

TITLE: Teasing apart explanations of a developmental delay in binding: experimental evidence from the comparison of SLI and Williams syndrome.

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ABSTRACT

This study investigates the knowledge of binding in 21 English-speaking children with SLI, aged 6;08-16;05, compared to 21 children with WS, language- and age-matched, and 21 language-matched control children, aged 4-7;10. Our results demonstrate no difficulties in the interpretation of reflexive or personal pronouns in SLI, revealing an intact knowledge of reflexive binding, as well as spared pragmatic functioning. Children with WS however show difficulties with their interpretation of pronouns, accepting the local binding of a pronoun, indicating impaired pragmatics. Not surprisingly, our language-matched typical controls, aged between 4-7;08 ($M=5;03$), showed a classic pattern of the Apparent Delay of Principle B Effect (ADPBE). In view of reported pragmatic but not memory deficits in WS, we interpret our results as consistent with the pragmatic deficit explanation but not the memory deficit explanation of the ADPBE.

1. INTRODUCTION

Comparisons of grammar in different kinds of impairments can lead to increased understanding both of the theoretical basis of the development of the computational system of language (grammar, broadly construed) and in the construction and evaluation of the theory of a particular impairment. Ultimately, we can hope that such an enterprise will help in the determination of genetic and physiological explanations of the impairment and, more generally, of language. In this paper, we illustrate how questions about the nature of Specific Language Impairment (SLI) and Williams syndrome (WS) can be answered via comparing grammatical

abilities in these two clinical populations and, furthermore, by comparing to a typically developing (TD) group, what is the basis for the developmental facts in general.

One of the most studied aspects of language in development is the binding theory, the module of grammar responsible for the distribution and interpretation of personal and reflexive pronouns (Chomsky 1981). The widely reported pattern is that the requirement that a reflexive be c-commanded by its antecedent (part of Principle A) is known at a quite early age and that the requirement that a personal pronoun may not be c-commanded by a local referential antecedent is not known (or at least not computed correctly) until much later (Jakubowicz 1984; Wexler & Chien 1985). We will see how the explanation for this well-known and much-studied error on pronouns may be aided by the comparison among clinical populations with different characteristics. Moreover, we can test much about the nature of some grammatical processes by testing the pattern on reflexive pronouns in these populations.

Williams syndrome is a rare genetic disorder known for a strikingly uneven profile of language and cognitive abilities, with early reports emphasising spared language skills in the face of significantly impaired cognitive, especially visuo-spatial skills (Bellugi, Marks, Bihrlé & Sabo 1988, Singer Harris, Bellugi, Bates, Jones & Rossen 1997, Clahsen & Almazan 1998). More recent studies unearthed difficulties with some aspects of complex grammar in this population, indicating that language abilities of WS are not intact, but at least comparable to those seen in much younger typical children (see Brock 2007, for review). With regard to binding, children with WS are reported to show a pattern of difficulties with the interpretation of pronouns and an intact performance on reflexives, the pattern observed in younger typical controls (Perovic & Wexler 2007). Perovic & Wexler argued that these results on WS supported the original suggestion proposed in the TD literature that the pronoun error in children was pragmatic in nature. This is not surprising for WS: despite extreme sociability (Mervis, Klein-Tasman & Mastin 2001), children and adults with WS are known to have major

difficulties with pragmatic language development (Davies, Udwin & Howlin 1998, Stojanovik, Perkins & Howard 2001; Laws & Bishop 2004). By the time they reach school age, children with WS may speak in grammatical sentences; however, they often do not refer to the appropriate situational context, and their conversation and narratives lack cohesion. Thus the formal processes seem to be relatively spared while the pragmatic relation to situations is extremely poor. Given Wexler & Chien's (1985) and Chien & Wexler's (1990) (among many later papers) theory that the difficulty with the pronoun error for TD young children is pragmatic, we would expect children with WS to have difficulty with ruling out the local binding of pronouns. Moreover a theory that attributes the difficulty to "memory problems" (e.g. Reinhart 2006) would not predict the difficulty in WS as individuals with WS are known for preserved verbal short term memory (Wang & Bellugi 1994, Vicari, Brizzolara, Carlessimo, Pezzini & Volterra 1996, Jarrold, Baddeley & Hewes, 1999, Rowe & Mervis 2006).

How else can we test this type of conclusion? Children with SLI present a natural comparison. Known for particular grammatical deficiencies in some areas, e.g. in the study of finiteness (Wexler 1996, 2013; Rice & Wexler 1996, and many others), these children do not have a pervasive pragmatic impairment.¹ Their pragmatic difficulty, if present,² is an order of

¹ See Leonard (2014) for a review of accounts of SLI focussing on specific deficits in linguistic knowledge (e.g. Rice & Wexler 1996) and others which focus on processing limitations, general (e.g. Kail 1994), or specific (e.g. Tallal & Piercy 1973).

² The standard assumption in the literature is that pragmatic difficulties are *not* a hallmark of SLI: language impaired children who show pragmatic difficulties are considered a separate population, in between SLI and autism. The terms often used in the literature are semantic-pragmatic syndrome (Rapin & Allen 1983), semantic-pragmatic disorder (Bishop & Rosenbloom 1987) or pragmatic language impairment (Bishop 2000). See however Bishop, Chan, Adams, Hartley & Weir (2000) for a discussion of a subgroup of children with SLI in their sample whose conversational responsiveness lagged behind their language skills.

magnitude less than that of children with WS (see Laws & Bishop 2004, for a direct comparison of the two populations on a measure of pragmatic aspects of linguistic knowledge). If the local binding of a pronoun is a pragmatic difficulty, we would predict that children with SLI do not have much trouble with this piece of grammar, especially if we compare them to children with WS. This is a key prediction of this paper, based on the hypothesis that the error of accepting the local binding of a pronoun is due to immature pragmatic development.

Furthermore, a standard conclusion is that at least some children with SLI have deficiencies in on-line language memory (Gathercole & Baddeley 1990; Hick, Botting & Conti-Ramsden 2005, Briscoe & Rankin 2009, see Bavin 2015, for an up to date review), often tested by non-word repetition (NWR) paradigm.³ For example, Bishop, Adams & Norbury (2006) establish that there are two independently inherited traits for a population of children with SLI: one linked to NWR and one linked to finiteness, as in the existence of a prolonged Optional Infinitive stage (Wexler 1990, Rice & Wexler 1996). Thus the overall pattern of impairment for children with SLI is: little pragmatic difficulty (compared to WS) and strong linguistic memory difficulties. If the pronoun binding error is due to pragmatics, we expect a pattern of difficulty for WS but not SLI. If the pronoun binding error is due to a memory difficulty, we expect a pattern of difficulty for SLI but not WS. Our paper will provide evidence relevant to these predictions.

To make sure that other constructions of about the same general level of surface structure difficulty are not affected in the same way by group as the local binding of a pronoun, we test the knowledge that a reflexive must be c-commanded by a local antecedent, using

³ In addition to NWR, studies show that children with SLI perform poorer on other measures of phonological short term memory, such as digit recall (e.g. Briscoe & Rankin 2009) and word recall (e.g. Lum, Conti-Ramsden, Page & Ullman 2012).

surface structures that are otherwise identical to the pronoun constructions. Thus general sentential comprehension/parsing difficulty is controlled. The non-local “distance” that has to be computed (the relation between antecedent and reflexive/pronoun) is held constant across pronoun or reflexive sentences, but, by the pragmatic hypothesis, there is a piece of pragmatic knowledge related to the pronoun. We know that children with WS do fairly well on reflexive binding (the c-command aspect of it) (Perovic & Wexler 2007) and we predict that when compared to language-matched children with SLI, the two groups do well and do not differ much from each other. This prediction however runs contrary to the results of early studies that children with SLI perform poorly both on reflexives (Franks & Connell 1996) and personal pronouns (van der Lely & Stollwerck 1997, Bishop, Bright, James, Bishop & van der Lely 2000). As will be outlined in the sections below, there are strong reasons to question the results of these studies, due to issues in their methodology and the lack of clarity in the presentation of results. Furthermore, recent literature shows no difficulties with either types of reflexive or personal pronouns in a language other than English (Hebrew: Novogrodsky & Friedmann 2010). It is thus one of the aims of the current study to establish the exact nature of the knowledge of this aspect of linguistic knowledge in children with SLI.

In the ensuing sections, we give a brief review of binding theory and its acquisition in typical and atypical development (section 2), followed by our own study comparing binding in SLI, WS and typical controls (section 3). Section 4 presents the discussion of our results.

2. BACKGROUND

2.1. Binding and typical development

The conditions regulating the interpretation of pronominal elements constitute what we refer to as ‘standard Binding Theory’ (Chomsky 1981, 1986). Principle A is responsible for the

distribution and interpretation of reflexive pronouns (*herself, himself*), whereas Principle B is responsible for the distribution and interpretation of personal pronouns (*her, him*). Principle A states that reflexives require local, agreeing and c-commanding antecedents,⁴ while Principle B states that pronouns require a non-local and non-c-commanding antecedent. Thus in the example (1) below, ‘herself’ must refer to Cinderella’s sister and not to Cinderella, while in the example (2), ‘her’ cannot refer to Cinderella’s sister, but only to Cinderella.

(1) Cinderella’s sister is washing herself.

(2) Cinderella’s sister is washing her.

Surprisingly, studies show that TD children show an apparent disparity in their mastery of reflexives as opposed to personal pronouns: they correctly interpret structures containing reflexives as early as age 3;06, while their interpretation of personal pronouns falters even at the age 6 (Jakubowicz 1984, Wexler & Chien 1985, Chien & Wexler 1990). This phenomenon, termed ‘(Apparent) Delay of Principle B Effect ((A)DPBE), or ‘Pronoun Interpretation Problem’, has attracted substantial interest from researchers working on a variety of languages, resulting in a wealth of literature on this topic, spanning several decades.⁵ Wexler & Chien (1985) and Chien & Wexler (1990) suggested that children accept a local co-referential antecedent for a personal (but not reflexive) pronoun because of a pragmatic difficulty in establishing referential relations. Chien & Wexler provided experimental evidence for this by

⁴ C-command: Node A in a phrase-marker c-commands node B if the lowest node that dominates A also dominates B.

⁵ Though early results relying on the original methodology of TVJ have recently been disputed (Conroy, Takahashi, Lidz & Philips 2009), the disparity between children’s comprehension of reflexives vs. pronouns is a robust result reported across a range of languages (see Guasti 2002, for a comprehensive review), and with different methods (see van den Akker, Hoeks, Spenader & Hendriks 2012, for picture selection task).

demonstrating that the same children who accepted a local co-referential antecedent for a pronoun (*Momma Bear washed her*, meaning *Momma Bear washed herself*) would not accept local binding with a quantified antecedent (would not accept *Every bear washed her* to mean that *Every bear washed herself*). Thus children know the grammatical Principle B that governs binding relations. But there is a second, discourse route to coreference, governed by situational/pragmatic considerations. According to the Wexler & Chien hypothesis, children have difficulties in knowing or computing these pragmatic conditions. Thus they accept a local referential antecedent for a pronoun.

Although we do not have the space here to discuss the extensive literature on the exact nature of the pragmatic error, which typically goes under the term “accidental coreference”, we can point to one well-known version of this hypothesis, Thornton & Wexler’s (1999) suggestion that children who mistakenly accept the coreferential interpretation are accepting what would be an appropriate adult interpretation if the pronoun is read as a particular “guise” (Heim 1998). On this hypothesis, children take *Momma Bear is washing her* to mean that Momma Bear is washing the person that is washing somebody. That is, “her” refers to Momma Bear in the guise of the person who is washing somebody. Such usages are acceptable in adult English. Consider “Zelda is an egotist. Right now there is a woman under discussion and Zelda is praising her. The woman under discussion must be Zelda.” *Her* is taken to be *Zelda* in the guise of the woman under discussion. Principle B does not rule out coreference (e.g. in *Zelda is praising her*) in the case of distinct guises of the coreferential noun phrases. Obviously there are pragmatic, situational conditions that allow a guise to be created in the discourse. If children are too liberal in their interpretation of guises, they are making a pragmatic error.

Large numbers of studies have come to the conclusion that young children (at approximately the age range of the local “binding” [actually coreference] error) over-use “the”, when a single referent hasn’t been established in the discourse (Maratsos 1976, Karmiloff-

Smith 1979, Wexler 2011). We may think of the local binding (or guise) error as involving the same kinds of pragmatic deficits as those that cause the determiner error, the failure to realize that listeners in the situation haven't identified a unique referent (for the determiner) that is in the child's mind or haven't established the guise that is in the child's mind. This error is someplace between semantics and pragmatics; for concreteness we are referring to it as pragmatic. It occurs in the relation between understanding what the situation entails to a listener and what the child herself understands.

The second explanation of ADPBE, the "memory" explanation, has many similarities to the first. Reinhart argues that children have memory/"cost" issues concerning various kinds of alternative comparisons. Applying this view to the ADPB error, Reinhart accepts the difference between binding and co-reference, and accepts that children know Principle B, as established by the quantifier experiments. The only difference for the memory view concerns the reason that children have difficulty with the referential possibility. Accepting a particular proposal for what governs co-reference, Reinhart's Rule I, which necessitates a comparison of the meaning of two forms, the memory explanation proposes that children have memory limitations that don't allow them to recall both forms as they are doing the comparison. It is then unclear to us whether the proposal is that children don't process or comprehend the sentence at all, providing a wild guess at the answer to the experiment or whether they actually choose one meaning or the other equally often, actually comprehending the sentence according to that choice. For our purposes it doesn't matter. The question is: do pragmatic difficulties cause the error or do memory difficulties cause the error?

Our study attempts to use comparative data from binding in children with WS and children with SLI to help to answer this question. By noting the relative strengths and weaknesses in pragmatic knowledge and memory in these two populations, we will provide

differential predictions for results on the acceptance of a local co-referential antecedent for a pronoun in the two populations.

2.2. Binding in atypical development

Considering the wealth of literature on binding in typical development, it is surprising how little research exists on SLI, with results still far from conclusive. Whether binding is impaired in SLI has important implications for our understanding of the course of language development in this population. Deficits in reflexive binding have recently been argued to be a defining characteristic of language impairment in populations such as Down syndrome (English: Ring & Clahsen 2005, Perovic 2001, 2006, Serbian: Perovic 2008, Greek: Sanoudaki & Varlokosta 2014) or autism with language impairment (ALI) (Perovic, Modyanova & Wexler 2013), who show an abnormal rather than a simply delayed pathway in the acquisition of this grammatical module.

The very first study on binding in SLI, by Franks & Connell (1996), reports significant errors in the comprehension of reflexives in 11 children with SLI (aged 3;09-7;08) and 13 age-matched TD children (personal pronouns were not tested). The TVJ method used in the study involved showing participants short video clips of characters involved in some action. Each video was followed by a sentence containing a reflexive and three potential antecedents, presented in a complex syntactic structure that involved subordination, e.g. ‘Did Bugs ask Ernie if Mickey poured juice for himself?’ The results are difficult to interpret since the methodology placed substantial demands on participants’ online processing skills, as observed in the low rate of correct answers even for the adult control participants. Moreover, we know that examples like the one just given are acceptable to adults even with some long-distance interpretations, e.g. when *himself* refers to *Bugs*. One well-known explanation is that when a

reflexive is not an argument of the verb, then it is not subject to Principle A, but rather is a kind of logophor, with a pragmatic condition governing it; its antecedent must be the “centre” of the sentence (Reinhart & Reuland 1993). So in the example, *himself* as a benefactive, an argument of *for*, is not an argument of *poured*. This eliminates the Principle A constraint on *himself*; rather, *himself* can have an antecedent that is the centre of the sentence; both *Bugs* and *Mickey* will serve as potential antecedents. Perhaps this current understanding will explain why even adults made errors in the Franks & Connell study. At any rate, we can’t conclude that children with SLI have difficulties with standard binding. Furthermore, sentences like these don’t test the requirement that a reflexive must be commanded by its antecedent, the subject of our study.

Van der Lely & Stollwerck (1997) tested comprehension of both reflexives and pronouns in 12 children with SLI, aged 9-13, and 3 groups of matched TD controls using a sentence-picture judgement task. Their first experiment, based on Chien & Wexler (1990), included a simple yes-no question (*Is Mowgli tickling him/himself?*) while the stimuli in the second experiment all consisted of a subordinate clause providing two potential antecedents for the pronominal element (*Mowgli says Balloo Bear is tickling him/himself*). The stimuli included both referential and quantified NPs.⁶

In the first experiment, children with SLI were at ceiling on the conditions involving reflexives bound by referential NPs (mean score of 5.92 out of 6 items), just like the TD controls. Their performance on pronouns was poorer (mean score of 3.83 out of 6 items) but comparable to that of the youngest language-matched TD controls, though worse than that of

⁶ The stimuli were separated into ‘match’ or ‘mismatch’, where the required answers to the match question was ‘yes’, and the required answer to the mismatch question was ‘no’. Research shows that participants generally perform better on ‘match’ than on ‘mismatch’ conditions, thus we summarise van der Lely & Stollwerck’s results only on the more difficult ‘mismatch’ experimental conditions.

older TD controls. Both the youngest TD controls and children with SLI showed difficulties in interpreting reflexives and quantifiers bound by quantified NPs.⁷ In the second experiment of this study which involved subordinate clauses, children with SLI showed difficulties interpreting both reflexives and pronouns. Despite the discrepancy in their performance on pronouns (worse) and reflexives (better) being obvious in both experiments on all conditions, the authors conclude that children with SLI do not know binding principles.

Two later studies, Bishop et al. (2000) and Norbury, Bishop & Briscoe (2002) used a reduced version of the second experiment of van der Lely & Stollwerck, with 4 sentences in each condition, match and mismatch, with only referential NPs as antecedents.⁸ Bishop et al. (2000) compared twins with language impairment to those with no language impairment, aged 7-13 years. Their results showed no difference on reflexives between language-impaired and unimpaired twins (on the sentence type most often used to test reflexives in the literature rather than the mismatch wrong-agent sentence type), with 3.2 vs. 3.5 out of 4 correct. Language-impaired twins also performed somewhat poorer on pronouns than the unimpaired twins (2.8 vs. 3.6 out of 4 correct). Statistical significance was calculated for results collapsed, showing that language impaired twins performed worse overall, but it is not made clear whether participants showed a disparity in their performance on reflexives vs. pronouns.

Using the same method, Norbury et al. (2002) investigated binding in a group of children with SLI divided into a younger (n=14, CA=7;02-10;09) and an older group (n=6, CA=11;09-13), compared to hearing-impaired children and TD controls. Only the younger

⁷ Children with SLI were worse than control children on five out of eight conditions: Name-Pronoun match and Name-Pronoun mismatch; Quantifier-Reflexive match and Quantifier-Reflexive mismatch; as well as Quantifier-Pronoun mismatch.

⁸ Their stimuli involved no quantifiers, but included an additional mismatch only condition showing an incorrect agent performing the correct action.

group with SLI performed worse than TD age matched controls, and no different to TD language-matched controls. The older SLI group performed no different from control children, suggesting that whatever difficulties were experienced in younger years, they get resolved by teen age. Unfortunately, the authors again do not provide the breakdown of the data, thus making it difficult to establish whether the children with SLI found reflexives or pronouns more problematic.

Norbury et al.'s findings that any difficulties with pronouns or reflexives in SLI seem to resolve by teenage years is supported by results of a recent study in Hebrew. Novogrodski & Friedmann (2010) report an intact comprehension of both pronouns and reflexives in 12 Hebrew-speakers with SLI, aged 9;03-13;10, on a sentence-picture matching task. No significant difference was found between these children's interpretation of pronouns and reflexives, and no significant difference was found between the SLI and the younger (unmatched) control group on the same conditions.

Literature on binding in WS also shows somewhat conflicting results. Two small-sample studies on teenagers with WS report intact performance on both reflexives and pronouns: Clahsen & Almazan (1998) tested 4 participants, and Ring & Clahsen (2005) tested 10 participants, 4 of whom were the same participants from the Clahsen & Almazan study. The studies used the methodology from the first experiment of van der Lely & Stollwerck (1997), with simple yes-no questions and no subordination. Interestingly, the three groups of control children, aged 5;03 to 7;10, matched on verbal mental age, performed at ceiling on both reflexives and pronouns. The lack of the classic problem with pronouns by the TD controls in this study makes it difficult to draw conclusions about the results of their participants with WS - perhaps something in the methodology eliminated the classic error on pronouns. The other clinical group used for comparison in this study, teenagers with Down syndrome, showed

severe problems with reflexives, confirming the pattern in the literature for this population (Perovic 2001, 2006, Sanoudaki & Varlokosta 2014).

A larger scale study with 25 children with WS, aged 6-16 (Perovic & Wexler 2007) showed a good performance on reflexives, but difficulties with the interpretation of pronouns – a pattern also reported in each of the three control groups, matched on grammar, vocabulary or non-verbal reasoning. The method used was a picture selection task, which included declarative sentences with possessive subjects, in order to provide two potential antecedents for the reflexive or pronoun. The pattern of poorer performance on pronouns as opposed to reflexives was especially apparent in the younger group of children with WS, aged 6-12, who scored only 63% correct on personal pronouns. Their performance was not different to that seen in two younger groups of TD controls, matched on grammar and non-verbal reasoning, but was lower than in the vocabulary-matched group of TD controls, who were the oldest of the three TD groups, but still significantly younger than the WS group.

It is worth noting that there is a population not previously defined for its syntactic difficulties that has a severe problem with reflexive binding. Children with autism who have a known language impairment (labelled as Autism Language Impaired – ALI, following established distinctions in the literature, e.g. Tager-Flusberg 2006), have been shown to accept the possessor rather than the full subject DP as the binder of an object reflexive in exactly the paradigm used in the current paper (Perovic et al. 2013). Thus it is not just a theoretical possibility that such a difficulty can exist, nor does the population have to be as severely intellectually impaired as children with Down syndrome to show such an effect.

Furthermore, the difficulties with reflexives reported in the population with ALI are particularly interesting in view of the recent debate concerning whether children with autism have similar profiles of grammatical impairments as children with SLI (Tager-Flusberg 2006).

If this were so, then we would expect that children with SLI would show the same error on reflexives that children with autism show. However, recent unpublished data suggest that children with SLI do not show the same pattern as those with autism (Perovic & Wexler 2014).

The above overview of relevant literature revealing disparities in the interpretation of reflexive vs. personal pronouns in different populations suggests that reflexive binding can serve as a litmus test for identifying a serious and pervasive grammatical disorder in a population. In populations with severe language impairments, such as ALI or Down syndrome, reflexive binding can be severely impaired. In populations where language is a relative strength compared to general cognitive functioning, such as WS, reflexive binding is not impaired (though other complex syntactic structures may be). Coreference however seems problematic in young TD children as well as WS.

The aim of our study is thus to establish knowledge of the constraint on the necessity of a local c-commanding binder for a reflexive and the constraint on the ungrammaticality of a local c-commanding co-referential DP for a pronoun, in both the SLI and WS populations, compared to TD controls. The three groups will be matched on crucial variables, including relevant linguistic knowledge. The sentences that we use for pronouns and reflexives will involve the same surface structure and vocabulary so that any differences in behaviour will be due to whether the sentence contained a pronoun or a reflexive. By following this well-known procedure from Wexler & Chien (1985) and Chien & Wexler (1990) we hope to simplify the experimental contexts so that differential behaviour on the pronoun and reflexive will be informative with respect to knowledge of the grammatical and pragmatic aspects of binding. In this way, we hope to:

(i) establish results on the nature of reflexive binding in SLI, an area where there has been lack of clarity in the literature;

(ii) establish results on the nature of pronominal binding in SLI, an area where there has been lack of clarity in the literature;

(iii) establish results that will help to distinguish the “pragmatic” from the “memory” explanation of the ADPB, by comparing the pronominal behaviour of the WS and SLI populations.

3. THE CURRENT STUDY

3.1. Method

3.1.1. Participants

Children with SLI ($n=21$, 18 boys) aged 6;08-16;05, $M=10;06$, were recruited from special schools for language impaired children and from language units for language impaired children attached to mainstream schools in England. All children received a diagnosis of primary language impairment by the school’s speech and language therapist and showed no evidence of mental retardation, autism, cerebral palsy, or hearing or visual disorders. Following standards in the literature, our inclusion criteria included only monolingual children with a score of 80 and above (10th percentile and above) on a measure of non-verbal reasoning⁹ and a score below the 10th percentile on two or more core language tests. Non-verbal reasoning was assessed by the Matrices subtest of Kaufman Brief Intelligence Test, while core language was

⁹ Some researchers use the cut-off point of 85 for standard scores on tests of non-verbal reasoning (Tomblin et al. 1997, Paul 2001) while others use the cut-off point of 80 (Bishop et al. 2000, Norbury et al. 2002). We follow the latter researchers in including the cut-off point of 80, based on findings of Tomblin & Zhang (1999) who show no difference in the patterns of language deficits in language-impaired children with non-verbal IQ of 85 and above, compared to those with an IQ of less than 85.

assessed by the Test of Reception of Grammar (TROG-2), British Picture Vocabulary Scales (BPVS 2) and two or more subtests from the Clinical Evaluation of Language Skills (CELF) (Preschool version or version 4). Since the focus of the study was grammar comprehension, we decided to include only those children who were clearly impaired on the TROG, with a score of 1.5 SD below the mean (SS of 78 and less). Some children showed a score on the vocabulary measure higher than 80, but these children all scored below the 10th percentile on one or both of the vocabulary measures from the CELF: Word Classes Expressive or Receptive. From our recruited sample of 43 children diagnosed as having primary language impairment, 21 fulfilled the above criteria.¹⁰

Children with WS (n=21, 11 boys) aged 6-16;06, $M=11;06$, were part of a larger sample recruited in the US with the help of the Williams Syndrome Association (WSA) (see Perovic & Wexler 2007, for details), all with a confirmed genetic diagnosis of WS. Four of the children were excluded from the original sample in order to allow the matching on TROG: three children with WS had too high TROG scores (both raw and standard scores) and one child was not tested on TROG. Typically developing controls (n=21, 9 boys), aged 4-7;08, $M=5;03$, were selected from the children who acted as controls for the children with WS in Perovic & Wexler (2007).

¹⁰ Seven children were excluded for not reaching the threshold on the test of non-verbal reasoning and thirteen children had TROG-2 scores that were within the unimpaired range (SS between 81 and 106). Three children were excluded because they were bilingual: one of the children with an unimpaired TROG score was also bilingual and two further children who otherwise fulfilled the criteria were bilingual.

Table 1 gives means and standard deviations for the standardised tests of language and cognition for all three groups.¹¹ All three groups were matched on receptive grammar (raw score on TROG 2), while the SLI and the WS groups were also matched on age. It was not possible to match the WS and the SLI group on gender, only the WS and the TD control group were matched on gender. Table 1 gives the characteristics of the three participant groups. As is noted in the literature, children with WS showed a wide variation in their non-verbal and verbal abilities, with their non-verbal IQ, as measured by the Matrices subtest of KBIT, within the impaired range. Not surprisingly, children with SLI scored significantly higher than the WS group on non-verbal IQ ($p < .001$). No significant differences between the two groups were found on the standard scores on the two language measures, receptive grammar and receptive vocabulary.

****INSERT TABLE 1 ABOUT HERE****

3.1.2. Experimental Materials and Procedure

To test children's comprehension of personal and reflexive pronouns, we used a two-choice picture-selection task developed in Perovic & Wexler (2007) and Perovic et al. (2013), based originally on Wexler & Chien (1985). The pictures showed the characters of the Simpson family, recognisable by children of different ages, involved in some action. The task was preceded by a training session where each participant was introduced to the characters and shown sample pictures depicting relevant actions (with no reflexive or personal pronouns

¹¹ The table does not provide details of CELF scores, since only children with SLI were tested on this assessment as part of our inclusion criteria. In the selected sample, 10 children were tested by our research team on CELF and the remaining 11 were tested by SLT teams at the child's school who confirmed that the children met our inclusion criteria on this assessment.

used). Participants were instructed to point to one of the pictures presented on the laptop screen which matched best the sentence uttered by the experimenter. The software we used allowed an automatic randomization of the order of the presentation of pictures, and recorded participants' responses automatically. Reflexives and personal pronouns were presented in two experimental conditions, Name Reflexive (NR) and Name Pronoun (NP), while two control conditions, Control Possessive (CP) and Control Name (CN), involved no pronominal elements. In order to provide two possible antecedents for the object, three of the four conditions involved a subject that was a possessive noun phrase: e.g. *Bart's dad* (i.e. *Homer*) which c-commands the object, and *Bart*, the possessor, which does not.

In NR, the sentence such as '*Bart's dad is washing himself*' was accompanied with a picture on one side of the screen where Homer (Bart's dad) is washing himself in a bathtub with Bart standing by: this was the correct choice. The picture presented on the other side of the screen where Homer is washing Bart who is sitting in a bathtub was the incorrect choice. The same two pictures were used in the NP condition, accompanied by a sentence such as '*Bart's dad is washing him*'. Here the picture showing Homer washing Bart sitting in the bathtub is the correct choice, and the picture showing Homer washing himself in a bathtub with Bart standing by is the incorrect choice.

Participants' understanding of possessive noun phrases and the relation of c-command was tested independently in the control condition CP: the sentence '*Bart's dad is eating an ice cream*' was accompanied with one picture showing Homer (Bart's dad) eating an ice cream (correct choice), and the other picture showing Bart eating an ice cream (incorrect choice). In the control condition CN, only proper names were used in the subject position, while no reflexives or pronouns were used in the object position (e.g. '*Bart is washing dad*'). Four verbs, 'wash', 'touch', 'point to', and 'dress' were used in the NP and NR conditions, with

each verb occurring twice. Each condition comprised of eight sentences, with 32 sentences in total.

Children were tested in a quiet room at their school, or in a separate room at the regional or national conferences of the WSA in the USA. The battery of standardised and experimental tasks (not all of them reported here) was administered over one or two sessions.

3.2. Results

Participants' responses (correct or incorrect) were analysed using the GLMM procedure in SPSS 22, using the logistic regression model known to be better suited to binomially distributed data than standard ANOVAs (Jaeger 2008). The fixed effects built into the model were Group (SLI, WS, TD), Sentence Type (NR, NP, CP, CN), Age and Group x Sentence Type interaction, with Participants treated as the random effect by this model.

The analysis showed a highly significant effect of Sentence Type $F(3, 239) = 16.326$, $p < .001$, but no significant effect of Group: $F(2, 239) = 0.255$, $p = .775$, Age: $F(1, 239) = 0.379$, $p = .775$, and no significant Group*Sentence Type interaction: $F(6, 239) = 1.667$, $p = .130$. Estimated mean probabilities correct for each Sentence Type and Group are given in Figure 1.

****INSERT FIGURE 1 ABOUT HERE****

On the condition CN, which controlled for participants' attention and understanding of the task, SLI group reached 0.92 mean proportion correct, while WS and TD groups both reached 0.94. On CP, which controlled for the knowledge of c-command, the SLI group reached 0.90, and both WS and TD reached 0.95 mean's proportion correct. The groups also

performed well on the experimental condition NR, with SLI reaching 0.90, WS group 0.87, and TD group 0.93. However, condition NP seemed most difficult, the TD and WS group reached 0.70 and 0.72, respectively, while the SLI group reached 0.83.

Our analysis allowed for comparisons (Sidak-corrected) between the performances on each sentence type within each group individually: it was revealed that the NP was the most difficult condition for the TD and WS groups. The TD group found NP more difficult to comprehend than either of the control conditions: CN ($t(239)=3.96$, $p<.001$); CP ($t(239)=4.291$, $p<.001$) or the experimental condition NR ($t(239)=3.971$, $p<.001$). The WS group found NP more difficult than CN ($t(239)=3.626$, $p=.002$); CP ($t(239)=4.175$, $p<.001$), as well as NR ($t(239)=2.510$, though this last difference was just about significant at $p=.050$). No other differences between sentence types within the TD or WS group were observed.

In contrast, the SLI group showed no statistically significant differences on any of the conditions. While their performance on NP was a bit lower than on the other conditions, with the estimated mean probability correct of 0.83, compared to 0.90 and above on other conditions, these differences were not close to being statistically significantly different: NP vs. CN: $t(239)=1.597$, $p=.508$; NP vs. CP: $t(239)=1.376$, $p=.607$; and NP vs. NR: $t(239)=1.232$, $p=.629$.

4. DISCUSSION

This study compared the knowledge of binding in TD children and two groups of atypically developing children who shared the presence of moderate language impairment, but differed with regard to the presence or absence of cognitive impairments: SLI and WS.

Unsurprisingly, all groups perform extremely well on the CN condition, in which there are no pronouns or anaphors. These are simple sentences, and the children in all groups can

comprehend them well. Good performance on this condition shows that the choice of pictures and sentences works; the method itself does not produce errors. All three groups also do very well on CP, the condition that tests knowledge of the possessive structure. In order to do well on this condition, children need to know that in a construction like “DP’s N”, the construction is a DP constituent. When the construction appears in subject position, the whole construction is the subject. They have to know that DP’s is the possessor (specifier) of a DP, the head noun of which is N. Part of this knowledge depends on children knowing that DP’s commands the rest of the constituent, so ability to calculate command is part of this knowledge. All three groups of children have this basic piece of grammatical knowledge. This helps to establish that the construction is suitable to test knowledge of the binding theory. If children make errors, it is not because they do not understand the possessive construction or because they cannot calculate c-command.

Overall, the children in all groups perform well on the NR condition, displaying excellent knowledge of the necessity that the antecedent of a reflexive must command it, part of Principle A. This is not surprising for the TD children; at their age it is completely consistent with the standard results of Wexler & Chien (1985). For the children with WS, the one large study (Perovic & Wexler 2007) found just these results (with almost the same set of WS children as in this study, as noted) and the other small studies we discussed also found intact performance on reflexives. Children with WS, who have certain strong difficulties with grammar (e.g. with raising, Perovic & Wexler 2007, or passive of psychological verbs, Perovic & Wexler 2010), have the knowledge that the antecedent of a reflexive must command it, and they perform well on sentences that require this knowledge.

Despite extensive research into different aspects of language abilities in SLI carried out in the past several decades, the literature has not established definitive results on the knowledge of the c-command constraint on the antecedent of a reflexive in this population. Some studies

show excellent knowledge, whereas other studies (subject to issues that we have discussed) do not agree with this. Our study, using classic methods of studying the c-command constraint in simple sentences, shows that in fact children with SLI have the knowledge of the c-command constraint on the antecedent of a reflexive. This is one contribution of our study.

Note that the literature is not in complete agreement on the nature of the grammatical incapacity in SLI. Delays in the development of obligatory finiteness in children with SLI are well known: Rice & Wexler, in particular, established with large groups and longitudinal studies that children with SLI perform significantly worse on every finite morpheme tested when compared not only to age-matched TD children, but also to language-matched TD children. There is no question but that in English (and other non-null-subject languages), difficulties with finiteness in obligatory contexts is a marker of SLI. The question immediately arises of whether *all* grammatical constructions are delayed in SLI. Rice & Wexler showed that subject/verb agreement was not affected in SLI in English. That fact, together with the late development of obligatory finiteness, is what established that the OI stage being much extended is a marker of SLI. It is not simply that children with SLI have trouble with morphology, as traditionally thought, but rather, there is a particular kind of deficit. However, it is important to establish which other grammatical constraints may also be deficient in this population: we can conclude from this paper that children with SLI (at least at the ages studied here) do not have a problem with the constraint on command of the antecedent of a reflexive.

We used the reflexive condition (NR) as a control, to see how the pronoun condition (NP) might produce different performance effects, even though the surface structures used in the experiment were quite similar in complexity. Namely, the sentences had essentially the same structure, with the pronouns and reflexives simply replacing each other, and the vocabulary was identical. Given this planning, we can conclude that the control worked; the children in all three groups did quite well on the reflexive (NR) condition.

Turning to the pronoun condition, NP, a different picture emerges. For both the TD group and the WS groups, the NP condition produced far worse performance than the reflexive condition and the other two control conditions. The TD results for children of this age replicate a long line of experimental studies using the same method, from Wexler & Chien (1985) on. We see in the current study that, for the TD children, the NP condition is significantly worse than all three of the other conditions: whereas for the three other conditions estimated mean probabilities correct were above 0.93, this was only .71 for the NP condition.

An important question discussed in the introduction was that of how children with WS would do on NP. The results are that they perform significantly worse on NP than on all three other conditions. As discussed in the introduction, children with WS are reported to have severe pragmatic difficulties, but not memory difficulties. Thus these results support the theory of Wexler & Chien (1985), Chien & Wexler (1990), Thornton & Wexler (1999) and many other papers, that the Principle B error is a pragmatic error. As discussed, children with WS do not have a severe memory deficit (Rowe & Mervis 2006). If the error of taking a local commanding DP as the antecedent of a pronoun (the Apparent Delay of Principle B Error) were a memory error, as argued by Reinhart (2006), we would not expect that children with WS would be impaired on NP. But they are, and it is not a general condition on all grammar in WS; cf. how well the children do on all the other conditions, including NR, with comparable surface structure and vocabulary. In view of the reported pragmatic difficulties in WS, the results on the study of pronominal binding in this population point to the cause of the ADPB error being due to a pragmatic difficulty and not a memory difficulty.

Turning to the SLI population, the results show that these children are not significantly worse on NP than on NR, the surface structure control. They do excellently on NR (an antecedent of a reflexive must command it) and just a little bit worse overall, but far from significantly worse, on NP than on NR ($p = .629$). In fact, an individual data analysis shows

that the somewhat larger NP error in children with SLI is due to only 4 out of 21 children. Two of these children, scoring 4 and 5 out of 8, were amongst the youngest in the SLI group: 6;08 and 7;08, which suggests that they could still overcome the ADPBE, just like TD children.¹² Two other children, however, again scoring 4 and 5 out of 8, were among the older ones (age: 11;09 and 11;10).

As noted in the literature review, at least a subset of children with SLI has been argued to have memory difficulties, e.g. difficulties with phonological working memory. In general they do not have severe pragmatic difficulties, especially as compared to WS (cf. Bishop & Laws 2004). If the ADPB error were due to memory, we would expect children with SLI to show ADPB. If it is due to pragmatics, we expect no particular ADPB error in children with SLI. The results from the children with SLI in our study thus tentatively support the theory that ADPB is due to a pragmatic difficulty, and seem inconsistent with the theory that ADPB is due to a memory difficulty. Our results are a first step, making the argument based on the literature results on pragmatic abilities in the populations plus our experimental results on binding. Even stronger results could be obtained in future studies by explicitly measuring pragmatic difficulties and relevant aspects of verbal memory in the two populations while controlling for the same measures that we have already controlled for.

The interesting fact is that it seems that both WS and SLI have some language impairment, as seen in poor receptive grammar and vocabulary scores, however, they do well on binding (in SLI, even pronouns seem unimpaired). Crucially, intellectual impairment does not seem to play a role: children with WS have an impaired non-verbal IQ, but children with

¹² To establish the exact effects of age in the acquisition of binding in SLI and any the resolution of ADPBE, future studies may include a larger number of participants under at least the age 8.

SLI do not – and they perform the same on reflexives, which strongly suggests that syntax is independent of IQ.

It is worth noting the advances in theoretical argumentation that have been made available in this paper depend on cross-syndrome comparisons. We can learn much not only about relative strengths of particular pieces of grammar in these syndromes, a somewhat obvious conclusion, but also about the nature of the theoretical issue in development. Knowing something about general capacities of each syndrome, and something about the nature of each grammatical construction, we can make predictions about relative strengths, and even mediate between alternative theoretical accounts.

Our results reveal that children with WS and SLI do not have difficulties with all kinds of binding. In particular, they know that reflexives have a c-commanding antecedent. On the other hand, children with WS do have difficulties with the constraint against a local antecedent for pronoun; they show a significant ADPB. Children with SLI, on the other hand, although of the same age as children with WS, do *not* show a significant ADPB error in this study.

Besides helping to establish the exact pattern of strengths and weaknesses in binding of children with WS and with SLI, our study also adds to a major on-going discussion in the literature on language acquisition. Namely, what is the cause of the difficulty with the constraint against local binding of a pronoun? Two ideas have been advanced: pragmatics and memory. The data and analysis made possible by a comparison of two very different impairments are consistent with the pragmatic theory and inconsistent with the memory theory. The comparative study of linguistic impairments can add in an important way to the study of the theory of linguistic development and, given the importance and difficulty of understanding the notion of reference, the theory of language itself. We hope in this paper to not only have added to knowledge on the question of binding in SLI and in WS, but also to the methodological

approaches that may aid in the development of theory. Our suggestion has been that cross-syndrome approaches, mediated by the general nature of each syndrome, can substantially aid the development of theory.

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Table 1. Ages and mean scores (standard deviations) on standardized tests of language and cognition for the three participants groups.

Group	SLI <i>n=21</i>	WS <i>n=21</i>	TD <i>n=21</i>
Age in months	128.09 (31.37)	139.61 (44.84)	64.09 (10.60)
Age range in months	82-198	72-200	44-85
KBIT Matrices RS	25.09 (5.38)	19.19 (6.08)	16.81 (4.56)
KBIT Matrices SS	95.52 (11.81)	72.19 (17.19)	104.24 (11.36)
PPVT-III RS	-	104.43 (27.14)	80.05 (18.84)
PPVT-III SS	-	80.09 (12.73)	106.47 (11.55)
BPVS 2 RS	70.14 (14.85)		-
BPVS 2 SS	74.33 (13.23)		-
TROG-2 RS	7.33 (3.03)	8.95 (3.43)	8.81 (3.26)
TROG-2 SS	63.86 (8.2)	68.52 (11.27)	101.66 (8.76)

Notes. Measures in bold are those on which the groups were matched. RS=raw score; SS=standard score. KBIT: Kaufman Brief Intelligence Test. BPVS: British Picture Vocabulary Scales. PPVT: Peabody Picture Vocabulary Test, the American standardisation of BPVS. TROG: Test for Reception of Grammar.

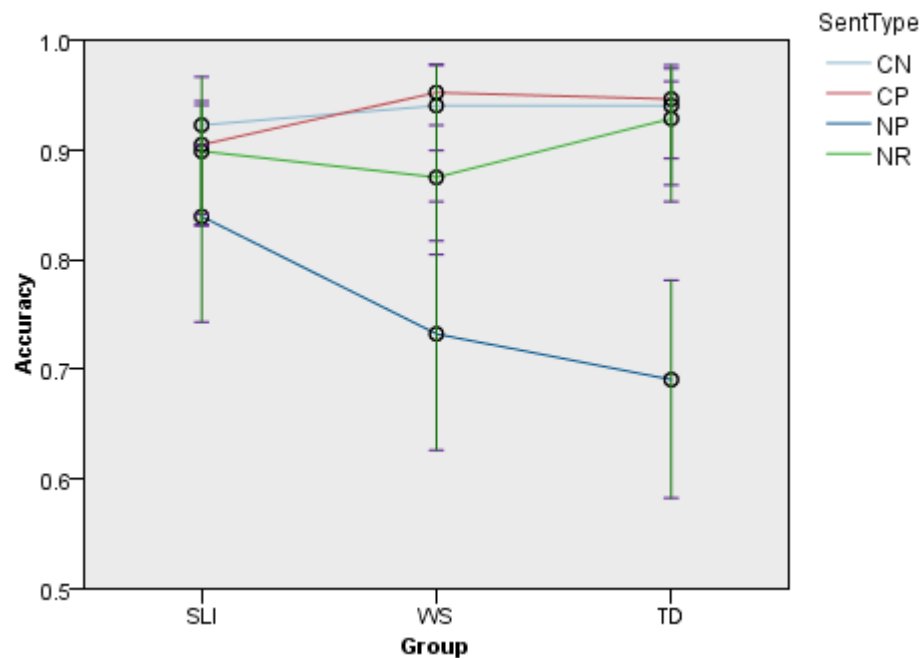


Figure 1. Estimated mean probabilities correct for each Sentence Type. CN=Control Name, CP=Control Possessive, NP=Name Pronoun, NR=Name Reflexive. Error bars represent 95% confidence intervals.