by definite descriptions (e.g. *the professor*), proper names (e.g. *John*), and possessives (e.g. *the professor's husband*, *John's brother*) (Strawson, 1950, 1952). These expressions presuppose the existence of their referents, as shown in (2) (presupposition is marked by ">>" below and throughout). Here, the fact that the professor in question exists is taken as the presupposed information, while the fact that she was sick yesterday is taken as asserted or nonpresupposed information.

(2) The professor was sick yesterday.

>> The professor exists.

Factive presuppositions in English are triggered by factive verbs such as *know*, *regret*, *discover*, and *find out* (Karttunen, 2016; Kiparsky & Kiparsky, 1971). As in Scoville & Gordon (1980), factive verbs are defined here as verbs that presuppose the veracity of the following complement, whereas nonfactive verbs do not. Factive verbs are typically followed by a complement clause and presuppose the truth of the complement clause, as shown in (3).

(3) John knows that Mary is a pianist.

>> Mary is a pianist.

In (3), due to the presence of the factive verb *know*, the veracity of the complement clause *Mary is a pianist* is presupposed. Whether the veracity of the complement clause is presupposed or not depends on the factivity of the preceding predicates. If the factive verb *know* in (3) is replaced by a verb that is not factive, such as *believe* in (4), the veracity of the complement clause is no longer presupposed (marked by "/>>" below and throughout).

(4) John believes that Mary is a pianist.

/>> Mary is a pianist.

The term *lexical presuppositions* is used as a convenient label for presuppositions triggered by two classes of lexical items: change-of-state verbs (e.g. *stop*, *begin*) (Abusch, 2002; Lorenz, 1992; Simons, 2001) and iteratives (e.g. *again, anymore*) (Karttunen, 2016; Levinson, 1983), as demonstrated below.[1]

(5) Sue has stopped going to the gym. (Change-of-state verb)

>> Sue used to go to the gym.

(6) The student was absent again. (Iterative)

>> The student was absent before.

While the triggers in (5) and (6) belong to different classes of lexical items, what lexical presuppositions have in common is that they rely on the interlocutors' understanding of the inherent meaning of the lexical items to derive the presupposition. Specifically, the interlocutors can infer from the inherent meaning of *stop* in (5) that the event described (i.e. Sue's going to the gym) had gone on prior to some contextually salient time in the past.

[1] Previous studies suggested that implicative verbs such as *manage* and *remember* should be regarded as triggers for lexical presuppositions (Karttunen, 1971; Levinson, 1983). More recently, however, Karttunen (2016) has argued that implicative verbs are more complex than previously thought and should not be analyzed as presupposition triggers. For this reason, implicative verbs are not discussed here.

Similarly, the interlocutors can infer from the inherent meaning of *again* in (6) that the event described (i.e. the student was absent) had happened before. This sets them apart from the other presupposition types described here; while those other presupposition types can also be triggered by individual lexical items (e.g. by certain factive verbs and certain determiners), those trigger-presupposition relationships are arbitrary and presumably must be memorized (e.g. there is nothing about the meaning of *know* that excludes the possibility of knowing something that is false), whereas lexical presuppositions come nonarbitrarily from the meaning of the word (e.g. it is impossible to stop something that had never been going on in the first place).

Structural presuppositions are presuppositions triggered by different constructions, such as cleft sentences and temporal clauses. This study focuses on temporal clauses, which can be headed by *after*, *since*, and so on in English (Beaver & Condoravdi, 2003; Heinämäki, 1974), as shown in (7).

(7) After David came, everyone was happy.

>> David came.

What is taken as the presupposed information in (7) is the clause *David came*, which is inside the temporal clause introduced by *after*.

As mentioned earlier, to date no study has been carried out on the four types of presupposition in children with ASD or typically developing children. Therefore, in addition to examining whether children with ASD show a deficit in the comprehension of presuppositions in general compared to typically developing children, the present study tested whether the pattern of such a deficit (if any) would differ as a function of presupposition type.

Method

Participants

In total, 21 children with ASD and 106 typically developing children participated in the study. Data for five of the typically developing children were excluded from further analysis (four because their age was not recorded, one because the participant had too many trials with missing data in the presupposition task). All children were students in primary schools in Hong Kong and their native language was Cantonese. According to the teachers' and parents' reports, they had normal visual acuity (with or without correction) and no hearing impairment. For information about the age, verbal mental age, nonverbal intelligence, and gender of the two groups of participants, see table 1.

Participants in the ASD group were recruited through the Speech Therapy Unit at the Hong Kong Polytechnic University. All were diagnosed with autism spectrum disorders by a pediatrician or a clinical psycholinguist in a government setting, either in public hospitals or in child assessment centers.

Participants in the typically developing group were recruited from mainstream primary schools. According to the teachers' and parents' reports, they had no known or suspected specific language impairment or psychological problem.

Tasks, materials, and procedure

To assess the participants' nonverbal intelligence, general language ability, and understanding of the four types of presupposition, three tasks were administered. All tasks were administered individually in Cantonese. Testing was conducted in quiet rooms in the Speech Therapy Unit at the Hong Kong Polytechnic University for the ASD group, and in the respective primary schools for the typically developing group. The test lasted approximately one hour for each child. Short breaks were given during testing at the experimenter's discretion. Table 1 summarises the age, general language ability, nonverbal intelligence, and gender of the ASD and typically developing groups.

Insert Table 1 about here

Nonverbal intelligence

Raven's Standard Progressive Matrices Test (Raven, 1981, 1989) was adopted to assess nonverbal intelligence. This is a standardized test used by speech therapists in Hong Kong to assess children's nonverbal intelligence. As this test can be used for children whose age range is 5;6 to 15;11, it was considered an acceptable choice for assessing nonverbal intelligence in the current two groups of children. The maximum raw score for the test is 60. For each participant we calculated the standard score based on the raw score and the participant's age.

General language ability

The Textual Comprehension Test in the *Hong Kong Cantonese Oral Language Assessment Scale* (HKCOLAS; T'sou et al., 2006) was used to assess children's general language ability. This is a standardised language test used by speech therapists in Hong Kong for testing children's textual comprehension skills. Children below the age of 7;8 were presented with texts 1 and 2, yielding a maximum raw score of 23, and children aged 7;8 or above were presented with texts 2 and 3, yielding a maximum raw score of 38. Since the test required

children's understanding of a wide range of vocabulary, phrases, and grammatical structures in order to properly comprehend the given texts, we considered it a valid test for assessing general language ability. Based on each participant's chronological age on the date the test was administered and raw score in the Textual Comprehension Test, we derived his or her verbal mental age (see table 1), which we used to represent general language ability.

Understanding of the four types of presupposition

To test their understanding of the four types of presupposition, children took part in six practice trials and 38 test trials.[2] The purpose of the six practice trials was to familiarise the participants with the notion of "presupposition". The format of the practice trials and the test trials was identical except that (a) the four types of presupposition investigated in this study (existential, factive, lexical, and structural) were not included in the practice trials, and (b) feedback was provided after each practice trial but not after test trials. All the trials were presented as audio files.

Each trial contained three utterances. Before the first utterance was played, a beep sounded to signal the start of the trial. The first utterance (spoken by a male) contained a presupposition trigger (see (8a)); the presupposition trigger is underlined for clarity). The

[2] There were altogether 40 test trials in this task. However, since two of the test trials were found to be invalid for testing children's understanding of presuppositions, they were excluded in our analysis and in the following discussion.

second utterance (spoken by a female) was a Cantonese sentence meaning 'That is to say' (8b), and the third utterance (spoken by another female) was either a correct (8c) or an incorrect (8d) presupposition. (8) is an example trial for existential presupposition.[3]

(8) a. Daai6man4 go3 sai3mui6 ceot1 nin4 sap6 seoi3. (Existential)

Daaiman Cl sister next year ten years.old

'Daaiman's sister will be 10 years old next year.'

b. Gam2jeong6 gong2 zik1hai6 waa6.

this.way say exactly say

'That is to say.'

c. Daai6man4 jau6 go3 sai3mui6.

Daaiman have Cl sister

'Daaiman has a sister.'

d. Daai6man4 mou5 sai3mui6.

Daaiman not.have sister

'Daaiman doesn't have a sister.'

[3] Cantonese romanisations used in this paper follow the Linguistic Society of Hong Kong Cantonese Romanisation Scheme.

After listening to each test trial, the participants had to indicate whether the last utterance they heard was correct or not by circling either tick (correct) or cross (incorrect) on the answer sheet for that particular trial. In the example above, if participants heard the sequence of utterances (8a,b,c), then they had to circle the tick mark for their answer to be considered correct. If they heard the sequence (8a,b,d), then they had to circle the cross to be considered correct.[4]

As mentioned before, existential presuppositions can be triggered by definite descriptions (e.g. *the English teacher*) in English. However, since Cantonese is a classifier language and does not have definite articles (Cheng & Sybesma, 1999), definite expressions introduced by demonstratives such as *go2 deoi1 jan4* 'that group of people' and possessives such as *Daai6man4 go3 sai3mui6* 'Daaiman's sister' were used as triggers for existential presuppositions in this test. We included a total of 10 test trials for existential presupposition, with five containing correct presuppositions, and five containing incorrect presuppositions.

As for factive presuppositions, we included six factive (e.g. *m4gei3dak1* 'forget') and six nonfactive mental state verbs (e.g. *ji5wai4* 'falsely think') in this test. Both factive and nonfactive mental state verbs were included to help ensure that the participants' answers were based on understanding of the distinct lexical semantics (in particular, factivity) associated

[4] Since the purpose of this test was to assess the participants' ability to distinguish presupposed and nonpresupposed information, no trials included utterances whose presuppositions were controversial.

with these two types of verb. An example of factive presupposition is given in (9).

(9) Maa1mi4 m4gei3dak1 mui6mui6 ting1jat6 jiu3 soeng51tong4.
mother forget younger.sister tomorrow need attend.class
'The mother has forgotten that the younger sister needs to attend a class tomorrow.'
>> Mui6mui6 ting1jat6 jiu3 soeng51tong4.
younger.sister tomorrow need attend.class
'The younger sister needs to attend a class tomorrow.'

For lexical presuppositions, we included change-of-state verbs (e.g. *gaai3* 'quit', *ting4* 'stop'), iteratives (e.g. *jau6* 'again', *mou5zoi3* 'not anymore'), and the Cantonese verbal particle *faan1*, which indicates resumption of an activity or a return to a state that has been interrupted, as shown in (10) (Matthews & Yip, 2011).

(10) Go1go1 duk6 faan1 syu1.
elder.brother study Prt book
'The elder brother has resumed his study.'
>> Go1go1 zi1cin4 jau5 dyun6 si4gaan1 mou5 duk6syu1.
elder.brother before have period time not.have study

'The elder brother didn't study for a period of time before.'

Since Cantonese has only a few change-of-state verbs and iteratives, only seven test trials were included here, with four carrying correct presuppositions and three carrying incorrect presuppositions.

Finally, for structural presuppositions, we included temporal clauses with *zi1cin4* 'before', *zi1hau6* 'after', *mou5noi6* 'not long after', and *go2zan6si4* 'at that time'. An example test trial with *go2zan6si4* 'at that time' is shown in (11).

(11) Go1go1 duk6 siu2hok6 go2zan6si4, mui6mui6 zung6mei6 ceot1sai3.
elder.brother study primary.school at.that.time younger.sister not.yet born
'At the time the elder brother was studying in primary school, the younger sister was not born yet.'
>> Go1go1 duk6 gwo3 siu2hok6.
elder.brother study Exp primary.school
'The elder brother studied in a primary school before.'

For structural presuppositions, a total of nine test trials were used, with five containing correct presuppositions and four containing incorrect presuppositions. Table 2 summarises

the number of test trials as well as the number of correct and incorrect presuppositions for each type of presupposition. The test trials were randomised before they were presented to the participants.

Insert Table 2 about here

As shown in table 2, we included both correct and incorrect presuppositions for each type of presupposition. This ensured that the participants' answers were based on understanding of presupposed versus nonpresupposed information.

Analysis

Some previous studies (see, for instance, Yi et al., 2013) have tested the difference between children with ASD and typically developing children by comparing the children with ASD to various groups of typically developing controls—for example, one group of controls that is matched to the children with ASD in terms of age, another group that is matched in terms of

general language ability, and so on. There are limitations to this method, however, because in nature these variables tend to be confounded. That is, children with ASD will tend to have lower general language ability than age-matched controls, and will tend to be older than language-matched controls. For the present study, we instead analysed the data using generalised (logistic) linear mixed models, which are a type of regression model. Regression is preferable to the method described above because it allows the statistical model to take all relevant variables into account at once (see, e.g. Balota, Cortese, Sergent-Marshall, Spieler, & Yap, 2004, for an example from visual word recognition). A regression model generates predictions (e.g. predicted accuracy on the presupposition task) for both ASD and typically developing children of a given age, general language ability, and nonverbal intelligence, and tests whether the predicted accuracy for children with ASD differs from the predicted accuracy for typically developing children.

The analysis was implemented in the `{lme4}` package in the R statistical environment. The model regressed the likelihood of a correct response on age, language ability, nonverbal intelligence, ASD status, type of presupposition, and all two-way interactions with presupposition type. Both age in months and nonverbal intelligence were sphered (z-scored). General language ability was coded as the midpoint of the range in months given by the HKCOLAS (for example, if a participant's general language ability score yielded a verbal mental age of 128–144, then his or her language ability was treated as 136 months in this

analysis) and then sphered. Autism status was deviation coded, with 0.5 for ASD participants and -0.5 for typically developing participants. Presupposition type was deviation coded with structural presuppositions as the baseline. The model included random intercepts, slopes, and correlation parameters of the deviation-coded presupposition type predictors for subjects, and random slopes of chronological age, verbal mental age, and autism status for stimuli. For stimuli, random intercepts and random correlation terms were suppressed so that the models would converge. Normal confidence intervals for fixed-model parameters were calculated via a bootstrap with 100 replicates, implemented through the `lme4::bootMer()` function. The full analysis code and model specification are available at https://osf.io/u2wsz/.

Results

To verify the validity of the test trials for assessing understanding of the four types of presupposition, the presupposition task was administered to 48 adult volunteers (aged 18−74 years, mean 31, SD 15, 23 males and 25 females) who were all native speakers of Cantonese living in Hong Kong. These participants were 99.2% accurate on existential presuppositions, 94.3% on factive presuppositions, 98.5% on lexical presuppositions, and 90.5% on structural presuppositions. Accuracy did not significantly change as a function of age (b = -0.06, z = -0.22, p = 0.829), which is expected under the assumption that typically developing

individuals reach ceiling performance in presuppositions by adulthood. That the adult participants showed over 90% accuracy on the four types of presupposition indicated that the test trials were valid for assessing understanding of the four types of presuppositions. The adult participants had a significant effect of presupposition type ($\chi^2(3) = 17.9$, $p < 0.001$), with marginally above average performance on existential presuppositions ($b = 3.98$, $z = 1.7$, $p = 0.089$) and below average performance on factive presuppositions ($b = -2.64$, $z = -2.31$, $p = 0.021$).

Figure 1 shows the relationship between the various predictors (i.e. age, general language ability, and nonverbal intelligence) and accuracy for the four types of presupposition in children with ASD and typically developing children.[5] The variance inflation factors (calculated based on an OLS regression model where each of these variables was aggregated by participant) were 2.17 for accuracy, 3.14 for general language ability, 2.78 for age, 1.24 for nonverbal intelligence, and 1.33 for ASD status, indicating that there was not a substantial multicollinearity problem in the dataset (see, e.g. Baayen, Feldman, & Schreuder, 2006), although it is worth noting that age and general language ability had a high correlation ($r = 0.74$).

As shown in figure 1, age, general language ability, and nonverbal intelligence all had positive relationships with accuracy in the presupposition task. Children with ASD (as shown

[5] The data are available at https://osf.io/u2wsz/.

in the solid lines) were less accurate than typically developing children (as shown in the dashed regression lines). Existential presuppositions (red lines; refer to the online version of the article for the color figure) tended to be responded to most accurately by both groups of children, whereas lexical and structural presuppositions (green and black lines) tended to be responded to less accurately, and factive presuppositions (blue lines) fell in the middle. The developmental trajectory of each presupposition type was similar, with one exception: lexical presuppositions did not appear to greatly improve with nonverbal intelligence.

Insert Figure 1 about here

Model comparisons (comparing the model described above to a maximally similar model with the relevant interaction term removed) indicated that presupposition type did not significantly interact with ASD status ($\chi^2(3) = 1.10$, $p = 0.776$), with age ($\chi^2(3) = 2.11$, $p = 0.550$), or with general language ability ($\chi^2(3) = 2.75$, $p = 0.431$), but there was a significant interaction between presupposition type and nonverbal intelligence ($\chi^2(3) = 10.46$, $p = 0.015$). The main effects were all significant. General language ability was significantly positively associated with accuracy ($b = 0.43$, 95% CI = [0.17, 0.67], $z = 3.53$, $p < 0.001$), as were

nonverbal intelligence (b = 0.31, 95% CI = [0.17, 0.45], z = 4.09, p < 0.001) and age (b = 0.47, 95% CI = [0.20, 0.72], z = 3.73, p < 0.001). Crucially, ASD participants were significantly less accurate than typically developing participants, even with differences in chronological age and verbal mental age accounted for (b = -0.52, 95% CI = [-1.14, -0.21], z = -3.67, p = 0.007). The interaction between presupposition type and nonverbal intelligence emerged because, although nonverbal intelligence had a numerically positive association with accuracy on each presupposition type, the magnitude of this association was significantly less than average for the lexical presuppositions (b = -0.51, 95% CI = [-0.88,-0.09], z = -2.65, p = 0.008).

There were also marginal differences between presupposition types, as indicated via model comparison between a model with no interactions (and the same random effects structure as the model described above) and a maximally similar model with the presupposition type predictors removed ($\chi^2(3) = 6.49$, p = 0.090). In the full model, accuracy was above average for existential presuppositions (b = 1.17, 95% CI = [0.60, 1.77], z = 3.95, p < 0.001), below average for lexical presuppositions (b = -0.84, 95% CI = [-1.39, -0.32], z = -3.28, p = 0.001), and not significantly different from average for factive presuppositions (b = 0.11, 95% CI = [-0.40, 0.62], z = 0.48, p = 0.634). Because structural presuppositions were the reference level for the effect of presupposition type, the model does not include a coefficient for these, but the coefficient can be mathematically inferred to be -0.44, indicating

that the accuracy for structural presuppositions was, numerically, slightly below average.[6] The fact that this effect of presupposition type did not interact with ASD status indicates that the dataset does not provide evidence for concluding that the relative difficulty of presupposition types differs between children with ASD and typically developing children.

The model results are illustrated in figure 2.

Insert Figure 2 about here

Discussion

The present study examined whether children with ASD show a deficit in the comprehension of presuppositions relative to typically developing children of comparable age, general language ability, and nonverbal intelligence; and whether the relative difficulty of the four types of presupposition differs between children with ASD and typically developing children.

[6] This inference is based on the fact that deviation-coded coefficients indicate how much the accuracy from that condition differs from the average accuracy across all conditions, and therefore the average of all conditions' coefficients must be zero. Since the coefficients for the other presupposition types are 1.17, -0.84, and 0.11, the value for structural presuppositions can be solved for algebraically as $0 = \frac{1.17-0.84+0.11+x}{4}$.

The results suggest that children with ASD showed a deficit in the comprehension of presuppositions compared to typically developing children beyond what could be accounted for by their lower-than-typical nonverbal intelligence and language ability. In other words, their deficit in the comprehension of presuppositions appears to be due to the disorder rather than being an epiphenomenon of deficits in general language ability or nonverbal intelligence.

With respect to the relative difficulty of the four types of presupposition, the present study did not find evidence that the relative difficulty differed between children with ASD and typically developing children. There also was not evidence that the relative difficulty changed substantially as a function of other developmental variables (except for the fact that accuracy on lexical presuppositions did not improve along with nonverbal intelligence as accuracy on other presupposition types did). Among the four types of presupposition, lexical presuppositions were the most difficult, followed by structural presuppositions, then factive presuppositions, and finally existential presuppositions.

As mentioned earlier, the test trials for factive presuppositions included both factive and nonfactive mental state verbs, and children's performance reflects their understanding of the distinct lexical semantics (specifically, factivity) associated with these two type of verbs. Previous studies have suggested that there is a link between understanding of mental state verbs and theory of mind in children with ASD (Ziatas, Durkin, & Pratt, 1998). *Theory of*

mind refers to the cognitive ability to infer one's own and other people's mental states, such as beliefs, desires, and intentions (Baron-Cohen, 2000). For instance, Ziatas et al. (1998) found a significant relationship between false belief performance and understanding of the factivity in the mental state verbs *think*, *know*, and *guess* for children with either autism or Asperger syndrome. If this is true, the finding that ASD children's performance on factive presuppositions was comparable to that of typically developing children at a later chronological age and verbal mental age may support the delayed development model of theory of mind skills, which suggests that the development of theory of mind skills in ASD follows the same order as that in typical development but at a later chronological and verbal mental age (Hoogenhout & Malcolm-Smith, 2014). Nevertheless, because the present study did not include any instrument to measure participants' theory of mind, no strong conclusion can be drawn concerning the applicability of the delayed development model of theory of mind skills on the ASD children. Furthermore, ASD children were found to show a deficit in the comprehension of presuppositions in general, which was ascribed to the disorder. It is possible that their poorer performance on factive presuppositions compared to the typically developing peers is solely due to their deficit in knowledge of presuppositions, which could be independent of their theory of mind skills. Future research is needed to examine the relation between theory of mind skills and knowledge of presuppositions. Along these lines, it will be useful to explore whether theory of mind skills interact with other predictors such as

general language ability and nonverbal intelligence, and how the findings can account for the deficit in the comprehension of presuppositions in ASD children.

In sum, results from the current study revealed that children with ASD showed a deficit in the comprehension of presuppositions, which was ascribed to the disorder. As knowledge of presuppositions is instrumental for successful communication, in future studies it will be critical to examine how the deficit in the comprehension of presuppositions in ASD children influences their communication and what types of error pattern are caused by the deficit.

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Declaration of interest

The authors report no conflicts of interest.

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Table captions

Table 1. Descriptive data for the two groups of participants.

Table 2. Description of the test trials for the four types of presupposition.

Figure captions

Figure 1. Relationship between accuracy on the various presupposition types and age (left plot), language ability (middle plot), and nonverbal intelligence (right plot). Lines represent model predictions.

Figure 2. Model parameter estimates for each subject or item; this plot shows the extent to which fixed-effect coefficients are consistent across subjects or across items. Each dot represents one subject or item; the dot's value is derived from the fixed-effect estimate for that parameter plus the best linear unbiased predictor (BLUP) for that subject or item for that parameter. The estimate is the change in log odds relative to an intercept of 1.79 (the log odds of a correct response across all conditions and participants). For presupposition types, the

estimate represents how much higher or lower the log odds of a correct response are for that presupposition type compared to the average log odds of a correct response. For ASD status, the estimate represents how much higher or lower the log odds are for individuals with ASD compared to typically developing individuals. For language ability, nonverbal intelligence, and age, the estimate represents the increase in log odds of correct response associated with a one-standard-deviation increase in the predictor. The gray lines surrounding the dots represent smoothed kernel density. The tall red line represents the fixed-effect estimate, and the red bar around it represents the 95% confidence interval of the fixed-effect estimate (calculated from the estimate SE and z statistic). This method of visualizing the model helps show the extent to which any given effect is robust across participants and items; for instance, it can be seen that children with ASD performed less accurately than typically developing children on all but one item (lower right portion) and that existential presuppositions elicited a higher-than-average response accuracy in every participant (upper left portion).

Table 1

	ASD group	Typically developing group
Number of participants	21	101
Chronological age (*SD*) in months	105.3 (21.3)	105.3 (19.4)
Range of chronological age in months	78 – 171	73 – 142
Verbal mental age (*SD*) in months	97.5 (18.6)	114.3 (20.5)
Range of verbal mental age in months	65.5 – 136	61.5 – 136
Nonverbal intelligence (*SD*)	109.6 (19.4)	110.3 (12.8)
Range of nonverbal intelligence	70 – 135	81 – 135
Gender (boy, girl)	18, 3	49, 52

Table 2

Types of presupposition	Correct presuppositions	Incorrect presuppositions	Total number of test trials
Existential	5	5	10
Factive	6	6	12
Lexical	4	3	7
Structural	5	4	9

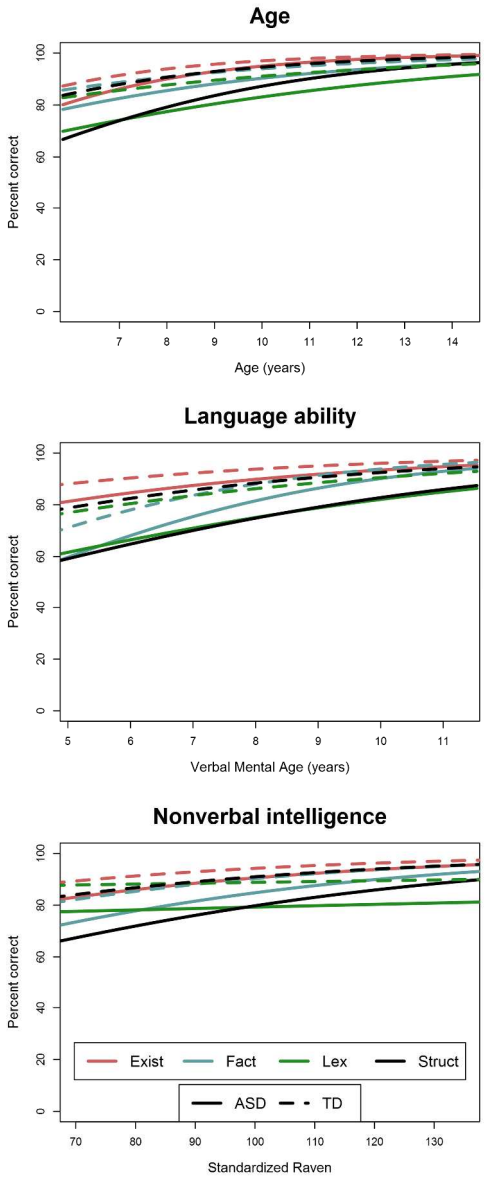

Figure 1. Relationship between accuracy on the various presupposition types and age (left plot), language ability (middle plot), and nonverbal intelligence (right plot). Lines represent model predictions.

127x304mm (300 x 300 DPI)

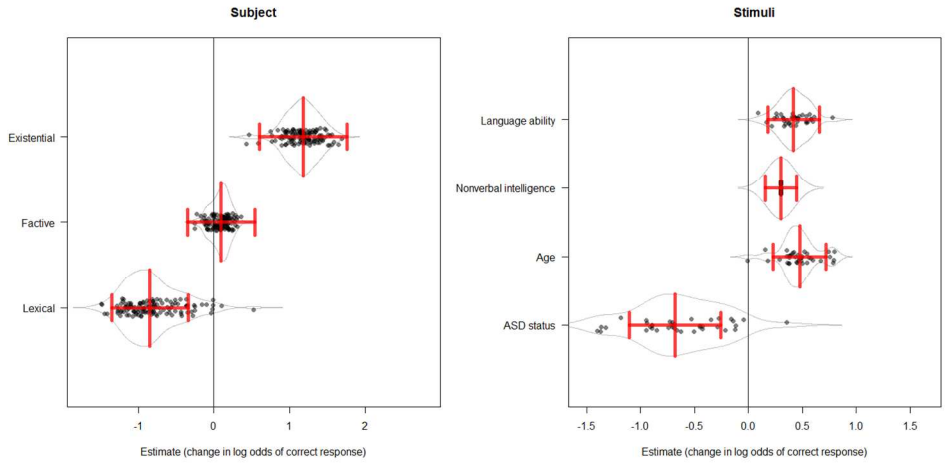

Figure 2. Model parameter estimates for each subject or item; this plot shows the extent to which fixed-effect coefficients are consistent across subjects or across items. Each dot represents one subject or item; the dot's value is derived from the fixed-effect estimate for that parameter plus the best linear unbiased predictor (BLUP) for that subject or item for that parameter. The estimate is the change in log odds relative to an intercept of 1.79 (the log odds of a correct response across all conditions and participants). For presupposition types, the estimate represents how much higher or lower the log odds of a correct response are for that presupposition type compared to the average log odds of a correct response. For ASD status, the estimate represents how much higher or lower the log odds are for individuals with ASD compared to typically developing individuals. For language ability, nonverbal intelligence, and age, the estimate represents the increase in log odds of correct response associated with a one-standard-deviation increase in the predictor. The gray lines surrounding the dots represent smoothed kernel density. The tall red line represents the fixed-effect estimate, and the red bar around it represents the 95% confidence interval of the fixed-effect estimate (calculated from the estimate SE and z statistic). This method of visualizing the model helps show the extent to which any given effect is robust across participants and items; for instance, it can be seen that children with ASD performed less accurately than typically developing children on all but one item (lower right portion) and that existential presuppositions elicited a higher-than-average response accuracy in every participant (upper left portion).

540x262mm (72 x 72 DPI)