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Intact Grammar in HFA? Evidence from Control and Binding

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Abstract

This study contributes original results to the topical issue of the degree to which grammar is intact in high-functioning children with autism (HFA). We examine the comprehension of binding and obligatory control in 26 HFA children, mean age=12;02, compared with two groups of younger typically developing (TD) children: one matched on non-verbal mental age (MA), mean age=9;09, and the other on verbal MA, mean age=8;09. On the binding task, our HFA group showed a good performance on reflexives on a par with TD matched children, in line with recent reports of intact knowledge of reflexive binding in higher but not lower-functioning children with autism. Their comprehension of personal pronouns was somewhat poorer, with no difference observed between the groups, again supporting the existing literature. Results on the control task, which probed mastery of syntactic relations never previously examined in autism, revealed that both HFA children and the two matched TD groups were at ceiling on single-complement subject control (*try*) and object control (*persuade*). However, a considerably poorer attainment on double-complement subject control (*promise*) was present equally in the HFA group and the verbal MA-matched TD group but not in the non-verbal MA-matched group. Performance on *promise* correlated with age only in the verbal MA-matched group, whilst in HFA it correlated with general cognitive and language abilities.

These novel findings demonstrate that regular obligatory control and reflexive binding are preserved in HFA. We contrast these results with previous literature that has demonstrated deficiencies with passives and raising in HFA populations. The emerging bifurcation suggests different analyses for the principles underlying these constructions: whereas the latter incorporate movement, control and binding do not. The poor performance on *promise* supports all previous literature on this lexically and syntactically idiosyncratic construction. Its breaking of locality, which in turn results in a conflict between lexical and syntactic requirements, is exceptional and introduces an extra step of learning. This step appears to be related to maturation in TD children, and to stronger language and cognitive skills in HFA children.

KEY WORDS: Autism, Syntax, Control, Binding

1. Introduction

In this paper we investigate comprehension of two examples of grammar in a group of high-functioning children with autism (HFA)[1]: obligatory control and binding. Autism Spectrum Disorder (ASD) is a lifelong developmental disability affecting social communication and interaction, associated with restrictive interests and behaviours, which are not a result of a global developmental delay or cognitive disability (American Psychiatric Association, 2013). Individuals with ASD are amply documented as having consistent difficulties with pragmatic aspects of language (e.g. Tager-Flusberg and Anderson, 1991; Happé, 1993; Norbury, 2005; Rundblad and Annaz, 2010), yet their level of grammatical competence has not been clearly established as investigations on complex syntactic structures in this population are still sparse. The heterogeneity in the cognitive and linguistic abilities in this population makes it yet more difficult to draw precise conclusions about their syntactic knowledge. Studies have reported different results for children who are high-functioning (HFA) from those who are low-functioning (LFA) (Boucher, 2009), or for children who have a language impairment (ALI) against those whose language is normal (ALN) (Tager-Flusberg, 2006). Recent experimental work points to certain advanced syntactic structures being problematic in both children and adults with ASD. Interestingly, all of these structures involve relations where the position that a phrase is interpreted differs from the position that the phrase is pronounced. That is, they all involve movement.[2] In a sentence repetition task, Riches, Charman, Simonoff and Baird (2010) found that English-speaking teenagers with ALI made significantly more errors than age-matched typically developing (TD) children on subject and object relative clauses. A severe difficulty in the comprehension of subject and object relative clauses is reported in Durrleman and Zufferey (2013) in HFA French-speaking adults, while Zebib, Tuller, Prévost and Morin (2013) found that French-speaking children with ASD would avoid fronted wh-questions in an elicitation task by opting for a more simple alternative (e.g. wh-in situ)

[1] High-functioning autism (HFA) usually refers to individuals diagnosed with ASD whose IQ is above 80, though some studies use a lower benchmark of IQ of 70 and above.

[2] The framework adopted here is that of generative grammar. For introduction and definition of relevant terminology the reader is referred to texts such as Radford (2004); Cook and Newson (2007); Isac and Reiss (2013).

whenever possible. These three studies focused on dependencies that involve A-bar movement, however, constructions involving Argument movement (from here on A-movement), such as passives and raising, have also been reported to cause children with ASD difficulty.[3] Severely compromised comprehension of passives was revealed in an early study by Tager-Flusberg (1981) and confirmed more recently in Perovic, Modyanova and Wexler (2007). The latter study also reported a deficient comprehension of raising in their sample of children with ASD. At this point then we can see that the few studies conducted in this area have shown that a number of constructions represented in standard formal theories as involving movement seem to be causing difficulty to individuals with ASD. These involve A and A-bar dependencies, as well as local and non-local movement, and children across the high- and low-functioning divide have exhibited problems with these relations.

A construction that appears not to cause any interpretative difficulties in autistic children at the higher-functioning level of the spectrum is that of reflexive binding, a local syntactic relation which does not involve movement. Perovic, Modyanova and Wexler (2013a, 2013b) report an impaired comprehension of reflexives (*himself*, *herself*) in their sample of English-speaking children with LFA, who also had an established language impairment, but an intact interpretation of these elements in an age-matched sample of children classified as HFA, with no accompanying language impairment. Thus we now have an example of syntax which is not derived by movement that is preserved in children with HFA.

This brief review of experimental research into the mastery of argument dependencies in the grammar of individuals with autism highlights a number of points. Firstly, it illustrates that more research on higher levels of grammatical ability is crucial to the question of if and how the autistic profile impacts upon grammatical development. The present study represents a contribution in this respect. It takes a hitherto unresearched area of grammar in this population, namely obligatory control, and asks, using the

[3] In A-movement, a phrase moves to an argument position (e.g. in the passive, an object moves to the subject position). In A-bar movement, a phrase moves to a non-argument position (e.g. in wh-movement, an object moves to the left periphery of the clause. See e.g. Rizzi (2013) for further explanation of these terms.

same paradigm as that for binding, raising and passives, whether HFA children exhibit any problems with its comprehension. Theoretical accounts of obligatory control differ according to whether they propose a movement-based analysis or not (see Hornstein, 2001; Boeckx and Hornstein, 2004 for movement-based analyses and Manzini, 1983; Landau, 2000; Janke 2007 for non-movement-based approaches and Kirby, Davies and Dubinsky 2010a for a review of some of the issues relevant to movement vs. non-movement approaches). Thus the second point of interest is theoretical. The degree to which our current participants succeed with obligatory control will contribute to the debate surrounding its classification. If it is not movement-based, our HFA participants' performance on the construction should pattern more closely with that found for binding, rather than revealing the same deficiencies as those found for raising and passives. This is because aside from not involving movement, binding and obligatory control share other fundamental syntactic properties (see Manzini, 1983; Koster, 1987).

In the next subsection, we set out the properties of binding and relay the acquisition trajectory of these constructions in typical development. In section 1.2, we do the same for obligatory control. This will take us to section 1.3, where we form our predictions with respect to the current study.

1.1 Binding and its acquisition

Pronominal elements include reflexives (e.g. himself/herself) and personal pronouns (e.g. him/her). Both elements are anaphoric, in that they depend upon a referential antecedent for their interpretation, but they differ in terms of the conditions that regulate this interpretative dependency. In standard formal theory, the regulations are stated as a set of conditions under which a reflexive or pronoun can be bound by an antecedent (see Chomsky, 1986). The conditions regulating reflexives demand a local, c-commanding antecedent for the reflexive.[4] These properties are illustrated in (1a) and (b) respectively. In (1a), the indices indicate that only the most local argument (John) can be linked to the reflexive, whereas (1b) shows that a non-c-commanding antecedent cannot be linked to the reflexive. C-command is a principle that captures the requirement that an antecedent occur in a structurally higher position in a sentence

[4] A formal definition of c-command is such that a constituent, 'X', c-commands a constituent, 'Y' if Y is sister to X or contained within X's sister.

than its dependent. By embedding the noun, *brother*, in a possessive construction, this structural superiority is broken. Pronouns contrast with reflexives in exhibiting an anti-locality requirement. If a pronoun takes a sentential antecedent, that antecedent must not be in a local relation with it: in (1c), the pronoun can refer to Peter or an external referent but not to John.

(1) a. Peter$_1$ said that John$_2$ should wash himself $_{*1/2}$
b. Peter$_1$'s brother$_2$ washed himself$_{*1/2}$
c. Peter$_1$ said that John$_2$ should wash him$_{1/*2/3}$

Children interpret reflexives accurately by the age of about four, however, pronouns can continue to cause difficulty even at the age of six (Jakubowicz, 1984, Chien and Wexler, 1990). The original methodology (i.e. the truth value judgment task) and the results of early studies have been disputed more recently (Conroy, Takahashi, Lidz and Philips, 2009), however, the finding of a differential comprehension of reflexives versus pronouns has been reported consistently across a range of languages (e.g. French, Russian, Icelandic, Dutch - see Guasti, 2004, for a comprehensive review as well as a discussion of clitic languages, where the effect has not been observed), and with different methods (e.g. forced-choice picture selection: van den Akker, Hoeks, Spenader and Hendriks, 2012).

The phenomenon of worse interpretation of pronouns as opposed to reflexives can be understood by looking further at the differing principles underlying these elements' regulation. The interpretation of reflexives is uniform in being regulated syntactically only. Under the structural configuration mentioned above, they are always interpreted as bound variables. In contrast, pronouns can either be bound variables or elements regulated by coreference.[5] In the former instance, the relation is syntactically determined but in the latter, they are regulated by pragmatic or processing constraints (see Chien and Wexler, 1990 for a pragmatic account; Grodzinsky and Reinhart, 1993 for a processing account). In their extra-syntactic guise, pronouns will be liable to failure and this extra level of complexity translates into later acquisition in TD.

[5] The difference between binding and co-reference is further observed in studies which have investigated children's interpretation of pronouns when bound by quantified antecedents, e.g. in 'Every bear$_i$ is washing her$_i$'. Here the co-referential reading is not available and the pronoun is successfully interpreted by children as a bound variable (see Guasti, 2004, for a review of relevant literature).

The contrast in the acquisition of reflexives and pronouns in TD has also been observed in clinical populations, though it may go in the opposite direction, with reflexives being more difficult to interpret than pronouns. The work undertaken on reflexive binding suggests the construction could serve as a litmus test for a grammatical deficit in a population. Groups known for their grammatical strengths relative to their other cognitive impairments, as, for example, Williams syndrome, perform well on tasks assessing reflexive comprehension (see Perovic et al. 2007; Perovic et al. 2013b; Ring and Clahsen, 2005). Those groups for whom morphosyntactic deficits are well documented, however, exhibit problems on these same tasks (for Down syndrome, see Perovic 2004, 2006; Ring and Clahsen 2005; Sanoudaki and Varlokosta 2014; for LFA children see the references mentioned above). Interestingly, no group differences have been revealed for pronoun interpretation: children with ASD, regardless of their high- or low-functioning classification, demonstrated the same variability in their performance as that of the TD children against whom they were matched.

In the next sub-section, we turn to obligatory control, which we will see exhibits a substantial overlap with reflexive binding in terms of its syntactic principles yet includes further components that need to be integrated during acquisition, which culminate in a more complex learning task.

1.2 Control and its Acquisition

Like reflexives, the understood subject in obligatorily controlled complements must have a local, c-commanding antecedent (see Manzini, 1983; Cohen Sherman and Lust, 1993; Goodluck, Terzi and Diaz, 2001). This can be seen in (2), where in (a), locality permits only ‘Peter’ to be interpreted as the potential dog walker and in (b), only ‘John’s brother’ (and not ‘John’) can be, since only the whole possessive NP c-commands into the infinitival clause.

(2)	a. John told Peter$_i$ [*ec*$_i$ to walk the dog].	OBJECT CONTROL
	b. John’s brother$_i$ tried [*ec*$_i$ to walk the dog]	SINGLE-COMPLEMENT SUBJECT CONTROL

These two sub-types of obligatory control are produced by children as young as three years of age but at five, children still alternate at the level of chance between subject- and object-oriented interpretations of object control, indicating acquisition is not yet complete (see Kirby, Davies and Dubinsky, 2010b for a recent review of the acquisition literature). Studies have also shown that young children will look beyond the sentential arguments when assigning a referent to the *ec* in obligatorily-controlled complements. McDaniel, Cairns and Hsu (1990/1), for example, identified a group of children between the ages of 3;9 and 5;4 who permitted an arbitrary interpretation of the *ec* in object-control structures.[6] Of further interest is that given the appropriate discourse environments, children appear not to stop at arbitrary referents. Some five-year-old children, for example, have been found to bypass the obligatory syntactic antecedent for the *ec* in obligatory control environments in favour of a sentence-external referent if that referent has been mentioned in the preceding discourse (Eisenberg and Cairns, 1994). This was more prevalent in structures with one main-clause argument (Grover, in a) rather than two (Big Bird and Ernie, in b).

(3) a. Grover decides [*ec* to pat Big Bird].
    b. Big Bird tells Ernie [*ec* to jump over the fence].

From these works, we can see that reflexives and obligatory control do not develop absolutely in tandem. Control appears to lag a little behind. If we pay attention to what distinguishes these constructions, too, we can see why control might provide a greater learning challenge. A reflexive is always a direct argument of a transitive verb. In this configuration it is strictly anaphoric so its interpretation is entirely predictable once this structural requirement has been grasped. In obligatory control, however, a child needs to determine which verbs, out of a set of transitive verbs, select for controlled complements (see C Chomsky, 1969; Cohen Sherman and Lust, 1993; Guasti, 2004). A further complication is that a verb the child has encountered as an obligatory-control verb in one instance can also occur with a different kind of complement, where the

[6] The reader is referred to the original paper (especially pages 302-306 and 323) for the authors' justifications for why the children's interpretations were classified as arbitrary rather than specific external ones.

relation is not obligatory control, in another (see Goodluck et al. 2001 for a discussion of this issue in Greek and Spanish children). This can be seen in (4a), which shows a prototypical control verb (tell) with its controlled complement, whose *ec* carries the object-oriented interpretation. Yet that same verb can combine with a clause which has a verbal gerund subject, whose *ec* is not restricted in the same way (4b). The *ec* in this type of construction can host a number of interpretations, including sentence-external ones, under the appropriate discourse conditions (see Bresnan, 1982; Janke, 2007; Janke and Perovic, accepted).

(4) a. Peter told John$_i$ [ec$_i$ to read the book].
b. Peter$_i$ told John$_j$ that [[ec$_{i/j/k}$ to read/reading the book slowly] was a mistake].

This alternative possibility opens up a further learning task for the child. Obligatory control is a member of a wider set of control relations, whose understood subjects differ in terms of how their interpretations are secured. Within obligatory control, they conform to a set of structural requirements, and when these are met, their interpretations are predictable (c.f. 'promise', which we discuss below). But there is also a class of control constructions which is not obligatory. In these instances, the reference of the understood subjects can be discourse determined, as in (4b and 5) or arbitrary, as in (6).

(5) A: The headmaster phoned.
B: What did he say?
A: He said [*ec*$_i$ to introduce yourself$_i$ to the class before he arrives]
(Janke, 2007:181, no 65)

(6) A: Did you lock the door?
B: Oh, I've nothing [*ec*$_{arb}$ to steal]. (Perovic and Janke, 2013:5; no 5b)

Unlike obligatory control, these non-obligatory-control structures are open to pragmatic manipulation. Interpretations are decided on the basis of a contextual cue, as shown by Bresnan (1982) for controlled verbal-gerund subjects.

(7) Tom$_i$ felt sheepish. [ec$_i$ Pinching those elephants was foolish].

(Bresnan, 1982)

As the topic of the sentence preceding the non-finite clause, 'Tom' provides the pragmatic lead to the *ec*'s reference (see also Reinhart, 1981, and Samek-Lodovici, 1996). The flexibility in terms of referent choice for non-obligatory control relates back to what is observed in early research on its obligatory counterpart (as in Eisenberg and Cairns above). The five-year-olds who permit sentence-external readings seem to have a wider set of constructions from which to narrow down to obligatory control and they haven't yet reached an adult grammar in which obligatory control is resilient to pragmatic interference. Once the structure of a controlled clause is built, the *ec* must receive a specification. If selected by a control verb, this will come from a designated argument in the main clause but if not, the value attributed to it can be arbitrary (where the value is minimal, such as +animate; see Haegeman, 1994) or become specific, given the right discourse conditions (see Ariel, 1988, 2000). The greater number of interpretative possibilities in control suggests an extra level of complexity in the learning task for obligatory control than that which exists for reflexive binding.

The last sub-type of control that is relevant to our current study is rather different from the regular examples of obligatory control shown in (2a and b) above, and notorious for the difficulty it causes in acquisition. This is double-complement subject control, represented almost exclusively by the verb 'promise'. In this construction, the locality principle otherwise strictly adhered to (see Rosenbaum, 1967) is broken and the child must work out that for this rogue sentence, the object is skipped in favour of the subject:

(8) John$_1$ promised Peter$_2$ [*ec*$_1$to walk the dog] DOUBLE-COMPLEMENT SUBJECT CONTROL

There is, as demonstrated in Cohen Sherman and Lust (1986), a conflict between the lexical and structural principles associated with 'promise', principles which need to be reconciled for acquisition to occur. The lexical subject-control property of 'promise' contradicts the unmarked structural requirement in double-complement control structures, namely that the closest c-commanding DP in the matrix clause be the antecedent. In contrast, in object control, the lexical and structural requirements tally with one another.

As expected on the basis of its idiosyncratic nature, and its breaking of an already acquired principle, the promise construction is acquired late. Children up to the age of ten can still falter on this example of control (see C Chomsky, 1969; Tavakolian, 1978; Pinker, 1984; Hsu et al. 1989; Eisenberg and Cairns, 1994; Kirby et al. 2010).

1.3 The Current Study

If we use the literature on binding and obligatory control in TD as a benchmark against which to measure our HFA children's progress, we can form some expectations with regard to their performance in the current study.

We have seen that performance on binding in ASD is mixed. The picture emerging is that children classified as LFA do exhibit problems in this area of grammar, however, HFA children perform on par with their non-verbal MA-matched peers. Following this literature, we expect that our HFA participants will exhibit a level of comprehension of reflexives and pronouns no different to that of their matched controls. Our ability to replicate the aforementioned results on pronouns is particularly important, given the pragmatic deficits for which this population is renowned.

The literature on the acquisition of binding and control in TD has also shown that reflexive binding is achieved before obligatory control. Specifically, for a short time, children continue to accept an incorrect reference in obligatory control after the age at which they perform flawlessly on reflexive binding. If our HFA children are following a typical trajectory, we expect their performance on reflexive binding and obligatory control to exhibit this same order, namely reflexives prior to obligatory control, or rather, an equal pattern of performance, if they are of an age when both of these constructions are already established in typical development. A pattern that deviates from this order would be one where the HFA children perform worse on reflexives than on obligatory control.

Our expectations with regard to performance on obligatory control are more exploratory since there is no work on this construction in ASD yet. We focus on single-complement subject control (e.g. *try*), object control (e.g. *persuade*) and double-complement subject control (e.g. *promise*). The single-complement subject control condition*,* which is the type of control acquired earliest in TD, will indicate whether children show any propensity to opt for a sentence-external, yet pictorially represented, referent. This task would indicate whether a purely visual distraction of an additional potential referent could lead children away from the obligatory antecedent. For object control, we aim to establish if the children adhere to locality, by disallowing a subject interpretation. Lastly, on the basis of the hypothesis that control is not derived by movement, the children's performance on regular control is expected to be far better than that reported in the HFA literature for structures whose underlying movement operation is uncontroversial, namely passives and raising. For double-complement subject control our question is whether HFA children exhibit similar problems to those witnessed in much younger TD children with respect to its breaking of locality (C Chomsky, 1969; Tavakolian 1978; Cohen Sherman and Lust, 1993). In light of what is known about the course of development of control constructions in TD children, we would like to see if our HFA children's performance suggests that same course, namely: single-complement subject control < object control < double-complement subject control.

It is possible that the complex learning task of acquiring different types of control constructions be affected by factors such as chronological age and general linguistic and cognitive skills, thus we shall also investigate the effects of these factors in the performance of our samples. This pertains especially to double-complement subject control constructions, whose tokens are rare and whose acquisition requires a resolution of opposing syntactic and lexical requirements. The same possibility extends to pronouns, which are subject to both syntactic and pragmatic constraints and whose acquisition is also delayed in typical development.

2. Method

2.1 Participants

Seventy-five[7] children took part in the study: twenty-six HFA children (4 girls) aged between 7;3-16;4 (*M*=12;02, SD=2;06) were matched individually to one group of twenty-four[8] TD controls (5 girls), aged 6;06-15 (*M*=9;09, SD=2;04) on non-verbal reasoning, and matched individually to another group of twenty-five[9] TD control children (4 girls), aged 5;06-13;01 (*M*=8;09, SD=2;04) on verbal MA.

HFA children were recruited from four specialist schools for children with ASD in greater London, Berkshire and Kent. The clinical diagnosis of ASD[10], a key entry requirement to the school, was made on the basis of either DSM-IV TR (APA, 2000) or ICD-10 (WHO, 1992). None of the children had any hearing impairments or any accompanying deficits (neurological or genetic disorder, such as Rett syndrome, tuberous scleroris, fragile X). Details of the participants' ages and scores on measures of verbal and non-verbal abilities are given in Table 1. Their non-verbal IQ, as measured on the Matrices subtest of the Kaufman Brief Intelligence Test (KBIT) ranged between 82-154, *M*=113.65 (SD=15.64). Following the standard literature on HFA classifications, only children whose non-verbal IQ was 80 or above were included. Their scores on standardized tests of verbal abilities were rather heterogeneous, in line with the literature (e.g. Kjelgaard and Tager-Flusberg 2001): on the British Picture Vocabulary Scales II (BPVS II), their standard scores ranged from 45 to 121, *M*=90.77 (SD=23.87), and on the Test of Reception of Grammar 2 (TROG) from 55 to 116, *M*=91.73 (SD=18.33).[11] TD controls, with no known developmental

[7] Two more HFA children were recruited but were excluded from this number for failing to complete the test battery.

[8] This group consists of 24 participants, as no suitable matches could be found for two HFA children who gained extremely high raw scores on KBIT (44 and 48 out of the possible 48).

[9] This group consists of 25 participants, as no suitable match could be found for one HFA child with a low raw BPVS score (45).

[10] One of the children had a diagnosis of Asperger syndrome rather than ASD, but since Asperger has been subsumed under the general ASD diagnoses in the latest version of DSM-5, it was decided to collapse both diagnoses in this sample.

[11] Despite the wide range of children's standard scores on the tests of grammar (TROG 2) and vocabulary (BPVS II), only three children in our sample could be classified confidently as Autism plus

delays or hearing impairment, were recruited from schools in greater London and Berkshire. One group of children, TD KBIT, was matched individually to the HFA children on non-verbal reasoning, as per the raw score on KBIT Matrices, as well as gender. The other control group, TD BPVS, was matched individually to the HFA children on verbal MA, as per the raw score on BPVS 2, and gender. Twelve adult controls from the same geographical regions were also recruited. Their performance on the experimental task was at ceiling.[12]

Table 1.1. Ages and Mean Standard and Raw Scores (Standard Deviation) on Tests of Language and Cognition for all Participant Groups.

Group	**HFA** *n*=26	**TD KBIT** *n*=24	**TD BPVS** *n*=25
Age in months	147.31 (31.14)	119.21 (28.77)	106.92 (29.55)
Range	88-197	80-180	68-158
KBIT SS	113.65 (21.09)	119.58 (15.63)	-
Range	82-154	88-158	
KBIT Raw Scores	**33.96 (7.04)**	**32.08 (6.13)**	-
Range	22-48	21-44	
BPVS-II SS	90.77 (23.87)	-	115.92 (13.99)
Range	45-121		97-149
BPVS-II Raw Scores	**100.69 (23.69)**	-	**102.44 (21.21)**
Range	45-137		61-141
TROG-2 SS	91.73 (18.34)	-	-
Range	55-116		

Language Impairment (ALI), having scored at/or nearly at floor on these measures. Their BPVS standard scores were 45 and 47 and their scores on TROG were 53 and 55. A further child could be classified as borderline impaired (Kjelgaard and Tager-Flusberg, 2001) on both measures: 79 on BPVS and 78 on TROG, while two more scored in the severely impaired range on the vocabulary measure (BPVS SS of 54 and 55) but not the grammar measure (TROG SS of 79 and 81). These were not classified as ALI.

[12] In some dialects of American English, *promise*, although always carrying a subject-reading, is a more marked construction. For this reason it was important that our adult participants' interpretations all converged, in their universally accepting the construction and rejecting an object reading.

TROG-2 Raw scores	14.69 (4.44)		
Range	4-20	-	-

Key: KBIT SS = Kaufmann Brief Intelligence Test Standard Scores; BPVS SS = British Vocabulary Scales Standard Scores; TROG SS = Test of Reception of Grammar Standard Scores. Measures on which HFA participants are matched to TD controls are in bold.

2.2 Materials

2.2.1 Binding Task

To test children's comprehension of binding, we employed a two-choice picture-selection task from Perovic and Wexler (2007) and Perovic et al. (2013a, b), who used it on a large number of typical children and children with developmental disorders such as ASD and Williams syndrome. The pictures, which involved the well-known characters from the Simpson family, were presented on a laptop screen (specific details about the procedure are given at the end of the Methods section, as they pertain to both the Binding and Control tasks).

The task included two critical conditions, *Name Reflexive* and *Name Pronoun*, and two control conditions, *Name Possessive* and *Name Name*. In *Name Reflexive* and *Name Pronoun*, the subject of the sentence was always a possessive noun phrase (e.g. *Bart's dad*) and the object was either a reflexive (e.g. *himself*) or a pronoun (e.g. *him*). Thus the *Name Reflexive* sentence '*Bart's dad is washing himself*' was presented with two pictures on the screen: one picture in which Homer (Bart's dad) is washing himself in a bathtub with Bart standing by (the correct choice), and the other picture in which Homer is washing Bart who is sitting in a bathtub (the incorrect choice). The *Name Pronoun* sentence '*Bart's dad is washing him'* was presented with one picture showing Homer washing Bart who is sitting in the bathtub (the correct choice), and the other picture showing Homer washing himself in a bathtub with Bart standing by (incorrect choice).

Possessive noun phrases as subjects provided two possible antecedents for the reflexive or pronoun: *Bart's dad* (i.e. *Homer*), which c-commands the object, and *Bart*, the possessor, which does not. In order to independently test participants' understanding of possessive noun phrases, and the crucial relation of c-command, the control condition *Name Possessive* also used a possessive subject (*Bart's dad*). For a sentence '*Bart's dad is eating an ice cream',* one picture showed Homer (Bart's dad) eating an ice cream (correct choice), and the other picture showed Bart eating an ice cream (incorrect choice).

Name-Name also served as a control condition, containing proper names in the subject position and no reflexives or pronouns in the object position (e.g. '*Bart is washing dad*'), in order to test that the child could understand the task.

Four verbs, 'wash', 'touch', 'point to', and 'dress' were used in the NP and NR conditions, with each verb occurring twice. Each of the four conditions included eight sentences, giving a total number of 32 sentences in the task.

2.2.2 Obligatory Control Task

A new two-choice picture-selection task using the same Simpsons characters as above was devised for the following control constructions: single-complement subject control (*try*), object control (*persuade*) and double-complement subject control (*promise*).[13] A simple SVO structure was used to test that the children understood the task. All sentence types included eight items.[14]

Prior to the trial, we used a structured interview technique to determine the children's understanding of the verbs independently of control. The specific questions that each child was asked, together with a representative selection of the children's responses can be found in Appendix D. Only one child with HFA gave a less than satisfactory answer on *try*, however, it was decided not to exclude him as his performance on this condition was at ceiling.

The following sentence types and corresponding pictures were used in the Control task:

[13] These verbs were chosen because they represent prototypical examples of control but also because they lent themselves well to the task adopted here.

[14] Two additional tasks, testing the adjuncts 'while' and 'after' were also included in the test battery but their results are not included in the current analysis.

Single Complement Subject Control (*try*): Four of the eight sentences in this condition included the main-clause subject performing an action on the complement's inanimate object with another unmentioned character depicted nearby. To illustrate, the sentence '*Bart tried to eat the sandwich*' was accompanied by a corresponding picture in which Bart was eating a sandwich while Lisa stood next to him, and a foil in which Lisa was eating the sandwich and Bart stood next to her. This tested whether the child would opt for a visually depicted yet unmentioned referent as the agent of 'eat' (Lisa in this instance) over the visually depicted sentence-internal referent. The other four sentences included the main-clause subject performing an action on the complement's animate object. Thus '*Homer tried to wash Bart'* was accompanied by a corresponding picture in which Homer was washing Bart, and a foil in which Bart was washing Homer. This checked whether the child might choose an incorrect referent on the basis of a 'last-heard referent' strategy.[15]

Object Control (*persuade*): This condition used corresponding pictures in which the matrix object engaged in an action. The foil pictures depicted the matrix subject engaging in the action. For the example sentence '*Homer persuaded Marge to drive the car*', the corresponding picture showed Marge driving, with Homer standing next to the car, whereas in the foil, Homer was behind the wheel with Marge standing by.

Double Complement Subject Control (*promise*): The corresponding pictures showed the matrix subject engaged in an action, whereas in the foils the matrix object was the actor. In the example sentence, '*Homer promised Marge to walk the dog*', the correct picture depicted Homer leading the dog with Marge standing by, whereas in the foil Marge led the dog and Homer stood next to her.[16]

Serving as a control condition to test that the participants could understand the task, the SVO condition contained simple subject-verb-object sentences with no embedding

[15] These two sets of sentences were originally treated as two sub-conditions: *try-animate* and *try-inanimate*, however, no difference was found in the children's performance and the responses were analysed together.

[16] Note that the main verbs in all of the above conditions were in the past tense. Following a pilot study in present tense with several children and adults, it was agreed that past tense best suited the *promise* sentences. To reduce variation between conditions, all of the verbs in the three experimental conditions were changed to past tense. The last version of the task was administered to the twelve adults, aged 18-55, all of whom demonstrated ceiling performance.

and no infinitive verbs. They included the same characters and similar types of action to the other pictures, for example, the sentence '*Homer is walking the dog*' was accompanied by two pictures, one showing Homer walking the dog with Marge looking on, and a foil in which the characters were reversed.

As can be observed in Appendix B, the sentences included a variety of actions, in order to keep the pictures and the task more engaging. The verbs were used at most twice in each of the conditions.

2.3 Procedure

Both Binding and the Control tasks involved an identical procedure. Participants were shown pictures on the laptop computer, and then asked to point to the picture that went best with the sentence they heard ('Point to the picture that goes best with what I say'). The instructions were given for the first and second trial, after which children continued to respond without further instructions. Each participant was presented with a different order of pictures, which was randomized automatically by the software used. The location of the correct picture (i.e. whether it occurred on the right or left) was balanced throughout.

Prior to the administration of each task, children were familiarized with the characters and the actions depicting the verbs used in the tasks (see Appendix C).

The test battery was administered in a quiet room at the children's schools by one of the two experimenters present in the room. The battery was presented over the course of two sessions, each lasting approximately 30 minutes. To keep the length of each session similar, the order of presentation was BPVS, KBIT and the Binding task in the first session, and TROG and the Control task in the second session. There was a space of 2-3 weeks between sessions. The scoring of the binding and control tasks was computerized, i.e. the software recorded the picture choice, while the standardized tests were scored by the experimenter administering the test on a scoring sheet. Aside from being presented on the screen, the sentences were uttered by the experimenter once. The children were free to ask for the sentence to be repeated if necessary and were not penalized if the sentence was repeated.

3. Results

Participants' responses to each item (correct or incorrect) were analysed using the GLMM procedure in SPSS, 21, as logistic regression models have been argued to be better suited to binomially distributed data than ANOVAs (Jaeger 2008; Quene and van der Bergh, 2008). The fixed effects built into the model were Group, Sentence Type and the Group*Sentence Type interaction. Separate analyses were carried out for the two tasks.

3.1 Binding

Table 1.2 shows estimated mean probabilities correct and the standard error for each sentence type. The analysis revealed no significant effect of Group (F(2, 288)=0.223, p=.801) but a significant effect of Sentence Type (F(3, 288)=14.793, p<.001). No significant Group*Sentence Type interaction was found (F(6, 288) = 0.999, p=.426).

Table 1.2 Estimated Mean Probabilities Correct (Standard Error) on Binding

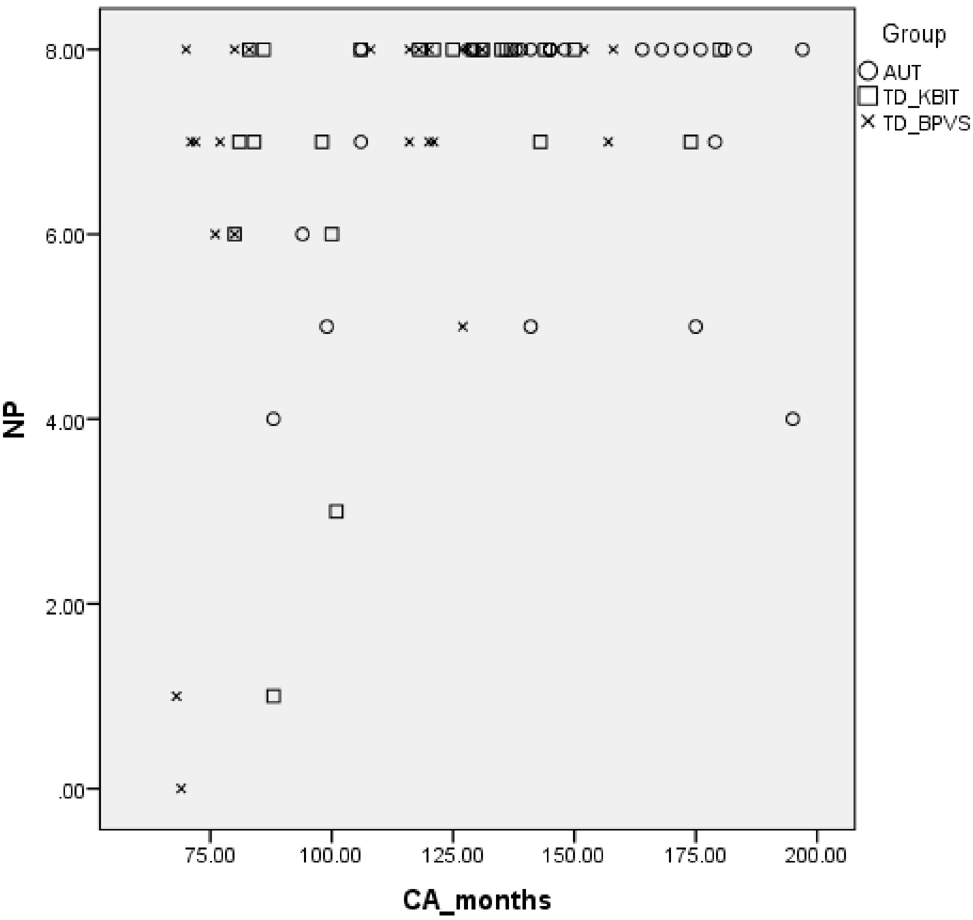
Sentence	HFA		TD KBIT		TD BPVS	
	Mean	*SE*	*Mean*	*SE*	*Mean*	*SE*
Name Pronoun	0.90	(0.04)	0.89	(0.04)	0.89	(0.04)
Name Reflexive	0.94	(0.03)	0.98	(0.01)	0.99	(0.01)
Name Poss.	0.99	(0.01)	0.99	(0.01)	0.99	(0.01)
Name Name	0.99	(0.01)	0.98	(0.01)	0.98	(0.01)

Note: HFA=high-functioning autism group, TD KBIT=typically developing group matched on raw score of KBIT, TD BPVS= typically developing group matched on raw score of BPVS.

Pair-wise comparisons (Sidak-corrected) uncovered no difference between groups on any of the conditions. As indicated by the significant effect of Sentence Type, for all groups collapsed, children performed better on all sentence types than on the Name-Pronoun condition: Name-Reflexive (t(288)=3.606, p=.001) (OR=6.93), Name-Possessive (t(288)=4.465, p<.001) (OR=19.85) and Name-Name (t(288)=4.191, p<.001) (OR=10.77). The groups' performance did not differ on other conditions: Name-Possessive vs. Name-Name (t(288)=.908, p=.722 (OR=1.84), Name-

Possessive vs. Name-Reflexive (t(288)=.941, p=.722 (OR=2.86) and Name-Name vs. Name-Reflexive (t(288)=.474, p=.722, (OR=1.55). In contrast to the uniformly ceiling performance on the other three sentence types, the individual data in the Name-Pronoun condition shows variation in all of the groups (see scatterplot in Figure 1), particularly in the youngest TD BPVS group and the HFA group.

Figure 1: Scatter plot showing the relationship between age (x-axis) and children's performance on *Name-Pronoun* (y-axis).

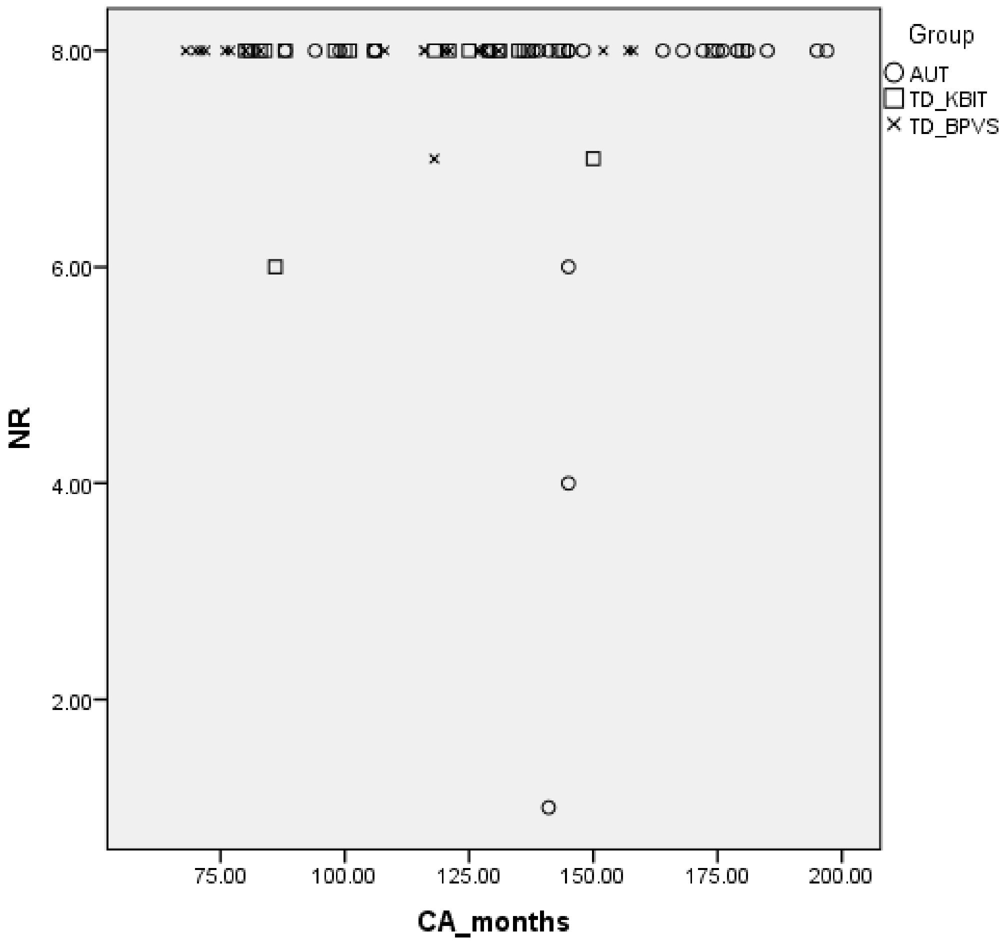


The Name-Reflexive condition also elicited a consistent ceiling performance from the TD groups, although three HFA children scored at or below chance[17] on this condition. Individual variability in the groups' performance is shown in the scatterplot in Figure 2. It is worth noting here that two of these children qualify as ALI (their score on Name-

[17] We consider the score of 6 out of 8, 75%, to be above chance.

Reflexive were 1/8 and 3/8 correct), while one child who scored 6/8 correct was borderline ALI (see footnote 11).

Figure 2: Scatter plot showing the relationship between age (x-axis) and children's performance on *Name-Reflexive* (y-axis).



3.2 Obligatory Control

The analysis revealed no significant effect of Group (F(2, 288)=2.078, p=.127), again a highly significant effect of Sentence Type (F(3, 288)=18.540, p<.001) and no significant Group*Sentence Type interaction (F(6, 288)=1.192, p=.310). Estimated mean probabilities correct and the standard error for each sentence type are given in Table 1.3.

Table 1.3. Estimated Mean Probabilities Correct (Standard Error) on Control

Sentence	HFA		TD KBIT		TD BPVS	
	Mean	*SE*	*Mean*	*SE*	*Mean*	*SE*
Promise	0.70	(0.06)	0.92	(0.04)	0.77	(0.05)
Try[18]	0.99	(0.01)	0.98	(0.01)	0.96	(0.01)
Persuade	0.96	(0.02)	0.94	(0.03)	0.95	(0.03)
SVO	0.99	(0.01)	0.99	(0.01)	0.97	(0.01)

The significant effect of Sentence Type for all groups when collapsed was sourced to their performance on *promise*. Sidak-corrected pair-wise comparisons revealed that the TD KBIT group performed significantly better on *promise* than the HFA group (t(288)=3.110, p=.006) (OR=4.93), and marginally better than the TD BPVS group ((t(288)=2.157, p=.063) (OR=3.43). There were no differences in the performance of the HFA group and the younger TD BPVS (t(288)=0.915, p=.361) (OR=1.43).

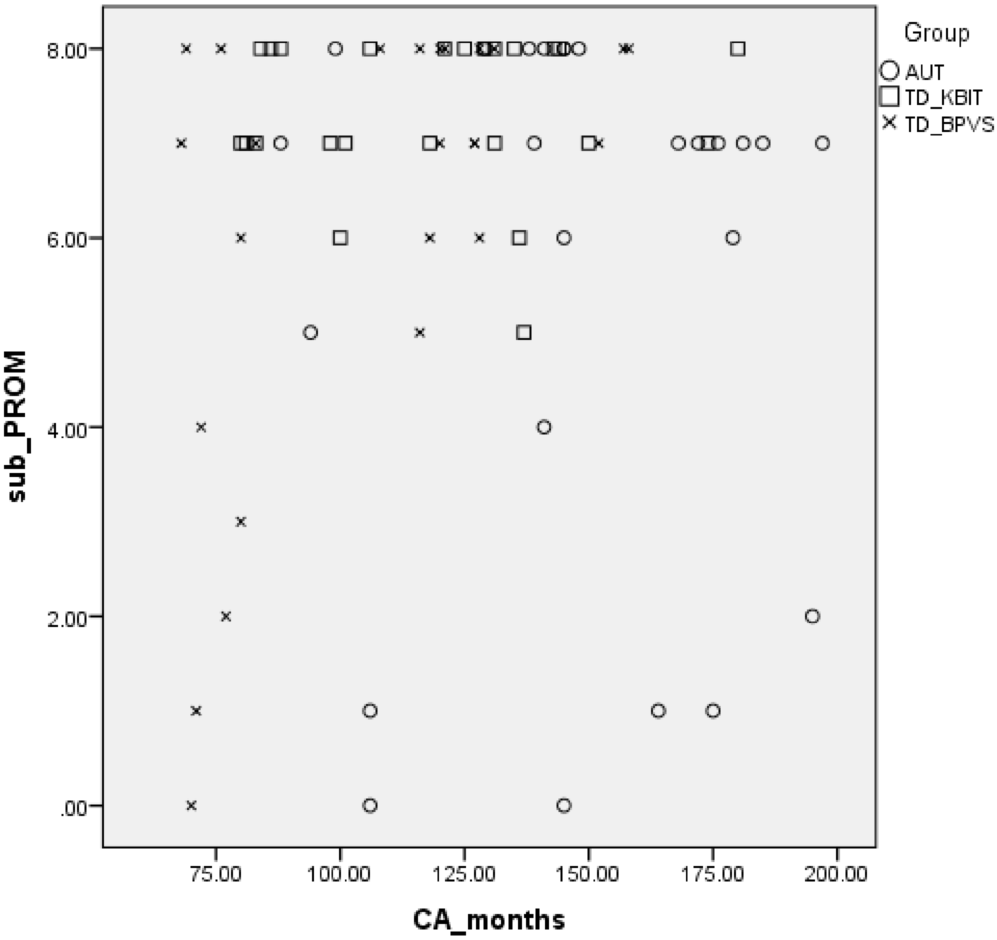
There were no statistically significant differences in the performance of the three groups on any of the remaining sentence types (estimated mean probabilities correct were between .94 and .99 for all groups):

- *try* - HFA vs. TD KBIT: (t(288)=0.090, p=.928) (OR=2.02), TD KBIT vs TD BPVS: (t(288)=1.348, p=.384) (OR=2.04), HFA vs. TD BPVS: (t(288)=1.446, p=.384) (OR=4.12);
- *persuade* -HFA vs. TD KBIT: (t(288)=0.465, p=.954) (OR=1.53), TD KBIT vs TD BPVS: (t(288)=0.170, p=.954) (OR=0.82), HFA vs. TD BPVS: (t(288)=0.300, p=.954) (OR=1.26)

[18] Note that there were two out of 85 children who made two errors on *try* (all other children made no errors, or one error only in the animate *or* inanimate sub-condition). The children who did make two errors were a HFA child, whose extremely low vocabulary and grammar scores indicated a clear language impairment, and one young typical child, aged 6;6. Their errors concerned only the animate sub-condition, which suggests that animacy may have played a role in the comprehension of *try* sentences in these two children.

- SVO - HFA vs. TD KBIT: (t(288)=0.429, p=.668) (OR=1), TD KBIT vs TD BPVS: (t(288)=1.347, p=.447) (OR=3.06), HFA vs. TD BPVS: (t(288)=0.987, p=.544) (OR=3.06).

Figure 3: Scatter plot showing the relationship between age (x-axis) and children's performance on *promise* (y-axis).



In the HFA group, eight children had significant difficulties interpreting *promise* (5 and less out of 8 correct), compared to six children in the TD BPVS group, and one child in the TD KBIT group (see scatter plot in Figure 3).

All incorrect responses on *promise* were examined to check whether difficulties could be sourced to occurrences of particular verbs, e.g. that the verb 'walk' was used twice in this condition, rather than once. This was not the case in any of the groups.

3.3. *Correlation Analyses*

In order to ascertain the influence of age and general verbal and non-verbal abilities on the accuracy of children's comprehension of the two sentence types which showed most variation, *promise* and *Name-Pronoun*, we ran three correlation analyses. Our findings show that age was positively correlated to performance on the *Name-Pronoun* and *promise* conditions only in the youngest TD BPVS group but not in the HFA group, or the TD KBIT group (see earlier scatterplots for a clearer view of the relationship between age and children's performance on relevant sentence types). Performance on KBIT (measuring non-verbal reasoning), BPVS (measuring receptive vocabulary) and TROG (measuring receptive grammar) was positively correlated to the HFA group's performance only on *promise*, but not on *Name-Pronoun.* The performance of the two typical groups on *Name-Pronoun* and *promise* was not correlated to their performance on KBIT or BPVS[19].

Table 3: Pearson correlation coefficients of the relationship between children's scores on *Name-Pronoun* (NP) and *promise* (out of 8 possible correct), and age, non-verbal reasoning (standard scores on KBIT), receptive vocabulary (standard scores on BPVS) and grammar (standard scores on TROG).

	HFA		TD KBIT		TD BPVS	
	NP	*promise*	NP	*promise*	NP	*promise*
Age	.226	.018	.387	.015	.439*	.549**
KBIT SS	.247	.447*	.208	.073	.370	.091
BPVS SS	.175	.474*	-.246	.148	-.003	.060
TROG SS	.361	.472*	-	-	-	-

4. Discussion

[19] The negative correlation coefficient between BPVS and Name-Pronoun in both TD groups was due to several younger children with very high BPVS SS, who scored low on Name-Pronoun due to their young age.

The present study drew a comparison between comprehension of reflexive binding and obligatory control in twenty-six British high-functioning children with autism and two groups of TD children, individually matched on verbal and non-verbal abilities. The choice of these two constructions was motivated by both clinical and theoretical considerations. Its clinical import is that of contributing to the as yet still limited literature on complex syntax in ASD. Obligatory control has not been studied at all in this population and reflexive and pronominal binding only to a limited degree. Of theoretical interest is whether the mechanism underlying control is the same or different to other constructions that have been traditionally argued to involve the same underlying syntactic mechanisms, such as raising. Specifically, if control is a dependency involving a relation between a trace and an antecedent, we expected our HFA children to exhibit difficulty with it on a par with that found for raising and passives. If not movement-based, however, we expected it to pattern more closely to the results found for binding. We found the latter to be true. The two sentence types that did cause difficulty, and showed most variation in the groups' performance, were pronominal binding (the *Name-Pronoun* condition), and particularly double-complement subject control (the *promise* condition). We start our discussion with binding, indicating how the current results map with the previous literature, and then move onto control, drawing a distinction between the three different sub-types and the contributions that the current disclosed patterns provide for our understanding of the HFA grammatical profile and for our more general understanding of the nature of the control relation.

As a group, the HFA children showed a very good comprehension of reflexives, with an estimated mean proportion correct of .94, suggesting intact reflexive binding. These results on British children tally precisely with those found for American HFA children's comprehension of reflexives as reported in Perovic et al. (2013a). Three children in the current sample of twenty-six showed less than perfect performance: two performed at or below chance on this sentence type, and one just above chance. Crucially, the first two children qualified as ALI ('autism plus language impairment') and the third as a border-line ALI, as per their scores on the standardized language assessments. This is again in line with Perovic et al. (2013b), whose sample of twenty-six ALI children also showed a chance performance on reflexives, which was interpreted as signaling deficient knowledge of reflexive binding. However, some variability in the performance of children with ALI is also noted here: one child classified as ALI showed a ceiling performance on reflexives.

No difference between the three groups was observed in the pronoun condition. The estimated mean proportion correct in HFA was .90, and in the two TD groups it was .89. Although this is a high performance, notable variation is still evident in all three groups. The variation we see in our current samples is also in line with the previous literature. In Perovic et al. (2013b), twenty-two children classified as ALN ('autism with normal language'), exhibited some difficulties in their interpretation of pronouns in an identical task, although again, their performance did not differ from a group of non-verbal MA-matched controls.

The literature on typical development reviewed in earlier sections reports that the problems with pronoun interpretation disappear with age. This age-dependent development is corroborated in our TD sample (especially in the younger TD BPVS group), but not in our HFA group. Both age and scores on the standardized assessments of non-verbal reasoning, vocabulary and syntax comprehension varied greatly in our HFA participants, but none of these correlated with their performance on pronouns. If we assume that there are variable levels of difficulty with pragmatics in our sample, and if the interpretation of pronouns is decided at the syntax-pragmatics interface, then the absence of any correlations on these measures is perhaps expected.

For the obligatory control conditions, the simplest construction tested was single-complement subject control (*try*). Incorrect answers would either have indicated that the children permitted free interpretation of the implicit agent (where the direct object in the infinitival was inanimate) or that they were employing a last-heard referent strategy (where the direct object in the infinitival was animate). Ceiling performance on this construction confirmed that this was not so. With regard to object control (*persuade*), there was also no difference between groups. As a first test on knowledge of this construction in HFA children, the results from these two regular examples of control offer support for the claim that the syntax underlying canonical obligatory control is preserved. The children's systematic preference for an adult-like reading points to a firm grasp of the obligatory nature of the interpretative link between the argument in the main clause and the understood subject in the complement.

We turn now to double-complement subject control (*promise*) for which there was a varied performance, especially in the HFA children and their language-matched control group with estimated mean probabilities correct of .70 and .77, respectively. First of all, our finding supports all the studies that have tracked this construction's development in TD children (e.g. Hsu et al. 1989; Cohen Sherman and Lust, 1993; Eisenberg and Cairns, 1994). The *promise* sentences proved exceptionally difficult for only a proportion of our HFA group. However, eighteen children demonstrated an adult-like grasp of this construction. Let us look more closely at the eight who did not. A first possibility we need to exclude is that they were not paying attention to the whole sentence string. If the children attended only to the final part of the sentence, then their poor performance is orthogonal to the control properties of this particular verb.[20] This would explain their choosing the object in the *persuade* and the *promise* constructions, since the picture fits with the main-clause object in both, as indicated by the underlining in the examples below:

(8) (a) Homer persuaded Marge to hold the dog
(b) Homer promised Marge to hold the dog

Lack of attention to the main-clause verb, however, would predict that the children who performed poorly on *promise* opted for the object in both *persuade* and *promise* uniformly, which is true only for one of the twenty-six children. The other twenty-five succeeded with *persuade* but gave mixed responses for *promise*; this equates with a stage of development for this construction suggested in much previous work on younger TD children (see references above).

Another possibility that needs to be ruled out is that it is the meaning of the verbs used in these control examples which is responsible for these children's poor performance on *promise*. If so, this again would be independent of any syntactic source to the

[20] We thank Nina Hyams for alerting us to this possibility.

problem. It is well known, for example, that individuals with ASD have an impaired ability to mentalise (Happé, 1993), and the obligatory-control verbs used here all involve intentions: *try* involves an intention on the part of the agent, and *persuade* and *promise* both relate to or involve a change in mental states. However, the children demonstrated their understanding of the verbs used in the task prior to the test itself – even those children who exhibited very poor comprehension of the *promise* constructions. Furthermore, problems with verbs relating to intentions cannot account for the discrepancy between the children's perfect performance on *try* and *persuade* and the flawed performance on *promise,* as all three conditions employed these verb-types. This line of argumentation would also not generalize to children without autism, whose delayed acquisition of the *promise* construction, and not the meaning of the verb itself (C Chomsky, 1969), is legendary and witnessed once again in the current sample of TD children.

The question remains as to what property of the *promise* construction makes it so difficult for children. The children giving mixed responses on *promise* appear reluctant to break locality. This could be because of a propensity to avoid long-distance dependencies generally, as reported for A-bar movement in ASD in Zebib et al. (2013) for example. However, we think it more likely that for this particular construction, the problem stems from the exceptional status of this type of control, and from the reconciliation needed between conflicting lexical and syntactic requirements for this construction, which simultaneously demand a subject and an object reference respectively (see references above). There is a large number of object-controlled double-complement structures (e.g. tell; order; force) relative to this one nearly isolated construction which contradicts an otherwise very predictable locality rule. To view the learning problem in this instance as one deriving from a deficit in establishing a long-distance syntactic dependency would be far-fetched in the absence of any other similar constructions against which to test. The handful of other examples of subject-controlled double complements involve verbs that are highly infrequent and/or have other complications (e.g. threaten; guarantee; vow to - see Boeckx and Hornstein, 2004), making them a poor means for comparison. Furthermore, in their responses, we have seen nothing different from that witnessed in the TD literature for younger children.[21] It is also worth highlighting that at the age at which TD children have mastered constructions with long-distance dependencies (see for example C Chomsky, 1969, and de Villiers, Roeper and Vainikka, 1990, and Thornton and Crain, 1994, on long-distance wh-movement) they still falter with *promise.*

It is noteworthy that the HFA children's performance on *promise* did again not correlate with age. This distinguishes them from the youngest language-matched TD group, where a highly significant age-related correlation for success on *promise* was observed. This correlation was also not observed in the older TD group matched on non-verbal-reasoning, though their ceiling performance precluded the possibility of seeing such a correlation. However, the HFA group's performance on *promise* correlated moderately with their performance on the standardized tests of language and non-verbal reasoning, a correlation not observed in either of the TD control groups. Thus it seems that strong vocabulary and syntax comprehension is needed for the above mentioned reconciliation between conflicting lexical and syntactic requirements for this construction.[22]

The design of the current task enables us to return to our earlier discussion of experiments on argument dependencies in autism, which adopted a similar experimental design (Perovic et al. 2013a, b; Perovic and Wexler, 2007), and relate these to the results on regular control and binding found here. Recall that LFA- but not HFA children performed deficiently on binding, whereas children with autism across the low- and high-functioning range seem to show difficulties comprehending passives and raising. Reflexives and the implicit subject in controlled complements require a local, agreeing and c-commanding argument from which they gain their reference. This much they share. On most theoretical accounts, they are also not derived by movement/displacement (see Williams, 1980; Manzini, 1983; Landau, 2000; 2013; Janke, 2007; Rooryck, 2007; but see Hornstein, 2001, for a raising-based account).

[21] See Caplan and Hildebrandt (1988) for data on two aphasic patients who also show a pattern of better performance on object control, *persuade*, and a poorer performance on subject control, *promise*.

[22] An approach that appears promising in terms of facilitating abstract representations of structures that children with SLI find difficult is set out in Garraffa, Coco and Branigan (2015), which used a sentence-priming paradigm effectively.

But the two relations cannot be conflated entirely (see also Lasnik, 1992). As mentioned in the introduction, the null subjects in control also form a heterogeneous set in terms of how their reference is determined, encompassing subject, object, discourse, and generic interpretations. In obligatory control, it must be established whether or not a particular verb selects for a controlled complement. If it does, there will be a designated controller and part of the child's learning task is to grasp the obligatory nature of this relationship. This selectional restriction is not operative for the *ec* in non-obligatory controlled clauses, whose interpretation is regulated extra-syntactically. Depending on the type of control then, namely whether it is an example of obligatory or non-obligatory control, correct interpretation can call upon lexical, syntactic and pragmatic knowledge. This is unlike *himself/herself*, which, whenever it is the direct argument of a verb, is always an anaphor. If, as we intimated above, acquisition of anaphoric dependencies is a similar yet less complicated learning task to obligatory control, then a natural expectation that arose from this was that our HFA children who succeeded on a picture-selection task on regular control would also succeed on a picture-selection task on reflexive binding. This is exactly what we found.

The results of studies on passives and raising reviewed earlier suggest a different picture for these constructions: problems appear to be evident in children across the spectrum, and, most relevant to our current discussion, to HFA children. If the syntactic principles underlying obligatory control differ from those that regulate passives and raising, in not involving A-movement, then the bifurcation emerging here, with obligatory control and binding on the one hand and passives and raising on the other, makes sense theoretically. As we noted in the introduction, there have been a number of recent studies into populations with ASD, using constructions whose underlying movement is uncontroversial, namely wh-questions (Zebib et al. 2013) and relative clauses (Riches et al. 2010; Durrleman and Zufferey, 2013). An interesting proposition emerging from this discussion is that HFA individuals have adult-like competence of reflexive binding and (regular) obligatory control but not of wh-movement, relative clauses, passives and raising. The relations that seem to cause difficulties involve both A-bar dependencies (relative clauses and wh-movement) and A-dependencies (passives and raising), yet all involve displacement of some kind. The A-bar dependencies that are most problematic are those which employ the greatest number of movement operations (or constructions involving the most distance between the place in which the argument surfaces and where it is interpreted), making it plausible that HFA children struggle with long-distance dependencies. Yet passives and raising are local relations, which suggests that displacement itself might be sufficient to cause the children difficulty. Future experimentation, perhaps also on more unaccusatives, can help us decide.

5. Conclusions

This paper forms a novel contribution to a line of studies dedicated to the more general question of whether complex grammar is intact in children on the autistic spectrum. It has taken a new example of complex grammar, namely obligatory control, and tested the preferred interpretations of these constructions in HFA children. The children's results on these constructions were compared with that of binding. One important finding is that for regular examples of subject- and object-control and the binding of reflexives, all but three children (who were classified as ALI) achieved a successful performance, a result that lends support to these examples of complex grammar being spared in this population. We have also discussed the degree to which properties of obligatory control and binding differ from other examples of complex grammar, in particular, passives and raising. The current study's results found binding and obligatory control to pattern together: both were unaffected in our HFA children. We contrasted this excellent performance with previous studies on passive and raising, which have reported deficiencies, and suggested that together, these support a distinction in terms of the syntactic operations underlying them. The significant difficulties observed for the *promise* construction were not restricted to our HFA group, but were also observed at a similar level in the language-matched TD controls. In line with previous literature on this anomalous construction, we attribute their difficulty to its breaking of locality, which is an otherwise robust grammatical principle that children have already acquired and can rely on for its consistency. Children have to abandon this rule for only one construction. Their reluctance to do so translates into compromised acquisition.

Appendices

Appendix A. Binding Sentences

1. Name Reflexive

Bart’s dad is touching himself.
Lisa’s mum is touching herself.
Bart’s dad is pointing to himself.
Lisa’s mum is pointing to herself.
Bart’s dad is washing himself.
Maggie’s mum is washing herself.
Maggie’s mum is dressing herself.
Lisa’s mum is dressing herself.

2. Name Pronoun

Bart’s dad is touching him.
Lisa’s mum is touching her.
Bart’s dad is pointing to him.
Lisa’s mum is pointing to her.
Bart’s dad is washing him.
Maggie’s mum is washing her.
Maggie’s mum is dressing her.
Lisa’s mum is dressing her.

3. Name Possessive

Bart’s dad is licking a lamp post.
Lisa’s mum is waving a flag.
Bart’s dad is patting a dog.
Maggie’s mum is patting a dog.
Lisa’s mum is driving a car.
Lisa’s mum is playing with blocks.
Bart’s dad is eating an ice cream.
Maggie’s mum is eating an ice cream.

4. Name Name

Bart is pointing to Dad.

Lisa is touching Mum.

Bart is washing Dad.

Mum is dressing Maggie.

Dad is pointing to Bart.

Mum is touching Lisa.

Mum is washing Maggie.

Mum is dressing Lisa.

Appendix B. Obligatory Control Sentences

1. Single-Complement Subject Control

Maggie tried to wash Marge.

Homer tried to wash Bart.

Lisa tried to dress Marge.

Marge tried to dress Maggie.

Lisa tried to eat the sandwich.

Homer tried to eat the sandwich.

Bart tried to hit the punch bag.

Marge tried to hit the punch bag.

2. Object Control

Homer persuaded Marge to walk the dog.

Marge persuaded Homer to walk the dog.

Lisa persuaded Bart to build the sandcastle.

Bart persuaded Lisa to build the sandcastle.

Marge persuaded Maggie to get in the bath.

Marge persuaded Homer to read the book.

Homer persuaded Marge to drive the car.

Marge persuaded Maggie to pat the dog.

3. Double-Complement Subject Control

Marge promised Homer to walk the dog.
Homer promised Marge to walk the dog.
Bart promised Lisa to play the trumpet.
Lisa promised Bart to play the trumpet.
Lisa promised Bart to write the letter.
Marge promised Homer to read the book.
Marge promised Homer to drive the car.
Maggie promised Marge to pat the dog.

4. SVO
Homer is walking the dog.
Lisa is eating a sandwich.
Lisa is throwing water.
Bart is playing the trumpet.
Marge is driving the car.
Maggie is patting the dog.
Maggie is having ice-cream.
Bart is swinging a bat.

Appendix C: Familiarization procedure

Prior to the experimental task, participants were presented with pictures depicting all the characters of the Simpson family on the laptop computer. The first picture showed all 5 members of the family together, and the experimenter pointed out to each character individually to the child: ‘This is Homer, he is the dad in this family. This is Marge, she is the mum in this family. These are the children: Bart, Lisa and Maggie.’ To ensure that the child is able to see the difference between Lisa and her younger sister Maggie, the experimenter would add: ‘See Maggie has a dummy here, she is a baby’.
The following sets of picture pairs were used to ensure that the child can distinguish between the characters, select the appropriate character out of the two presented on the screen, and understand that the correct picture can be on either left or right side of the screen:

1. Homer (left side) and Bart (right side), with the instruction: ‘Point to Homer.’
2. Homer (left side) and Bart (right side), with the instruction: ‘Point to Bart.’
3. Marge (left side) and Lisa (right side), with the instruction: ‘Point to Marge.’
4. Marge (left side) and Lisa (right side), with the instruction: ‘Point to Lisa.’
5. Lisa (left side) and Maggie (right side), with the instruction: ‘Point to Lisa.’
6. Lisa (left side) and Maggie (right side), with the instruction: ‘Point to baby Maggie.’

The presentation of the above pictures was followed by pictures showing relevant characters involved in an action described by the verbs used in the task: e.g. wash, dry, point to and touch (Binding), and e.g. drive a car, walk the dog, play the trumpet (Control).

The instructions uttered by the experimenter included sentences such as:

‘Look, here we have washing/drying/touching/pointing. Marge is washing/drying/touching/pointing to Maggie.’ (Binding)

‘Look, here we have driving/building/reading/walking/playing’. ‘Homer is walking the dog/driving the car/playing the trumpet.’ (Control)

The experimenter would ensure that the participants can distinguish between the characters before proceeding with the task. All the participants were able to follow these instructions and were able to distinguish between the characters.

Appendix D: Questions used to determine knowledge of verbs independently of control and representative sample of responses.

Try: what does it mean when you try?

- It’s when you do something and you’re not sure you can do it.
- You might not be able to do it but if you really really want to do it you can do it.
- It’s like you give it a go….but you might not be able to do it.

Persuade: what does it mean when you persuade someone?

- You make someone do something.
- You convince someone that they do it.

- It's when you make someone do something.

Promise: what does it mean when you promise someone something?

- It's like when you say you'll definitely do it.
- I say I'll do something for sure.
- Once I've said I'll do it, I have to do it.

The promise question was followed up with: If you promise your mum that you will tidy up your room, does that mean that you do it or you don't do it?

- It means I do it.
- I do it… well if I keep my promise.
- I do it.

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