

Complex syntax in autism spectrum disorders: a study of relative clauses

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Abstract

Background: The few studies that have evaluated syntax in autism spectrum disorder (ASD) have yielded conflicting findings: some suggest that once matched on mental age, ASD and typically developing controls do not differ for grammar, while others report that morphosyntactic deficits are independent of cognitive skills in ASD. There is a need for a better understanding of syntax in ASD and its relation to, or dissociation from, nonverbal abilities. **Aims:** Syntax in ASD was assessed by evaluating subject and object relative clause comprehension in adolescents and adults diagnosed with ASD with a performance IQ within the normal range, and with or without a history of language delay.

Methods & Procedures: Twenty-eight participants with ASD (mean age 21.8) and 28 age-matched controls (mean age 22.07) were required to point to a character designated by relative clauses that varied in syntactic complexity. **Outcomes & Results:** Scores indicate that participants with ASD regardless of the language development history perform significantly worse than age-matched controls with object relative clauses. In addition, participants with ASD with a history of language delay (diagnosed with high-functioning autism in the DSM-IV-TR) perform worse on subject relatives than ASD participants without language delay (diagnosed with Asperger syndrome in the DSM-IV-TR), suggesting that these two groups do not have equivalent linguistic abilities. Performance IQ has a positive impact on the success of the task for the population with ASD.

Conclusions & Implications: This study reveals subtle grammatical difficulties remaining in adult individuals with ASD within normal IQ range as compared with age-matched peers. Even in the absence of a history of language delay in childhood, the results suggest that a slight deficit may nevertheless be present and go undetected by standardized language assessments. Both groups with and without language delay have a similar global performance on relative clause comprehension; however, the study also indicates that the participants with reported language delay show more difficulty with subject relatives than the participants without language delay, suggesting the presence of differences in linguistic abilities between these subgroups of ASD.

Keywords: autism spectrum disorders, Asperger syndrome, language delay, French, syntax, relative clauses.

What this paper adds

What is already known on the subject?

Studies evaluating syntax in autism spectrum disorders (ASD) are sparse and controversial. Some suggest that once matched on mental age, ASD and typically developing controls do not differ for grammar, while others report that morphosyntactic deficits are independent of cognitive skills and reminiscent of specific language impairment. Elucidating syntax in ASD and its relation to, or dissociation from, nonverbal abilities is a timely topic.

What this paper adds?

This study is the first assessment of relative clause comprehension in ASD and thus contributes to addressing the lacuna in the literature on complex syntax in ASD. This report explores whether adults with ASD within normal IQ range show differences in performance compared with normal age-matched controls on a task evaluating complex syntax. We further seek to understand if potential differences are more pronounced in the subgroup of adults with a history of language delay (previously diagnosed with high-functioning autism) than the one without (previously diagnosed with Asperger syndrome). Finally, as relative clauses have been explored with similar materials in specific language impairment, we offer a tentative comparison of these two clinical groups, which we suggest deserves closer investigation.

Introduction

Delays and deficits in language and communication are part of the defining characteristics of autism spectrum disorders (ASD), and difficulties in speech are amongst the first concerns by parents of children with this condition (Short and Schopler 1988). Language difficulties are however heterogeneous: while 15% of the population remains nonverbal at age 9 (Gotham *et al.* 2010), at the other end of the spectrum no residual grammatical impairment may be visible at the same age (Kelley *et al.* 2006). However, even when fluency is ultimately attained, a diagnosis of autism would only be given with the previous *Diagnostics and Statistical Manual of Mental Disorders IV—Revised* (DSM-IV-TR) (American Psychiatric Association [APA] 2000) with a history of language delay. According to the DSM-IV-TR, autistic traits without language delay during childhood would give rise to a diagnosis of Asperger syndrome. The distinction between these subgroups is no longer expressed in the recent DSM-5 (APA 2013), which instead situates autism and Asperger syndrome at different levels of severity along the same continuum, referred to as ASD. Nevertheless it is well known that the age of language acquisition impacts the level of language reached in typical development (Johnson and Newport 1989) and work on ASD also suggests that early delays in this population may affect their eventual attainment of grammatical abilities (Paul and Cohen 1984, Eigsti and Bennetto 2009). With this work, we explore whether adults with ASD within normal IQ range show differences in performance to normal age-matched controls on a task of complex syntax targeting relative clauses and if these potential differences are more pronounced in the subgroup of adults diagnosed with high-functioning autism than the one with Asperger syndrome, due to their different language development histories. In light of the recent DSM-5, we will refer to these groups as ASD with LD (language delay in childhood) and ASD without LD and, by comparing their respective levels of syntactic comprehension, will evaluate the impact of language acquisition delays in individuals with ASD and intelligence within normal range.

This study thus contributes to an on-going debate in the literature regarding the nature of syntactic impairment in ASD, as the few studies that have evaluated syntax in ASD have yielded conflicting findings (Eigsti *et al.* 2007). While earlier studies have claimed that once matched on mental age, ASD and typically developing (TD) controls do not differ for grammatical development (Bartak *et al.* 1975, Pierce and Bartolucci 1977, Tager-Flusberg *et al.* 1990), in more recent years new studies have argued that morphosyntactic deficits can be independent of cognitive skills (Eigsti *et al.* 2007, Kjelgaard and Tager-Flusberg 2001, Roberts *et al.* 2004, Zebib *et al.* 2013) and insist that specific grammatical deficits exist in ASD (Perovic *et al.* 2013, Terzi *et al.* 2012). More specifically, researchers have now shown that some subgroups with ASD present syntactic profiles reminiscent of specific language impairment (SLI) (e.g. Roberts *et al.* 2004, Tager-Flusberg 2006, Riches *et al.* 2010), and that performance on syntactic tasks does not correlate with IQ measures such as those yielded by Raven's Matrices (Zebib *et al.* 2013). One possible explanation for these differences in reports may be due to the fact that gross measures of emerging syntax based on language samples were generally used in earlier investigations (e.g. The Mean Length of Utterance, Brown 1973; The Index of Productive Syntax, Scarborough 1990), while more fine-grained, experimental tasks tapping into specific grammatical abilities (such as tense and wh-questions) have been applied in recent work. However, despite these recent experimental investigations of syntax in ASD, data are still lacking regarding a number of important structures characterizing complex syntax. In addition, the question remains whether or not the delay in language acquisition during the childhood of individuals with ASD of intelligence within the normal range leads to deficits that remain detectable in adulthood and which may potentially differentiate this group from adults with ASD without a history of language delay, who are reported to have normal syntactical speech (Tager-Flusberg and Joseph 2005, Slocombe *et al.* 2013).

This study contributes to addressing this issue by targeting the comprehension of relative clauses such as

(1) and (2) below, translated from the experimental material in French:¹

- (1) *Montre-moi le chien qui mord le chat.*
'Show me the dog that is biting the cat'.
- (2) *Montre-moi le chat que le chien mord.*
'Show me the cat that the dog is biting'.

Example (1) illustrates a case of subject relative clause (SR), thus called because the relative pronoun *that* designates the subject of the clause (the dog). Example (2) on the other hand is a case of object relative clause (OR), with the pronoun *that* this time designating the object of the clause (the cat).

In typical language development, ORs are acquired later than SRs (Friedmann *et al.* 2009, Adani 2011, Bentea and Durrleman 2013). This difference in acquisition is generally explained by the fact that SRs respect the canonical subject–verb–object word order in languages such as English and French, while ORs do not. In an OR, the object is fronted in the clause, and the word order thus becomes object–subject–verb. By assessing both types of relative clauses in individuals with ASD, we can determine if a form of impairment is already present at the level of the simpler subject relatives, or if their potential difficulty is only manifest at the more difficult OR level. Our choice of relative clauses was also motivated by the fact that they have been shown to be a useful tool for detecting syntactic difficulty in various conditions such as SLI (Friedmann and Novogrodsky 2004), mild-to-moderate hearing loss (Delage 2008) and agrammatic aphasia (Grodzinsky 1989). Because of this body of existing studies, the scores of individuals with ASD can also be compared with that of other populations, especially children with SLI, in order to validate possible convergences between the linguistic abilities within these two conditions.

To sum up, if syntax in ASD is intact, then performance of the clinical group on relative clauses should be in the same range as that of their age-matched control group, whereas the presence of deficits should yield significant differences in results between ASD and controls. In addition, if a history of language delay in childhood has consequences for grammatical abilities attained in adulthood, then individuals with ASD with LD should perform differently from those without LD, while a similar level of performance is expected for both subgroups if childhood delays are caught up. Finally, if syntax in ASD is similar to that reported for SLI on a similar task, then subject relative clauses should be intact in the population, with object relative clauses showing selective impairment.

Methods

Populations

The Lausanne University Hospital Ethical Committee approved the protocol and a written informed consent was obtained for all participants. Participants were recruited via their physicians and included 28 native French-speaking adolescents and adults with ASD (mean \pm SD age = 21.8 ± 7.8 years, age range 13–41 years, 23 males and 5 females). All participants were diagnosed with ASD according to DSM-IV-TR criteria (APA 2000) as well as ADOS-G (Lord 1994). Their IQ was in the normal range (mean \pm SD = 106 ± 14) (performance IQ measured either by the Wechsler non-verbal scale for participants up to age 22 [WNS]; Wechsler and Naglieri 2006; or the Wechsler Abbreviated Scales of Intelligence from the age of 23 [WASI]; Wechsler 1999). All participants had normal or corrected to normal vision and none had hearing impairments. From the population, 10 individuals had a history of language delay and were previously diagnosed with high-functioning autism (mean \pm SD age = 22.3 ± 9 years, age range 14–41 years, 7 males and 3 females) and 18 did not have a history of language delay and were previously diagnosed with Asperger syndrome (mean \pm SD age = 21.11 ± 7 years, age range 13–39 years, 16 males and 2 females). They did not differ on chronological age (Mann–Whitney $U = 87$, $p = 0.9$) or IQ ($U = 123.5$, $p = 0.11$). In addition, a control group of 28 age-matched subjects (CA group) (mean \pm SD age = 22.07 ± 7 years, age range 13–42 years, 23 males and 5 females) was tested on the same task.

Procedure

Each participant was tested individually in a quiet room. Participants with ASD completed the performance IQ test first (i.e. the WNS or the WASI) and then the relative clause task, while controls only completed the relative clause task. No time limit was imposed during the testing. The task began with a warm-up procedure designed to ensure that participants recognized the characters that appeared in the experimental items and were cooperative and precise at pointing. All participants succeeded at the warm-up task. Participants were then presented with a booklet composed of simple cartoons (material adapted from Coyer 2009), with characters performing an action in reversed roles, such as for example a dog biting a cat and a cat biting a dog. The experimental material included 28 relative clauses in French, read aloud by the experimenter (see appendix A for examples of stimuli and details on the experimental procedure). From these sentences, participants heard 14 SRs and 14 ORs, which were intermixed. They were requested to point to the correct character in one of the two images.

Experimenters ensured that participants were paying close attention throughout, so as to prevent potential concentration problems from impacting performance. Pointing to wrong characters was coded as incorrect. Every correct response was awarded one point and the scores of the experimental task was a sum of successes.

Statistical analyses

The CA control group's global performance (global success score encompassing SRs and ORs) in the experiment task reached ceiling, showing a nearly total absence of variability (99.6% of success). Therefore, it could not be included in a statistical model. In order to determine whether the ASD group had significantly lower scores compared with the control group and given that the data did not follow a normal distribution, we dichotomized the global success score into two categories: ceiling vs. not ceiling and compared the number of individuals from both groups in the two categories using Fisher's exact test. Indeed if the task were to pose no difficulty for the group with ASD, then the proportion of individuals performing at ceiling should not differ between the two groups. Bonferroni corrections were applied for multiple testing for post-hoc comparisons.

Within the ASD group the use of a linear regression analysis with repeated measures was not possible due to the nature of the scores (a sum of successes following a binomial distribution). We first conducted a generalized linear mixed model (GLMM) (McCulloch and Searle 2001) with a binomial distribution on the number of success of the relative task with participants' status (ASD with versus without LD) as between effect and type of relative clause (subject versus object) as within effect and participants as random effect. The R software was used with the LME4 package (Bates and Maechler 2010). As we did not have enough participants to test the role of age and IQ simultaneously with the participant status, we tested a second GLMM model with participants as random effect on the number of success of the relative task with age and IQ as covariates.

Finally, we looked for correlations between the ages when ASD participants produced their first words and their ability to understand subject and object relative clauses using Spearman's rank correlation coefficient.

Results

We first compared global success scores of the ASD group (i.e. including both LD vs. no LD) with the control group on the ceiling versus not ceiling distinction, as explained above. The contingency table is reported in table 1. Fisher's exact test indicates that the difference between the number of individuals reaching ceiling between groups is significant ($p < 0.001$). Post-hoc tests showed significant differences between ASD without LD and controls, and ASD with LD and controls (both

Table 1. Contingency table of the number of participants reaching the ceiling (100% of success) across populations for global success score

	Ceiling	
	No	Yes
CA controls	3	25
ASD with LD	9	1
ASD without LD	13	6

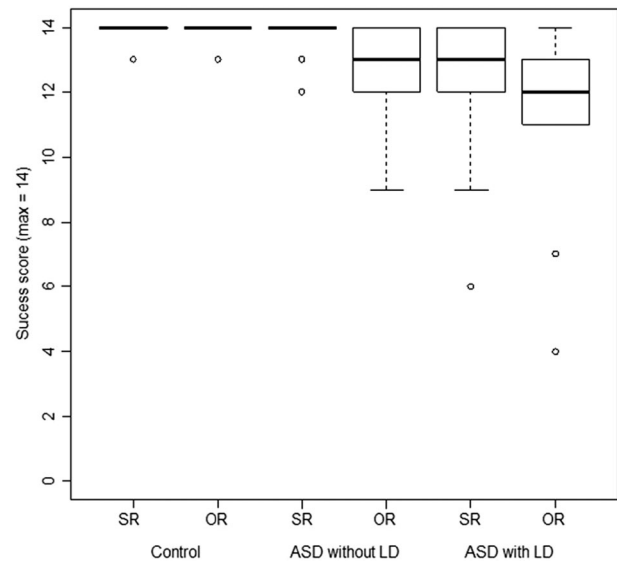


Figure 1. Distribution of the number of successes by group (control, ASD without LD and ASD with LD) and type of relative clause (SR versus OR). The middle line represents the median (second quartile). The first line represents the first quartile and the third line the third quartile.

$p < 0.0001$). ASD with LD did not differ from ASD without LD for the global success score ($p = 0.37$).

Results from the GLMM revealed a significant main effect of relative clause type (the likelihood of success at ORs being lower than SRs, $z = -7.34$, $p < 0.0001$), and the analysis revealed a main effect of language delay ($z = 2.64$, $p = 0.008$), the group without LD having a higher probability to succeed at the task than the group with LD. We also observed the presence of a significant interaction between relative clause type and diagnosis ($z = -2.67$, $p = 0.007$), showing that individuals without LD have a higher probability to succeed at SRs than those with LD while the two groups do not differ for ORs (figure 1).²

Subsequent GLMM analyses reveal that the ASD group without LD had a higher probability to succeed the SRs than the ORs ($z = -3.73$, $p = 0.0001$), while ASD participants with LD did not ($z = -0.71$, $p = 0.47$). In addition, IQ was also observed to have a significant impact on success (OR and SR confounded, score between 0 and 28) at this task for the ASD group (GLMM: $z = 3.42$, $p < 0.001$) when tested as only

covariate. Similarly, analyses exploring correlations between performance and age also showed a significant positive correlation ($p = 0.013$).

The Spearman's rho revealed a statistically significant negative relationship between the age at which subjects produced their first words and their ability to understand subject relative clauses ($r = -0.84$, $p = 0.017$). No significant relationship was found between the age at which subjects produced their first words and their ability to understand object relative clauses ($r = -0.26$, $p = 0.23$).

Discussion

Our experiment reveals subtle difficulty with the comprehension of relative clauses by the ASD population when compared with results of age-matched controls. While the former show variability in the processing of these structures, CA controls were virtually at ceiling. The variability in performance amongst the ASD population was further seen to correlate with performance IQ (PIQ), with higher PIQ implying also better language performance. This is in contradiction to that which has been claimed in a recent study by Zebib *et al.* (2013), where IQ scores for 20 ASD participants (mean age 8;7, IQ range 48–108) as measured by Raven's Matrices were reported as not correlated with formal language abilities. Given that the majority of the participants had a diagnosis of ASD without LD, and that analyses had to be conducted on the group as a whole for statistical reasons, it would now be interesting to see if this correlation between PIQ and syntactic skills also holds in a group made up of only individuals with ASD with LD. We leave this for future work.

Our results indicate that individuals with ASD, regardless of their language development history, have a significantly higher probability to master SRs than ORs. This is reminiscent of what is reported for ASD by Riches *et al.* (2010) who also note more errors with ORs than SRs in a sentence-repetition task. This pattern of improved performance for SRs than ORs is also what is generally reported for TD children (Berman 1997, Brown 1972, Correa 1982, 1995, McKee *et al.* 1998, Roth 1984, Sheldon 1974, Tavakolian 1981; Friedmann *et al.* 2009), indicating that language in high-functioning ASD appears to be slightly delayed rather than fundamentally deviant. More specifically, ORs, emerging later in typical acquisition, yield lower scores in ASD than structures which are acquired earlier by TD children, namely SRs. Future research should seek to determine at what age TD children's scores for ORs match those of the adult ASD group. However, based on results from similar tasks in the literature, we predict that this age should be situated around 10 years (Bentea and Durrleman 2012). Regarding SRs, these are

mastered early in typical development, with children age 6 years already reaching 95% accuracy (e.g. Friedmann and Novogrodsky 2004). It is therefore noteworthy that these structures are still not at ceiling in adults with ASD, and scores obtained are even below those reported for children with SLI age range 7;3–11;2 on a similar task, which is 98.5% (with a standard deviation of .05%; Friedmann and Novogrodsky 2004).

Lower scores for ORs as compared with SRs plausibly stem from a combination of two complexity factors: (1) embedding and (2) the non-canonical (object–subject–verb) word order derived by the fronting of the object. Object fronting involves a process referred to as 'syntactic movement'. Challenges with such movement are commonly reported in language-impaired groups, and have recently been found in ASD populations (Perovic *et al.* 2007). Studies also suggest difficulty in ASD with embedding (e.g. Tager-Flusberg 2000, Durrleman and Zufferey 2013) while embedding appears to be spared in SLI (e.g. Fattal *et al.* 2011).

The reported weakness with embedding in ASD could be the source of the attested subtle difficulty for the participants with SRs, and potentially help to differentiate the language profile of ASD from that of SLI. Indeed with a similar procedure, SRs have been found to be mastered by children with SLI (Friedmann and Novogrodsky 2004), with ORs showing selective impairment. The pattern of slightly lagged performance of SRs in the population of adults with ASD has moreover been replicated for children with this condition (Durrleman and Franck 2012).

Scores obtained by the subgroup of participants with ASD without LD indicate that they perform better than individuals on the spectrum with LD, in particular for SRs, suggesting a difference between these groups in terms of language development, in line with the distinction that was previously made in the DSM-IV-R. This difference could stem from the presence or absence of observable language delays in children with ASD, an explanation which is upheld by the fact that scores for SRs were lower for adults with ASD whose first words were produced later than for those whose first words were produced earlier. Participants with ASD without LD nevertheless do not perform completely on a par with adult controls. This shows that a slight delay may be present during childhood for these individuals but go undetected by standardized language assessments. It becomes conceivable that these individuals may have struggled in school as the demands for language complexity increased. Clinicians should be aware of these subtle differences so as to accordingly implement interventions. Given that only subtle deficits show up with the task involving response accuracy, the use of a more refined measure such as response time or reading time may prove more effective at uncovering possible

syntactic difficulties in this group. Also, work assessing a wider array of syntactic structures would potentially uncover additional sources of grammatical delay, although it lies outside the scope of the present study. Finally, given that the participants showed variability on age, and in light of recent findings indicating a potential delay in maturation of the white matter of the brain in ASD, including in language networks (Bakhtiari *et al.* 2012), links between performance and age were explored and results showed a significant positive correlation. This finding suggests that amelioration continues during a later phase in ASD as compared with that observed in TD, as suggested by Bakhtiari *et al.* (2012).

Conclusion

This study of relative clauses reveals that subtle grammatical difficulties remain in adult individuals with ASD within normal IQ range as compared with CA controls. Higher scores with SRs than with ORs are reminiscent of the pattern reported for typically developing children, suggesting that a language delay in the acquisition of these structures may lead to a plateau of certain abilities in adulthood. The level of performance for SRs is different to that reported in the literature for children with SLI for a similar procedure, potentially indicating a distinction between these groups. A targeted study including populations with ASD and SLI evaluated with the same experimental task is needed to address this apparent difference in syntactic profiles. The increased difficulty of ORs attested in the population with ASD can be explained in terms of the additional challenge for the syntactic computational system presented by these structures. Even in absence of a history of language delay in childhood, the results show that a slight delay may nevertheless be present and go undetected by standardized language assessments. Future research involving more refined measures may allow to further highlight subtle impairments in this population. Even though both groups of individuals with ASD have a similar global performance in the task, the study also reveals differences, with individuals with LD showing more difficulty with SRs than individuals without LD. This suggests that some distinctions in linguistic abilities exist between ASD adults with and without LD in childhood.

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Notes

1. One difference between English and French relative clauses is that the form of the relative pronoun in English is *that* for both subject and object relative clauses, while it changes in French from *qui* for subject relatives (1) and *que* for object relatives (2). Despite this difference, cross-linguistic evidence shows that in languages that use a single relative pronoun for both subject and object relative clauses, relative clauses are not acquired significantly earlier or later than in French. For example, Italian makes use of one form only, *che*, and in a pointing procedure task like ours, Adani (2011) reports that Italian children at age 7 attain 93% accuracy for subject relatives while these same relatives yield a similar 96% accuracy in French-speaking children age 7 (Frank *et al.*, 2009). Hebrew also makes use of a single relative pronoun and object relatives in this language are shown to be acquired at the same age as in French: Friedmann *et al.* (2009) use an image-selection task with Hebrew-speaking children aged 4;6 years and report that they obtain 70% for object relatives, while with a similar image-selection procedure French-speaking children age 4;5 also obtain exactly 70% (Coyer 2009).
2. Score percentiles for relative clauses for the two groups with ASD are: ASD with LD (score percentiles ORs: 25th = 10; 50th = 12; 75th = 13.25; SRs: 25th = 11.25; 50th = 13; 75th = 14). ASD without LD (score percentiles ORs: 25th = 11.25; 50th = 13; 75th = 14; SRs: 25th = 13.75; 50th = 14; 75th = 14).

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Appendix

Warm up

Montre-moi le chien.
'Show me the dog'

Montre-moi la princesse.
'Show me the princess'

Montre-moi le petit garçon.
'Show me the little boy'

Tu verras à partir de maintenant deux images sur chaque page. Je vais te demander de trouver le bon personnage sur l'une des images. Par exemple: Montre-moi le petit garçon qui couvre l'éléphant.

'You will see from now on two images on each page. I'm going to ask you to find the right character on one of the images. For example: Show me the little boy who is covering the elephant.'

Examples of experimental items (full list available upon request)

Subject relative clauses

Montre-moi le chat qui mord le chien.
'Show me the cat that is biting the dog'

Montre-moi les grands-parents qui coiffent la petite fille.
'Show me the grandparents who are combing the little girl'

Object relative clauses

Montre-moi le chat que les chiens mordent.
'Show me the cat that the dogs are biting'

Montre-moi la petite fille que la grand-mère coiffe.
'Show me the little girl that the grandmother is combing'