

University of Groningen

Children with autism spectrum disorder show pronoun reversals in interpretation

Overweg, Jessica; Hartman, C.A.; Hendriks, Petra

Published in:
Journal of Abnormal Psychology

DOI:
[10.1037/abn0000338](https://doi.org/10.1037/abn0000338)

IMPORTANT NOTE: You are advised to consult the publisher's version (publisher's PDF) if you wish to cite from it. Please check the document version below.

Document Version
Final author's version (accepted by publisher, after peer review)

Publication date:
2018

[Link to publication in University of Groningen/UMCG research database](#)

Citation for published version (APA):

Overweg, J., Hartman, C. A., & Hendriks, P. (2018). Children with autism spectrum disorder show pronoun reversals in interpretation. *Journal of Abnormal Psychology*, 127(2), 228-238.
<https://doi.org/10.1037/abn0000338>

Copyright

Other than for strictly personal use, it is not permitted to download or to forward/distribute the text or part of it without the consent of the author(s) and/or copyright holder(s), unless the work is under an open content license (like Creative Commons).

Take-down policy

If you believe that this document breaches copyright please contact us providing details, and we will remove access to the work immediately and investigate your claim.

Downloaded from the University of Groningen/UMCG research database (Pure): <http://www.rug.nl/research/portal>. For technical reasons the number of authors shown on this cover page is limited to 10 maximum.

Children with autism spectrum disorder show pronoun reversals in interpretation

Authors

Jessica Overweg¹

Catharina A. Hartman²

Petra Hendriks¹

¹ University of Groningen, Center for Language and Cognition Groningen (CLCG), Groningen, The Netherlands

² University Medical Center Groningen, Department of Psychiatry, Groningen, The Netherlands

Word count: 8995

Published in 2018 in Journal of Abnormal Psychology 127:2, 228-238

© 2017, American Psychological Association. This paper is not the copy of record and may not exactly replicate the final, authoritative version of the article. Please do not copy or cite without authors permission. The final article will be available, upon publication, via its DOI: 10.1037/abn0000338

Abstract

Pronoun reversals, saying *you* when meaning *I*, in children with Autism Spectrum Disorder (ASD) are generally viewed as manifest in early development and speech production only. This study investigates pronoun reversals in *later development* (age 6-12) in *interpretation* in 48 Dutch-speaking children with ASD and 43 typically developing (TD) peers. We contrasted children's interpretation of *I* and *you* in indirect and direct speech reports, the latter type requiring an additional perspective shift. To examine which cognitive processes are involved in pronoun interpretation, additional tasks were administered to measure Theory of Mind (ToM) understanding, cognitive inhibition, cognitive flexibility and working memory. We found that children with ASD showed more problems than TD children interpreting pronouns in direct speech, resulting in pronoun reversals in interpretation. Children with ASD hardly improved with age. Older children with ASD thus showed more pronoun reversals than their TD peers. ToM understanding, working memory, IQ and verbal ability, but not inhibition and flexibility, were associated with pronoun interpretation. ToM understanding in particular was associated with correct pronoun interpretation in older TD children relative to younger TD children, but this improvement was not found in children with ASD. These findings indicate that pronoun reversals most likely result from perspective-shifting difficulties. We conclude that pronoun reversals are more pronounced in individuals with ASD, occur beyond early development and require sufficient cognitive resources. The relation with ToM understanding, but not inhibition and flexibility, suggests that pronoun reversals are best classified as a social communication problem in the diagnosis of ASD.

Keywords

Autism Spectrum Disorder, perspective shifting, pronoun reversals, pronoun interpretation, Theory of Mind

General Scientific Summary

Pronoun reversals are viewed as a characteristic of the early language use of children with Autism Spectrum Disorder. This study suggests that pronoun reversals also occur beyond early development and in interpretation, and result from listeners' difficulties in shifting to another person's perspective.

Introduction

Pronoun reversals, for example saying *you* when meaning *I* and vice versa, are a well-known early characteristic of the language and communication problems in children with Autism Spectrum Disorder (ASD) (Baltaxe, 1977; Tager-Flusberg, 1994). Research on pronoun reversals in children with ASD has mainly focused on pronoun use. The few studies on pronoun interpretation in children and adolescents with ASD (e.g., Hobson, Lee, & Hobson, 2010; Jordan, 1989; Lee, Hobson, & Chiat, 1994) found little or no evidence of errors in the interpretation of pronouns in simple sentences. In a study with adults, however, Mizuno et al. (2011) showed that, compared to an adult control group, adults with high-functioning ASD were slower and more error prone when they needed to shift perspectives to correctly interpret sentences containing *I* and *you*. This would suggest that pronoun reversals, including reversals in pronoun interpretation, are due to perspective-shifting difficulties and that these reversals are more extensive and longer-lasting in individuals with ASD than hitherto assumed. The present study therefore investigates pronoun interpretation in complex sentences that require perspective shifting by primary school-aged children diagnosed with ASD.

Pronouns are extremely common in everyday speech, for instance when parents talk to their children (Cameron-Faulkner, Lieven, & Tomasello, 2003), emphasizing the importance of correct pronoun interpretation. Typically developing (TD) children have been found to correctly use and interpret the personal pronouns *I*, *you* and *he/she* before primary school-age (Brener, 1983; Chiat, 1986; Halliday, 1975). Pronoun reversals are documented in the speech of very young TD children, but these reversals do not persist (Lee et al., 1994). In children with ASD, pronoun reversals are also mostly viewed as manifest in early language development and persisting only in individuals with ASD with a low intelligence (i.e., “low-functioning” ASD) (Kanner, 1943; Tager-Flusberg, 1994).

Several explanations have been proposed for the pronoun reversals in the speech of young children with and without ASD. Kanner (1943) originally explained pronoun reversals in children with ASD as echolalia, or the repetition of speech (see also Bartak & Rutter, 1974). This view is still present in the DSM-5, where the use of *you* when referring to self is mentioned as an illustration of repetitive speech (American Psychiatric Association [APA], 2013; p. 54). Subsequent explanations refer to the linguistic, social or cognitive aspects involved in pronoun use that are supposed to be extra challenging for children with ASD. For example, according to the name hypothesis (Clark, 1978) children may assume that pronouns, like proper names, have a fixed reference. Hence, rather than shifting the reference of pronouns, these children consistently use *you* to refer to themselves and *I* to refer to others. Social or pragmatic explanations (e.g., Charney, 1980; Hobson, 1990; Hobson et al., 2010; Tager-Flusberg, 1996; Tager-Flusberg, Paul, & Lord, 2005) hold that children are limited in their representation of themselves in relation to others, or have difficulties understanding the different discourse roles in conversation. This results in pronoun reversals, as the correct use of *I* and *you* depends on who is the speaker and who is the addressee and shifts with a change in discourse roles. Cognitive or performance-based explanations (e.g., Dale & Crain-Thoreson, 1993) hypothesize that children know that pronouns require a shift in perspective, but lack the cognitive resources needed for such perspective shifting. Based on this hypothesis, it is expected that perspective shifting more often fails in cognitively demanding or complex situations. Two recent studies have suggested that pronoun reversals are not caused by one single factor, but rather by the interaction between multiple factors in children's development (Evans & Demuth, 2012; Naigles et al., 2016). Specifically, Naigles et al. (2016) suggest that children reverse pronouns due to an asynchronous development of their linguistic and social abilities, in particular when children's linguistic abilities are ahead of their social abilities (see Evans & Demuth, 2012, for a related explanation). Thus, there is

no consensus yet as to the explanation of pronoun reversals in production. Also, it is unclear whether the proposed explanations for pronoun reversals in production generate correct predictions for pronoun interpretation.

Although most primary school-aged TD children have developed a full pronoun system, the interpretation of personal pronouns is still challenging for these children in situations that require an additional perspective shift. Such situations occur when talking about what other people have said. Suppose James says to me: “You won the prize!”. If I want to report this to my brother, I can use an indirect speech report or a direct speech report:

(1a) Indirect speech report (uttered by me): James said that I won the prize.

(1b) Direct speech report (uttered by me): James said, “You won the prize!”

The pronoun *I* in (1a) and the pronoun *you* in (1b) both refer to me, the speaker of the utterance. To select the correct referent of *you* in (1b), the hearer needs to shift from the perspective of the actual speaker, me, to the perspective of the reported speaker, James (Köder, Maier, & Hendriks, 2015). If my brother fails to shift to the perspective of James, he will incorrectly interpret *you* in (1b) as referring to himself, the hearer, in the same way that *you* in an indirect speech report also refers to the hearer. The result is pronoun reversal in interpretation. Such pronoun reversals in interpretation have been studied in TD children and adults, but not in children with ASD. Köder and Maier (2016) found that primary school-aged TD children find it challenging to shift perspective to select the correct referent for pronouns in direct speech. Unlike adults, these children tended to interpret pronouns in direct speech as in indirect speech.

The present study is the first to investigate how primary school-aged children diagnosed with ASD interpret pronouns in direct versus indirect speech. We hypothesize that

primary school-aged children with ASD know that they have to shift perspective when interpreting the pronouns *I* and *you*, but experience more difficulties shifting perspective in complex situations. Thus, we expect all children to be adult-like in their interpretation of pronouns in indirect speech, which only requires one perspective shift from the listener to the actual speaker. In addition, we expect children with ASD to have more difficulties than their TD peers interpreting pronouns in direct speech, as direct speech requires an additional perspective shift from the actual speaker to the reported speaker. These expectations are in accordance with the cognitive explanation, the social explanation and the asynchronous development explanation, but do not follow from the repetitive speech explanation and the name hypothesis. The repetitive speech explanation would predict no difficulties at all in pronoun interpretation, whereas the name hypothesis would predict no differences in performance between pronouns in direct speech and indirect speech. To enhance our understanding of the difficulties involved in pronoun interpretation in direct speech, we additionally investigate the possible influence of four cognitive processes on pronoun interpretation. Firstly, primary school-aged children might need *Theory of Mind* (ToM) for pronoun interpretation. ToM is the ability to mentally take the perspective of other people to understand their beliefs, desires and intentions (Wimmer & Perner, 1983). We hypothesize that hearers need ToM to make the additional perspective shift from the actual speaker to the reported speaker.

In addition to ToM, other cognitive processes, like working memory, inhibition and flexibility, could be needed in pronoun interpretation. These executive functioning processes allow for the flexible alteration of thought and behaviour in response to changing contexts (Welsh & Pennington, 1988). The hearer may need *cognitive inhibition*, which is the efficiency with which one can suppress irrelevant information (Dagenbach & Carr, 1994), to inhibit his representation of the actual speaker's perspective in order to take the reported

speaker's perspective (Köder et al., 2015). In addition, to shift to the reported speaker's perspective, the hearer may need *cognitive flexibility*, which is the mental ability to shift between different thoughts or actions (Scott, 1962). Finally, *working memory (WM)*, which is the capacity to actively maintain information for short periods of time (Baddeley, 1986), could be needed. A hearer with low WM capacity may be unable to keep the reported speaker's perspective in mind and thus interpret the pronoun from the reported speaker's perspective. All four cognitive processes have been argued to be impaired in individuals with ASD (Baron-Cohen, Leslie, & Frith, 1985; Christ, Kester, Bodner, & Miles, 2011; De Vries & Geurts, 2012; Geurts & Vissers, 2012; Hill, 2004), which could explain why children with ASD may find pronoun interpretation in direct speech even harder than TD children.

Method

Participants

Forty-eight children with ASD and 43 TD children were tested. All children in the ASD group were diagnosed with ASD by clinicians on the basis of the DSM-IV-TR criteria (APA, 2000). Additionally, the Autism Diagnostic Interview Revised (ADI-R; Rutter, Le Couteur, & Lord, 2003) and the Autism Diagnostic Observation Schedule (ADOS; Lord, Rutter, DiLavore, & Risi, 1999) were administered by certified professionals. Two children from the ASD group (both clinically diagnosed with Pervasive Developmental Disorder-Not Otherwise Specified) were excluded because they met neither the ADOS nor the ADI-R criteria for ASD (cf. the ASD2 criteria of Risi et al., 2006). One child from the TD group met the ADOS criteria for autism and was therefore excluded, leaving 46 children with ASD (M=9;55, SD=2;21) and 42 TD children (M=9;15, SD=2;03) for further analysis.

When recruiting the children with ASD and the TD children, only mono-lingual Dutch-speaking children with no diagnosis of any language disorder were included. IQ scores on a clinically administered full IQ test were used to include only children with ASD with an IQ score of >75 in our sample. We expected all TD children in our sample to have an IQ of >75, since all of them went to regular primary schools and none had reported learning difficulties. Because we wanted to compare the IQ scores of all participants, we additionally estimated each child's IQ using two subtests (Vocabulary and Block Design) of the WISC-III-NL (Kort et al., 2002). We also derived a normed verbal ability (VA) quotient from the standardized Peabody Picture Vocabulary Test (PPVT-III-NL; Schlichting, 2005) to assess children's VA. The background data of the two groups of participants with group means and standard deviations for age, estimated IQ and VA can be found in Table 1.

[Insert Table 1]

Children with ASD and their parents were recruited via outpatient clinics for child and adolescent psychiatry in the north of the Netherlands and a national website for parents who have a child with ASD. TD children were recruited via information in newsletters and brochures at schools in the north of the Netherlands. Children were tested individually on a single day in a quiet room with two experimenters present. All children participated in a larger study on language and communication in ASD. The medical ethical committee of the University Medical Hospital Groningen evaluated this study as not falling under the Medical Research Involving Human Subjects Act (WMO). Nevertheless, we followed the required procedures and obtained informed consent from parents.

Pronoun comprehension task

Participants watched short movies where 3 animals were playing a game in which one animal decided who was going to get a particular object. First, the animals (hand puppets of a dog, pig and frog) and 6 objects (e.g., ball, car, glasses) were introduced on the computer screen. For each animal, a different male voice was used, to make it easier for the participant to identify the speaker. Furthermore, three practice items were administered to check whether the participant understood the task.

Each participant first received a pretest, consisting of 15 simple statements with either a first, second or third person singular pronoun (*ik* 'I', *jij* 'you' or *hij* 'he'), to check their understanding of personal pronouns in simple statements. Third person pronouns were added to avoid that participants could simply choose the speaker as the referent of *I* and the remaining referent as the referent of *you*. In each item, a movie showed one animal (the speaker) telling another animal (the hearer) who was going to get the object. A third animal (the non-participant) stood further away facing the other direction. After the movie a voice-over asked the question who got the object. The participant pressed one of three buttons to select the answer. See Figure 1 for an example item.

[Insert Figure 1]

Next, the speech report task was presented, consisting of 15 direct speech items (test condition) and 15 indirect speech items (control condition) with either the personal pronoun *ik* 'I', *jij* 'you' or *hij* 'he' (5 items per pronoun per condition). These items were randomized in two blocks with a short break in between. Similar to the procedure in the pretest, each item consisted of a movie in which one animal (the actual speaker) is telling another animal (the hearer) who will get the object. The participant pressed one of three buttons to select the

answer. Figure 2 shows an example item in the direct speech condition and in the indirect speech condition.

[Insert Figure 2]

In this example item, Pig whispers into Frog's ear who will get the car. The participant only hears unintelligible whispering. Then, Frog tells Dog what Pig has said using a direct or indirect speech construction. After the short movie, the voice-over asks the question: Who gets the car? The participant presses one of three buttons to select which of the three animals will get the car. The selected answer is highlighted by a colored frame.

In Dutch, the direct and indirect speech sentences differ from each other. Direct speech sentences have verb-second word order, while indirect speech sentences have verb-final word order and include the complementizer *dat* 'that'. Note that the indirect *he* items (*Pig said that he gets the car*) are special in that the pronoun *he* can also refer back to the subject of the clause (the reported speaker), instead of referring to the non-participant in the movie directly (for more details, see Köder & Maier, 2016; Köder et al., 2015).

The roles (speaker, hearer, non-participant), pronouns (*I, you, he*), speech types (direct, indirect), and the used objects were counterbalanced, resulting in six different lists. Stimuli were presented and data recorded using the computer software E-Prime 2.0 (Schneider, Eschmann, & Zuccolotto, 2002). The experiment took approximately 25 minutes.

Cognitive processes

ToM. The Bake Sales task, a False Belief (FB) Task adopted from Hollebrandse, van Hout and Hendriks (2014), was used to test ToM. Their stories were modelled after Perner and Wimmer's (1985) "ice cream truck story". The task consisted of eight stories, each of

which contained a first-order FB question (involving the belief of one other person) and a second-order FB question (involving the belief of another person about a third person). The task was conducted with the computer software E-Prime 2.0 (Schneider et al., 2002). The measures of ToM1 and ToM2 were calculated using the mean accuracy (ACC) on the eight first-order FB questions and second-order FB questions, respectively.

Cognitive inhibition. In the Flanker test (Amsterdam Neuropsychological Test battery (ANT) version 2.1; De Sonneville, 1999) participants had to identify the colour of a target stimulus that was surrounded by eight distracters (flankers). The target colour was associated with the left (red) or right (green) button. The flankers were in the same colour as the target (compatible) or in the colour that was associated with the opposite response of the target (incompatible). The participant received 40 compatible and 40 incompatible items. The mean ACC and mean reaction time (RT) of cognitive inhibition was measured by subtracting the mean ACC or RT on compatible trials from the mean ACC and RT on incompatible trials (resulting in the congruency effect; see Mullane, Corkum, Klein, & McLaughlin, 2009).

Cognitive flexibility task. To test cognitive flexibility, a classical switch task was used (Rogers & Monsell, 1995). This task is an adaptation of the gender-emotion switch task (De Vries & Geurts, 2012). Pictures of round or square figures, in black or white, were displayed on the computer screen. Participants had to press the left or right button of a button box to report the shape (round or square) or the colour (black or white) of the figure. The cue at the top indicated if the shape or colour had to be reported. The test part consisted of 216 trials. One-third of these trials were switch trials (switching from colour to shape or vice versa). Stimuli were presented and data recorded using the computer software Presentation (version 16.3; Neurobehavioral Systems, Inc). The mean ACC and mean RT of switch costs was measured by subtracting the mean ACC or RT on repeat trials from the mean ACC and RT on switch trials (cf. De Vries & Geurts, 2012).

Working Memory. In the N-Back task (Owen, McMillan, Laird, & Bullmore, 2005) participants had to remember pictures presented on a screen and indicate per picture if that picture matched the picture of the current trial or the picture of one or two trials before. Three conditions were administered: the 0-back (baseline: is the current picture a car or not?), 1-back and 2-back. Each participant received a practice session of 15 trials per condition. The test session consisted of 60 trials per condition. Stimuli were presented and data recorded using the computer software E-Prime 2.0 (Schneider et al., 2002). The mean ACC on the 2-back condition was calculated as a measure of WM.

Data analysis

The results of the pronoun comprehension pretest confirmed that pronoun interpretation in simple statements is intact in both groups. Likewise, our findings indicated that the two groups have no problems interpreting pronouns in indirect speech, as hypothesized (additional data are given in Online Resource 1).

To answer our research questions, we focused on the direct speech condition. The outcome variable of this condition was coded binary (0 for incorrect, 1 for correct). Generalized Linear Mixed Models (GLMMs) are designed for binomially distributed outcomes (Jaeger, 2008; p.442). Also, GLMMs do not require prior aggregation into proportions, as the aim is to provide estimates of the likelihood of a success (or failure) for each individual observational unit (Baayen, 2012; p.675). Therefore, the data of the direct speech condition were analyzed using GLMM analyses in IBM SPSS Statistics 23, using a logit link to accommodate the repeatedly measured binary outcome variable Accuracy (cf. Heck, Thomas, & Tabata, 2012; Jaeger, 2008). Compound symmetry was used as covariance matrix. Contrasts between Pronoun were dummy-coded. The pronoun *he* was used as

baseline, resulting in Pronoun1 (*he vs. I*) and Pronoun2 (*he vs. you*). The possible presence of *I vs. you* differences were subsequently checked through shifting the reference category. Age was mean-centered and additionally included in the model. Interactions with no effect on Accuracy ($p > .05$) were removed from the model one by one, choosing the largest p-value for removal, after which we refitted the model. This resulted in model 1, which shows whether difficulties in pronoun interpretation in direct speech are more pronounced in children with ASD than in TD children. For purposes of interpreting the interaction effects, we illustrated the significant interaction effects using the median split method.

Next, all relevant parameters derived from the ToM task (ToM1 and ToM2), Flanker task (Cognitive inhibition ACC and Cognitive inhibition RT), cognitive flexibility task (Switch costs ACC and Switch costs RT) and N-Back task (WM) were mean-centered around a value of zero. These cognitive processes were examined as main effects and in interaction with the significant predictors from model 1 in seven separate analyses. In each analysis, the cognitive process was included as a predictor. The data of 3 participants (2 ASD and 1 TD) were missing in the Cognitive inhibition ACC and RT analyses, leaving the data of 44 ASD and 41 TD participants. Based on the outcomes of these analyses per predictor, we combined the cognitive processes with (main or interaction) effects on Accuracy ($p < .05$) and added these with the significant predictors of model 1 in a model with multiple predictors to evaluate their effects adjusted for one another (cf. Kuijper, Hartman, & Hendriks, 2015). This resulted in model 2, which shows the relevant cognitive processes that had an effect on the interpretation of pronouns in direct speech and explained possible Group differences.

Finally, the relevant parameters derived from the PPVT (VA) and WISC (estimated IQ) were included in two separate analyses as fixed factors to model 1. These general background variables were added to the model to check whether these variables changed found associations between our cognitive processes of interest and pronoun interpretation. If

these variables had an effect on Accuracy ($p < .05$), they were added to model 2 and evaluated in model 3. Given the significant group differences (see Table 1) in estimated IQ ($B = -12.94$; $SE = 3.29$; $p < .001$) and VA ($B = -8.85$; $SE = 2.69$; $p < .01$), this approach provides a statistical alternative to a priori matching on VA and IQ.

Results

Model 1 showed a main effect of Age and interactions of Group*Pronoun2 and Group*Age (see Table 2).

[Insert Table 2]

The Group*Pronoun2 interaction ($p = .02$; see Table 2) found in model 1 is plotted in Figure 3. This figure shows that the ASD group had a lower Accuracy than the TD group with the pronoun *you* vs. *he*.

[Insert Figure 3]

In Figure 4, the Group*Age interaction ($p = .04$; see Table 2) found in model 1 is plotted. We used the median split method to plot Accuracy of pronoun interpretation per age group (Young: ≤ 111 months old vs. Old: > 111 months old) to illustrate how the interaction effect took form. Figure 4 shows that older TD children, but not older children with ASD, performed substantially better than their younger peers in interpreting pronouns in direct speech.

[Insert Figure 4]

We have subsequently checked in model 1 the presence of *I* vs. *you* differences. No *I* vs. *you* differences were found (p-values >.05; see Table 2). Also, no differences were found between the type of errors made by children with ASD and their TD peers. An error analysis showed that in 98% of the errors in the direct speech condition, children selected the indirect speech referent.

Next, we examined, one by one, which cognitive processes were associated with Accuracy. All significant interactions and main effects of these analyses per predictor (see Online Resource 1) were combined in model 2 along with the effects identified in model 1. Table 2 lists all remaining effects in model 2.

With respect to Group differences, model 2 included interactions of ToM2*Group*Pronoun1 and ToM2*Group*Pronoun2 (p-values <.05; see Table 2). These interactions are plotted in Figure 5. The median split method is used to plot Accuracy of pronoun interpretation per ToM2 group (low ToM2: $\leq .75$ vs. high ToM2: $> .75$) to illustrate the direction of the interaction effect. The mean ToM2 scores in the figure caption provide background information about the ToM performance of each specific group. As is shown in Figure 5, ASD children with low second-order ToM understanding performed worse with *I* vs. *he* (p=.01; see Table 2) and *you* vs. *he* (p=.02; see Table 2) than TD children with low second-order ToM understanding.

[Insert Figure 5]

Model 2 additionally included a significant interaction of ToM2*Group*Age (p=.02; see Table 2), which is plotted in Figure 6. Again, the Accuracy of pronoun interpretation per

ToM2 group (low ToM2: $\leq .75$ vs. high ToM2: $> .75$) is plotted. The mean ToM2 scores in the figure caption provide background information about the ToM performance of each specific group. The older ASD children performed similar to the younger ASD children. As is shown in Figure 6, second-order ToM understanding had a larger effect on pronoun interpretation in older TD children than in older ASD children.

[Insert Figure 6]

Model 2 further showed interactions of WM*Pronoun1 and WM*Pronoun2 (p-values $< .05$; see Table 2), indicating that in general children with a lower WM had more problems interpreting pronouns in direct speech (see Online Resource 1).

Finally, in model 3 we checked if the effects of the background variables IQ and VA on the interpretation of pronouns, first separately and then combined, altered findings in model 2 (additional data are given in Online Resource 2). The results of model 3 showed that with the addition of IQ and VA, the effects in model 2 were highly similar, with a slightly reduced effect of ToM*Group*Pronoun2. This indicates that the associations of WM and ToM understanding with pronoun interpretation remained after taking into account the group differences and individual differences in IQ and VA. Model 3 additionally showed an interaction effect of IQ*Pronoun2 ($p=.01$; see Table 2), indicating that in general children with a lower IQ had more problems interpreting *you* and *he* in direct speech. Also, an interaction of VA*Age ($p=.02$; see Table 2) was found, indicating that not only young children, but also older children with low verbal abilities had problems interpreting pronouns in direct speech (see Online Resource 2). Table 2 lists all effects in model 3.

It should be noted that the interactions of Group*Pronoun1 and Group*Pronoun2 remained significant in models 2 and 3. This indicates that ToM, WM, IQ and VA could not

fully explain why children with ASD showed more problems than their TD peers with the interpretation of *I* and *you* in direct speech. However, with the addition of these cognitive processes and background variables, the interaction effect of Group*Age disappeared.

Discussion

We investigated the interpretation of the personal pronouns *I* and *you* in perspective-shifting situations created by direct speech reports in primary school-aged children with and without ASD. Summarizing our findings, we found that 1) all children, both with and without ASD, had problems with the interpretation of pronouns in direct speech, but not with the interpretation of pronouns in indirect speech, and 2) children with ASD had more problems than their TD peers interpreting pronouns in direct speech. Also, we found that 3) all children, but especially the TD children, made fewer errors in direct speech when they were older. Compared to older TD children, older children with ASD had thus more problems interpreting pronouns in perspective-shifting situations. Our cognitive processes analysis showed that 4) a better WM and 5) a better second-order ToM understanding were associated with better pronoun understanding in direct speech. Especially children with ASD with a low second-order ToM understanding made more errors than their TD peers interpreting *I* and *you* compared to *he* in direct speech. Considering age, 6) a better second-order ToM understanding was associated with better pronoun understanding in older compared to younger TD children, while this was not the case for pronoun understanding in children with ASD. Considering the background variables of VA and IQ, we found that 7) like young children in general, older children with low verbal abilities had more problems interpreting pronouns in direct speech than children with high verbal abilities, and 8) a higher IQ was

associated with better pronoun understanding in direct speech. Finally, no effects of cognitive inhibition and cognitive flexibility were found.

The first aim of this study was to find out whether primary school-aged children diagnosed with ASD experience more difficulties than their TD peers interpreting pronouns in direct speech. As expected, we found that primary school-aged children with and without ASD are adult-like in their interpretation of the pronouns *I* and *you* in indirect speech, but have difficulties interpreting these pronouns in direct speech. Like Köder and Maier (2016), we found that children who have difficulties interpreting pronouns in direct speech interpret these pronouns as in indirect speech. That is, they incorrectly interpret pronouns in direct speech from the perspective of the actual speaker instead of the reported speaker. This indicates that primary school-aged children have difficulty making the additional perspective shift from the actual speaker's perspective to the reported speaker's perspective, which is needed to correctly interpret pronouns in direct speech. Failing to make this additional perspective shift, they interpret *I* as *you* and *you* as *I*, resulting in pronoun reversals in interpretation.

Köder and Maier (2016) showed that primary school-aged TD children do not yet interpret pronouns in direct speech at an adult level. This indicates a relative late acquisition of pronoun interpretation in perspective-shifting situations in TD children. Our study is the first to show that pronoun interpretation in linguistic contexts requiring an additional perspective shift is even more challenging for primary school-aged children with ASD than for their TD peers. As expected, children with ASD showed more pronoun reversals in interpretation than their TD peers, especially with the pronoun *you*. Possibly, children with ASD, like TD children, find it easier to interpret *I* than *you* in direct speech because the referent of *I* is explicitly mentioned in the reporting clause (Köder & Maier, 2016; Köder et al., 2015). Moreover, compared to older TD children, older children with ASD showed more

pronoun reversals in interpretation. It probably takes primary school-aged children with ASD longer than their TD peers to develop a good understanding of pronouns in perspective-shifting situations. The prevalent view is that pronoun reversals only persist in the speech of young children with ASD and low intelligence (Baltaxe, 1977; Tager-Flusberg, 1994), but disappear in young children with an average intelligence (so-called “high-functioning” ASD). Our study provides evidence that pronoun reversals in children with ASD, in the more subtle interpretational form, are not only present in early development or in individuals with low intelligence, but persist in later development and in individuals of average intelligence.

A second aim of this study was to shed more light on potential explanations of pronoun reversals. Below, we relate our findings on the pronoun comprehension task and the cognitive tasks to the various explanations proposed in the literature. In line with cognitive explanations of pronoun reversals (e.g., Dale & Crain-Thoreson, 1993), we found that the correct interpretation of pronouns in direct speech requires sufficient cognitive resources. A better WM and a higher IQ, which are argued to be strongly related to each other (Ackerman, Beier, & Boyle, 2005), help children with ASD as well as TD children in their understanding of pronouns.

Furthermore, our results suggest that social abilities are involved in the interpretation of pronouns in direct speech, in particular ToM understanding. Children with ASD and TD children were found to show a better understanding of pronouns in direct speech when they have a better second-order ToM understanding. This finding is in line with social explanations of pronoun reversals (e.g., Charney, 1980; Hobson, 1990; Hobson et al., 2010; Tager-Flusberg, 1996) as well as with the asynchronous development explanation (e.g., Evans & Demuth, 2012; Naigles et al., 2016). Naigles et al. (2016) showed that toddlers with ASD with a larger vocabulary and with better joint attention skills, which is seen as an essential precursor of ToM understanding (Baron-Cohen, 1989; Charman et al., 2000),

produced fewer pronoun reversals. Similarly, we found that primary school-aged children with ASD with sufficient linguistic abilities and better social abilities, namely better ToM understanding, show fewer pronoun reversals. In particular, second-order ToM understanding seems to enhance pronoun interpretation in older TD children compared to younger TD children, while we did not observe this improvement in children with ASD. This could indicate that pronoun reversals occur when children's social abilities lag behind their linguistic abilities and derive from social immaturity (cf. Naigles et al., 2016).

The suggestion that social abilities, in particular sufficient ToM understanding, are a prerequisite for the mature use and interpretation of personal pronouns, is also corroborated by the study of Durrleman and Delage (2016). Durrleman and Delage (2016) found a relation between first-order ToM understanding and the production of first-person accusative clitic pronouns in French-speaking children with ASD (aged 5-16). Our interpretation results are parallel to their production results, as we found that especially children with ASD with low ToM understanding have problems interpreting first-person and second-person (nominative full) pronouns in direct speech. The relation we found with second-order ToM understanding in particular is indicative of problems with shifting perspective twice. Like in second-order ToM understanding, two shifts are needed to correctly interpret pronouns in direct speech: first, the listener must shift to the perspective of the actual speaker; next, in order to interpret the direct speech report, the listener needs to shift to the perspective of the reported speaker. The interpretation of the pronouns *I* and *you* can thus be seen as indicators of (un)successful perspective shifting.

According to the asynchronous development explanation (e.g., Naigles et al., 2016), pronoun reversals may also derive from linguistic immaturity. However, we did not find support for this view. Linguistically immature children with ASD might have difficulty with the interpretation of pronouns and treat pronouns as having a fixed reference (in accordance

with the name hypothesis, cf. Clark, 1978). If so, we would have found no difference in performance between pronoun interpretation in direct and indirect speech, as under this view pronouns are predicted to have a fixed reference across different contexts. However, we found that children with and without ASD performed almost at ceiling with pronouns in indirect speech, while making a substantial number of errors with pronouns in direct speech. Furthermore, we found that all children who made pronoun reversals in direct speech predominantly chose the indirect speech referent, suggesting that all of these children had problems making the second shift in perspective.

Our findings also do not lend support to the repetitive speech explanation (i.e., Kanner's view of pronoun reversals, see Kanner, 1943). This account predicts that pronoun reversals should not occur in interpretation. We found, however, that children do show pronoun reversals in interpretation. Moreover, restricted, repetitive behaviours in ASD, including repetitive speech (echolalia), have been found to be related to executive functioning impairments such as reduced cognitive flexibility and inhibition problems (Miller, Ragozzino, Cook, Sweeney, & Mosconi, 2015; Mosconi et al., 2009). The absence of a relation between pronoun interpretation and cognitive inhibition or cognitive flexibility in our study corroborates our conclusion that pronoun reversals should not be approached as repetitive speech forms. This suggests that in the clinical diagnosis of ASD pronoun reversals are better approached as a social communication problem rather than a restricted, repetitive pattern of behavior like echolalia (see DSM-5; APA, 2013).

The effects of ToM, WM, IQ and VA on pronoun interpretation could not fully explain why children with ASD had more problems than TD children interpreting *I* and *you* in direct speech (i.e., the group difference remained significant in our models 2 and 3). This suggests that additional processes are at work here. Köder et al. (2015) point out that, in the Dutch language, direct speech is signaled by syntactic cues such as word order and prosodic

cues such as a greater overall pitch range. While some studies report intact syntactic and prosodic skills in individuals with ASD (Diehl, Friedberg, Paul, & Snedeker, 2015; Janke & Perovic, 2015), other studies suggest that individuals with ASD have problems with syntactic dependencies in questions and relative clauses and prosodic cues signaling discourse prominence (Durrleman, Hippolyte, Zufferey, Iglesias, & Hadjikhani, 2015; McCann & Peppé, 2003; Terzi, Marinis, & Francis, 2016). If children with ASD indeed struggle with syntactic dependencies and prosodic cues, they may be less sensitive to the syntactic and prosodic cues that signal direct speech. Also, it has been argued that syntactic skills are needed for ToM understanding (De Villiers, 2007; De Villiers, Hobbs, & Hollebrandse, 2014; De Villiers & Pyers, 2002), especially in children with ASD (Durrleman et al., 2016; Lind & Bowler, 2009). It could be argued that problems with pronoun interpretation in direct speech in children with ASD reflect difficulties with syntactic components of language rather than perspective-taking difficulties. However, the children with ASD in our study did not have problems interpreting indirect speech reports, which consist of a complement clause introduced by a verb of communication (e.g., ‘Pig said that I get the car’). This shows that they have at least some understanding of complex syntactic structures. Future studies could explore the relation between syntactic skills and ToM understanding in the development of pronoun interpretation in reported speech.

An important limitation of the current study is that our cross-sectional design does not allow us to make firm statements about the longitudinal development of pronoun reversals in children with and without ASD. It is conceivable that other factors, for example linguistic factors, play a role in pronoun reversals in early development than the factors that we found to be relevant in later development. Future studies could examine pronoun production and interpretation in combination with linguistic, social and cognitive abilities in children with ASD in a longitudinal study. Such studies will provide more insight into the potential causes

of pronoun reversals and will help to determine which factors play a role in which developmental stage. Another limitation is the generalizability of our study, since our sample includes a high proportion of children with the milder form of ASD (i.e., PDD-NOS, a subcategory of ASD in the DSM-IV (APA, 2000)). Furthermore, since we found differences between children with ASD and TD children in our study, we expect any problems with pronoun interpretation that are linked to the severity of autistic symptoms to be even larger in a sample containing more children with severe autistic symptoms. The use of severity levels of ASD in the DSM-5 (APA, 2013) may help to determine whether the level of severity of ASD is related to the amount of pronoun reversals in interpretation.

In sum, we draw the following three conclusions. First, our study shows that children with ASD aged 6 to 12 have problems interpreting *I* and *you* in direct speech, resulting in pronoun reversals in interpretation. Therefore, such pronoun reversals do not only occur in early development of children with ASD, as suggested by the literature, but in their later development as well. Second, like in the production of pronouns, where reversals are more extensive and longer-lasting in children with ASD than in TD children, our data suggest that also in the interpretation of pronouns children with ASD lag behind their TD peers. Third, based on the associations with ToM understanding, our results suggest that pronoun reversals most likely result from perspective-shifting difficulties. Cognitive inhibition and flexibility, which are both associated with repetitive behavior, are not needed for better pronoun interpretation. We therefore propose that in the clinical diagnosis of ASD, pronoun reversals are best classified as a social communication problem rather than a repetitive behavior.

Acknowledgments

The authors thank all children and their parents for participating in this study, Accare Groningen for helping with participant recruitment, Franziska Köder for her help with our design, Sanne Kuijper for her statistical assistance, and the anonymous reviewers for their helpful comments and suggestions.

References

- Ackerman, P. L., Beier, M. E., & Boyle, M. O. (2005). Working Memory and Intelligence: The Same or Different Constructs? *Psychological Bulletin*, *131*(1), 30–60.
<http://doi.org/10.1037/0033-2909.131.1.30>
- American Psychiatric Association. (2000). *The diagnostic and statistical manual of mental disorders* (4th ed.). Washington: APA.
- American Psychiatric Association. (2013). *The diagnostic and statistical manual of mental disorders* (5th ed.). Washington: APA.
- Baayen, R. H. (2012). Mixed-effect models. In A. C. Cohn, C. Fougeron, & M. K. Huffman (Eds.), *The Oxford handbook of laboratory phonology* (pp. 668–677). Oxford: Oxford University Press.
- Baddeley, A. D. (1986). *Working Memory*. New York: Oxford University Press.
- Baltaxe, C. (1977). Pragmatic Deficits in the Language of Autistic Adolescents. *Journal of Pediatric Psychology*, *2*(4), 176–180. <http://doi.org/10.1093/jpepsy/2.4.176>
- Baron-Cohen, S. (1989). Perceptual role taking and protodeclarative pointing in autism. *British Journal of Developmental Psychology*, *7*(2), 113–127.
<http://doi.org/10.1111/j.2044-835X.1989.tb00793.x>
- Baron-Cohen, S., Leslie, A., & Frith, U. (1985). Does the autistic child have a “theory of

- mind" ? *Cognition*, 21(1), 37–46. [http://doi.org/10.1016/0010-0277\(85\)90022-8](http://doi.org/10.1016/0010-0277(85)90022-8)
- Bartak, L., & Rutter, M. (1974). The Use of Personal Pronouns by Autistic Children. *Journal of Autism and Childhood Schizophrenia*, 4(3), 217–222.
<http://doi.org/10.1007/BF02115227>
- Brener, R. (1983). Learning the Deictic Meaning of Third Person Pronouns. *Journal of Psycholinguistic Research*, 12(3), 235–262. <http://doi.org/10.1007/BF01067669>
- Cameron-Faulkner, T., Lieven, E., & Tomasello, M. (2003). A Construction Based Analysis of Child Directed Speech. *Cognitive Science*, 27(6), 843–873.
<http://doi.org/10.1016/j.cogsci.2003.06.001>
- Charman, T., Baron-Cohen, S., Swettenham, J., Baird, G., Cox, A., & Drew, A. (2000). Testing joint attention, imitation, and play as infancy precursors to language and theory of mind. *Cognitive Development*, 15(4), 481–498. [http://doi.org/10.1016/S0885-2014\(01\)00037-5](http://doi.org/10.1016/S0885-2014(01)00037-5)
- Charney, R. (1980). Speech Roles and the Development of Personal Pronouns. *Journal of Child Language*, 7(3), 509–528. <http://doi.org/10.1017/S0305000900002816>
- Chiat, S. (1986). Personal Pronouns. In *Language acquisition* (pp. 339–355). Cambridge: Cambridge University Press.
- Christ, S., Kester, L., Bodner, K., & Miles, J. (2011). Evidence for Selective Inhibitory Impairment in Individuals with Autism Spectrum Disorder. *Neuropsychology*, 25(6), 690–701. <http://doi.org/10.1037/a0024256>
- Clark, E. (1978). From Gesture to Word: On the Natural History of Deixis in Language Acquisition. In J. S. Bruner & A. Garton (Eds.), *Human Growth and Development : Wolfson College lectures* (pp. 85–120). Oxford: Oxford University Press.
- Dagenbach, D., & Carr, T. (1994). *Inhibitory Processes in Attention, Memory, and Language*. San Diego: Academic Press.

- Dale, P. S., & Crain-Thoreson, C. (1993). Pronoun Reversals: Who, When, and Why? *Journal of Child Language*, *20*(3), 573–589.
<http://doi.org/10.1017/S0305000900008485>
- De Sonneville, L. (1999). Amsterdam Neuropsychological Tasks: A computer-aided assessment program. In B. P. L. M. den Brinker, P. J. Beek, A. N. Brand, F. J. Maarse, & L. J. M. Mulder (Eds.), *Cognitive Ergonomics, Clinical Assessment and Computer-assisted Learning: Computers in Psychology* (pp. 87–203). Lisse: Swets & Zeitlinger.
- De Villiers, J. (2007). The interface of language and theory of mind. *Lingua*, *117*(11), 1858–1878. <http://doi.org/10.1016/j.lingua.2006.11.006>
- De Villiers, J., Hobbs, K., & Hollebrandse, B. (2014). Recursive complements and propositional attitudes. In T. Roeper & M. Speas (Eds.), *Recursion: Structural Complexity in Language and Cognition* (pp. 221–242). Cham: Springer International Publishing. <http://doi.org/10.1007/978-3-319-05086-7>
- De Villiers, J., & Pyers, J. E. (2002). Complements to cognition: A longitudinal study of the relationship between complex syntax and false-belief-understanding. *Cognitive Development*, *17*(1), 1037–1060. [http://doi.org/10.1016/S0885-2014\(02\)00073-4](http://doi.org/10.1016/S0885-2014(02)00073-4)
- De Vries, M., & Geurts, H. (2012). Cognitive flexibility in ASD; Task switching with emotional faces. *Journal of Autism and Developmental Disorders*, *42*(12), 2558–2568.
<http://doi.org/10.1007/s10803-012-1512-1>
- Diehl, J. J., Friedberg, C., Paul, R., & Snedeker, J. (2015). The Use of Prosody During Syntactic Processing in Children and Adolescents with Autism Spectrum Disorders. *Development and Psychopathology*, *27*(3), 867–884.
<http://doi.org/10.1017/S0954579414000741>
- Dunn, L. M., & Dunn, L. M. (1997). *Peabody Picture Vocabulary Test (PPVT)-III-NL*. Amsterdam: Harcourt Test.

- Durrleman, S., Burnel, M., Thommen, E., Foudon, N., Sonié, S., Reboul, A., & Fourneret, P. (2016). The language cognition interface in ASD: Complement sentences and false belief reasoning. *Research in Autism Spectrum Disorders, 21*, 109–120. <http://doi.org/10.1016/j.rasd.2015.10.003>
- Durrleman, S., & Delage, H. (2016). Autism spectrum disorder and specific language impairment: Overlaps in syntactic profiles. *Language Acquisition, 23*(4), 361–386. <http://doi.org/10.1080/10489223.2016.1179741>
- Durrleman, S., Hippolyte, L., Zufferey, S., Iglesias, K., & Hadjikhani, N. (2015). Complex syntax in autism spectrum disorders: A study of relative clauses. *International Journal of Language & Communication Disorders, 50*(2), 260–267. <http://doi.org/10.1111/1460-6984.12130>
- Evans, K. E., & Demuth, K. (2012). Individual Differences in Pronoun Reversal: Evidence from Two Longitudinal Case Studies. *Journal of Child Language, 39*(1), 162–91. <http://doi.org/10.1017/S0305000911000043>
- Geurts, H., & Vissers, M. (2012). Elderly with Autism: Executive Functions and Memory. *Journal of Autism and Developmental Disorders, 42*(5), 665–675. <http://doi.org/10.1007/s10803-011-1291-0>
- Halliday, M. A. K. (1975). *Learning How to Mean: Explorations in the Development of Language*. New York: Elsevier.
- Heck, R., Thomas, S., & Tabata, L. (2012). *Multilevel modeling of categorical outcomes using IBM SPSS*. New York: Routledge.
- Hill, E. (2004). Executive dysfunction in autism. *Trends in Cognitive Sciences, 8*(1), 26–32. <http://doi.org/10.1016/j.tics.2003.11.003>
- Hobson, R. P. (1990). On the Origins of Self and the Case of Autism. *Development and Psychopathology, 2*(2), 163–181. <http://doi.org/10.1017/S0954579400000687>

- Hobson, R. P., Lee, A., & Hobson, J. (2010). Personal Pronouns and Communicative Engagement in Autism. *Journal of Autism and Developmental Disorders*, *40*(6), 653–64. <http://doi.org/10.1007/s10803-009-0910-5>
- Hollebrandse, B., van Hout, A., & Hendriks, P. (2014). Children's first and second-order false-belief reasoning in a verbal and a low-verbal task. *Synthese*, *191*(3), 321–333. <http://doi.org/10.1007/s11229-012-0169-9>
- Jaeger, F. (2008). Categorical data analysis: Away from ANOVAs (transformation or not) and towards logit mixed models. *Journal of Memory and Language*, *59*(4), 434–446. <http://doi.org/10.1016/j.jml.2007.11.007>
- Janke, V., & Perovic, A. (2015). Intact Grammar in HFA? Evidence From Control and Binding. *Lingua*, *164*, 68–86. <http://doi.org/10.1016/j.lingua.2015.06.009>
- Jordan, R. (1989). An Experimental Comparison of the Understanding and Use of Speaker-addressee Personal Pronouns in Autistic Children. *British Journal of Disorders of Communication*, *24*(2), 169–179. <http://doi.org/10.3109/13682828909011954>
- Kanner, L. (1943). Autistic Disturbances of Affective Contact. *Nervous Child*, *2*, 217–250.
- Köder, F., & Maier, E. (2016). Children Mix Direct and Indirect Speech: Evidence From Pronoun Comprehension. *Journal of Child Language*, *43*(4), 843–866. <http://doi.org/10.1017/S0305000915000318>
- Köder, F., Maier, E., & Hendriks, P. (2015). Perspective Shift Increases Processing Effort of Pronouns: A Comparison Between Direct and Indirect Speech. *Language, Cognition and Neuroscience*, *30*(8), 940–946. <http://doi.org/10.1080/23273798.2015.1047460>
- Kort, W., Compaan, E. L., Bleichrodt, N., Resing, W. C. M., Schittekatte, M., Bosmans, M., ... Verhaeghe, P. (2002). *WISC-III NL. Handleiding*. London: The Psychological Corporation.
- Kuijper, S., Hartman, C. A., & Hendriks, P. (2015). Who is he? Children with ASD and

- ADHD take the listener into account in their production of ambiguous pronouns. *PLoS ONE*, *10*(7), 1–18. <http://doi.org/10.1371/journal.pone.0132408>
- Lee, A., Hobson, R. P., & Chiat, S. (1994). I, You, Me, and Autism: An Experimental Study. *Journal of Autism and Developmental Disorders*, *24*(2), 155–176. <http://doi.org/10.1007/BF02172094>
- Lind, S. E., & Bowler, D. M. (2009). Language and Theory of Mind in Autism Spectrum Disorder: The Relationship Between Complement Syntax and False Belief Task Performance. *Journal of Autism and Developmental Disorders*, *39*(6), 929–937. <http://doi.org/10.1007/s10803-009-0702-y>
- Lord, C., Rutter, M., DiLavore, P. C., & Risi, S. (1999). *Autism Diagnostic Observation Schedule: Manual*. Los Angeles: Western Psychological Services.
- McCann, J., & Peppé, S. (2003). Prosody in Autism Spectrum Disorders: A Critical Review. *International Journal of Language & Communication Disorders*, *38*(4), 325–350. <http://doi.org/10.1080/1368282031000154204>
- Miller, H. L., Ragozzino, M. E., Cook, E. H., Sweeney, J. a, & Mosconi, M. W. (2015). Cognitive Set Shifting Deficits and Their Relationship to Repetitive Behaviors in Autism Spectrum Disorder. *Journal of Autism and Developmental Disorders*, *45*(3), 805–815. <http://doi.org/10.1007/s10803-014-2244-1>
- Mizuno, A., Liu, Y., Williams, D., Keller, T., Minshew, N., & Just, M. A. (2011). The Neural Basis of Deictic Shifting in Linguistic Perspective-taking in High-functioning Autism. *Brain*, *134*(8), 2422–2435. <http://doi.org/10.1093/brain/awr151>
- Mosconi, M., Kay, M., D’Cruz, A., Seidenfeld, A., Guter, S., Stanford, L., & Sweeney, J. (2009). Impaired Inhibitory Control is Associated With Higher-order Repetitive Behaviors in Autism Spectrum Disorders. *Psychological Medicine*, *39*(9), 1559. <http://doi.org/10.1017/S0033291708004984>

- Mullane, J., Corkum, P., Klein, R., & McLaughlin, E. (2009). Interference control in children with and without ADHD: A systematic review of Flanker and Simon task performance. *Child Neuropsychology*, *15*(4), 321–342. <http://doi.org/10.1080/09297040802348028>
- Naigles, L., Cheng, M., Xu Rattanasone, N., Tek, S., Khetrapal, N., Fein, D., & Demuth, K. (2016). “You’re Telling Me!” The Prevalence and Predictors of Pronoun Reversals in Children With Autism Spectrum Disorders and Typical Development. *Research in Autism Spectrum Disorders*, *27*, 11–20. <http://doi.org/10.1016/j.rasd.2016.03.008>
- Owen, A., McMillan, K., Laird, A., & Bullmore, E. (2005). N-back working memory paradigm: A meta-analysis of normative functional neuroimaging studies. *Human Brain Mapping*, *25*(1), 46–59. <http://doi.org/10.1002/hbm.20131>
- Perner, J., & Wimmer, H. (1985). “John thinks that Mary thinks that...” Attribution of second-order beliefs by 5- to 10-year-old children. *Journal of Experimental Child Psychology*, *39*(3), 437–471. [http://doi.org/10.1016/0022-0965\(85\)90051-7](http://doi.org/10.1016/0022-0965(85)90051-7)
- Risi, S., Lord, C., Gotham, K., Corsello, C., Chrysler, C., Szatmari, P., ... Pickles, A. (2006). Combining Information From Multiple Sources in the Diagnosis of Autism Spectrum Disorders. *Journal of the American Academy of Child & Adolescent Psychiatry*, *45*(9), 1094–1103. <http://doi.org/10.1097/01.chi.0000227880.42780.0e>
- Rogers, R., & Monsell, S. (1995). Costs of a predictable switch between simple cognitive tasks. *Journal of Experimental Psychology: General*, *124*(2), 207–231. <http://doi.org/10.1037/0096-3445.124.2.207>
- Rutter, M., Le Couteur, A., & Lord, C. (2003). *The Autism Diagnostic Interview Revised (ADI-R)*. Los Angeles: Western Psychological Services.
- Schlichting, L. (2005). *Peabody Picture Vocabulary Test-III-NL*. Amsterdam: Harcourt Test Publishers.
- Schneider, W., Eschmann, A., & Zuccolotto, A. (2002). *E-Prime user’s guide*. Pittsburgh:

Psychology Software Tools.

Scott, W. (1962). Cognitive Complexity and Cognitive Flexibility. *Sociometry*, 25(4), 405.

<http://doi.org/10.2307/2785779>

Tager-Flusberg, H. (1994). *Constraints on Language Acquisition: Studies of Atypical Children*. Hillsdale: Laurence Erlbaum.

Tager-Flusberg, H. (1996). Brief Report: Current Theory and Research on Language and Communication in Autism. *Journal of Autism and Developmental Disorders*, 26(2), 169–172. <http://doi.org/10.1007/BF02172006>

Tager-Flusberg, H., Paul, R., & Lord, C. (2005). Language and Communication in Autism. In F. Volkmar, A. Klin, R. Paul, & D. J. Cohen (Eds.), *Handbook of Autism and Pervasive Developmental Disorders* (3rd ed., pp. 335–364). Hoboken: Wiley.

Terzi, A., Marinis, T., & Francis, K. (2016). The Interface of Syntax with Pragmatics and Prosody in Children with Autism Spectrum Disorders. *Journal of Autism and Developmental Disorders*, 46(8), 2692–2706. <http://doi.org/10.1007/s10803-016-2811-8>

Welsh, M., & Pennington, B. (1988). Assessing frontal lobe functioning in children: Views from developmental psychology. *Developmental Neuropsychology*, 4(3), 199–230. <http://doi.org/10.1080/87565648809540405>

Wimmer, H., & Perner, J. (1983). Beliefs about beliefs: Representation and constraining function of wrong beliefs in young children's understanding of deception. *Cognition*, 13(1), 103–128. [http://doi.org/10.1016/0010-0277\(83\)90004-5](http://doi.org/10.1016/0010-0277(83)90004-5)

Tables

Table 1. Description of participants with Autism Spectrum Disorder (ASD) and typically developing (TD) participants

Background variables	ASD (N=46)	TD (N=42)	Group differences (General Linear Model ANOVA analyses)
Gender (boys:girls)	39:7	34:8	<i>n.s.</i>
Chronological Age (Year;Month)			
Mean (<i>SD</i>)	9;4 (2;2)	9;2 (2;0)	<i>n.s.</i>
Range	6;0-12;5	6;2-12;7	
Clinical diagnosis of ASD subtype according to DSM-IV criteria (N):			
Autistic Disorder	4	0	-
Asperger's Disorder	2	0	-
PDD-NOS ^a	42	0	-
Number of participants meeting ASD2 criteria ^b on:			
ADOS and ADI	33	0	-
ADOS only	10	1 (excluded)	-
ADI only	3	0	-
No ASD on ADOS and ADI	2 (excluded)	42	-

Estimated IQ (WISC) ^c			
Mean (<i>SD</i>)	99.87 (16.92)	113.21 (13.86)	TD > ASD***
Range	66.65-145.48	72.71-145.48	
Verbal ability score (PPVT) ^d			
Mean (<i>SD</i>)	104.48 (13.9)	113.62 (11.53)	TD > ASD**
Range	77-139	87-138	

Note. ^a PDD-NOS: Pervasive Developmental Disorder-Not Otherwise Specified; ^b The ASD2 criteria of Risi et al. (2006) are: “a child meets criteria on Social and Communication domains or meets criteria on Social and within 2 points of Communication criteria or meets criteria on Communication and within 2 points of Social criteria or within 1 point on both Social and Communication domains” (Risi et al., 2006; p.1100) ^c Estimated IQ on the basis of two subtests of the Dutch version of the Wechsler Intelligence Scale for Children (WISC-III-NL; Kort et al., 2002); ^d Normed verbal ability score from the Dutch version of the Peabody Picture Vocabulary Test (PPVT-III-NL; Schlichting, 2005); ** $p < .01$; *** $p < .001$

Table 2. Estimated effects of models 1, 2 and 3 on pronoun interpretation in direct speech

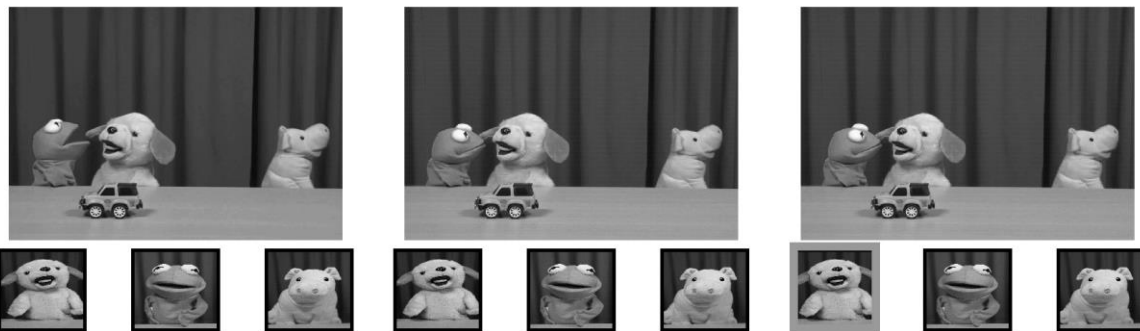
Variables	Model 1			Model 2			Model 3		
	<i>Estimate</i>	<i>SE</i>	<i>p</i>	<i>Estimate</i>	<i>SE</i>	<i>p</i>	<i>Estimate</i>	<i>SE</i>	<i>p</i>
Intercept	-1.10	0.32	.00**	-1.84	0.52	.00**	-1.72	0.44	.00**
Group	-0.04	0.43	.93	0.91	0.65	.17	0.84	0.59	.17
Age	0.04	0.01	.01*	-0.0	0.02	.87	-0.0	0.02	.85
Pronoun1	0.27	0.22	.22	0.35	0.31	.26	0.32	0.34	.34
Pronoun2	0.03	0.21	.89	-0.05	0.26	.84	-0.33	0.27	.22
Group*Pronoun1	-0.58	0.35	.10	-0.93	0.41	.02*	-0.94	0.43	.03*
Group*Pronoun2	-0.76	0.31	.02*	-0.99	0.35	.01*	-0.81	0.35	.02*
Group*Age	-0.03	0.02	.04*	0.0	0.02	.86	0.01	0.02	.54
ToM1				-1.43	1.91	.46	-0.37	1.76	.83
ToM2				3.7	1.45	.01*	3.24	1.31	.01*
WM				1.67	2.37	.48	1.93	2.14	.37
ToM2*Group				-2.8	1.91	.15	-2.33	1.7	.17
ToM2*Pronoun1				-1.37	0.95	.15	-1.34	0.98	.17
ToM2*Pronoun2				-0.48	0.75	.52	-0.67	0.7	.34
ToM2*Age				0.08	0.04	.046*	0.04	0.05	.35
WM*Pronoun1				2.59	1.2	.03*	2.7	1.38	.05
WM*Pronoun2				2.31	1.1	.04*	3.06	1.23	.01*
ToM2*Group*Pronoun1				3.56	1.41	.01*	3.61	1.54	.02*
ToM2*Group*Pronoun2				2.45	1.07	.02*	2.1	1.13	.06
ToM2*Group*Age				-0.17	0.07	.02*	-0.14	0.06	.01*
IQ							0.02	0.02	.29
Verbal ability							-0.03	0.02	.23

Verbal ability*Age			0.0	0.0	.02*
IQ*Pronoun1			0.0	0.0	.88
IQ*Pronoun2			0.03	0.01	.01*

* p<.05; **p<.01;

Note. Pronoun1 is *he* vs. *I* and Pronoun2 is *he* vs. *you*. Analyses in model 1 with reference category shifting (*I* is baseline) showed no *I* vs. *you* differences: Group*Pronoun1 (*I* vs. *you*) (B=0.18; SE=0.27; p=.51); Pronoun1 (*I* vs. *you*) (B=-0.24; SE=0.14; p=.09)

Figures



Frog tells Dog:

Jij krijgt de auto.

“You get the car”

Question of voice over:

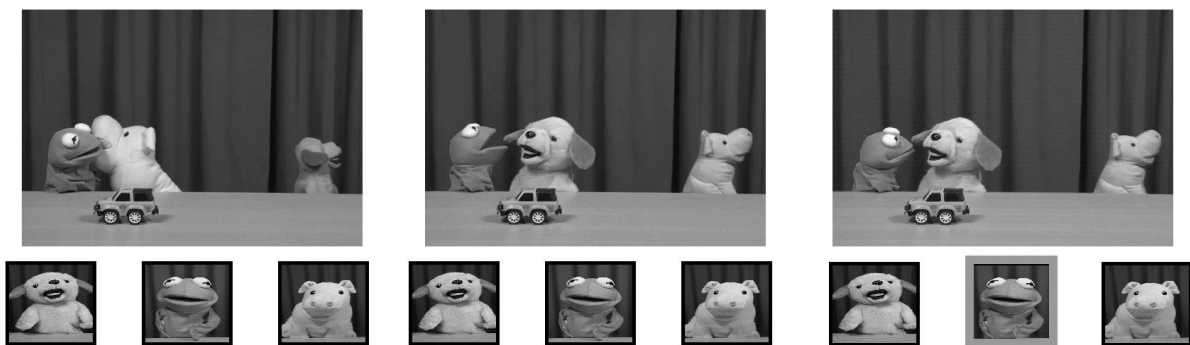
Wie krijgt de auto?

“Who gets the car?”

Selected answer is highlighted

by colored frame.

Fig. 1 Story board with a pretest example including the original Dutch sentences and their English translations



Pig whispers in Frog’s ear.

Pig and Dog switch

positions.

Frog reports to Dog in **direct speech:**

Varken zei: ‘Jij krijgt de auto’

“Pig said: ‘You get the car’ ”

Selected answer is

highlighted by colored frame.

or **indirect speech:**

Varken zei dat hij de auto krijgt.

“Pig said that I get the car.”

Question of voice over:

Wie krijgt de auto?

“Who gets the car?”

Fig. 2 Story board with a direct speech and an indirect speech example including the original Dutch sentences and their English translations

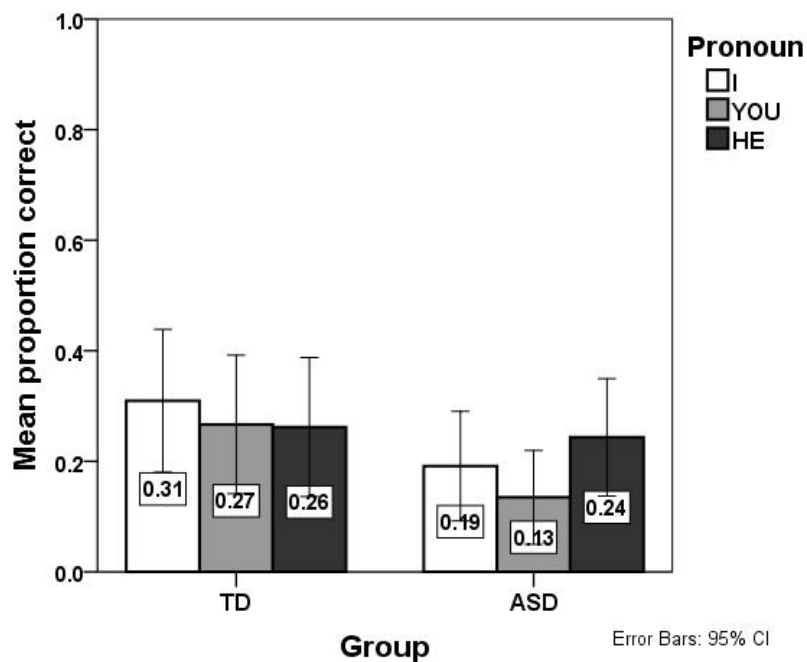


Fig. 3 Accuracy of pronoun interpretation in direct speech per group (TD vs. ASD) plotted per pronoun (*ik* ‘I’, *jij* ‘you’, *hij* ‘he’)

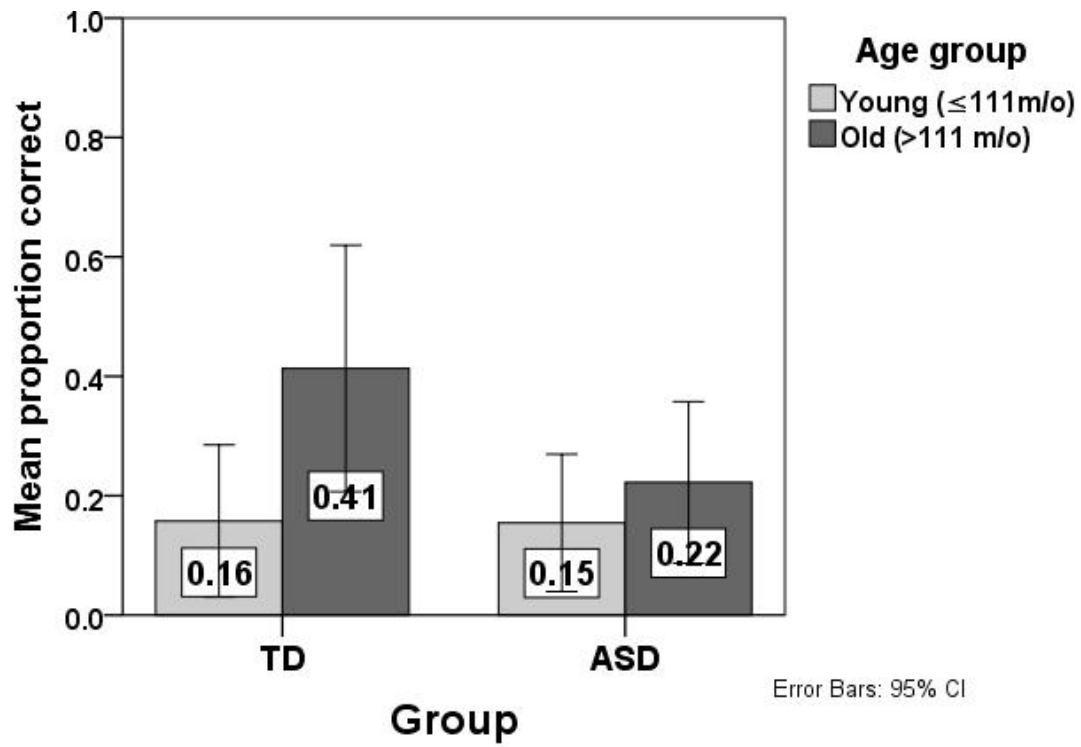


Fig. 4 Accuracy of pronoun interpretation in direct speech per group (TD vs. ASD) plotted per age group (Young: \leq median vs. Old: $>$ median; median=111 months old (m/o))

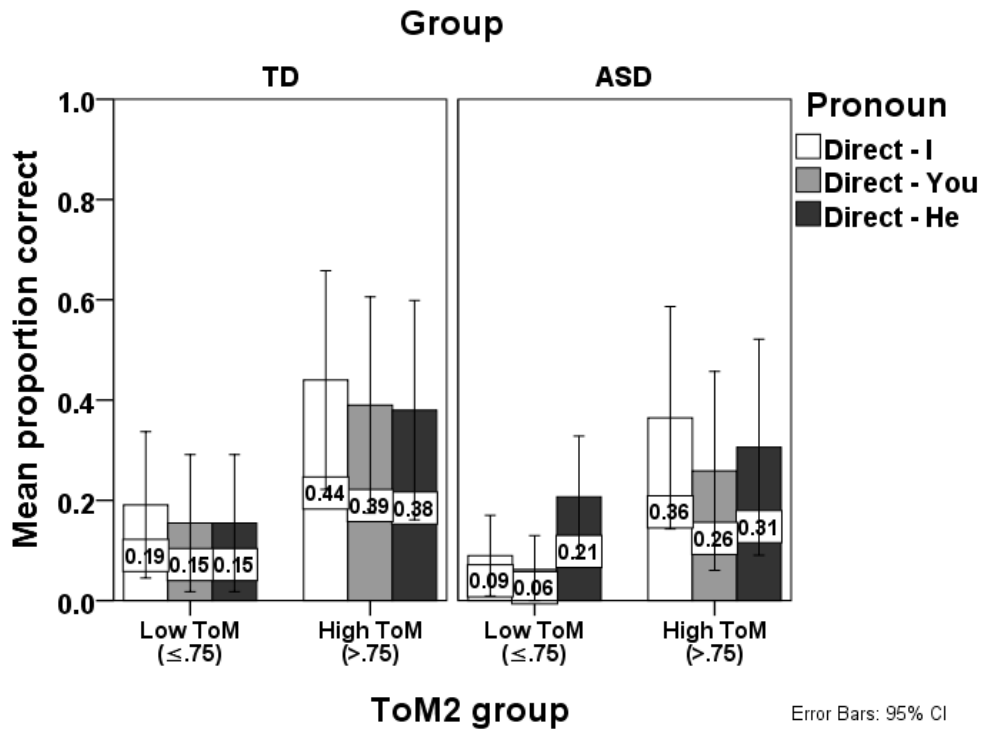


Fig. 5 Accuracy of pronoun interpretation in direct speech per group (TD vs. ASD) and ToM2 group (low ToM: \le median vs. high ToM: $>$ median; median=.75) plotted per pronoun (ik 'I', jij 'you', hij 'he') Background information: The mean ToM2 scores per plotted group are: TD with low ToM2: .41; TD with high ToM2: .95; ASD with low ToM2: .37; ASD with high ToM2: .93.

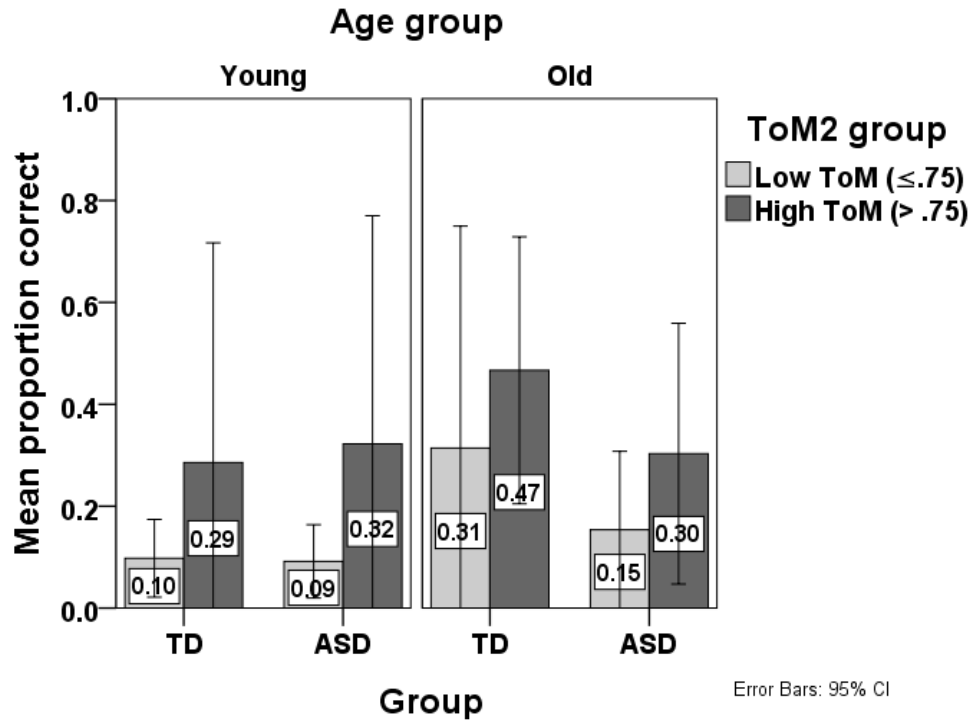


Fig. 6 Accuracy of pronoun interpretation in direct speech per age group (Young: ≤ 112 m/o vs. Old: > 112 m/o) and group (TD vs. ASD) plotted per ToM2 group (low ToM: \leq median vs. high ToM: $>$ median; median = .75). Background information: The mean ToM2 scores per plotted group are: TD-young-low ToM2: .34; TD-young-high ToM2: .94; ASD-young-low ToM2: .27; ASD-young-high ToM2: .92; TD-old-low ToM2: .55; TD-old-high ToM2: .96; ASD-old-low ToM2: .49; ASD-old-high ToM2: .94).