Grammatical Knowledge in Children with Autism

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A thesis submitted in fulfillment of the requirements for the degree of

DOCTOR OF PHILOSOPHY

Department of Linguistics

Faculty of Human Sciences

Macquarie University

Sydney, Australia

2015

Acknowledgement

The preparation of this thesis has been a long and satisfying journey. Many people have contributed towards it in different ways. Some have directly provided help with it and some have always been there with their support. Most notably, I am deeply indebted to my principle supervisor Associate Professor Rosalind Thornton for helping me embark on this new terrain of research in linguistics and acquisition. Sincere thanks to all members of the Language Acquisition Group who have always lent a patient ear to listen to my long presentations and provided me with constructive feedback, special thanks to Prof Stephan Crain for always being available for any help and advice and Dr Jon Brock for his constant support. Thanks to my friends, Kelly Rombough and Corry Bill for helping me prepare my stimuli and Anna Notley for her assistance. Special mention for all other members of the Department of Linguistics, Faculty of Human Sciences and Members of the Ethics Committee at Macquarie University who have lent their untiring support towards the preparation of this thesis.

This thesis would not have been possible without the parents of children diagnosed with autism and those children who willingly participated in this research. I am indebted to Northern School of Autism, Melbourne, Macquarie University Special Education Centre (MUSEC), Autism Spectrum Australia (ASPECT) and Giant Steps for big help towards recruitment and spreading the word. Hope the results from this research are useful for this special population. I would also like to thank my daughter's school Thornleigh West Public School (TWPS) in Sydney for helping me spread a word regarding my study for the recruitment of typically developing children. Finally special mention to all other people who helped pilot the experiments described here.

I am also very indebted to family for their support, my parents, sister, other family members and my two lovely daughters. My family deserves a special mention for their support from India! This thesis would not have been possible at all without their endless support and encouragement. I extend special thanks to my friends for constantly engaging me in stimulating discussions that helped shape this project.

Most importantly, I wish to acknowledge the financial support provided to me in the form of International Post Graduate Scholarship (IPRS) for completing this degree at Macquarie University.

Dedicated to Children with Autism, my family, friends and to my two lovely daughters Pari and Chia

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Declaration

The research presented in this thesis is my original work and it has not been submitted for a higher degree in any other institution. In addition, I certify that all information sources and literature used are indicated in the thesis. The research presented in this thesis has been granted ethics approval from Human Research Ethics Committee here at Macquarie University (ref: 5201200880) on 13/03/2012.

The chapters are prepared (chapters 3, 4 & 5) as separate papers for potential publications in keeping with the requirements of thesis by publication. These chapters will be sent for publication in the future with Neha Khetrapal as the first author. Therefore there may be some duplication of literature across the chapters. The experiments comprising the chapters were administered by the first author who also wrote the first draft. The supervisors played a significant role in refining these.

Signed:

Neha Khetrapal

Dated: 10th October, 2015

Thesis Summary

This thesis examines syntactic skills of children with autism in a series of experiments framed within the generative theory of linguistics (Chomsky, 1981). The participants were children aged between 5;6 and 12;7 years and were classified as high functioning as tested by non verbal IQ, but varied as to their classification as 'Language Impaired' or 'Language Normal'. First two experiments tested children's understanding of reference relations for reflexives and pronouns and follows up on a study by Perovic et al. (2013b), which claimed that children with autism do not have hierarchical relationship of c-command as it relates to Principle A. The novelty of this experiment is the incorporation of an independent test of c-command alongside Principle A sentences like *Bart's dad washed himself with soap.* Results did not show problems with Principle A or c-command formulation. Experiment three investigated comprehension of sentences with pronouns subject to Principles B and C (e.g. *Jasmine wiped her with a cloth* and *He covered Ironman with a sheet* respectively) to see whether children with autism show a pragmatic delay as assessed by Principle C. The results did not show any deviance either for Principle B or C. The final experiment investigated children's interpretation of sentences like *The boy who is on the bridge will not get a ball or a toy car.* This gives rise to the conjunctive entailment of disjunction, that is, the sentence means the boy who is on the bridge will not get a ball and the boy who is on the bridge will not get a toy car. Again the results indicate typical performance. The current findings critically suggest that syntactic development may not be qualitatively different compared to typical linguistic development possibly rendering the slow but normal characterization of language development a more viable approach in autism.

Grammatical Knowledge in Children with Autism

Chapter 1

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Overview of the Literature

1. Introduction

Autism Spectrum Disorder (ASD) is a lifelong developmental disorder defined in terms of social communication impairments co-occurring with repetitive and restricted behaviours (American Psychiatric Association, 2013). Prevalence of ASD is noted to be approximately one in 165 children (Fombonne, 2003) with only 25% of the cases showing intellectual impairment (Chakrabarti & Fombonne, 2001) with males consistently outnumbering females by about 5:1 (Hill, Zuckerman & Fombonne, 2014). Although communication impairments are a necessary criterion for diagnosis and, therefore, a universal feature of the condition, it is important to underscore that there is no 'specific' autistic language profile (Rapin & Dunn, 2003). Language development varies across the autism spectrum with children ranging from no 'spoken' or usable language to children with some language coupled with a striking inability to communicate, and even children with adult-like language skills for whom the content and use of language is sometimes bizarre. To complicate the whole picture, the differential language profiles can be witnessed at different points in time in a particular child with autism.

Despite the complexity of defining a language profile for children with autism, most autism researchers make a distinction between the formal aspects of "language" and "communication" – its application in social interactions (Frith, 2003). All are agreed that children with autism are not skilled in 'social pragmatics' that is, in using appropriate language in various social contexts. However, much less is known about children's linguistic knowledge. There are few thorough investigations of children's morphological, syntactic and semantic knowledge. This dissertation probes aspects of children's knowledge of syntax and semantics in children with autism.

The studies in the present dissertation will be framed in the theory of Universal Grammar (UG) (Chomsky, 1975; 1981; 1986). This is for two reasons. One reason is that the motivation for the current studies was two studies on children's knowledge of possible reference relations in reflexives and pronouns by Perovic, Modyanova & Wexler (2013a; 2013b) which were themselves framed in the theory of UG. A second reason is that this area of linguistics has been subject to extensive cross-linguistic investigation and there is a rich and detailed theory available for testing.

The dissertation focuses on an area of the theory known as 'binding theory'. Binding theory comprises three linguistic principles that constrain the distribution and meaning of 3 kinds of noun phrases, reflexives (like *himself* or *herself*), pronouns (like *him* or *her*) and names (like *John* and *Spiderman*). These 3 principles, known as Principles A, B, and C are argued to be part of UG, and therefore effectively constrain the sentence representations of all language learners. The three principles of binding theory are principles that are formulated using structural rather than linear notions. An important element of the statement of each of the principles is the structural configuration called 'c-command'. C-command is a relationship between nodes in the hierarchical representation for a sentence. This abstract structural configuration will be introduced in more detail in the next chapter.

In addition to the experiments testing children's interpretation of sentences containing reflexives and pronouns, we will also introduce a separate experiment that investigates whether or not children with autism are sensitive to this abstract hierarchical relationship. This is an important part of the dissertation as Perovic et al. (2013a; 2013b) claim that the c-command component of one of the binding principles, Principle A, is damaged, or not operating in children with autism (who score poorly on standardized tests of language). In contrast to these researchers, however, our experiments will demonstrate that the children with autism tested in our study do remarkably well at comprehending sentences with reflexives, pronouns and names.

We will conclude that these children have no difficulty with syntactic computation, and they also have mastered the pragmatic knowledge associated with two of the principles, Principles B and C.

Before we turn to our investigation of children's knowledge of the linguistic behaviour of reflexives, pronouns and names within sentences, it will be helpful to set the scene, by describing what is already known about language in children with autism.

2. **Language in Autism**

Our review of language skills in children with autism will cover 3 areas; semantics, syntax and pragmatics. Then we will consider previous studies that look specifically at the use of pronouns. It is important to be aware that terms differ across fields of study. The terms that are used by researchers of autism are not necessarily those used by linguists. This can cause some confusion.

2.1. Semantics

The term 'semantics' refers to the meaning of language, either at the lexical level ('lexical semantics') or at the level of the sentence. Most of the autism literature that refers to children's semantic knowledge is concerned with lexical semantics not sentence-level semantics. Here, I review key literature on lexical semantics, but it should be noted that my own studies explore children's semantic interpretations of sentences.

Problems with semantics lie at the core of the influential 'weak central coherence' account of autism propounded by Uta Frith (Frith, 2003). According to this account, people diagnosed with ASD demonstrate reduced "capture by meaning". There is, however, little evidence for difficulties in processing the meaning of individual words. For instance, a common way of assessing semantic processing is through priming where processing of a word is

facilitated by a semantically related stimulus that precedes it. Thus it is easier to process the word ‘car’ when it is preceded by ‘jeep’ rather than ‘ice-cream’. Studies generally point towards normal semantic priming effects in ASD (Lopez & Leekam, 2003; Toichi & Kamio, 2001), contrary to the predictions of the weak central coherence account.

A further claim of the weak central coherence account is that children with autism struggle to draw disparate information together in order to come up with a coherent whole. Evidence here comes from studies that involve reading homographs - words with different meanings but the same spelling - that can only be understood by considering the surrounding context. Examples include ‘tear’ that could stand for ‘tear’ from the eye or ‘tear’ on a dress. Children and adults with autism tend to make more errors when reading homographs. That is, they are more likely than control participants to give the contextually inappropriate pronunciation and meaning (Frith & Snowling, 1983). In a similar study, Hoy, Hatton & Hare (2004) asked their participants to listen to sentences containing homophones (ambiguous spoken words) followed by a second sentence containing disambiguating information. Participants with autism and lower language scores performed less well than the comparison group. Similar results were obtained by Norbury (2005). The suggestion is that difficulties in using context to extract meaning are found only amongst those with poorer language skills.

Individuals rely on semantic contexts in order to process words faster. For instance if the semantic category of countries is activated then the names of all countries may be processed faster. Research studies show that ASD children fail to make effective use of this semantic category for processing closely related words. This was evident in neural signature as well as higher error rates in response patterns (Dunn & Bates, 2005; Dunn, Vaughan Jr, Kreuzer, & Kutrzberg, 1999). Semantic processing is helpful not only for words but also assists in the formation of lexical categories. Categories are formed by extracting most common features of all category members. In this regard, members sharing many features are classified earlier and

more easily than members sharing fewer features. For example, the category of birds evokes features like wings and the ability to fly. A study was conducted by Church, Krauss, Lopata, Toomey, Thomeer, Coutinho, Volker, et al. (2010) on the ability to categorize and distinguish shapes based on over all similarity. The initial part of the study provided feedback for assistance, study results showed that participants with autism performed less well than their typical peers indicating that autism is marked by difficulties in extracting features across examples that aids in forming category prototypes, results here are interpreted within the 'weak central coherence' account. Similar problems have been found for categorizing dot patterns (Gastgeb, Dundas, Minshew & Strauss, 2012).

Following anecdotal reported links between syntactic (defined below) and semantic abilities, some researchers have examined the relations between these two domains in two groups of children with high functioning autism (e.g. McGregor, Berns, Owen, Michels, Duff, Bahnsen & Lloyd, 2011). One group consisted of children with syntactic deficits and the other group had children who did not suffer from syntactic deficits. The researchers also included a comparable group of children like those diagnosed with developmental language impairment. And there were also two control groups of typically-developing children, one matched on age and the other matched on syntactic development. All the children were between 9 to 14 years of age and their non verbal IQ as assessed by Kaufman Brief Intelligence Test-2 (Kaufman & Kaufman, 2004) was more than 85. Some of the children with autism and the group of children with language impairment or Specific Language Impairment (SLI) were identified as language impaired if they scored 1 standard deviation below the mean on the syntactic subtests (Formulated and Recalling sentences) of the Clinical Evaluation of Language Fundamentals-Version 4 (CELF-4) (Semel, Wiig & Secord, 2003).

Semantic knowledge, where this refers to children's knowledge of lexical semantics, was assessed by verbal definition task that required generation of a definition for word stimuli and a verbal association task that required children to provide a word association for each word.

In addition to those tasks, children completed standardized vocabulary tests such as the Expressive Vocabulary Test (EVT) (Williams, 2007) and the Peabody Picture Vocabulary Test – III (PPVT) (Dunn & Dunn, 1997). The participants also completed a sentence production task where they were expected to formulate sentences of the given word stimuli which were later analyzed for syntactic complexity. All the three experimental measures used the same abstract and concrete nouns and verbs that varied in frequency of usage.

The results showed that ASD children diagnosed with language impairments produced fewer clauses just like their SLI counterparts in the sentence production task consistent with their common language impairments. In addition, ASD children with language deficits and the SLI group scored below average on the PPVT but showed greater deficits on the EVT. These two groups of children gave partially complete or incomplete word definitions and less mature word associations. Moreover there was positive correlation between CELF-4 and performance on word association task. The performance of ASD children without language impairments and age matched typically-developing group was comparable. The researchers therefore explained that deficits of syntax in high functioning children with autism predicts problems with semantic knowledge and high functioning children with such deficits are comparable to children with SLI.

2.2. Morphosyntax and Syntax

It is now well known that children with SLI have great difficulty with the morphology and lexical items associated with finiteness (see, for example, Rice & Wexler, 1996). It has been of interest, then, to investigate whether or not these difficulties extend to children with autism. In the last decade, researchers have asked whether autistic children with language difficulties might be characterized as having comorbid SLI (Durrleman & Zufferey, 2009; Kjelgaard & Tager-Flusberg, 2001; Roberts, Rice & Tager-Flusberg, 2004) – a condition defined in terms of

language delays that cannot be explained in terms of sensory deficit or more general intellectual difficulties (Leonard, 1998).

A study by Eigsti & Bennetto (2009) used a grammaticality judgment task with high functioning English-speaking children with autism, aged 9 to 17 and discovered that they had lower sensitivity to morphosyntactic violations than their typically-developing peers matched on age, verbal and non verbal abilities. Deficits were significant for omitting the third person singular *–s* and progressive aspect *–ing*. Elicited productions of past tense *-ed* on verbs is also noted as an area of concern (Bartolucci and Alberts, 1974). These studies support the proposal that characteristics of SLI may surface in children with autism. It should be noted, however, that the characterization of SLI in Rice & Wexler (1996) would not expect the progressive aspect *–ing* morpheme to be affected, since this is not a morpheme that expresses finiteness.

The debate on syntactic competence in children with autism has focused on whether syntax is simply delayed or deviant in nature. Tager-Flusberg (1985) argued that autistic symptomatology entails unaffected syntactic development as compared to other aspects of language. This was because the earlier studies showed intact performance with the use of word order for enacting sentences (Tager-Flushberg, 1981). Swensen, Kelley, Fein & Naigles (2007) used an eye tracking methodology to test the comprehension of transitive sentences, which involve an agent appearing first and doing an action to a recipient (e.g. "The girl is pushing the boy"). Children with autism and their language matched typically-developing group looked reliably at the correct picture matching transitive sentences.

Children with autism have been found to produce fewer syntactically complex utterances (Jarrold, Boucher & Russell, 1997). For example, Zebib, Tuller, Prévost & Morin (2013) showed that French-speaking children with autism produced less appropriate *wh*-questions. *Wh*-questions (who, when, why) deviate from standard Subject-Verb-Object (SVO) order. The "wh" word is the direct object of the verb in these phrases, so the speaker is

expecting the listener to fill in the missing information. For example the "wh" questions are uttered in order to ask for some missing argument (e.g. "What did she wear"?), ask for a subject (e.g. "Who saw the teacher?") or even object for a sentence (e.g. "Who does the class teacher like?"). Zebib et al. also reported avoidance of complex *wh* structures, producing complements which require one propositional argument to be embedded under another proposition (e.g. "Who does John know that Mary likes"). However, other studies have shown relatively good comprehension of *wh*-questions. For instance, Goodwin, Fein & Naigles (2012) showed that children with autism develop stable comprehension of *wh*-questions by 54 months of age when they attain comparable language levels as for 28-month-old typically developing peers. Some of the conclusions drawn for better syntactic performance could have been the result of mean length of utterance or MLU which essentially means that a higher MLU overestimates syntactic complexity just because sometimes these children have longer utterances (see Scarborough et al., 1991).

Other studies aimed to classify ASD children on the basis of their scores on standardized tests of verbal and non verbal abilities (Kjelgaard & Tager-Flusberg, 2001; Roberts, Rice & Tager-Flusberg, 2004). The researchers found that some children with autism diagnosis had normal language scores whereas others scored below their chronological age and qualitatively similar to children diagnosed with SLI. On this direction, Roberts et al. (2004) reported that performance of children with autism was poorer than could be expected for their general level of linguistic and cognitive development, indicating a specific morphosyntactic deficit in this population.

To date, there is little data on the comprehension of complex syntactic structures. As reported, investigations of grammar in autism traditionally involve the study of spontaneous speech and scores on standardized tests of language abilities, involving a comparison with SLI children. Although valuable these studies are limited in providing a reliable picture of the

grammatical competence of children with autism. Sporadic studies of complex grammar suggest that passives (Perovic, Modyanova, Hanson, Nelson, & Wexler, 2007) and relative clauses (Riches, Loucas, Charman, Simonoff, & Baird, 2010) also seem to be impaired in autism. There are two studies we have already mentioned by Perovic, Modyanova & Wexler (2013a; 2013b) that investigate children's knowledge of the distribution and interpretation of reflexives and pronouns within sentences. In contrast to the results obtained by Perovic and colleagues, Terzi, Marinis, Kotsopoulou & Francis (2014) showed that Greek speaking children diagnosed with autism actually do well on Greek reflexives. Acknowledging the cross-linguistic differences, this is still a rich area for future research work.

2.3. Pragmatics

Pragmatics is understood to be the most impaired domain of language in individuals with autism (Lord & Paul, 1997; Young, Diehl, Morris, Hyman & Bennetto, 2005), being affected even in children on the spectrum with well-developed syntactic or semantic ability (Tager-Flusberg, Paul & Lord, 2005). Pragmatic deficits therefore set autistic children apart from children diagnosed with other developmental language delays (Rice, Warren & Betz, 2005). But, of course, pragmatics can mean many things. As noted earlier, there seems to be consensus that pragmatics in the sense of appropriate use of language in different social contexts is an area that is challenging for children with autism. In the non verbal domain, pragmatic deficits are noted with prosody or the tone of voice, problems interpreting facial and emotional expressions (see Evers, Kerkhof, Steyaert, Noens & Wagemans, 2014), deviant eye gaze (Ristic, Mottron, Friesen, Iarocci, Burack & Kingstone, 2005), lack of responsiveness to being called by name (Crane & Winsler, 2008), and difficulties with gestures (Watson, Crais, Baranek, Dykstra & Wilson, 2013). These are all considered to be aspects of impaired pragmatics in autism.

Pragmatic deficits in the verbal domain are marked by problems in shared or social referencing[1]. Referencing at a basic level establishes a relation between two or three objects where the objects are interrelated to each other. In a social setting the objects could be replaced by people. Difficulties with referencing disrupts social functioning and children are shown to have problems with making a verbal request (Paparella, Goods, Freeman & Kasari, 2011), use of demonstratives like 'this' and 'that' (Hobson, Garcia-Perez & Lee, 2010), telling coherent stories and narrating an event (Capps, Losh, Thurber, 2000; see also Stirling, Douglas, Leekam & Carey, 2014), appreciation of humour (Reddy, Williams & Vaughn, 2002) and appropriate response to questions and comments (Capps, Kehres & Sigman, 1998).

These pragmatic difficulties are typically understood with respect to theory of mind (ToM) functioning. ToM concerns the ability to attribute mental states like beliefs and desires to others and thus aids in explaining and predicting the behaviour of others for whom these states are attributed. ToM functioning is generally tested through false belief tasks that are typically passed by children by the age of 4 (Wellman, Cross and Watson, 2001). Children with autism are considerably delayed in their acquisition of ToM skills, even when taking their verbal intelligence into consideration (Happé, 1995). Pragmatic impairments may, therefore, arise because children (and adults) with ASD fail to infer the communicative intent of other people's utterances.

Pragmatic deficits for autism are hard to measure with the help of traditional language tests as the latter account for linguistic structure rather than pragmatic language usage (Anderson, Lord & Heinz, 2005). Part of the problem lies in the fact that measuring pragmatic language is difficult as it is context dependent. Therefore a rigid structure of formal language assessments fail to take into account the flexibility afforded by pragmatic usage of language

[1] Informally defined 'social referencing' stands for the ability to recognize, understand, respond to and alter behaviour with respect to the emotional expressions of a social partner(s). This sort of dyadic or even triadic interaction can occur between adults, adults-children and even between animals and humans.

(Adams, 2002). To circumvent this problem to certain extent, the Test of Pragmatic Language (TOPL; Phelps-Terasaki & Phelps-Gunn, 1992) was developed to assess for a range of typically developing pragmatic behaviours. The test is a picture based task where a child is presented with pictures depicting common social situations and the child is expected to generate a response for the featured characters; for instance a reason explaining the behaviour of a pictured boy at a doctor's clinic holding his stomach and bearing a distressed facial expression. Pictured items increase in difficulty initially targeting simple behaviours and progressing to complex phenomena like attribution of mental states. Scores on TOPL successfully discriminate participants with ASD from a typical population (Young, Diehl, Morris, Hyman & Bennetto, 2005). The study conducted by Young and colleagues had 17 participants diagnosed with autism ranging in age from 6 to 14 years. All participants had normal cognitive and structural language abilities. Their performance was compared to a matched group of typically-developing children. The results showed lower performance for the ASD group as opposed to the typically-developing group.

Assessments of pragmatic skills are also conducted by people who know children very closely as a means of understanding pragmatic functioning for children on the autism spectrum. Usually such ratings are requested from primary caregivers or parents. These ratings have the advantage of assessing a larger range of pragmatic language impairments as opposed to artificial test conditions. The Children's Communication Checklist-2 (CCC-2; Bishop, 2003; 2006) is one such instrument where respondents are requested to rate the frequency of children's behaviours covered under each question or item. Using this instrument researchers have shown that children with autism fair poorly as compared to a control group of typically-developing children matched on age (Bishop & Baird, 2001) or in comparison to the published norms (Botting, 2004).

Despite widespread difficulties with pragmatics, a number of recent studies have found evidence that individuals with autism are able to make some pragmatic inferences in the form of scalar implicatures. Implicatures are derived from under-informative sentences like "Some students are linguists" (see Grice, 1975; Guasti, Chierchia, Foppolo, Gualmini & Meroni, 2005). Although the sentence logically allows for the possibility that all students are linguists, listeners will typically infer that this is not the case – otherwise the speaker would have used 'all' instead of 'some'. Pijnacker, Hagoort, Buitelaar, Teunisse, & Geurts (2009) found that adult participants with high verbal IQ performed better than their counterparts with lower verbal IQ on scalar implicatures. Building on this work, Chevallier, Wilson, Happé & Noveck, (2010) tested 'scalar' inferences associated with "or". Sentences like "Mary will get a beer or juice" raise an implicature of exclusivity. Generally, adults understand such a sentence as meaning that Mary will either get beer or juice, even though logically it is consistent with Mary getting both the things. Thus pragmatically a hearer understands that if the speaker intended to say that Mary will get both juice and beer, he would have rather used 'and'. Adolescent participants with autism with high verbal IQ or intelligence were not impaired at drawing these implicatures in a task where test sentences were presented in the auditory mode and had to be matched with corresponding pictures (Chevallier, Wilson, Happé & Noveck, 2010).

Pragmatic behaviours as assessed by the TOPL, the CCC-2 and described under the non verbal domain encompasses every day pragmatic knowledge commonly studied in children on the spectrum. Studies testing scalar implicatures could be understood as efforts to investigate 'linguistic pragmatics'. The latter is an area which is less well investigated for children on the spectrum.

2.4. Pronouns

Personal pronouns offer unique challenges to a young learner as they do not have fixed references unlike common names (e.g. *John* and *Mary*). Use of 'I' and 'you' vary depending

upon the speaker and the addressee (Tager-Flusberg, 1993). Therefore, pronouns are difficult to learn through imitation of adult speech (Cooley, 1908). Hamann (2011) hypothesizes that pronoun interpretation is subject to pragmatic sensitivity. But correct usage of pronouns is also dependent upon the ability to master a range of other semantic, syntactic and morphological distinctions (Lee, Hobson & Chiat, 1994).

Difficulties with pronouns are a common feature of language in autism. In his initial description of autism, Kanner (1943) noted that many of the children in his sample tended to reverse pronouns, saying "you" instead of "me" or "I" (see Evans & Demuth, 2012), and vice versa. Kanner (1946) interpreted pronoun reversal in terms of another common feature of autism – echolalia, whereby children repeat verbatim the phrases and sentences they hear, often out of context (Rutter, 1978). Echolalia is especially common in autistic children with minimal expressive language (McEvoy, Loveland & Landry, 1988) and may be rooted in difficulties responding effectively to commands and questions (Carr, Schreibman and Lovaas, 1975). When it is utilized as the dominant strategy, it leads to pronoun reversal. To state an example, if a therapist asks a child, "Do you want some water?" The child may not reply back in a typical manner by saying 'yes' or 'no' but might be heard saying, "you want some water", where "you" refers to their own selves (child).

A different hypothesis considers visual perspective-taking skills or the knowledge of differing spatial perspectives as more important for the pragmatics of proper pronoun usage. Loveland (1984) tested 27 children ranging from 2;0 to 3;3 years on the comprehension and production of 1st and 2nd person subject and possessive pronouns. She found a positive correlation between the comprehension of other people's different spatial points of view and better comprehension of pronouns. On similar lines, Ricard, Girouard, and Décarie (1999) tested English and French speaking toddlers on pronoun usage and visual perspective-taking skills again finding a positive correlation between the two measures.

Our final studies on pronouns (and reflexives) are the studies by Perovic, Modyanova & Wexler (2013a; 2013b). These studies are framed within the theory of UG, and probe children's comprehension of the potential referents for these elements inside sentences (not in the discourse or context). Using a picture selection task, Perovic et al. (2013a) found that the autism group matched to typically-developing groups based on language and non verbal abilities performed similarly to two groups of younger controls on the comprehension of pronouns although their performance of reflexives (e.g. himself) was disproportionally affected. The authors interpreted this finding as impairments of grammatical knowledge instead of a general language delay. This was followed up by a second study on children with autism (Perovic, Modyanova, & Wexler, 2013b). They classified their participants as those with concomitant language impairments (ALI) and those with no language impairment (ALN). Using the same picture task, the authors found that reflexives were only a problem for ALI children. They concluded that children with ALI are at a disadvantage as they have problems in establishing the complex syntactic dependency that is required for correctly interpreting reflexives. These studies will be introduced in more detail in the literature review for our experiments in Chapters 3 and 4.

3. Concluding Remarks

This brief review highlights the core problems with language in autism and the basic theme that cuts across syntactic, semantic and pragmatic domains is a non-specific autistic language profile. Even though there is no agreed upon 'autistic language' profile, there still seem to be some language deficits that are observed across the spectrum. Out of these, echolalia and pragmatic deficits by far are the most marked. Problems with pragmatics are most noted for the non verbal domain and when problems are noted for the verbal domain, these are linked with verbal IQ or intelligence such that individuals with a high verbal IQ are less impaired then autistic individuals with a low verbal IQ. High verbal IQ seems to play a compensatory role not

only for pragmatic but also for syntactic and semantic processing. Another direction that seems to be less explored is how pronouns, that pose challenges for learning to an autistic child, are processed during a comprehension task. Are these difficult for children due to their pragmatic deficits? This is a possibility as pronouns do not have a fixed referent like proper names and require considerable pragmatic skills to decode. But pronouns are often embedded within sentential contexts and comprehending these requires grammatical skills too. So do children with autism falter on pronouns because some of them may also have deficits in the domain of morphosyntax akin to a distinction between formal aspects of "language" and "communication" on one hand and use of language for social interactions on the other hand? This is a pertinent issue and is explored here within the UG framework that is described in detail in the next chapter. The next chapter also spells out some constraints on learnability that cut across the comprehension of sentential pronouns.

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Chapter 2

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Theoretical Background

1. Introduction

The experiments in this thesis are carried out in the framework of Chomsky's Universal Grammar (Chomsky, 1981; 1986) approach. Chomsky's proposal is that children are born with a Language Acquisition Device or LAD, otherwise known as Universal Grammar (UG) that interacts with incoming language input from parents and caregivers. The output of this interaction is the 'steady state', which is the adult grammar of the environmental language.

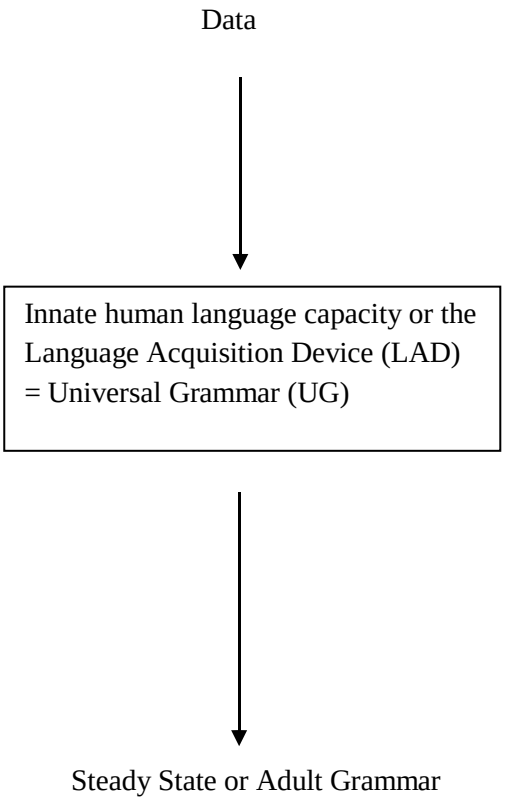

Figure 1: Schematic Representation of a language acquisition model as envisioned by Chomsky

UG contains a system of parameters that account for diversity in the properties of human languages. It also contains principles; these are universal and apply to all languages. It is these linguistic principles that are our focus in this thesis. Linguistic principles are sometimes known as 'constraints' because they 'constrain' the grammar by imposing limitations on dependencies,

movement and so on. The UG principles that make up the binding theory constrain possible relationships between noun phrases within a sentence. These principles, known as Principle A, Principle B and Principle C regulate the use of reflexives, pronouns and names inside sentences and are the focus of our studies on children with autism. There is now a substantial literature on typically-developing children's acquisition of these linguistic principles, but as one would expect, few studies investigating linguistic constraints in children with autism (that is the focus of this dissertation). The studies by Perovic, Modyanova & Wexler (2013a; 2013b) investigating the principles constraining reflexives and pronouns in children with autism are the exception, and were the motivation for the experiments that comprise this thesis. Our experiments follow Perovic et al. (2013a; 2013b) in using UG as the framework for our study of children's knowledge of how reflexive, pronouns and names are used within the sentence. Before we introduce the principles, it is worth outlining the role of principles in the linguistic theory, and the predictions for language acquisition.

1.1. Constraints and Learnability

Chomsky's argument for the existence of constraints as part of UG is based on the 'poverty of the stimulus' argument (Chomsky, 1965). Chomsky noted that the linguistic stimulus, that is, the input to children, is too impoverished to provide them with all the information that is part of the adult grammar. If children have linguistic knowledge that they have no evidence for (also called 'negative evidence'), how did they come to have it? One possibility is that they could learn it through teaching from parents and caretakers. The problem with this possibility is that it is well accepted that parents do not correct their children's grammatical knowledge (although they may correct other aspects of children's linguistic behaviour) (Brown & Hanlon, 1970; Morgan & Travis, 1989). Therefore, if children are not taught about the relevant linguistic knowledge, then it can be inferred that it is part of UG.

The basic idea of a constraint is that it imposes limitations on the grammar, ruling out certain sentence forms that might otherwise have been possible, and ruling out certain meanings that might otherwise have been hypothesized to be possible. Because constraints are negative statements, prohibiting certain sentence forms and sentence meanings, they cannot be learned from the linguistic input (see White, 2003). This is because the surface or the 'visible' properties of the language like word order do not provide any reliable clue about the underlying linguistic representations. Even if such input were available, it is not available in sufficient quantity or systematically throughout the course of development in order to guarantee that children eventually converge on an adult grammatical system. Because constraints prohibit various sentence forms and sentence meanings, they guide the acquisition process. There are certain errors that children simply can't make, due to the constraints that are part of UG.

Imagine a language system with no such constraints in place as exemplified in Figure 2. A language with no constraints will increase the learning load of the young learner as compared to a language that has constraints in place. Imagine this scenario for the interpretation of pronouns. A young learner who has to figure out the meaning of reflexive like 'himself' in a sentence like *Sam washed himself* would put in a considerable amount of time to figure out that 'himself' cannot refer to anyone else outside the sentence in which the reflexive is used or in other words the referent of 'himself' should be found within the same sentence as the reflexive. Nobody instructs the child of the meanings that are ruled out, so one might think that until such time that the child has the system figured out, they might make many errors.

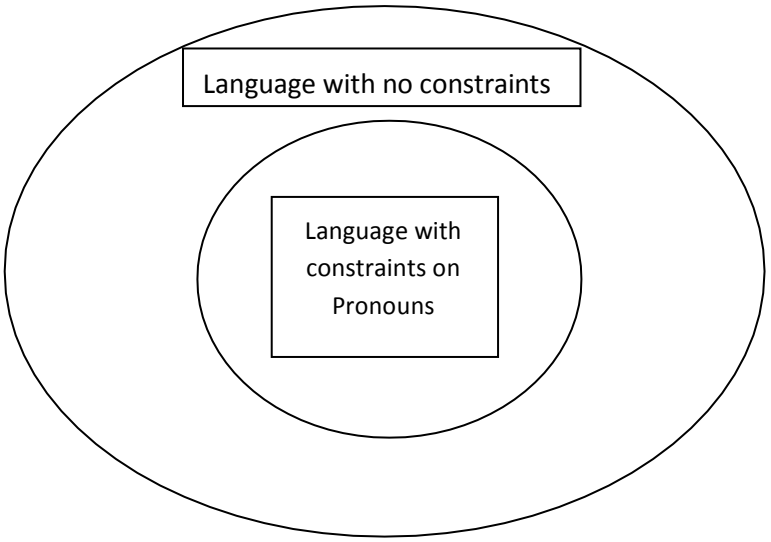

Figure 2: Schematic Comparison of a Hypothetical Language with no constraints versus a language with constraints

Next we turn to the more technical aspects behind the principles of the binding theory that are the focus of this dissertation.

1.2. Hierarchical Sentence Structure and C-Command

Generative linguistic theorists argue that sentence representations are not merely a linear order of words like 'beads on a string'[2]. This is counterintuitive, given that when we hear a sentence in the speech stream, one word comes after the other. However, the proposal is that when we build a representation for a sentence in our minds, it has a hierarchical structure, not a linear structure. Generative linguists argue that without hierarchy, there are many aspects of language that cannot be explained. It is argued that any linguistic rule that a child might hypothesize is formulated in terms of hierarchical structure; that is children's hypotheses are always 'structure-dependent' (Chomsky, 1971). They are never 'structure-independent', or based on linear order.

[2] The study of the grammatical relation and structure between the words and other units of sentences is called syntax (see Carnie, 2002). Therefore the words 'grammatical' and 'syntax' are used interchangeably.

This was tested in an experiment on yes-no question formation by Crain & Nakayama (1987). Their finding was that children do not form yes-no questions that are based on structure-independent rules.

There is a structural configuration in hierarchical sentence structures called 'c-command' that plays an important role in generative grammar (Reinhart, 1976). This structural configuration is part of the statement of the constraints that regulate the linguistic behaviour of reflexives, pronouns and names, Principles A, B and C, so it is introduced here. Consider the abstract hierarchical structure in Figure 3.

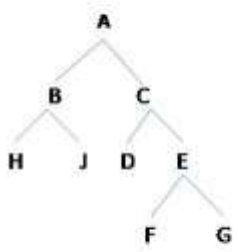

Figure 3: A Hierarchical Structure

Before c-command is defined, we need to introduce the term 'dominate'. In the hierarchical structure, a node is said to dominate another node if it is higher in the structure. Therefore B dominates H and J, and A dominates every node beneath it, but G does not dominate E and so on. Now, we turn to the definition for c-command. B is said to c-command C, for example, *if and only if* B does not dominate C, and the first branching node dominating B (which is A in this case) dominates C. Put another way, B c-commands its sister, node C and everything under it. We can apply the definition to other nodes in the hierarchical linguistic structure (the 'tree'). For example H c-commands J in this structure, but it does not c-command C or any of the nodes beneath it. H is too low in the structure to c-command C and the nodes

beneath it. This situation arises in some of the sentences that are tested in our experiments where the subject noun phrase is a possessive noun phrase. Consider Figure 4 for an example.

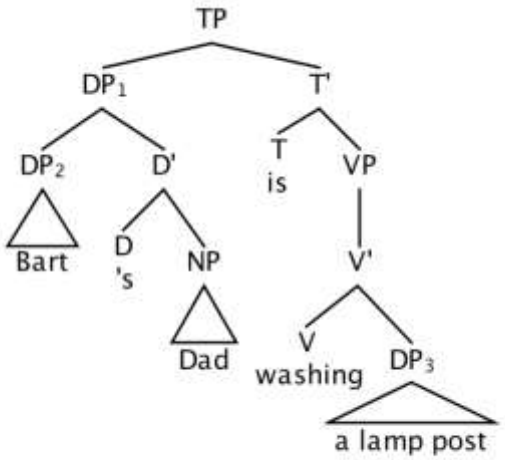

Figure 4: C-command in a sentence with a possessive subject, 'Bart's dad'

Figure 4 uses the format for sentence representations that will be used throughout the thesis. In this linguistic tree, Tense Phrase (TP) stands for a sentence like *Bart's dad is washing a lamp post*. In this structure or linguistic tree DP_1 or *Bart's dad* is the subject of the example sentence. DP_1 is broken down into further components like DP_2 or *Bart* and D' containing the possessive marker and the Noun Phrase (NP) *Dad*. This complex linguistic structure is needed to represent the structure of possessive sentences or phrases. By the definition of c-command introduced earlier, DP_1 c-commands T' as both these nodes do not share a dominating relationship and the first branching node (TP) that dominates DP_1 also dominates T'. In other words, DP_1 (Bart's Dad) c-commands the predicate T' which includes the whole phrase, '*is washing a lamp post'*. Next we turn to the linguistic constraints known as the binding principles, Principles A, B and C.

1.3. Binding Principles A, B, and C

1.3.1. Principle A

Principle A is the principle that regulates the linguistic distribution of reflexives, in English, words like *himself, herself, themselves* and so on. Principle A requires a reflexive to find a local antecedent in the same clause that c-commands it. Consider the examples in (1) to (4). The subscript indices show intended referent.

(1) Mary$_i$ likes herself$_i$

(2) *Susan$_i$ said Mary likes herself$_i$

(3) [Mary's mother]$_i$ likes herself$_i$

(4) *Mary$_i$'s mother likes herself$_i$

In (1), Mary is a potential antecedent for the reflexive because it is local, in the same clause, and it c-commands it. It also matches for gender, which is necessary in English. (*John likes herself* would be ungrammatical as the name 'John' is marked for gender). Example (2) shows that Susan cannot be an antecedent for the reflexive as it is not local; it is in another clause. In (3), there is a local antecedent to c-command the reflexive, *Mary's mother*. As we saw above, this whole possessive DP c-commands the reflexive. In (4), we show that Mary cannot be an antecedent for the reflexive; it is a local antecedent in the same clause, but it does not c-command the reflexive.

There is one more term that will be used in the thesis: 'bind'. A noun phrase (or DP) that is both coindexed with and c-commands another noun phrase is said to bind it. Therefore in (1) Mary 'binds' the reflexive, and in (3), *Mary's mother* 'binds' the reflexive.

1.3.2. Principle B

Principle B requires that a pronoun cannot have a local antecedent that c-commands it (and is coindexed with it). Let us consider how this works in the following sentences.

(5) *Mary$_i$ likes her$_i$

(6) Mary$_i$ likes her$_j$

(7) Susan$_i$ said Mary likes her$_i$

(8) Susan$_i$ said Mary$_i$ likes her$_i$

(9) *[Mary's mother]$_i$ likes her$_i$

(10) Mary$_i$'s mother likes her$_i$

In (5), *Mary* c-commands and is coindexed with the pronoun. Therefore it violates Principle B, because *Mary* binds the pronoun. It rules out the meaning whereby 'Mary likes herself'. It can, of course, mean that Mary likes some other female, as is indicated in (6), where the pronoun has a different index. In Chapter 4, however, it will be seen that in certain contexts, *her* can refer to *Mar*y. In these special contexts, there is said to be 'coreference' between the two NPs (Grodzinsky & Reinhart 1993; Reinhart, 2011). In this chapter we only introduce binding, but it is worth noting briefly here, that children are said to allow coreference in these contexts until age 5 or 6. This is often termed the 'Delay of Principle B Effect' (DPBE), although the term is a misnomer, as we shall see in Chapter 4.

Principle B also has a locality component. Although it cannot have a c-commanding local antecedent, it can have an antecedent that c-commands it but is in another clause. This is the case in (7), where *Susan* is shown to be an appropriate antecedent for *her*. In (9), we have a possessive subject. This entire subject, *Mary's mother*, cannot be an antecedent for the pronoun because it is coindexed with it and c-commands it. So (9) is ungrammatical. However (10)

shows that *Mary* is an appropriate antecedent for the pronoun. Although it is in the same clause, it does not c-command it, so the pronoun is still free in its clause.

1.3.3. Principle C

Principle C regulates the reference of names, often termed referring expressions (R-expressions). The term 'name' includes noun phrases that are commonly called names, such as 'John' or 'Superman', but also noun phrases such as 'the President' or 'the chair' and so on. Principle C states that R-expressions (i.e. names) must be 'free'. This means that a name cannot have the same reference as a pronoun that c-commands it and shares the same index.

(11) *She$_i$ saw Tina$_i$ in the mirror

(12) She$_i$ saw Tina$_j$ in the mirror

(13) *She$_i$ said Susan saw Tina$_i$ in the mirror

In (11), the pronoun c-commands and is coindexed with the name, *Tina*, so the sentence cannot have the meaning whereby *she* and *Tina* are the same person, that is, the meaning on which Tina saw herself in the mirror. Therefore, the pronoun must take 'disjoint reference' from the noun. The sentence can mean that some other female saw Tina in the mirror, as (12) illustrates. In the case of Principle C, a name must always be 'free'. A name cannot have a local c-commanding antecedent, and even if the potential antecedent is in a different clause, as in (13), the relationship between the two noun phrases is ruled out.

Just as with Principle B, according to Grodzinsky and Reinhart (1993) and Reinhart (2011), coreference (but not binding) is, in principle permitted in special contexts. We will return to this in Chapter 4 as it is relevant to our experiments.

1.4. Scope

We finish our introduction to theoretical terms and definitions by briefly introducing the term ‘scope’. The term is frequently used when discussing the meanings of sentences containing logical operators or quantifiers. One quantifier is said to take scope over another, if it c-commands it. For example, in the sentence in (14), there is a quantificational element, ‘every’ and a logical operator, ‘negation’, here seen as a negative auxiliary verb. Both the quantificational element and the logical operator can participate in scope relations.

(14) Every horse didn’t jump over the fence.

This sentence is ambiguous in English. Most native speakers can get two interpretations, depending on the scope relations between the quantificational element and the logical operator. One interpretation aligns with the surface order of the quantificational element and the logical operator or where ‘every’ takes scope over ‘negation’. The interpretation in this case is that none of the horses jumped over the fence. The alternative reading is that not every horse jumped over the fence. On this reading, at the level of interpretation, ‘negation’ takes scope over ‘every’.

The issue of scope comes up in our last experiment, which also serves as the independent c-command control in the experiment testing Principle A. In this experiment, the two elements at issue are negation (‘not’) and the disjunction word ‘or’. Consider the two sentences in (15) and (16) which are tested in the experiment.

(15) The boy who is on the bridge will not get a toy car or a ball

(16) The boy who isn’t on the bridge will get a toy car or a ball

In (15), negation is in the main clause, so it is in a position where it c-commands the disjunction phrase ‘a toy car or a ball’. In English, when negation c-commands disjunction, this gives rise to what is known as a conjunctive entailment (see Crain, 2012). The sentence means

that the boy who is on the bridge will not get a toy car and the boy on the bridge will not get a ball. In (16), on the other hand, negation does not take scope over disjunction. This is because it is inside the relative clause 'who isn't on the bridge'. For this reason, the conjunctive entailment is not generated. Here, the sentence means that the boy who isn't on the bridge will get a toy car or the boy who isn't on the bridge will get a ball (or possibly both).

2. Aims of the Current Research

As mentioned, the experiments that will be presented in the thesis build on Perovic et al.'s (2013a; 2013b) previous experiments on Principles A and B. These experiments will be described in more detail in the experimental chapters, Chapters 3 to 4. In their second study, Perovic et al. (2013b) divided their (autism) participants into two subgroups according to the presence of language impairment (ALI) and absence of language impairments (ALN) based on their scores on standardized tests of receptive and productive language. They concluded that although the ALN participants adhered to Principle A, the ALI participants had problems in interpreting reflexives. The authors claimed that Principle A is either missing or incorrectly represented in individuals with autism with language impairment and second that there was insensitivity to c-command that is required for computing the correct antecedent for a reflexive. Thus, these authors claim that this subgroup of children with autism have a syntactic deficit in their grammar. With respect to Principle B, Perovic et al. concluded that there is no difficulty with Principle B itself. Although they anticipated that children with autism may incorrectly allow coreference at a greater rate than typically-developing children, this was not the case. They argued that the 'Delay of Principle B Effect' was present, but not different from typically developing children.

The current thesis builds upon the previous literature and was planned with the following aims or objectives in mind:

A. The experiments introduce a new methodology, the dynamic version of the Truth Value Judgment Task (Crain & Thornton, 1998) to see if it improves performance on tests of the binding principles in children with autism.

B. We aim to replicate an experiment comparing Principle A and Principle B by Perovic et al. (2013a; 2013b) to see if syntactic deviance for Principle A emerges. In addition, since Perovic et al. claim that it is c-command that is impaired for Principle A, we introduce an independent test of c-command outside the domain of pronouns and reflexives.

C. Since Perovic and colleagues established severe problems with respect to reflexives and c-command for autistic children with concomitant language impairment or ALI, the second aim would be to compare the performance of children on the spectrum after categorising them as either ALI or ALN. Although children will be categorized as either ALI or ALN from the current sample, the sample size of both of these categories will be small as it was difficult to recruit only those children beforehand who could be classed under one of these categories.

D. Perovic et al. (2013a; 2013b) tested only Principle A and B. We introduce an experiment investigating Principle C, and compare it with performance on Principle B. On some accounts, both of these principles allow local coreference in special contexts (Grodzinsky & Reinhart 1993; Reinhart 2011). Perovic et al. showed that children with autism allow coreference, showing a pattern like typically-developing children. However, typically-developing children do not permit coreference for sentences governed by Principle C. The study presented in this thesis investigates whether or not children with autism show the same pattern, that is, illicit coreference for Principle B but not for Principle C.

E. We also investigate children's knowledge of scope relations in complex sentences with negated disjunction. We compare sentences in which negation c-commands disjunction

and ones in which there is no c-command relation because negation is inside a relative clause. The goal is to see if children with autism compute c-command in a sentence structure that is not governed by the binding principles. The complex structures are a good test of children's ability to compute complex syntactic relations in a sentence structure that is not affected by pragmatic factors.

3. Organization of the Thesis

The remainder of the thesis is now organized as follows. Chapter 3 reports investigations of Principle A and the independent tests of c-command that focus on studying the structural relations between negation ('not') and the disjunction word 'or'. The results of this chapter will be helpful in understanding whether children with autism show any deviance of syntax as assessed by Principle A and the independent test of c-command. Moreover it will illuminate us on whether children with ALI perform differently than children with ALN with respect to Principle A and c-command. Importantly if all children with autism show insensitivity to c-command, that is required for computing the correct antecedent for a reflexive, then the children tested will also have problems in computing the structural relations between negation and disjunction in test sentences.

Chapter 4 presents comparison of findings for Principle B and Principle C sentences. The results from here will provide important data to show if children with autism allow illicit coreference for sentences governed by Principle B or their performance is closer to the performance of the participants tested by Perovic and colleagues. In addition this chapter provides insight on how children fare on Principle C, the binding principle which has never been tested before in autism. Finally, a comparison of performance between these two principles will show if children perform better on one versus the other. For example, illicit coreference for Principle B but not for Principle C would be indicative of a typical pattern.

In Chapter 5, children's knowledge of scope relations in complex sentences with negated disjunction is explored. A comparison of differential performance between one set of sentences where a c-command or hierarchical relation is shared between negation and disjunction and the other where negation and disjunction do not share such a relation would critically tell us if children on the autism spectrum are able to compute complex syntactic relations outside the domain of binding.

Finally, Chapter 6 concludes the whole thesis by summarizing the experimental findings from the three experimental chapters. Discussions focus on the implications of the obtained findings for children with autism and their language development. Scope for future research directions is identified.

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Chapter 3

Reflexives in the Grammars of Children with Autism

Abstract

Although pragmatic deficits have been widely established in autism, the issue of grammatical knowledge is less settled in nature. Debates centre on whether grammar is deficient or delayed in nature. The current study investigated children's development of complex grammar, in particular their knowledge of constraints on the interpretation of reflexive pronouns. We employed a novel paradigm called the Truth Value Judgment (TVJT) task. In two different TVJTs, we investigated understanding of reflexives and another core syntactic principle, c-command that underpins the relationship between a reflexive pronoun and its referent. 12 children diagnosed with autism and aged between 5;4 to 12;11 participated. The experimental findings showed that children do not have problems in interpreting reflexives and c-command relations. Findings indicate no deviance of development and are consistent with preserved grammatical knowledge hypothesis.

1. Introduction

Autism Spectrum Disorder (ASD) characterizes a lifelong developmental disorder. Individuals with ASD are known to have difficulties with language and communication. Individuals present with little functional communication at one end of the spectrum to relatively well-developed language skills at the other (American Psychiatric Association, 2000)[3]. Nevertheless, no matter how proficient the language skills, all individuals diagnosed with autism share impairments in everyday language skills. Less clear is the status of grammatical knowledge in individuals with ASD. Some researchers have argued that grammatical knowledge is simply delayed in nature (Fein & Waterhouse, 1979; Lord & Paul, 1997; Tager-Flusberg, 1981) while others argue that there are aspects of grammatical knowledge that are deficient (Pierce & Bartolucci, 1977; Bartolucci, Pierce & Streiner, 1980; Perovic et al., 2013a; 2013b). This study aims to add to the understanding of syntactic knowledge in children with autism.

There have been few studies on complex syntactic structure in children with autism, and there is not yet consensus on whether or not aspects of syntactic knowledge are impaired in children with autism. The issue is complicated to some extent by the range of language abilities in ASD. Those who are classified as high functioning, or who score at least 70 on test of non verbal IQ[4] (Howlin, 2003), tend to do well and show sophisticated grammatical knowledge. One area of weakness that has been noted is morphosyntax. Difficulties have been noted for children's production of grammatical morphemes that mark 'tense'. This is of interest given that tense poses problems for children with Specific Language Impairment (SLI) (Roberts, Rice & Tager-Flusberg, 2004). However, deficits on advanced syntactic structures have been noted most for participants with low functioning autism (Boucher, 2009) or for those who are also diagnosed with concomitant language deficits across studies (Tager-Flusberg, 2006).

[3] *Diagnostic and Statistical Manual of Mental Disorders–Fifth Edition* (DSM V) hypothesizes an autism dyad as comprising of social communication difficulties and repetitive, stereotyped behavior. Abnormalities of sensory perception that were previously designated a peripheral feature of ASD, are considered a core feature in *DSM-5*.

More recently, there have been investigations into the comprehension of advanced syntactic structures such as *wh*-questions (Zebib, Tuller, Prevost & Morin, 2013), relative clauses (Riches, Charman, Simonoff & Baird, 2010; Durrleman, Hippolyte, Zufferey, Iglesias & Hadjikhani, in press; Durrleman & Zufferey, 2013), raising and passives (Perovic, Modyanova & Wexler, 2007). Riches et al (2010) showed that English-speaking teenagers diagnosed with autism and concomitant language deficits made significantly more errors than their age matched typically-developing counterparts on object and subject relative clauses when tested on a sentence repetition task. A severe difficulty was also reported for the comprehension of object and subject relative clauses in French speaking adults diagnosed with high functioning autism by Durrleman & Zufferey (2013) while avoidance of fronted *wh*-questions was reported for French speaking children diagnosed with autism on an elicitation task (Zebib, Tuller, Prevost & Morin, 2013). Importantly, these studies involved movement or those structures that encompass relations where the position that a phrase is interpreted differs from the position that the phrase is pronounced. A recent study by Perovic et al. (2013a) is important in this regard. The authors showed that children with autism experience difficulty in understanding the correct referent for reflexive pronouns such as *himself*[5] but fewer problems with the interpretation of personal pronouns such as *him* when tested on a picture selection task. This pattern of development is not attested in typical children who are observed to master the comprehension of reflexives earlier than the comprehension of pronouns. This led Perovic et al. to hypothesize that children's knowledge of possible referents for reflexive pronouns follows an atypical pattern in development in children with autism.

The claim by Perovic et al. (2013a) that children with autism permit illicit referents for reflexives was motivation for a further study by Terzi, Marinis, Kotsopoulou & Francis (2014) comparing performance of reflexives and pronouns in Greek speaking children. It is important to

[4] It is more common for studies on acquisition to use a score of 80 and above (Norbury, 2005).
[5] A local syntactic relation that does not involve movement

describe the system of Greek pronouns and reflexives, as they have different properties from English. Greek language classifies the Greek counterparts of *him* or *her* into strong or full pronouns and clitic pronouns which have different forms. English, on the other hand only has strong pronouns. The strong pronouns in Greek differ from clitic pronouns in several ways. First, strong pronouns carry lexical stress which is absent for clitics. Second, clitic pronouns can attach to the verb. Both kinds of pronouns also share important features. They both inflect for gender, number and case, and they are never used to refer to an antecedent that appears within the same clause (or in other words are subject to Principle B as explained below in section 2). Consistent with this, research has shown that Greek typically developing children master both strong and clitic pronouns at an early age[6] (see Varlokosta, 2000). Greek reflexives are also complex forms and are inflected for case and number. Their antecedents appear in the same clause unlike the pronouns. Most importantly, reflexivity is not just expressed through reflexive pronouns but it is also expressed through special verbal morphology (which is termed 'nonactive morphology'). The morphology of these verbs is shared by passive verbs too. Because of these interesting comparisons, the authors investigated how children with autism interpret Greek reflexives, strong and clitic pronouns, nonactive morphology and passive verbs.

The Greek children with autism were classified as high functioning based on their high non verbal (< 80) IQ. The control group consisted of typically-developing children individually matched to the autistic participants based on raw scores of a vocabulary test or a picture pointing task. The results revealed that children with autism interpret Greek reflexives in a typical manner unlike the autistic participants of Perovic et al. (2013a). However the Greek children with autism performed worse than typically-developing children on interpreting clitics. In fact their performance on clitics was lower than their performance on reflexives and strong pronouns. The

[6] Varlokosta (2008) explain that the early mastery of Greek pronouns as compared to non-mastery of English pronouns could be explained by the differential nature of Greek pronouns that also function as demonstratives. Demonstratives can also be used to refer to non-human entities unlike strong pronouns that can only be used to refer to human entities.

children were found to frequently interpret the clitic pronouns as reflexives, which the authors labeled as theta-role reversal. Moreover a follow-up production experiment showed that these same children produced clitics less often, providing evidence in support of the proposal that these children had problems with the syntactic and pragmatic conditions under which clitics are licensed. The autism group did not show problems with nonactive morphology but were less accurate with passives rather than reflexive verbs.

Building upon the findings of Perovic and colleagues (2013a, 2013b) and Terzi et al. (2014), the current study investigates further the claim that children permit illicit referents for reflexives due to a syntactic deficit. The current study examines the performance of high functioning children with autism with a methodology that is arguably more suited to a population with ASD than the picture selection tasks employed in previous studies. The present study also takes the further step of including a control structure that tests a structural configuration raised by Perovic et al. as potentially problematic for children with ASD. This structural relation is known as c-command and will be discussed in detail below. Therefore the aim of the present study is to test the performance of children on reflexives and on a structure that tests c-command independently in order to better understand whether grammatical knowledge is deficient in autism. Moreover, an appropriate task ensures that the performance data does not reflect the contributions of general cognitive skills. This is important as some argue that disentangling the effects of general cognitive deficits from language skills may be a concern in many research studies, particularly in low functioning children (Boucher, 2009).

2. Linguistic Background

In Chomsky's theory of 'Universal Grammar', the interpretation of reflexives, regular pronouns (such as *him, she* etc.) and names such as *John,* or *the President* and so on is regulated by what is known as Binding Theory (see Chomsky, 1981, 1986). There are three linguistic principles, known as Principle A, B and C constraining our interpretation of these elements, so

that we do not assign referents that are not sanctioned in the adult grammar. The present study is primarily concerned with Principle A and the interpretation of reflexives, but we will also compare reflexives briefly with pronouns, which are subject to Principle B. We will not discuss the third principle, Principle C here.

Reflexives and pronouns are often described as being in a complementary distribution for the purpose of assigning reference. A reflexive pronoun requires that the referent or the antecedent occurs within the same clause or locally in the sentence; the antecedent cannot be in a different clause. For example, in (1), below, *himself* can refer to *Peter*, since the noun phrase *Peter* occurs within the same clause and is of the same gender. The intended reference relations are shown by the subscripts on the relevant noun phrases. Principle A rules out the possibility that *himself* can refer to *John* in (1), since *John* is not in the same clause. On the other hand, *John* is a legitimate antecedent for the pronoun *him* in (2). The linguistic principle that constrains the interpretation (and production) of reference for pronouns is Principle B. This principle prohibits a pronoun from having a local antecedent, so in this case *Peter* is not a potential antecedent, but the noun phrase *John*, which is in a different clause, can function as an antecedent for the pronoun.

(1) John$_i$ said that Peter$_j$ washed himself$_j$[7]

(2) John$_j$ said that Peter$_i$ washed him$_j$

The examples in (1) and (2) describe the distribution of reflexives and pronouns, but in order to introduce Perovic et al.'s proposal, we also need to explain a more technical aspect of the principles behind the distributional criteria we have discussed. Principle A, the principle that constrains reference relations for reflexives, not only requires that the antecedent for a reflexive be coindexed and in the same clause, it also needs to be in a particular structural relation with the reflexive. This hierarchical structural relationship is known as 'c-command'. Therefore, in (1),

the antecedent must c-command the reflexive. In (2), the pronoun cannot be c-commanded by a local antecedent it is coindexed with. In order to understand the notion of c-command (refer to Figure 1) we will first consider the relationship in an abstract structure, and then see how it works in the kind of sentence tested by Perovic et al, such as *Bart's dad is washing himself*. The structure with a possessive subject noun phrase like *Bart's dad* will be used in our own experiment on Principle A as well. Possessive noun phrases are shown to appear early in language acquisition, approximately by 4 years of age (Bannard & Matthews, 2008).

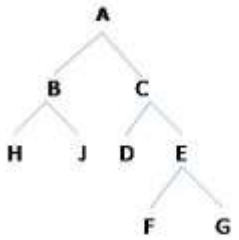

Figure 1: A Hierarchical Structure

In the hierarchical structure shown in Figure 1, a node is said to dominate another node if it is higher in the structure. Therefore B dominates H and J, and A dominates every node beneath it. Now, we turn to the definition for c-command. B is said to c-command C, for example, if *and only if* B does not dominate C, and the first branching node dominating B (which is A in this case) dominates C. Put another way, B c-commands its sister, node C and everything under it[8].

Returning to Principle A now, a reflexive must not only find its antecedent in the same clause, but the antecedent must c-command the reflexive. Let us now consider the sentence with a possessive noun phrase subject, like *Bart's dad is washing himself*. Intuitively, we know that

[7] Antecedents and reflexives/pronouns share the same indices.

Bart's dad is the only legitimate antecedent for *himself*, but the other potential antecedent, the noun phrase *Bart,* is not. We will find that the larger noun phrase *Bart's dad* c-commands *himself,* whereas *Bart* is in a position where it does not. Consider Figure 2.

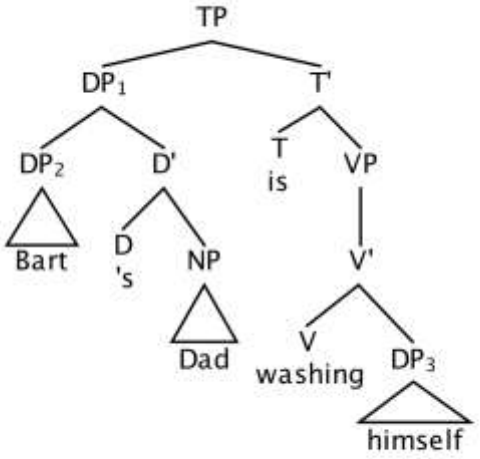

Figure 2: C-command relation in *Bart's dad is washing himself*

In Figure 2, Tense Phrase (TP) is the sentence-level phrase (sometimes called 'S' or 'IP') for the sentence *Bart's dad is washing himself.* In this phrase structure tree, DP_1 or *Bart's dad* is the subject of the sentence. DP_1 is broken down into further components like DP_2 (*Bart*) and D' containing the possessive marker and the Noun Phrase (NP) *Dad*. This complex linguistic structure is needed to represent the structure of possessive sentences. By the definition of c-command, DP_1 c-commands T' as both these nodes do not share a dominating relationship and the first branching node (TP) that dominates DP_1 also dominates T'. On the other hand, the first branching node dominating DP_2 or *Bart* (that is DP_1) does not dominate the reflexive. Therefore, *Bart* does not c-command the reflexive and despite being in the same clause it is not a potential antecedent.

[8] A c-commands nothing as it dominates everything. B c-commands C, D, E, F, G but not A. C c-commands only B, H, J. D c-commands only E, F, G. E c-commands only D. F and G c-command each other only and so is the case for H and J that c-command each other only.

3. Children's Knowledge of Reflexives

The most cited study on the development of Principle A in typically-developing children was first conducted by Wexler and Chien (1985) who tested a large number of English speaking children from 2;6 to 6;6 years of age. Children were tested on a two choice picture identification task for possessive sentence structures like *Cinderella's sister points to herself/her*. On a typical trial, one picture showed the sister pointing to Cinderella, and the other picture showed the sister pointing to herself. The entire NP, *Cinderella's sister* as opposed to *Cinderella* c-commands the pronoun or reflexive here. The task of the child was to choose the correct picture for the sentence presented. Children older than 5;6 showed their understanding of hierarchical structural relation of c-command and always chose a local antecedent (*Cinderella's sister)* for the reflexive. This knowledge was noted to be fully developed by 6;6.

In a further experiment, Chien & Wexler (1990) tested English speaking children between 2;6 and 6;6 years of age. The task was a truth value judgment task using pictures. The children were shown just one picture, and their task was to answer 'yes' or 'no' to questions posed by the experimenters. The questions either contained a pronoun or a reflexive as shown in sentences 3 and 4.

(3) This is Mama Bear. This is Goldilocks. Is Mama Bear washing herself?

(4) This is Mama Bear. This is Goldilocks. Is Mama Bear washing her?

On half of the trials, the picture was a 'yes' match for the experimenter's question. For example, a match trial for (3) showed Mama Bear washing herself and Goldilocks watching. On a mismatch trial, the picture illustrated Mama Bear washing Goldilocks, and so the correct answer to the experimenter's question in (3) was 'no'. The results showed that children clearly demonstrated their knowledge of Principle A at the age of 5 years because their performance was 90% correct at this age for both match and mismatch trials.

Other recent studies show that adults respect Principle A very early in sentential processing in line with its early manifestation in children. These early preferences have been noted with time sensitive measures like event related potentials and eye movements (Harris, Wexler & Holcomb, 2000; Xiang, Dillon & Phillips, 2009).

The first study to investigate Principle A in autism was conducted by Perovic and colleagues (2013a). Since the studies by Perovic et al. (2013a, 2013b) are the motivation for the present study, these studies will be introduced in some detail. The Perovic et al. (2013a) study was based on the truth value judgment task used by Wexler & Chien (1985). The difference was that the pictures used different characters, the Simpson family characters from the popular TV show, and the pictures were presented on a laptop computer for judgment. The child had to point to one of the two pictures that best matched the sentence spoken by the experimenter. The experimental stimuli in Perovic et al. consisted of four different kinds of sentences, shown in (5) to (8) below.

(5) Bart's dad is touching himself — Name Reflexive (NR)

(6) Bart's dad is touching him — Name Pronoun (NP)

(7) Bart's dad is licking a lamp post — Control Possessive (CP)

(8) Bart is pointing to Dad — Control Name (CN)

Notice that the subject noun phrase in these sentences is a possessive noun phrase 'Bart's dad'. This kind of noun phrase was chosen as the subject because it allows for 2 potential referents (*Bart's dad* and *Bart*) for reflexives/pronoun giving a choice between a c-commanding referent (*Bart's dad*) and non c-commanding referent (*Bart*). A control condition with the same possessive subject noun phrase and no pronoun or reflexive in the predicate as in (7) was also included in order to test whether children knew the structure of possessive noun phrases and could distinguish between *Bart's dad* and *Bart* in sentences that were not related to knowledge of pronouns or reflexives. This condition also tested the c-command relation independently of

binding in the sense that if children are able to compute the subject-predicate relations correctly here then they should be sensitive to c-command.

Fourteen children diagnosed with autism, ranging in age from 6 to 17 years (M = 11;6) were tested along with 27 typically-developing children aged 3-9 years matched on Kaufman Brief Intelligence Test (KBIT) and the Test for Reception of Grammar (TROG). For the autism group, the mean standard score (SS) for the matrices subtest of the KBIT standardized test assessing non verbal IQ was 65.96 and the mean for the TROG, a standardized test that assesses grammatical comprehension, was 56.5. The experimental findings revealed a persistent problem with sentences containing a reflexive like (5), as compared with ones containing a pronoun like (6). The autism group had a mean percent correct of 67% on the sentences containing a pronoun in (NP) like (6), while the two control groups, KBIT-TD and TROG-TD both scored a mean 71% correct. On the sentences containing reflexives (NR) like (5), the autism children did not score well, with a mean of 43% correct. Their performance level is below chance. This contrasted with and was significantly different from the control groups; the KBIT-TD group scored a mean of 92% correct and the TROG-TD group was 83% correct. There was some individual variation, however, with 2 of the 14 participants showing the pattern of better performance on (5) rather than (6). On the control items containing a name (CN), the children with autism were significantly different from the KBIT-TD group but not the TROG-TD group. Typically-developing matched children tend to show better performance on sentences containing reflexives as early as age 5 (Wexler & Chien 1985; Chien & Wexler, 1990)[9]. The mean percentage correct from the ASD group for each type of sentence in (5) to (8) is summarized in Table 1 below.

[9] The delay in understanding pronouns as compared to reflexives has been explained in various terms but the most popular explanation is couched in terms of late developing pragmatic knowledge in children (Chien & Wexler, 1990). Different constraints govern personal pronouns and reflexives as these are in complementary distribution. Binding principles regulate syntactic binding only. Reflexives fall under this category. Children's errors with pronouns are due to their immaturity with pragmatic processing. This differential explanation for the two principles was put forward to explain that children have innate knowledge of syntactic principles irrespective of the language

Table 1: Percentage of Correct Responses from ASD Children (Perovic et al., 2013a)

Group	Control Possessive (CP)	Control Name (CN)	Name Pronoun (NP)	Name Reflexive (NR)
Autism	77*	80*	67	43*
TROG-TD	86	89	71	83*
KBIT-TD	93*	95*	71	92*

*signifies significant differences in performance

A quick glance at the table shows that only on the NR condition was the performance of children with autism significantly different from both the control groups. The autism group also performed significantly worse than the KBIT-TD group on CN and their performance was just significantly different on CP again in comparison to KBIT-TD.

The findings are interpreted in line with impaired syntactic functioning in autism over and above any well established pragmatic difficulties in the disorder. There were two facets to this interpretation. First, because ASD children did not do well on reflexives, the authors interpreted this to mean that Principle A was either lacking or deficient in some way in autism. They consider the proposal that children are assigning reference using a linear strategy, rather than hierarchical relationships, but leave this possibility open. They state that "The principle is missing, or incorrectly represented, in the grammar of children with autism" (Perovic et al. 2013a, p.23). Second because hierarchical relations of c-command are needed to establish the antecedent for reflexives as explained before, the authors interpreted this to mean that "children with autism do not show sensitivity to c-command in establishing the complex syntactic dependency of binding, where the antecedent of a reflexive must c-command the reflexive" (Perovic et al. 2013a, p.25). As they point out, to say that children are missing c-command from their grammars completely would have serious implications, as this would affect structures throughout the grammar. For this reason, they do not commit to this position, and claim only that it is missing for Principle A.

they learn to speak but their performance falters due to other factors like pragmatic delays that take time to develop. This is the reason why development of pronouns lags behind the development of reflexives.

These findings were later re-examined by Perovic and colleagues (2013b) and the experiment was replicated with a larger group of children with autism aged 6-18 years of age using the same two-picture selection task. This study again tested sentences containing reflexives, pronouns, control name and control possessives. In this study, the participants were divided into two subgroups according to the presence of language impairment (ALI) and absence of language impairments (ALN) based on their scores on tests of receptive (TROG-2; PPVT-3) and productive language (KBIT). The ALI group consisted of participants scoring below the 10th percentile on at least 2 of the three tests. The findings showed that only the ALI group performed worse on the Name Reflexive (NR) sentences in (5) as compared to the Name Pronoun (NP) sentences like (6). The performance of the other three groups did not differ on this condition. The results provide further support for the claim that Principle A is either missing or incorrectly represented in individuals with autism with language impairment. This was further explained as a lack of c-command that is required for computing the correct antecedent for a reflexive. The authors state that "children with autism do not show sensitivity to c-command in establishing the complex syntactic dependency of binding" (Perovic et al. 2013b, p. 146). Thus, both the potential antecedents (possessor noun phrase and the entire subject noun phrase comprising of the possessor and the possessee) would equally serve as a referent for the reflexive with chance performance shown by children in choosing between the two. Consistently, the ALI group showed chance performance. Their performance was not different between the NP and other control conditions, CP and CN. However there is a result that is important to underscore here. The ALI group did not do badly on the CP condition (*Bart's dad is licking a lamppost*) that was hypothesized to test for c-command relations outside the domain of binding.

It is worthwhile to point out that the authors elaborate their proposal here. They stated that "It is not necessarily the case that children with ALI cannot compute c-command; they might be able to use it to constrain representations in other constructions" (Perovic et al. 2013b, p. 146). The authors further explained that the "ALI version of Principle A constrains the ALI

child only to having a clause-mate antecedent of the reflexive, missing the c-command part of Principle A" (Perovic et al. 2013b, p. 146). Although their conclusions with respect to Principle A were more tempered than their previous conclusion, there are still questions to ask. The main question is: If children do well on sentences like *Bart's dad is licking a lamppost*, and can identify the correct clause-mate antecedent within the clause[10], why can they not identify the correct clause-mate antecedent in sentences containing a reflexive such as *Bart's dad is touching himself*?

The performance of the ALN group could be distinguished from the ALI group as the former showed better performance on Name Reflexive sentences like (5) while the ALI group showed below chance performance (less than 50%). Both groups showed delayed comprehension of pronouns in the sentences containing pronouns like (6), in line with delayed established pragmatic knowledge in child language. These results are summarized in Table 2[11].

Table 2: Percentage of Correct Responses from ALI and ALN (Perovic et al. 2013b)

Group	Control Possessive (CP)	Control Name (CN)	Name Pronoun (NP)	Name Reflexive (NR)
ALI	77	79	71	49
ALN	99	98	83	96

The findings from the two previous studies conducted by Perovic and colleagues suggest that syntactic knowledge is of a qualitatively different nature in autism, especially for children who could also be classified as language impaired. This finding has considerable implications for acquisition of grammatical knowledge, so it is important to investigate the claim thoroughly. The

[10] *Bart's dad* rather than *Bart* is the correct clause-mate antecedent in the sentence, "Bart's dad is licking a lamppost"

[11] The authors concluded that the scores obtained by the ALN group on NP could be interpreted as DPBE because their scores were not different from the group of control children matched on chronological age. In light of this finding, the problems with the interpretation of pronouns were expected given their chronological age. The DPBE is explained to be stronger in the ALI group as their performance was no different from the group of control children matched on non verbal reasoning or the raw scores of KBIT matrices. Thus the performance of ALI group on pronouns could be equated to the performance shown by a younger group of children that was not matched on chronological age but scores on standardized test.

experiment presented in the next section with some changes adds to these previous experiments in two ways. We discuss the motivation for these changes next.

3.1. Motivations

The first and the foremost motivation is to see whether the current sample of children err like the sample of Perovic et al. (2013) or perform successfully with reflexives, like the Greek speaking children studied by Terzi et al. (2014). Another important addition to our enquiry into Principle A in children with autism is the inclusion of a separate structure that tests children's knowledge of c-command. For this independent c-command test, we replicated an experiment from the child language literature on children's knowledge of scope in negated disjunction (Crain, Gardner, Gualmini & Rabbin, 2002). In the Principle A experiment (Perovic et al., 2013), there is a c-command relationship between the noun phrase in subject position and the reflexive/pronoun/predicate. In this experiment, however, the c-command relationship that is relevant for interpretation holds between two logical operators, negation *not* and the disjunction word *or*. This c-command control part of the experiment will contrast sentences like those shown in (9) and (10).

(9) The boy who is on the bridge will not get a ball or a car

(10) The boy who is not on the bridge will get a ball or a car

In the sentence in (9), the negative marker *not* c-commands the disjunction word *or* in the hierarchical representation for the sentence (see Figure 3). When negation c-commands disjunction, this gives rise to a conjunctive entailment, so the sentence means that the boy who is on the bridge will not get a ball and the boy who is on the bridge will not get a car. In sentence (10), however, a conjunctive entailment does not arise. This is because the negative marker *not* is not in the main clause but inside the relative clause *who is not on the bridge* (see Figure 4). The negation cannot c-command disjunction from this position inside the relative clause, and so no

conjunctive entailment is generated. Instead, the disjunction in (10) receives disjunctive truth conditions. The sentence means the boy who is not on the bridge will get a ball or the boy who is not on the bridge will get a car.

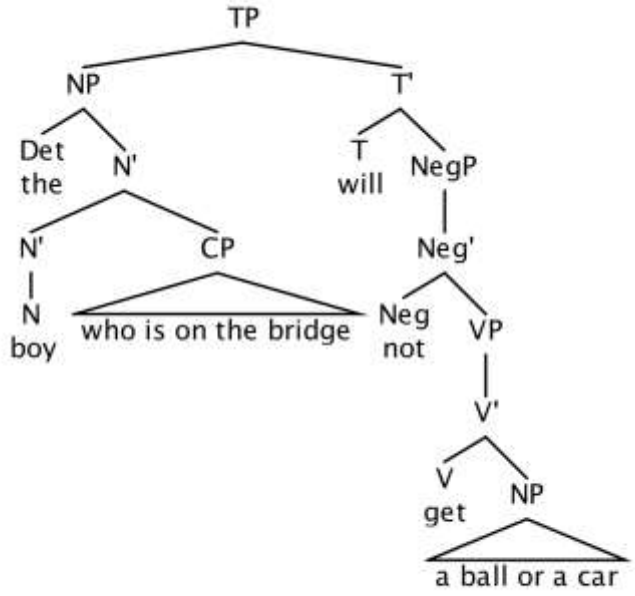

Figure 3: C-command relation between Negation (not) and disjunction 'or'

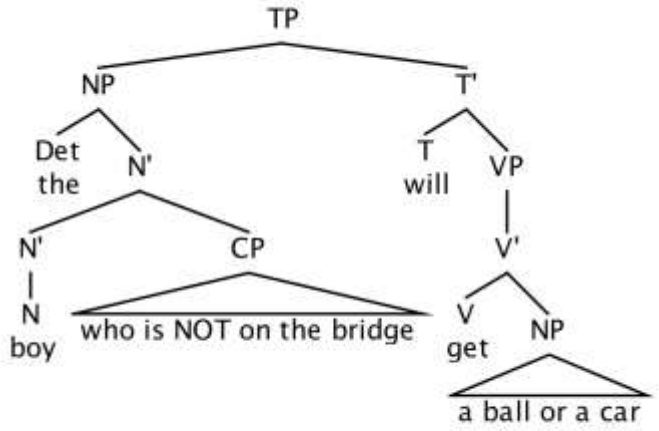

Figure 4: No c-command relation between negation (not) and disjunction 'or'

The prediction is that if children know the hierarchical relationship of c-command and can compute it in these complex sentences, then they will generate a conjunctive entailment for (9) but not for (10). Or in other words, children will interpret (9) to mean that the boy who is on a particular bridge will not get anything as compared to (10) that could be interpreted to mean that the boy who is not on a particular bridge will either get a car or a ball. Notice that if children assign an interpretation of disjunction based on linear order, then they should assign the same interpretation to both sentences – presumably they would not generate a conjunctive entailment. Or in other words sentences (9) and (10) should have a similar interpretation. This is because from a linear perspective, negation *not* precedes *or* in both (9) and (10). Therefore, this additional test allows us to investigate whether children with autism are computing the dependency between *not* and *or* using a hierarchical computation or relying on linear precedence, as Perovic et al. (2013a) seem to suggest. The next section introduces the experimental details.

Instead of a Truth Value Judgment task based on pictures where children judge the truth value of sentences presented by experimenters against the pictures, we used a dynamic version of the Truth Value Judgment Task (TVJT) (Crain & Thornton, 1998). This methodology does not

require children to interpret pictures and to make inferences in order to reject an incorrect interpretation. In the dynamic TVJT, stories are acted-out with toy characters and props who discuss the reasons for their actions. This means that the reason for why a given sentence is false has always been presented explicitly in the story, thus causing less of a burden on the child's implementation of pragmatic knowledge. The experiments by Perovic et al. used a picture selection task. These tasks tend to give rise to a yes-bias when the children are not sure about their answers and require children to understand the conventions in the pictures.

The stories presented in the dynamic version of the TVJT should have another ingredient in place which is called the condition of plausible dissent (Crain & Thornton, 1998; Crain, Thornton, Boster, Conway, Lillo-Martin, and Woodams, 1996). It simply means that the testing situation should provide substantial grounds for children to say 'no'. Keeping the above example in mind, it should have been the case that the character or 'Mama Bear' should have considered washing herself but later changed her mind. This introduces the basic ingredients for the task deployed in the current experiment and is called a dynamic TVJT where a child judges the truth value of the presented sentence against a story background. It is important to underscore here that giving an isolated picture posed with a test sentence may confuse a child where the child is tempted to say 'yes' when she is unsure of an answer. Therefore any improved methodology that gives substantial grounds to a child to evaluate a test sentence against a pre-introduced scenario is likely to give a better picture of the grammatical competence of the child.

4. The Experiment

The experiment is divided into two parts: Part A tests children's knowledge of Principle A in the same sentence structure as tested by Perovic et al. (2013a; 2013b), and Part B tests children's knowledge of c-command in sentences with negated disjunctions.

4.1. Part A: Test of Principle A

4.1.1. Methods

4.1.1.1. Participants

Twelve children on the autism spectrum participated in the study[12]. Their age ranged from 5;4 to 12;7, with a mean of 9;11 years. The sample had 10 boys and 2 girls. Children clinically diagnosed with autism were recruited from special schools across Sydney and Melbourne. The children in Sydney were recruited from Macquarie University Special Education Centre (MUSEC), the children from Melbourne were recruited from the Northern School of Autism (NSA), Preston campus and children were also recruited from advertisements placed on Autism Spectrum Australia (ASPECT) website. The children who made up the control group were recruited from general advertisements across Macquarie University, Sydney. Only children whose first language was English were recruited in both the groups. In addition, 8 adults were also tested in order to ensure the viability of the tasks. They were recruited from general advertisements across Macquarie University.

The children with autism group all had verbal communication skills. This group of children was tested on standardized tests of language and cognition. These tests included the matrices part of Kaufman Brief Test of Intelligence (KBIT) measuring non verbal IQ and the Test for Reception of Grammar Second Edition (TROG-2)[13]. The mean of the standard score (SS) for the KBIT was 94.41 and the mean of SS for the TROG was 76.58. In addition the participants were classified as those with concomitant language impairment (ALI) based on their scores on TROG, along the lines suggested by Perovic et al. (2013b). Participants in their study were categorized as ALI if they scored below the 10th percentile on two of the three language measures (Whitehouse, Barry & Bishop, 2008). Our study only had one language measure but we categorized a child as ALI if he/she scored below the 10th percentile on TROG as it

[12] One girl aged 8;11 was excluded as she showed a tendency for "wrong bias" for all the answers on test of c-command including the practice trials.

[13] It is worthwhile to point out that the TROG requires children to understand relative clauses like, *The square is in the star that is blue*. This is handy as experimental stimuli assessing c-command relations also require children to understand relative clauses; a domain explained as problematic for ASD participants in some of the previous research.

importantly tests for Reception of Grammar. As a result 6 participants were in the ALI category and the rest were considered ALN.

Based on the scores of the KBIT, the autism group can be described as high functioning as the majority of children had a standard score of more than 80 (Norbury, 2005; Howlin, 2003). The typically-developing children were matched to the children with autism within 2 points of the KBIT raw scores. The age of the children in the matched comparison group ranged from 5;10-8;10, M = 7 years, 1 month. Their mean of the standard score (SS) of KBIT was 114.8. Refer to Table 3 for the scores.

Table 3: Participants' ages and mean scores (standard deviations) on standardized tests of language and cognition

	Autism (n = 12)	**Typically Developing (n = 12)**
Mean Chronological Age in Years (SD)	9;11 (2;4)	7;1 (0;9)
Range	5;4 to 12;7	5;10-8;10
KBIT Matrices Standard Scores (SD)	94.41 (12.19)	114.8 (11.10)
Range	74-121	91-127
KBIT Matrices Raw Scores (SD)	25.75 (6.19)	25.25 (6.07)
Range	15-34	16-34
TROG 2 Raw Scores (SD)	9.67 (5.06)	-
Range	3-16	-
TROG 2 Standard Scores (SD)	76.58 (17.05)	-
Range	55-104	-

4.1.1.2. Procedure

The children were tested on Principle A using the dynamic version of the TVJT (Crain and Thornton, 1998). The task involves two experimenters; one experimenter manipulates toys and props and tells a story. The other experimenter plays the role of a puppet and at the end of the story, tries to say what happened. This is the presentation of the test sentence to the child. The task of the child is to judge whether the sentence delivered by the puppet is true or false in the context, that is, matches the story acted out by the first experimenter or not respectively. For this

study, the stories and the puppet's delivery of the test sentences were presented by two native English speakers and videotaped as short clips and presented on a mini iPad[14].

Each child was tested individually either in a quiet corner of a room at one of the above schools or at the Language Acquisition Lab at Macquarie University. The testing for each child, including the standardized tests lasted for approximately 1.5 hours. If the child had difficulty paying attention, the session was split into two parts. All participants were told that they will watch short stories and hear a puppet say something at the end of each story. Their task would be to evaluate whether the puppet in the iPad presentation was right or wrong. If the puppet was wrong, children were asked why they thought that the puppet was wrong. The experimental items were preceded by two practice items, one designed to be a 'Yes' answer, and the other a 'No' answer. The experimenter then proceeded to the main task. The first story presented to children was always an NR story (containing a reflexive) followed by a control possessive structure story. Subsequent stories were presented randomly. Children's judgments of the test sentence were scored as 'Yes' (true) or 'No' (false). Percentages of correct rejections for particular items were calculated for each child. All the verbal responses of children were recorded on a small digital recorder for later analysis.

4.1.1.3. Stimuli

The target sentences for Part A were Name Reflexive (NR) sentences like *Bart's dad washed himself with soap*. This was the same structure as used in the Perovic et al. experiment, with the addition of a Prepositional Phrase such as *with soap* sentence-finally, to make the sentence seem more natural in a story context. Also included in this part of the experiment were Control Possessives (CP) structures like *Bart's dad washed the dog with shampoo*. The CP question always followed the NR for all the stories. There were 4 sentences of each type. See Appendix 1

[14]The iPad was used to engage the special population of children with autism due to anecdotal evidence for the strength of the visual modality (see Cardon & Azuma, 2012; Quill, 1997). Use of the iPad also ensured that native speakers of English told the stories and delivered the sentences.

for a complete list of Principle A and CP sentences. The correct response associated with NR was always a rejection of the test sentence. The target sentences are designed to be false to ensure that children are not saying 'Yes' because it is easier. In order to show their knowledge of the constraint, children have to go out of their way to reject the sentence in context, and to explain why it is false. The Control Possessive sentences were split; 2 were true and 2 were false.

Below, we illustrate the design of the NR stories such as (11).

(11) "Bart's dad washed himself with soap"

Meaning 1: *Bart's dad washed Bart with soap

Meaning 2: Bart's dad washed himself with soap

Our experimental hypothesis is that all children including children with autism have Principle A as a constraint that is part of their innate linguistic knowledge. If that is the case, their grammars will not allow Meaning 1. The null hypothesis is that children lack the Principle A constraint. If that turns out to be the case then children could potentially find (11) ambiguous; they would sometimes allow Meaning 1 and other times Meaning 2. In order to avoid Type 1 errors, the interpretation that favours the null hypothesis is set up as the interpretation aligned with a 'yes' response. To demonstrate knowledge of Principle A, children must say 'no'. Both Meaning 1 and Meaning 2 should be made available in the story. Consider the sample story in (12) where one experimenter manipulated the toys and narrated the story and the other acted as a dog puppet making predictions:

(12) Sample NR Story

> Bart and Bart's dad visit the zoo in the school holidays. The zoo has some fun activities with animals. The zoo keeper says, "You can give this cute little giraffe a bath using the

soap bottle here. The giraffe loves it". Both Bart and Bart's dad agree and Bart's dad picks up the soap bottle. Bart's dad says "Come here little giraffe. It's time for your bath!" But look the giraffe jumps into a puddle and runs away <giraffe goes away>. Bart's dad says, "Oh no, the naughty little giraffe jumped into the puddle full of muddy water, and now we are all dirty and need some washing. I will get my dirty clothes clean using this soap here". Bart says, "Dad, the naughty little giraffe made me more dirty than you. I can't stand it. Can you help me get clean?" Bart's dad says, "I was going to get my clothes clean, but I don't really mind having dirty clothes so I will help you instead. I will stay dirty. Come on over here and I will give you a nice wash" <Bart's dad picks up the soap bottle and gives Bart a wash>

Puppet Dog: That was a good story about Bart and Bart's dad. The giraffe jumped into a puddle and made Bart's dad and Bart dirty. And I know one thing that happened - *Bart's dad washed himself with soap*

If the children understand the test sentence to mean that Bart's dad washed himself, then they should say "no" to the test sentence. On the other hand if Principle A is not in place, they could equally take the reflexive to refer to Bart, in which case they would say "yes" to the test sentence, since this is what happened in the story. The meaning by which Bart's dad washed himself was under consideration at one point in the story but it was not the actual outcome of the story.

The Control Possessive story tests the c-command condition associated with this structure in the sense that Meaning 1 and Meaning 2 are aligned with the two potential antecedents that makes up the possessive noun phrase. The Control Possessive stories were designed to be either true or false and to elicit a corresponding 'yes' and 'no' response based on the adult interpretation. This was so that ideally, the NR stories and the CP stories elicited a balance of 'yes' and 'no' responses. A sample story is given in (13) where one experimenter manipulated the toys and narrated the story and the other acted as a dog puppet making predictions:

(13) Sample CP Story[15]

> Here is Bart's dad again. Bart and Bart's dad have rescued a dog and brought it home. Bart says to his dad, "Dad, I think our new dog is a bit stinky. We need to wash him. But we don't have any dog shampoo". Bart's dad says, "Don't worry son, I will quickly run to the supermarket and get some suitable shampoo" <Goes>. Bart's dad comes back with some dog shampoo and says, "Son you can give the dog a good wash". Bart says, "Dad, I would like to give him a wash but I don't know how to give baths to dogs. I can't do it. Could you please do it the first time?" Dad agrees. "OK, I will wash him this time." <Dad washes the dog> and says, "Just hold him like this. He is a brilliant dog, I love dogs" Bart's dad says "good doggie, good doggie>

[15] Testing for control possessives with the help of TVJT is considered an improvement. To reiterate, this condition allowed us to evaluate whether children had the ability to distinguish for example between 'Bart's dad' and 'Bart'. If children are able to compute these differential relations here then they are sensitive to c-command independently of binding in line with Perovic and colleagues.

Puppet Dog: That was a good story again about Bart and Bart's dad. Bart's dad got some shampoo for the new dog. And I know one thing that happened –

Bart's dad washed the dog with shampoo.

In this story, if children take the entire possessive noun phrase *Bart's dad* to be the subject of the predicate, they should say 'yes' to the story. If children do not understand possessive phrases, and allow a non-commanding noun phrase to be the subject of the predicate, then they could take *Bart* to be the subject some proportion of the time. In this case, children could be at chance, or at least reject the sentences on some trials.

There are three more design features that are part of the experimental design (Crain and Thornton, 1998). The design should satisfy the condition of falsification where the story context should make the negation of the test sentence a true description of the events transpiring in the story. In order to achieve this, a salient character is added to serve as a possible referent of the reflexive '*himself*', which is '*Bart's dad'* in this case. The design should also satisfy the condition of Plausible Dissent as stated above. For instance, if Bart's dad never considered washing himself, then this would violate the condition of Plausible Dissent. Finally it is important to remind the children about the final events of the story by situating the characters in a way that reminds them about what happened in the end, taking care that the event corresponding to Meaning 1 is acted out towards the end (refer to picture 1).

Picture 1: Events at the end of the NR story

This helps in two ways, first if children do not have Principle A in place then the recency of the event should make them say "yes". On the other hand, if children go out of their way to say "no" then this is compelling evidence to show that children do not entertain Meaning 1. This strategy could be very important in testing children with autism who have been argued to show problems with complex reasoning (e.g. Ozonoff, Pennington, & Rogers, 1991). If these children go out of their way to say "no" then we can be confident of accepting our experimental hypothesis as opposed to the null hypothesis.

Another manner in which our experimental set up meets the criterion of a stringent design is by the way of introducing a linguistic antecedent in such a manner that should not be biased towards Meaning 2. This is achieved by the following statement, "That was a good story about Bart and Bart's dad. The giraffe jumped into a puddle and made Bart's dad and Bart dirty. And I

know one thing that happened". Importantly the wrong antecedent, 'Bart' is mentioned last and hence it is more salient. If children follow a linear order strategy, it becomes easy for them to choose the incorrect antecedent.

4.1.1.4. Results

The main finding was that both the children with autism and the typically-developing control group all performed extremely well on the task. The adults performed correctly 100% of the time on both NR and CP. Refer to table 4 for group mean results. A look at the table shows that the mean percentage of correct responses (or correct rejections) for reflexives or NR is 79% and for possessives or CP is 85% for ASD while for the matched controls the mean percentage of correct responses for NR is 94% and for CP is 83%.

Table 4: Percentage of Correct Responses (Group Mean) for ASD (n = 12) and Typical Controls for Name Reflexive & Control Possessive

Sentence Types	ASD	Typical Control	Group Difference
NR	79%	94%	Not Significant
CP	85%	83%	Not Significant

Refer to Appendix 2 for percentage of correct responses calculated for each child and averaged across the four stories. Each 'No' response for the NR test sentences was scored as correct rejection. Responses under the CP condition were scored depending upon whether children correctly accepted or rejected the test sentences. A Mann-Whitney Test was used to compare the patterns of responses by children with autism and typically-developing children. The group difference (ASD versus typically-developing) was not significant for reflexives ($Z = 1.0681$, $p = 0.28462$) or for the possessives ($Z = 0.2887$, $p = 0.77182$). Even differences between NR and CP phrases were not significant for both ASD ($Z = 0.0289$. $p = 0.97606$) and for the typically-developing control group ($Z = 1.5588$. $p = 0.11876$). When children were asked why they rejected the test items, all the children from both groups gave correct justifying responses.

For instance, consider (11). Children's stated reason for rejecting it was that *Bart's dad washed Bart with soap*.

It is important to investigate whether or not the ALI participants performed less accurately. Half of the participants were categorized as ALI based on the scores as mentioned before. The mean percentage of correct response for NR was 71% and for CP was 75% for the ALI group. On the other hand, for the ALN group or participants with no language impairment, the mean percentage of correct response for NR was 87.5% and for CP it was 95.83%. Refer to Table 5 for individual scores of the ALI group on TROG and their performance on NR and CP.

Table 5: Categorization of Children as ALI and their Performance Scores on NR & CP

ASD Children	Percentile (TROG)	Age	NR (% Correct)	CP (% Correct)
Participant 2	<1	6;7	75%	50%
Participant 4	<1	12;0	100%	75%
Participant 6	<1	10;6	100%	75%
Participant 7	<1	7;5	0%	75%
Participant 11	7	12;4	50%	100%
Participant 12	7	10;10	100%	75%

As is evident from the table, although the ALI participants were less accurate, they nevertheless did quite well. The ALI participants were not at chance performance as a group for NR and CP. Only Participant 7 showed no knowledge of reflexives while Participant 11 showed chance performance on NR. It is important to point out that even for these two participants their performance on CP which assesses c-command independent of binding was above chance. The only participant who showed chance performance for CP was participant 2. Crucially, this participant was 75% correct on NR hinting at the possibility that even for children with autism who are language impaired there seems to be no problems in establishing syntactic dependency relations for Principle A. We will further examine their performance on the independent test of c-command in the second part of the experiment. Until then it is worthwhile to state that none of the matched typically-developing children gave chance performance for NR and CP except for a

young participant (Participant 7) who is 5;4 years of age. The result could have been the effect of age.

Generally, the group of children with autism as a whole performed better than the participants in the previous study other than some individual variations. Another look at the individual results showed that children performed above chance levels on the NR condition except for two young participants (Participants 7 and 8). Participant 8 is 5;4 so it may be argued that the result may be due to the effect of age. An older participant (Participant 11) was also at chance for NR. At the same time, the performance of all the participants on the CP condition was above chance except for one young participant (Participant 2). The results obtained are different from those reported in an earlier study (Perovic et al., 2013a 2013b) for Principle A. A look at the individual responses from the typically developing matched children show that for all of them individually, their scores were above chance levels on both NR and CP except for one very young participant 7 aged 5;4.

4.2. Part B: Test of C-command

Part B tests children's interpretation of minimal pairs like the sentences in (14) and (15), repeated below.

(14) The boy who is on the bridge will not get a ball or a car (C-command)

(15) The boy who is not on the bridge will get a ball or a car (Non C-command)

In the 'C-command' sentences like (14) the negative marker 'not' c-commands disjunction, giving rise to a conjunctive entailment of the sentence (or in other words children interpret this to mean that the boy who is on the bridge will not get anything at all) while in the 'Non C-command' sentences, negation is embedded in a relative clause, and disjunction receives disjunctive truth conditions (or in other words children interpret this to mean that the boy who is

not on the bridge will either get a ball or a car). However negation precedes disjunction for both the categories. Thus if children rely on a linear strategy for interpreting sentences of each type then they would give similar responses for both C-command and Non C-command sentences as negation precedes disjunction for both but negation only c-commands disjunction for C-command phrases.

4.2.1. Method

4.2.1.1. Participants

The same child participants who participated in Part A also participated in Part B. 10 new adults who did not participate in Principle A were also included in order to ensure the viability of the tasks. They were recruited from general advertisements across Macquarie University, Sydney.

4.2.1.2. Procedure

Part B of the experiment also used the dynamic TVJT (Crain & Thornton, 1998). In order to make the presentation of test sentences containing the disjunction word 'or' felicitous, the task was used in 'prediction mode' (see Chierchia, Crain, Guasti & Thornton, 1998). Prediction mode is appropriate for sentences containing disjunction because it introduces uncertainty. In prediction mode, the story that is being acted-out by the first experimenter is interrupted half way through. The first experimenter acts as a dog puppet and asks Kermit who is watching what he thinks will happen next in the story. Kermit replies, using the test sentence that contains disjunction. The story resumes and at the end of the story, Kermit repeats his prediction. All other aspects of the procedure were the same as Part A.

The experimental items were preceded by two practice items. Children's judgments of the test sentence were scored as 'Yes' (true) or 'No' (false). Percentages of correct rejections for C-command sentences and percentages of correct rejections or acceptances for Non C-command

sentences were calculated for each child. All the verbal responses of children were recorded on a small digital recorder for later analysis.

4.2.1.3. Stimuli

The stimuli consisted of 4 C-command sentences as in (1) and 4 Non C-command sentences as in (2). The C-command sentences were designed to be false, while the Non C-command sentences were associated with either rejection or acceptance. Three of these stories were paired with a true response. All these stories were randomly presented to each child. See Appendix 3 for complete list of C-command and Non C-command sentences; sample stories for C-command and Non C-command sentences also appear in the Appendix.

4.2.1.4. Results

The adult participants correctly rejected the C-command sentences 100% of the time and were 82.5% of the times correct on Non C-command sentences. The main finding was that the group with autism also correctly rejected the C-command sentences, 89.6% of time while they showed correct performance on Non C-command sentences, 66.66% of the time[16]. The typically-developing children rejected the C-command sentences 100% of the time while they showed correct performance on the Non C-command sentences 68.75% of the time. Refer to Table 6 for the group results.

Table 6: Percentage of Correct Responses (Group Mean) for ASD (n = 12) and Typical Controls on C-command & Non C-command

Sentence Types	ASD	Typical Control	Group Difference
C-command	89.6%	100%	Not Significant
Non C-command	66.66%	68.75%	Not Significant

When children were asked why they rejected the C-command sentences, the children from both groups gave similar justifications. For example for the sample sentence, *The boy who*

is on the bridge will not get a ball or a car, the child would say that the puppet is wrong as the boy on the bridge got a car whereas he was not supposed to get anything. A Mann-Whitney Test showed there was no significant difference in the responses of the autism group and the typically-developing children for the C-command sentences (Z = 1.3568, p = 0.17384) or for the Non C-command sentences (Z = 0.4907, p = 0.62414). Appendix 6 shows the percentage of correct responses calculated for each child and averaged across the four stories. In addition, the performance data on C-command and Non C-command sentences for ALI children were examined. The mean percentage of correct response for C-command was 83% and for Non C-command was 63% for the ALI group. On the other hand, the mean percentage of correct response for C-command was 95.83% and for Non C-command it was 70.83% for the ALN group. The individual results of the ALI group are shown in Table 7.

Table 7: Categorization of Children as ALI and their Performance Scores on C-command & Non C-command

ASD Children	Percentile (TROG)	Age	C-command (% Correct)	Non C-command (% Correct)
Participant 2	<1	6;7	50%	75%
Participant 4	<1	12;0	75%	50%
Participant 6	<1	10;6	100%	50%
Participant 7	<1	7;5	75%	75%
Participant 11	7	12;4	100%	50%
Participant 12	7	10;10	100%	75%

As is evident from the table, ALI participants were not at chance performance as a group for C-command and Non C-command sentences. Only Participant 2 gives a chance performance on C-command sentences. Three participants showed chance performance for Non C-command sentences. At the same time, it is important to underscore that some children on the autism spectrum who are not classified as ALI also gave chance performance for only Non C-command sentences. Three of the matched typically-developing controls (Participants 6, 8 and 10) showed chance and below chance performance on Non C-command sentences only. Overall, the data

[16] Each 'No' response for the C-command test sentences was scored as correct rejection. Responses under the Non C-command condition were scored depending upon whether children correctly accepted or rejected the test

shows that children with autism who are language impaired do not have problems in formulating complex hierarchical relations like c-command.

5. General Discussion

This section summarizes the results obtained so far from 12 Australian high functioning children with autism and a typically-developing group of children matched individually on non verbal IQ. We argue that the results from our sample show that children on the spectrum do not display any presence of grammatical deficits as reported previously (Perovic et al., 2013a; 2013b) but are in line with the results of Terzi et al. (2014). The results are also consistent with the latest findings reported by Janke and Perovic (in press). This recent study showed that 26 British high functioning children with autism (non verbal IQ > 80 as assessed by the Matrices subtest of KBIT) showed intact comprehension of reflexives. The authors furthermore classified the children as ALI based on their performance on standardized language tests. Only three children in the ALI (n = 4)[17] group showed less than perfect performance on reflexives. Next we elaborate our findings discuss the implications of our results for language in autism and innate linguistic constraints in general.

First the results shown by the typically-developing children aged 5;10-8;10 are consistent with the previously described literature on both reflexives and c-command. Children older than 5 years except for one child aged 5;4 showed close to perfect performance on sentences containing reflexives and successfully chose the correct local antecedent (Wexler & Chien, 1985). This choice shows that they are able to construct the hierarchical structural relation of c-command for interpreting such sentences. These children also showed adult like performance on Control Possessive sentences and hence demonstrate their knowledge of hierarchical structural relation

sentences.

[17] This effort to classify children as ALI based on their scores on two standardized language tests one of which included the TROG, parallels our efforts of classification. The authors did not take a prior decision to recruit children as ALI or ALN in order to assess for comprehension of reflexives.

outside the domain of binding except for the same child aged 5;4 who again showed chance performance.

The autism group also showed adult like performance on Principle A except for some individual variation where two children showed chance performance. Out of these, one child was aged 5;4 and the other was 12;4. The younger child's performance is similar to the chance performance result obtained from the typically-developing child as noted before who was also 5;4 years of age. Thus it could be argued that this may be the effect of age. There was another child on the spectrum aged 7;5 who obtained a score of zero (or 0% correct performance) on reflexives. These three children however gave above chance performance on control possessives. Thus possessive structures seem to be within the reach of this group just like the matched control group. The result is in line with the previous findings on typically-developing children (Tomasello, 1998), and as reported by Perovic et al. (2013a). It seems reasonable to conclude that except for some individual variation, children with autism are able to successfully find the antecedents of reflexives. Our findings are different from the previously reported results of Perovic et al. (2013a; 2013b) who stated that "The principle is missing, or incorrectly represented, in the grammar of children with autism" (Perovic et al. 2013a, p.23). We do acknowledge that there is some individual variation but even the sample investigated by Perovic et al. (2013a) had individual variations where two participants on the spectrum did well on reflexives as compared to the others in the sample.

How do the observed patterns of performance match our linguistic predictions as outlined earlier? Recall that our experimental hypothesis stated that all children including children with autism have Principle A as a constraint that is part of their innate linguistic knowledge. Our data supports the acceptance of our experimental hypothesis for reflexives. However, we make room for the argument that the development seems to be delayed in autism for some reason in our study although this is a topic worthy of future research attention. Our results are consistent with

performance of Greek children on binding (Terzi, Marinis, Francis & Kotsopoulou, 2012). These authors showed that Greek speaking children diagnosed with autism do not show deficient performance on reflexive binding. Our results also agree with the findings of typical like performance on Dutch strong and weak reflexives as shown by Dutch children diagnosed with autism (Geutjes, 2014). Although there are language specific differences between Greek, Dutch and English, which may introduce further variables, Principle A is nevertheless a universal principle, and so in principle, there should be no cross linguistic differences (see Thomas, 1991). A thorough cross linguistic comparison of binding in autism will thus be a fruitful research direction in this regard.

The developmental lag in autism reported in other studies such as those conducted by Perovic and colleagues could, in part, be attributed to different methodology[18]. This is an important issue to underscore here as an important concern in child acquisition studies is to know whether a particular concept or knowledge that is being tested is in place or not. But a confounding variable that gets in the way of testing linguistic competence is performance factors. The TVJT helps in minimizing such performance factors by first removing the memory load placed on the child being tested with other modes. This is a concern for the previous picture judgment tasks that were employed specially with the clinical population on the spectrum to investigate the developing syntactic constraints (see Perovic et al., 2013a; 2013b). Apart from this participants may find the judgments of ambiguous sentences easier in TVJT, as there is a specific story context that provides a backdrop for such judgments giving a chance to the investigators to see whether participants will judge unambiguous sentences as ambiguous. The presented sentences will be judged ambiguous if the relevant grammatical constraints are not in place. When the participants do judge a sentence to be false they are asked for an explanation

[18] Very recently Janke & Perovic (in press) showed intact performance for comprehension of binding relations as assessed by a two-choice picture selection task. Their methodology was patterned on the lines followed by Perovic et al. (2013a; 2013b). However, this does not undermine our results as their autistic participants were older than our

thus giving another chance to the investigators to establish whether the participants' judgments are based on relevant reasoning and not merely grounded on lack of attention. Most importantly, a TVJT provides conditions of plausible dissent that is not possible with traditional picture judgment tasks. This is where the story context gives enough reasons to the child to reject a potentially false grammatical reading. Without the support of the story contexts, infelicitous testing conditions may be created making it hard for investigators to uncover grammatical constraints for a young child.

It is worth pointing out that Perovic et al. (2013b) classified their participants as those with either concomitant language impairment and as those with no language impairment in their second study. Only the participants with language impairment showed problems with reflexives and the authors stated that "ALI version of Principle A constrains the ALI child only to having a clause-mate antecedent of the reflexive, missing the c-command part of Principle A" (Perovic et al. 2013b, p. 146). The authors also stated in their first study that as a result the child may rely on a linear strategy or in other terms they may use a rule where they take the antecedent of a reflexive to be the one that immediately precedes it. Following this strategy will yield good performance on simple sentences like *Mary washed herself* as opposed to complex sentences like *Mary's mother washed herself*. Although our study did not have such simple sentences to provide a comparison of performance, half of the sample in our study was classified as language impaired based on their TROG scores. And these participants as a group did not show any signs of grammatical deviance except for few individual variations as discussed above.

The current set of findings are aligned with those of Terzi et al. (2014) who argued that a better performance on reflexives could be the result of high functioning (non verbal IQ more than 80) autism. To support their reasoning they included three children with autism who were not included in the final sample as their non verbal IQ was less than 80 and found that these new

participants and they also fared better on KBIT as compared to our sample. Therefore a better result on the picture

children performed worse on reflexives. To account for this possibility, the children in our study who scored below 80 (n = 2) on KBIT (Participants 6 & 7) were classified as low functioning children but unfortunately these same children were also classified as ALI and hence it is difficult to tease apart the role played by language impairment or low functioning autism. Therefore performance comparison on reflexives across ALI and low functioning children with autism warrants future investigation.

Part B of our experiment provides compelling evidence to show that children with autism show sensitivity to statements containing disjunctions and negation where negated disjunctions are logically equal to conjunctive interpretation (Boster & Crain, 1993) due to the presence of their structural arrangement (syntactic property of c-command). This finding shows that core syntactic properties of language are intact in contrast to evidence that shows problems with syntactic development (Pierce & Bartolucci, 1977; Bartolucci, Pierce & Streiner, 1980) in autism. Data from typically-developing matched children are consistent with the previously reported findings in the literature. All the participants scored 100% on the C-command phrases although their performance differed for Non C-command sentences. They were less accurate on these phrases (68.75% correct) along with the adult group (82.5% correct) who also showed a less accurate performance. In light of these results, it may be argued that since children saw both C-command and Non C-command stories there might have been some carry over effect. This is because the right answer for C-command stories is a 'no' response all four times but for Non C-command stories a right answer is a 'yes' response three times and children with autism may have been more affected by this carry over effect. Children in the previous experiment (Crain et al., 2002) either saw the C-command or the Non C-command test sentence or in other words Crain et al.'s study was a between subject design. This issue is open for further research exploration.

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selection task may have been the result of age and a higher functioning sample as assessed by KBIT.

The findings from the children on the spectrum deserve another mention in this regard. The autism group showed less proficient performance on sentences where negation only preceded but did not c-command disjunction. The correct performance percentage was 66.66% but this was not much different from the performance percentages reported in other studies. For instance, a study conducted by Musolino, Chunyo & Landau (2010) on people diagnosed with Williams Syndrome (WS)[19] on both of these types of sentences showed that these participants had a 75% correct performance on sentences where negation preceded and c-commanded disjunction. These percentages reported for the special population is lower than the performance percentages reported for typically-developing children. For example, the study conducted by Crain et al. (2002) on 4 and 5 year olds showed that they performed 92% correct on sentences where negation c-commanded disjunction but 87% correct on sentences where negation did not c-command disjunction. The percentage of correct performance of typically developing children corresponds with the performance of children with autism in our study where negation and disjunction are in a c-commanding relation. Could this effect be due to the similar methodology of TVJT employed in both the studies? This may be a possibility and requires further investigation as the study by Musolino and colleagues (2010) employed vignettes with outcomes from each declared at the end of each vignette without utilizing a TVJT in a prediction mode.

It is worth pointing out that none of our ALI participants scored at chance level on the crucial c-command sentences except for only Participant 2 who performed at chance but this participant showed a 75% correct performance on NR sentences in Part A of the experiment. The other ALI children (Participants 7 & 11) who showed chance or less than chance performance on Principle A scored 75% and 100% respectively on the c-command sentences. This suggests that even though children with autism may struggle with linguistic processing due to either their ASD

[19] WS is characterized by spared linguistic abilities with deficits for number and spatial concepts processing (Mervis et al., 1999).

diagnosis or any other concomitant language diagnosis, they are not likely to show deficient performance in all domains of linguistic functioning.

Importantly from our viewpoint, children with autism were able to distinguish between the c-command and non c-command sentence groups just like adults and typically matched children. This is a significant result, as these sentences are complex structures that contain a relative clause inside the subject noun phrase. Furthermore, relative clauses have been analyzed within linguistic theory as involving *wh*-movement, which have been noted as problematic in some children with autism. We can also interpret the results according to our earlier prediction. Recall that we predicted that if children know the hierarchical relationship of c-command and can compute it in complex sentences containing negation and disjunction, then they will generate a conjunctive entailment for sentences where negation c-commands disjunction. On the other hand, if children assign an interpretation of disjunction based on linear order, then they should assign the same interpretation to both types of sentences. This is because from a linear perspective, negation *not* precedes *or* in both sentence groups. Therefore, this additional test confirms our theorizing that children with autism are computing the dependency between *not* and *or* using a hierarchical computation rather than relying on linear strategy as Perovic et al. suggest.

At any rate our conclusions contrast with those of Perovic et al. (2013) who reasoned that children with autism have trouble in interpreting sentences that contain reflexives (e.g. *himself* or *herself*) as they misrepresent c-command relations in their syntactic repertoire. Problems with c-command do not appear to be the case in this independent test and hence it cannot be proposed that children only have problems with c-command when it comes to interpreting reflexives. This is because the c-command relation is not just required for one particular domain. C-command relations are hierarchical structures of language that support grammatical reference (Chomsky, 1957) and helps in the organization of sentences.

It is important to note here that the current sample of autistic children had high non verbal IQs as assessed by the KBIT. This score is higher than the score of the children investigated by Perovic and colleagues. A better non verbal IQ has been argued to be an important prognostic variable for clinical population in general and for autism in particular (Szatmari, Bartolucci, Bremner, Bond and Rich, 1989). Comparatively, lower functioning children in the spectrum are at a higher risk for language impairment irrespective of intellectual impairment (Kjelgaard & Tager-Flusberg, 2001). Our sample does not distinguish between individuals with higher versus lower functioning as assessed by non verbal IQ in order to establish the generalization of the current findings to lower functioning children. This is a possible future direction in need of further investigation.

On a general level, our data holds important implications for the innate versus usage based accounts towards language acquisition. Under the usage based account, theorists argue that environmental factors and domain general mechanisms (e.g. imitation) are important for acquisition of language (e.g. Tomasello, 2006). The current results are consistent with the innate approach to language acquisition. More specifically, principles like Principle A are negative statements that are not proposed to be part of our learned linguistic knowledge. So if children show adherence to these principles then it can be concluded that knowledge of Principle A is part of an innate language faculty. This is because, on generative linguistic theory, all of us are endowed with a special biological module devoted to language making it easier for the children to work out the rules for language (Chomsky, 1957) although the overt expression of this biological module may seem to be delayed or requires a sensitive testing methodology like TVJT in disorders like autism. Therefore, deficits of general learning mechanisms characterizing the autistic disorders are not expected to interfere with the biological module of language.

This issue brings us back to the connections between testing methodology and linguistic theorizing. The explanations put forward by Perovic and colleagues seem to suggest that children

with autism lack a critical component of LAD/UG but our results suggest that the problems with language arise due to some other issues although LAD/UG may be intact. The latter is a more parsimonious explanation of the obtained findings. Quite possibly children with autism tested across studies come with an intact innate language acquisition device. But some of these children may suffer from additional working memory/executive functioning deficits. When children with such deficits are tested on a difficult task like a picture truth value judgment task (that already places high demand on working memory), their performance may be subject to high processing load. This may be the reason that very few ASD children did well on reflexives in the study conducted by Perovic et al. (2013a; 2013b) although this is in contrast with the findings obtained by Janke and Perovic (in press) for their high functioning British sample diagnosed with autism. This calls for an investigation of interrelations between working memory/executive functioning, autism diagnosis and performance on KBIT. Until such studies are underway, these issues cannot be resolved as there were no independent tests that accounted for working memory or executive functioning in our study or the study conducted by Perovic and colleagues and Janke & Perovic. This issue is in need of further research investigation (see Fortunato-Tavares, Andrade, Befi-Lopes, Limongi, Fernandes & Schwartz, 2015).

6. Conclusions

The present set of experiments is a first investigation to use the dynamic version of the TVJT in order to investigate binding principles in English speaking children with autism. The findings reveal that children on the autism spectrum do not show problems with Principle A and they do not have any difficulty with the hierarchical relationship of c-command, as demonstrated in our negated disjunction control experiment. Our sample was also categorized according to concomitant language impairment or ALI as tested by Perovic et al. (2013b). Our results did not show any deficits in grammatical development in the ALI group. Thus grammatical development may at best be described as following a typical although a delayed pattern of acquisition. One

possibility is that traditional testing tasks like the picture selection task may be less well suited to testing children with autism. Under these circumstances, it may be that the TVJT which tries to act-out scenarios in real time may be able to show preserved grammatical competence even for such special children and hence serves as an important direction for further exploration. Consistent with this suggestion, Sanoudaki & Varlokosta (2015) showed that Greek children performed better on Greek strong pronouns when they were tested with a TVJT as opposed to a picture selection task.

A recent study by Janke & Perovic (in press) deserves a special mention here. The authors propose that reflexive binding does not pose a problem for high functioning children with autism as it is a local syntactic relation which does not involve movement for comprehension unlike other structures like *wh*-questions. Notable in this regard is the typical pattern of performance shown by our autism group on the negated disjunction control experiment. As mentioned before, the phrases tested in this experiment involve complex structures that contain a relative clause inside the subject noun phrase. These phrases can be analyzed within linguistic theory as involving *wh*-movement and our high functioning sample does not show problems with these structures including the ALI group. As the ALI group was small, these results do not provide conclusive evidence regarding what sort of structures pose difficulty for children with low functioning autism or autistic children diagnosed with concomitant language deficits. Thus a future study involving high and low functioning children with autism and comparing their performance on local versus syntactic relations that involve movement (e.g. A-movement as involved in *wh*-questions) would be worthy of investigation.

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Appendices

Appendix 1: List of sentences for Principle A

Name Reflexive (NR)	Control Possessive (CP)
Bart's dad washed himself with soap	Bart's dad washed the dog with shampoo.
Robot's master covered himself with a blanket	Robot's master poked the creature with a stick
Donald Duck's friend dressed himself in the costume.	Donald Duck's friend decorated the bird with the feather.
Spiderman's Brother dusted himself with the hairbrush	Spiderman's Brother cleaned the rock with the circus hat

Appendix 2: Percentage of Correct Responses for NR and CP averaged across the 4 stories for ASD and their matched typical controls

ASD Participants (Age)	Name Reflexive (NR)	Control Possessive (CP)	Typical Matched Participants (Age)	Name Reflexive (NR)	Control Possessive (CP)
1 (12;7)	75%	75%	1 (7;7)	100%	100%
2 (6;7)	75%	50%	2 (5;10)	100%	75%
3 (8;9)	100%	100%	3 (7;9)	100%	100%
4 (12;0)	100%	75%	4 (7;2)	100%	75%
5 (10;9)	100%	100%	5 (7;2)	100%	100%
6 (10;6)	100%	75%	6 (7;0)	75%	75%
7 (7;5)	0%	75%	7 (5;4)	50%	50%
8 (5;4)	50%	100%	8 (7;7)	100%	75%
9 (12;7)	100%	100%	9 (8;10)	100%	100%
10 (9;7)	100%	100%	10 (6;8)	100%	75%
11 (12;4)	50%	100%	11 (7;5)	100%	100%
12 (10;10)	100%	75%	12 (7;7)	100%	75%

Appendix 3: List of sentences for C-command and Non C-command

No	C-command Sentences	Correct Response (character gets one of the objects mentioned)
1	The boy who is on the bridge will not get a ball or a car	Reject
2	The cat who is on foot will not get a fish or milk	Reject
3	The Dino who is on the building will not get a potato chip or peanut	Reject
4	The Penguin who is on the barrel will not get a coin or a jewel	Reject
No	**Non C-commanding Sentences**	**Correct Response**
1	The girl who is not on her bed will get cheese or salad	Reject
2	The mermaid who is not on the plant-island will get a crown or a seahorse	Accept
3	The thief who is not on the speed boat will get a blanket or tea	Accept
4	The gardener who is not on the barrel will get a hat or a seed-bottle	Accept

Appendix 4: Sample Story for C-command

Design of the story for c-command sentences is illustrated below for the following test sentence:

The boy who is on the bridge will not get a ball or a car

Meaning 1: *The boy who is on the bridge will get a ball or the boy who is on the bridge will get a car.

Meaning 2: The boy who is on the bridge will not get any of those objects

The experimental hypothesis is that all children including children with autism will compute c-command relations and hence the test sentence will only give rise to Meaning 2. The null hypothesis is that children are unable to compute c-command relations and may use some sort of linear strategy as suggested by Perovic and colleagues. If this turns out to be the case then children should find the test sentence ambiguous; they will sometimes allow Meaning 1 and other times Meaning 2.

Story

Here one experimenter acts as a dog puppet and narrates the story while the other experimenter acts as the Kermit and makes predictions about the next events. This one is a boy's race organized at the high school and this time we have a special judge. The judge is the Superman. Only two brothers are participating. Here is the older brother, here is the younger brother. Our judge Superman will fly over this bridge in the middle of the race to judge the brothers. The prize for the winner is a ball. The other prize is a toy car. The brothers please make sure that you cross this bridge as quickly as possible in order to reach the finish line. One who reaches the finish line first will be the winner of this race. The race starts now. The older brother runs very fast [crosses the bridge] "I am the first to cross the bridge yay". I made it!" the younger brother stops at the bridge, "I have never seen a Superman flying, if I finish the race first I will not be able to see a flying Superman. I will just stand here on the bridge". Here comes the Superman flying over the bridge with the prizes in a special bucket.

At this stage story is interrupted and the dog puppet asks the Kermit,

"What do you think will happen next Kermit?"

Kermit: "The boy who is on the bridge will not get a ball or a car".

Story continues

Superman goes to the older brother at the finish line says, "you have done a good job" gives a toy car, also gives a toy ball to him. "You are the winner". The older brother is a winner. He goes back on the bridge, says to the younger brother, "why are you still standing on this bridge"? The brother replies, "If I had crossed the bridge, I would not have seen you flying". The superman says, "Ok, you can have this toy car".

Kermit: "I said that the boy who is on the bridge will not get a ball or a car".

Now if children only generate Meaning 2 then they should say "no" to the test sentence. On the other hand, if they are unable to compute c-command relations, they could equally take the sentence as true. In other words if they rely on some sort of linear strategy they would say "yes" since this is what happened in the story. The meaning by which the boy on the bridge was supposed to get nothing was under consideration at one point in the story but it was not the actual outcome of the story.

Appendix 5: Sample Story for Non C-command

Design of the story for Non c-command sentences is illustrated below for the following test sentence:

The mermaid who is not on the plant-island will get a crown or a seahorse

In these sentences 'not' does not c-command 'or' and hence it is predicted that all children will find these unambiguous. On the other hand, since 'not' does not share a proximal position with 'or', these sentences may be difficult to process as compared to the C-command phrases. It may be a possibility that as negation and disjunction do not share a c-command relation; children cannot rely on hierarchical relation for interpretation. In the absence of hierarchical relation, these phrases may be more ambiguous as compared to C-command sentences for all children alike.

Story

Here again one experimenter acts as a dog puppet and narrates the story while the other experimenter acts as the Kermit and makes predictions about the next events. This is the underwater treasure hunt at the Pacific Ocean. Here is the Magic man [introduced] who organized it. These two mermaids (introduced) are participating, the magic man announces some rules, "listen mermaids, I have hidden some treasure behind these sea-plants. The winner will be the one who finds the maximum amount of treasure. But the condition is that you cannot leave your plant island. You can move around on your islands." One mermaid says, "This is so hard,

we don't have any legs". Magician says, "This is the rule. The winner will get some seahorses, some crowns". One mermaid hops around on the plant island, finds treasure, "yay". The other mermaid says, "Well I will leave the island, it's easier to swim rather than to hop around like this".

At this stage story is interrupted and dog puppet asks the Kermit,

"What do you think will happen next Kermit?"

Kermit: "The mermaid who is not on the plant-island will get a crown or a seahorse".

Story continues

At the end of the hunt, the magic man goes to the winner, "you have done a good job finding the maximum amount of treasure. You can have this sea horse. You can also have this crown." He goes to the other mermaid, "why are you not on your plant-island? The rules of the hunt were pretty strict." The mermaid explains "well I already said that I don't have legs. It was so hard for me. But I tried to find some treasure". Magic man says, "Ok, you can have this crown in this case".

Kermit: "I said that the mermaid who is not on the plant-island will get a crown or a seahorse".

Now children can only say "yes" to the test sentence as this is what happened in the story. Some may be predicted to say "no" due to the non-proximal position of *not* and *or* which may lead to processing difficulties as c-command relations are not required to be computed making these sentences more difficult to process as compared to c-command sentences.

Appendix 6: Percentage of Correct C-command and Non C-Commanding sentences averaged across the 4 stories for ASD and Matched Typical Group

ASD Participants (Age)	**C-command Sentences**	**Non C-commanding Sentences**	**Matched Participants (Age)**	**C-command Sentences**	**Non C-commanding Sentences**
Participant 1 (12;7)	75%	50%	Participant 1 (**7;7**)	100%	75%
Participant 2 (**6;7**)	50%	75%	Participant 2 (**5;10**)	100%	75%
Participant 3 (**8;9)**	100%	100%	Participant 3 (**7;9**)	100%	75%
Participant 4 (**12;0**)	75%	50%	Participant 4 (**7;2**)	100%	75%
Participant 5 (**10;9**)	100%	50%	Participant 5 (**7;2**)	100%	75%
Participant 6 (**10;6**)	100%	50%	Participant 6 (**7;0**)	100%	25%
Participant 7 (**7;5**)	75%	75%	Participant 7 (**5;4**)	100%	100%
Participant 8 (5;4)	100%	50%	Participant 8 (7;7)	100%	50%
Participant 9 (**12;7**)	100%	100%	Participant 9 (**8;10**)	100%	75%
Participant 10 (**9;7**)	100%	75%	Participant 10 (**6;8**)	100%	50%
Participant 11 (**12;4**)	100%	50%	Participant 11 (**7;5**)	100%	75%
Participant 12 (**10;10**)	100%	75%	Participant 12 (**7;7**)	100%	75%

Chapter 4

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Constraints on the Interpretation of Pronouns and Names in Autism

Abstract

The present study investigates knowledge of two principles of binding theory, Principle B, and Principle C (Chomsky 1981; 1986), in children diagnosed with autism spectrum disorder, ranging in age from 5;4 to 12;7 (mean 10;5 years). Principles B and C constrain syntactic binding in sentences but these also have a pragmatic component. The pragmatic component regulates whether or not coreference is permitted in certain contexts (Chien & Wexler 1990; Grodzinsky & Reinhart 1993; Reinhart 2011). This pragmatic component is delayed in typically-developing (TD) children who permit sentences like *John washed him with a sponge* to mean John washed himself until about 6 years, but not delayed in Principle C sentences where children disallow coreference. Perovic et al. (2013a; 2013b) predicted an exaggerated delay for Principle B in autism but found it is no more delayed than in TD children. Our study introduces sentences governed by Principle C, such as *He washed Superman with a sponge* in addition to the Principle B sentences, to see whether there is a similar pragmatic delay, or whether in this case, children with autism, like TD children, disallow coreference due to some kind of directionality effect (Reinhart, 2011). The experimental findings show that the children with autism perform quite accurately on both sentence types. The conclusion is that they adhere to Principles B and C and they have no difficulty with the pragmatic knowledge or computing the pragmatic knowledge necessary for implementation of these principles.

1. Introduction

Autism Spectrum Disorder (ASD) is a lifelong developmental disorder characterized by difficulties with language and communication (American Psychiatric Association, 2000). The spectrum is associated with a range of language abilities with little functional communication at one end to relatively well-developed language skills at the other. Despite this range in language abilities, all individuals diagnosed with autism share impairments in everyday language skills and pragmatics. Less is known about grammatical knowledge. Some researchers have argued that grammatical knowledge is simply delayed in nature in autism (Fein & Waterhouse, 1979; Lord & Paul, 1997; Tager-Flusberg, 1981) while others have found deficits in the grammar (Pierce & Bartolucci, 1977; Bartolucci, Pierce & Streiner, 1980; Perovic et al., 2013a; 2013b). This paper builds on the investigations of Perovic et al. (2013a; 2013b) whose experiments argue for a grammatical deficit. The Perovic et al. experiment investigates the assignment of reference within sentences for reflexives and pronouns in children with autism, ones like *Bart's dad washed himself/him*. Our study investigates children's grammatical development using similar sentences with pronouns; ones like *John washed him with a cloth*, but adding additional sentences containing pronouns and names, like *He washed Spiderman with a sponge*. Our study investigated whether children with autism interpret these sentences in the same way as typically-developing children.

The studies by Perovic, Modyanova and Wexler (2013a; 2013b) investigate assignment of reference within the theory of Universal Grammar (UG) (Chomsky 1981; 1986). UG contains linguistic principles, among them, principles that constrain interpretation of reflexives, pronouns and names. These principles, Principles A, B and C are known as 'binding' principles. It is of interest to investigate whether children know the effect of these principles, or 'constraints' on the grammar because they are negative statements. The binding principles state what relationships between noun phrases in a sentence are <u>not</u> permitted.

Because the binding principles rule out certain relationships between noun phrases, sentences with these prohibited relationships do not appear in the parental input. If the knowledge that certain relationships between noun phrases are disallowed is part of UG and it guides children's acquisition, no problem arises. But, given that there is no appropriate input that informs language learners of the constraints, or of the sentence forms and meanings ruled out by the constraints, the facts are a challenge for usage-based theories (e.g. Tomasello, 2006). How would language learners come to know these facts? Research shows that such corrective feedback is not available at the right time and in sufficient quantity to promote learning of negative constraints (Crain, 1991; Crain & Pietroski, 2002). For these reasons, children's acquisition of constraints and binding principles in particular, is of considerable interest to child language researchers, and of special interest in children with autism, where facilitation of language learning may not be optimal.

According to the findings of Perovic et al. (2013b), the principle of grammar that regulates assignment of reference for reflexive pronouns like *himself* or *herself* known as Principle A may be either incomplete or absent for a group of children with autism. This contrasts with the principle responsible for assignment of reference of pronouns, Principle B, which shows the same delayed pattern of development as a control group of typically-developing children. For reference assignment in simple sentences like *John washed him*, typically-developing children have been found to allow the pronoun *him* to refer to *John*, until they are about 4 to 5 years of age (Chien & Wexler, 1990; McDaniel & Maxfield. 1992; Thornton & Wexler, 1999). That is, unlike adults, they allow such sentences to mean that 'John washed himself'. This delay is thought to be due to a delay in acquiring the relevant pragmatic knowledge (Chien & Wexler, 1990; Grodzinsky & Reinhart, 1993). Given the well-known deficits in pragmatics in ASD, Perovic et al. (2013a; 2013b) anticipated that the delay

would be exaggerated in children with autism, but this did not turn out to be the case. The delay was comparable to that observed in typically-developing children.

The study presented in this paper continues the investigation into children's interpretation of pronouns. Like Perovic et al. (2013a; 2013b), we investigate sentences that are regulated by Principle B (such as *John washed him with water*) but we compare these with sentences in which there is a pronoun in subject position of the sentence and a name in object position, such as *He washed Spiderman with a sponge*. The interpretation of this kind of sentence is constrained by a third principle named Principle C. Principle C prohibits the name *Spiderman* from referring to the previous pronoun *he*, which is why intuitively, we take the person designated by *he* to be someone other than *Spiderman*. Sentences like *He washed Spiderman with a sponge* that are regulated by Principle C are anticipated by some researchers to also show a delay in adult-like interpretation for children, like sentences with Principle B (cf. Chien & Wexler, 1990; Grodzinsky & Reinhart, 1993; see Reinhart, 1976). This is because both of these binding principles share a pragmatic component and it is this pragmatic component that is reported to be delayed for Principle B. However, a number of experiments with typically-developing children investigating Principle C have shown an asymmetry between Principles B and C, with only sentences governed by Principle B (like *John washed him*) showing the delay (e.g. Thornton & Wexler, 1999). According to Grodzinsky & Reinhart (1993) and Reinhart (2011), this asymmetry may be due to directionality[20] factors. Thus, in principle, the two kinds of sentences have a pragmatic component that may be delayed, but in practice, the delay only surfaces for the Principle B sentences.

While Perovic et al. compared children's performance on reflexives and pronouns (Principle A versus Principle B), the current study compares children's performance on

[20] Directionality is understood in terms of the position of pronouns that may either appear in the object or subject position of sentences. Thornton &Wexler explain it as the "the crucial difference between sentences subject to principle B and those subject to principle C is the obvious one: In the former, the pronoun is in object position, and in the latter, the pronoun is in subject position" (Thornton &Wexler, 1999 p. 106).

pronouns versus names (Principle B versus Principle C). This allows us to reinforce previous results by Perovic et al. (2013a, 2013b), but also to address some further questions.

The first question is whether or not children with autism show the same asymmetry between Principles B and C found in typically-developing children. That is, do children with autism, like typically-developing children, permit non-adult coreference for *John washed him with water* but adult-like interpretation of sentences like *He washed Spiderman with a sponge*? This investigation will give us further insight into the nature of a pragmatic deficit in autism. The second issue we take up concerns c-command, the hierarchical relationship between noun phrases that is at the heart of all three principles of the binding theory, Principles A, B and C (Chomsky, 1981). According to Perovic et al., c-command is not active in children with autism for sentences with reflexives (like *John washed himself*). We will explore whether c-command underpins Principles B and C in these children's grammars.

2. Background

2.1. Grammatical Knowledge in Autism

Studies of language conducted to date show that children with autism have problems with morphosyntax as compared to their typically developing peers matched for age, verbal and non verbal abilities. Basically the deficits are significant for omitting the third person singular *–s* (Roberts, Rice & Tager-Flusberg, 2004) and progressive aspect *–ing* (Eigsti & Bennetto, 2009). Elicited productions of past tense *-ed* is another area of concern (Bartolucci and Alberts, 1974). There are few studies on the comprehension of complex syntactic structures in the literature. However investigations of grammar in autism traditionally involve the study of spontaneous speech and scores on standardized tests of language abilities. Although valuable, these studies are limited in providing a reliable picture of the grammatical competence of children with autism, and cannot investigate adherence to constraints like the binding

principles. Recently, it has been suggested that later-developing structures such as passives (e.g. *the ball was kicked by John*) may be impaired (Perovic, Modyanova, Hanson, Nelson, & Wexler, 2007; Tager-Flusberg, 1981). Another area of weakness is reported for raising structures like *Sam seems to Janet to be riding a bicycle* (Perovic et al., 2007). Understanding these sentences correctly involves moving the subject 'Sam' from the subject position in the embedded clause to the subject position of the main clause. This sort of movement is found to be problematic in autism. There are also reports that relative clauses are impaired in autism (English: Riches, Loucas, Charman, Simonoff, & Baird, 2010 and French: Durrleman, Hippolyte, Zufferey, Iglesias & Hadjikhani, in press).

As a background to our study investigating comprehension of pronouns in sentences, it is worth noting that people diagnosed with autism are reported to have problems in identifying the orientation of others, or in other words correctly working out the listener versus the speaker stance (Hobson, 1990; 1993). This affects use and interpretation of pronouns which varies, depending upon identifying the shifting roles of the listener and/or speaker. As a consequence, young children on the spectrum make pronoun reversal errors, using 'you' to refer to themselves and 'I' to refer to others. Typically developing children make these errors too but these fade by approximately 2;5 years of age (Evans & Demuth, 2012). On the other hand children with autism continue to make these errors in line with their reported deficits on identifying shifting roles for speakers and listeners.

Individuals with autism also struggle with third person pronouns like 'he', 'him', 'his' etc. They have been found to use more ambiguous pronouns or pronouns without any clear referent in a story telling task (Novogrodsky, 2013), which has been linked to an inability to take their listener's perspective into account for the purpose of narrating a coherent story (Ariel, 2001). This difficulty extends to adults with autism. For example, Colle, Baron-Cohen, Wheelwright and van der Lely (2008) showed that in a story telling task, adults with ASD

produced ambiguous pronouns for characters except the main character. For this reason, appropriate use of third person pronouns in narratives has been used as an indicator of pragmatic development and inappropriate use is understood as deficits in pragmatic functioning (Hamann, 2011). Other studies examining the use of third person pronouns in a story context also noted inappropriate use by children on the spectrum. Arnold, Bennetto & Diehl (2009) tested children aged 9 to 17 years and reported that young children with autism used fewer pronouns than their older counterparts on a story narration task. The intergroup difference was more pronounced for entities that had been previously mentioned. On the other hand, Tager-Flusberg (1995) tested third person subject pronoun in children aged 10 to 12;1 and compared them with a group of typically-developing children matched on receptive vocabulary. The results showed that children with autism failed to introduce new characters with full noun phrases on a story narration task from a wordless picture book. They tended to use pronouns perhaps as the entity was more accessible in their own minds. The results indicate a lack of sensitivity to the comprehension needs of their listeners. The majority of these studies make clear that both children and adults on the spectrum have some difficulty in using pronouns appropriately in conversational discourse and narratives. Children with autism may have problems with narratives at a general level. Stirling and Barrington (2007) investigated a small corpus of spontaneous written story retellings by a single child with autism that exhibited sophisticated episodic structure but unusually presented the relative knowledge states of story participants and narrator. Other studies have found problems with narratives of personal experience (Losh & Capps, 2003).

Drawing on comments by Schaeffer (2003) that there are different kinds of pragmatic knowledge, Perovic et al. note that the term ‘pragmatics’ is used in many different ways with implications for research on pragmatics in autism. “The pragmatics that relates to social rules may be differentially affected in children than the pragmatics that relates more directly to

language, the pragmatics, for example, that is part of the governing conditions for reference" (Perovic et al. 2013b, p. 149). As we have seen from Perovic et al.'s experimental findings, children with autism respond in the same way as typically-developing children to sentences like *John washed him with a sponge*, allowing coreference between *him* and *John* for some period of time before mastering the adult conditions on coreference. So Perovic et al. conclude that if this is 'linguistic pragmatics,' then there does not seem to be a deficit. Our experiment will investigate whether children with autism treat sentences governed by Principle C also in the same way as typically-developing children. If so, this would be further confirmation that 'linguistic pragmatics' or processing of rules of 'linguistic pragmatics' is not affected in this group of children.

The next section outlines the sentence types that will be tested in this study, the linguistic principles that constrain their interpretation, and previous experimental findings from studies with typically-developing children.

2.2. Binding principles and typical acquisition

Pronouns can be challenging to interpret because they do not signify an individual entity directly as compared to names e.g. 'Sam', 'Pat' etc. Furthermore, in some sentences, they can have two potential referents, while in others, there is no ambiguity, and only one referent is possible. In (1), for example, the pronoun is ambiguous; the pronoun *him* can refer to Spiderman, but it could also refer to some male referent not mentioned in the sentence. Crucially, it cannot refer to 'John', the other name in the sentence. On the other hand, in (2), the pronoun *him* has only one possible referent. It cannot refer to the noun phrase 'John' that is mentioned in the sentence and can only refer to a male who has presumably already been introduced in the context. Likewise, in (3) the pronoun *he* has two potential referents, Spiderman or a male in the context, while in (4), the pronoun can only refer to the male in the

context, and Spiderman is not a potential referent. This is a complex set of facts for children to acquire. Our investigation asks whether or not children with autism know that in sentences like (2) and (4) the interpretation of the pronoun is restricted? Do children know that there is no ambiguity and there is only one potential referent?

(1) Spiderman said John washed him with a sponge

(2) John washed him with a sponge

(3) Spiderman said he washed John with a sponge

(4) He washed Spiderman with a sponge

Next we introduce the principles of UG that are claimed to constrain our interpretations of such sentences. Our focus is on Principles B and C, but since Perovic et al. (2013a; 2013b) claim that c-command may be missing as it relates to Principle A, we will briefly introduce Principle A, and the study that motivates this claim.

2.2.1. Principle A

Principle A requires that reflexives like *himself* and *herself* find an antecedent in the same clause[21]. The antecedent must be in a particular structural relationship with the reflexive in the hierarchical sentence structure; it must 'c-command' the reflexive, and it must also be coindexed with it. The mechanism of coindexation shows the anaphoric link between the two noun phrases (NPs), and is only possible if they match in gender, number and so on.

The hierarchical relationship of 'c-command' (refer to Figure 1a and 1b) exemplified in a sentence like *John washed himself with a sponge*, shows that 'John' is an appropriate antecedent because the node dominating the antecedent *John* also dominates (is higher than) the reflexive in the structure, and therefore c-commands it. That is, the first branching node

[21] The antecedent also has to be the correct gender and singular or plural as appropriate, but this is not important here.

above the potential antecedent *John*, the TP, also dominates the reflexive, *himself*. As a general rule, a node dominates another node if one can run down the backbone of the tree and get to the dominated node. This is the case, and therefore *John* is a legitimate antecedent for the reflexive, *himself*. In the sentence *John's father washed himself with a sponge*, however, *John* is no longer a potential antecedent, because it is not in a position where it c-commands the reflexive. This is illustrated in Figure 1b. The category Determiner Phrase, or DP is like a large noun phrase and allows the possessive,'s' to be represented. The category labels are not important for our purposes. It can be seen that the first branching node above *John* is the DP node *John's father*. This node does not dominate the reflexive; it is too low in the subject noun phrase. Therefore although *John* and *himself* are coindexed in Figure 1b, because *John* does not c-command the reflexive, Principle A is violated.

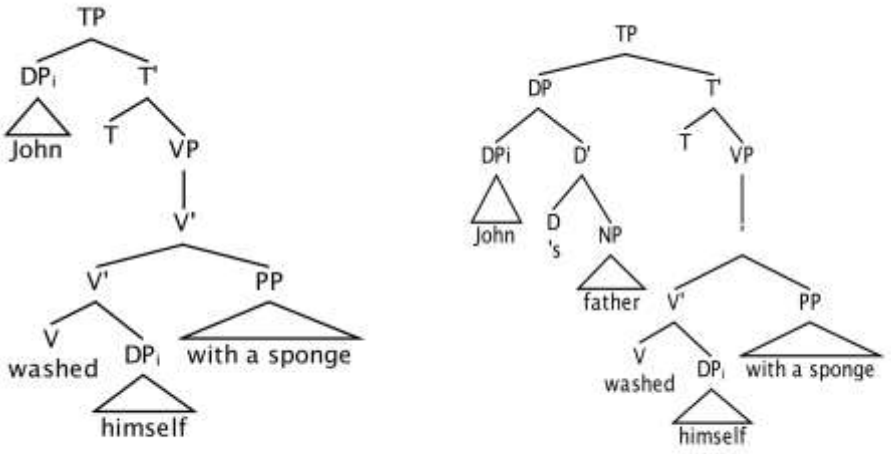

Figure 1 (a and b) Structures exemplifying c-commanding and non c-commanding relations between antecedents and reflexives

Experimental findings have shown that Principle A is in place early in development. In typically-developing children Principle A is shown to be in place by age 4 (Chien & Wexler, 1990). Children are sensitive to the c-command aspect for referent assignment to work

properly for reflexives by 5;6 (Wexler & Chien, 1985). The tool for this classic investigation was a picture identification task with structures that contained reflexives. For example consider a sentence like *Cinderella's sister points to herself*. Sentences like these were paired with two pictures where one picture depicted Cinderella pointing to her own self and the other picture depicted the sister pointing at her own self. The children had to choose the correct picture for the presented sentence. Wexler and Chien showed that children older than 6 years were 90% right in choosing the correct referent for the reflexive. They further tested children's sensitivity to c-command in sentences like, *The sister of Cinderella points to herself*. They reasoned that if children were relying on c-command then the correct referent of reflexive (*the sister*) would be chosen in this case whereas if children were just following a linear order strategy, the incorrect referent (*Cinderella*) would be chosen. Children older than 5;6 were more than 80% correct in their responses. These aspects as investigated in typically-developing children are often considered as the litmus test for grammatical deficit.

In populations characterized by syntactic deficits like Down Syndrome (Perovic, 2001) and low functioning children with autism (Perovic et al., 2013a), comprehension of reflexives is shown to be a problem. As mentioned before, Perovic, Modyanova and Wexler (2013a) examined the comprehension of reflexives in 14 children with autism aged 6;6-17 years. They used a picture selection task adapted from Wexler and Chien (1985). The task of the children was to choose the correct picture matching a test sentence. For instance a test sentence, *Bart's dad is washing himself* was paired with two pictorial scenarios one showing Bart's dad washing the child and the other showing Dad washing his own self with the child just standing. The children with autism showed problems in choosing the correct picture for the reflexives, which as noted, they interpret as a difficulty with the c-command part of Principle A.

2.2.2. Principle B

Principle B requires that a pronoun cannot have an antecedent in the same clause that c-commands it and is coindexed with it. Put another way, the pronoun cannot be 'bound' by its antecedent. This principle governs sentences like *John washed him with a sponge*, as in Figure 2. In this sentence, the pronoun has an antecedent in the same clause that c-commands it and if we assume that the person who washed *him* is 'John', then we can assume that the two noun phrases are coindexed. This binding configuration is shown in Figure 2. Figure 2 shows a violation of Principle B because the pronoun is bound by its antecedent in the same clause. Therefore, the referent of 'him' must be found outside the sentence and this sentence cannot mean that 'John washed himself with a sponge'.

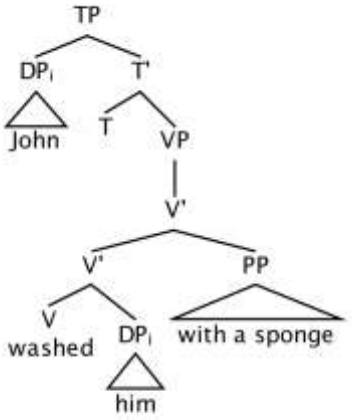

Figure 2: Exemplification of Principle B

In order to explain why sentences like *John washed him with a sponge* are claimed to draw on a pragmatic component that is delayed, it is necessary to touch on the difference between the terms 'binding' and 'coreference'. Binding occurs when a c-commanded pronoun or reflexive is a variable. The intuition is clearer if illustrated with a quantificational noun phrase. In the sentence *Every superhero washed his face with a sponge*, the pronoun (a possessive pronoun in this case) does not refer to a particular individual's face; rather we

understand the relationship to be one between various superheroes and their faces. So, *his* is a variable, and because it is c-commanded by its antecedent, it is termed a 'bound' pronoun. A pronoun that is a bound pronoun is always c-commanded by its antecedent and coindexed with it. The pronoun in Figure 2 is a bound pronoun.

Pronouns are not always bound variables, however. In certain cases, they have a different use, and take on direct reference. This is when there is 'coreference' between a pronoun and the antecedent. In these cases, it looks like there is a violation of Principle B, but it can be argued that these cases have an alternative grammatical representation, and the pronoun is not a bound pronoun. The pronoun may or may not be c-commanded by its antecedent, and there is no use of indices for coreference. An example that is given in Reinhart (2011) illustrating a legitimate case of coreference is given in (5).

(5) Despite the big fuss about Felix's candidacy, when we counted the votes, we found out that, in fact, only *Felix* voted for *him*.

In cases like (5), the pronoun almost unexpectedly refers back to *Felix*. In such cases, the pronoun may also receive heavy stress, and sometimes may be accompanied by deixis. Such uses of coreference clearly depend heavily on the context, and for this reason, these kinds of uses are claimed to be regulated by pragmatic principles. The pragmatic principle that regulates pragmatic coreference is called Principle P by Chien and Wexler (1990) and Rule I by Grodzinsky and Reinhart (1993).

How are the two options of binding and coreference implemented when children (and adults) hear sentences in discourse? Reinhart (2011) suggests that hearers first apply binding, and see whether it outputs a legitimate interpretation. So, in the case of *John washed him with a sponge* shown in Figure 2, children would apply Principle B, and find that the representation with syntactic binding violates Principle B. So next they would see whether coreference yields

a legitimate representation by applying Rule I. Rule I requires speakers to compare the two different sentence representations, the binding one, and the coreference one, to see if they are distinguishable. If these are distinguishable, coreference is permitted. Adults would come to the conclusion that the two representations are not distinguishable, and therefore that coreference is not permitted for *John washed him with a sponge*, but they would sanction coreference for (5), for example. However, Grodzinsky & Reinhart (1993) and Reinhart (2011) argue that children do not have the processing capacity to do the comparison of the two representations. For this reason, children end up guessing, and this is why they sometimes allow sentences like *John washed him with a sponge* to mean 'John washed himself with a sponge'. In sum, children do not violate the syntactic constraint, Principle B. Rather, they do not have the computational power to know when coreference is permitted, via computation of Rule I. Children's erroneous acceptance of coreference in sentences like *John washed him with a sponge* is called the Delay of Principle B Effect (DPBE), though the name is rather misleading, given that it is the Rule I and not Principle B that is delayed. However, we will use DPBE since this is the established term in the literature.

Acquisition studies show that children obey Principle B after the age of 6 (Chien & Wexler, 1990; Jakubowicz, 1984). The effect has been replicated in a number of different studies, sometimes showing earlier mastery, depending on the methodology (Thornton, 1990; Boster, 1991; Avrutin & Thornton, 1994; Thornton & Wexler, 1999). The same study by Perovic, Modyanova and Wexler (2013a) tested comprehension of pronouns in autism. The autism group showed DPBE similar to two groups of typically-developing children matched on non verbal IQ and receptive grammar. The typically-developing children were much younger, ranging from about 3 to 9 years of age. The authors concluded that the autistic children's performance was due to a delay in acquisition of the pragmatic rule. Although the autistic

children were older than the typically-developing children, the rate of the acceptance of coreference was not out of line with these control groups.

2.2.3. Principle C

Principle C applies to sentences like *He washed Spiderman with a sponge* in (4) above. Principle C states that a name cannot have the same reference as a pronoun that it is c-commanded and coindexed with[22]. The constraint has the effect of forcing the pronoun and the name to refer to different individuals that is to be 'disjoint' in reference. This means that a sentence like *He washed Spiderman with a sponge* must mean someone other than 'Spiderman', who is salient in the context, washed 'Spiderman'. The representation that violates Principle C is shown in Figure 3.

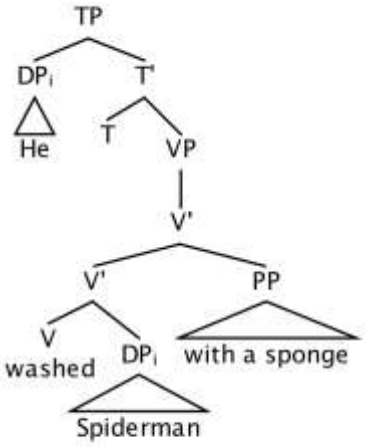

Figure 3: Exemplification of Principle C

According to Chien and Wexler (1990) and Grodzinsky and Reinhart (1993), sentences like *He washed Spiderman with a sponge* could also have a coreference representation that is

[22] Again to remind the reader, c-command is a hierarchical relation in a phrase structure tree while coindexation refers to a match between a pronoun and a noun (e.g. *he* for *Sam* or *they* for *children*) based on gender, number and so on.

regulated by pragmatics in addition to the one that is regulated by the binding Principle C. If so, the expectation would be that just as with sentences like *John washed him with a sponge*, children sometimes fail to apply the pragmatic rule correctly and allow a coreferential interpretation, that is, one on which *he* and *Spiderman* corefer. On this coreferential interpretation, the sentence would mean that 'Spiderman washed himself' with a sponge. Although the expectation is that children would have difficulty applying Rule I, Grodzinsky and Reinhart (1993) and Reinhart (2011) argue that there is an independent factor which is at stake that disables the application of the pragmatic rule in this case. They suggest that it may be directionality, namely the fact that the pronoun precedes the name, or it may be because the pronoun is in subject position – either way, this is not clear yet and further research is warranted (see Reinhart, 2011). It is worth pointing out, however, that in our experiment, a target sentence in the experiment such as *He washed Spiderman with a sponge* is never presented out of the blue without any preceding discourse.

Whatever the exact reason for the fact that the pragmatic rule is disabled, child language studies have not found that children give non-adult judgments for sentences like *He washed Spiderman with a sponge*. Rather, starting with Crain and McKee (1985), it has been shown that children give robust judgments implying that disjoint reference must be enforced in such sentences (see Conroy & Thornton, 2005; Crain & Thornton, 1998, Eisele & Lust, 1996). This can be shown as early as 30 months of age (Lukyanenko, Conroy & Lidz, 2014) with a preferential looking task.

In a classic study conducted by Crain and McKee (1986), children as young as 3-4 years of age were shown to obey Principle C sentences. In their experiment 62 English speaking children with a mean age of 4;2 years were tested. They had two groups of sentences like (6) and (7) & (8) and (9). Crain and McKee were interested in testing whether children would allow a name to refer to a preceding pronoun (that is allow 'backwards anaphora' in

cases when Principle C is not in effect). In (6) and (7), Principle C does not apply because the pronoun that precedes the name is in an embedded clause, and therefore does not c-command it. In (8) and (9) on the other hand, the pronoun in subject position c-commands the name and Principle C applies, ruling out the interpretation shown.

(6) When he$_{i/j}$ stole the chickens, the lion$_{i}$ was in the box.

(7) When she$_{i/j}$ was outside playing, Strawberry Shortcake$_{i}$ ate an ice cream cone.

(8) *He$_{i}$ washed Luke Skywalker$_{i}$.

(9) *He$_{i}$ ate the hamburger when the Smurf$_{i}$ was in the fence.

Children accepted 6 and 7 for either a disjoint interpretation (81% of the time) or a coreferent interpretation (73% of the time). At the same time, children rejected sentences 8 and 9, 88% of the time showing respect for Principle C in their grammars. Crain and McKee concluded that English-speaking children process backward anaphora in an adult like manner.

2.3. Summary and Predictions

The child language research for typically-developing children has shown that there is an asymmetry in children's responses to Principle B and C sentences. For sentences like *John washed him with a sponge* that are subject to the syntactic binding principle, Principle B there is also the possibility of coreference. Coreference is regulated by a pragmatic principle that is not accessible by young children, or causes a computational burden. Given this, children's judgments of coreference in sentences like *John washed him with a sponge* fluctuate, and children often accept a coreferential interpretation. Perovic et al. (2013a; 2013b) have found this result also for children with autism, though to no greater extent than for typically-developing children. We expect a similar result for such sentences.

Our experiment compares Principle B sentences with ones subject to Principle C, ones like *He washed Spiderman with a sponge*. To date, interpretations of such sentences have not been investigated in children with autism. As noted, according to Grodzinsky and Reinhart (1993) and Reinhart (2011), the pragmatic principle is disabled in these particular sentences, perhaps due to directionality factors. Therefore, if children with autism behave like typically-developing children, then we expect robust rejections of a coreference interpretation for Principle C sentences. In brief, we expect a Principle B/C asymmetry. However, there is one caveat. Grodzinsky and Reinhart (1993) and Reinhart (2011) argue that the asymmetry occurs due to an independent factor, perhaps directionality. If this independent factor were not in place in children with autism, then we could see a delay in Principle C in children with autism. In this case, the prediction would be that children would accept the coreference interpretation of sentences like *He washed Spiderman with a sponge*, essentially allowing it to mean that 'Spiderman washed himself with a sponge'.

3. The Experiment

The experiment is divided into two parts: Part A tests children's knowledge of Principle C and Part B tests children's knowledge of Principle B in sentence structures as described above.

3.1. Part A: Test of Principle C

3.1.1. Methods

3.1.1.1. Participants

10 children on the autism spectrum were tested on TVJT, assessing knowledge of Principle C. Their age ranged from 5;4-12;7 years, M = 10.5. The sample had 9 boys and 1 girl. Children clinically diagnosed with autism were recruited from special schools across Sydney and Melbourne. Children from Sydney were recruited from Macquarie University Special Education Centre (MUSEC), children from Melbourne were recruited from Northern School of

Autism (NSA), Preston campus and children were also recruited from advertisements placed on Autism Spectrum Australia (ASPECT) website. Typically-developing children for the comparison group were recruited from general advertisements across Macquarie University, Sydney. Only children for whom the first language was English were recruited in both the experimental and control groups. In addition, 10 adults were also tested in order to ensure the viability of the tasks. They were recruited from general advertisements across Macquarie University.

The autism group was tested on standardized tests of language and cognition. These tests included the matrices part of Kaufman Brief Test of Intelligence (KBIT) measuring non verbal IQ and Test for Reception of Grammar Second Edition (TROG-2). The mean of the standard score (SS) of KBIT was 98.6 and the mean of SS for TROG was 86.1. In addition the participants were classified as those with concomitant language impairment (ALI) along the lines as suggested by Perovic et al. (2013b) based on their scores on TROG. Participants in their study were categorized as ALI if they scored below the 10^{th} percentile on two of the three language measures (Whitehouse, Barry & Bishop, 2008). Our study only had one language measure but we categorized a child as ALI if he/she scored below the 10^{th} percentile on TROG as it importantly tests for Reception of Grammar. As a result only 3 participants from the sample of 10 were classified as ALI.

Based on the scores of the KBIT, the autism group can be described as high-functioning as majority of children had a standard score of more than 80 (Norbury, 2005; Howlin, 2003). Therefore, a group of typically developing children were matched to the children with autism within 2 points of KBIT raw scores. The age of matched comparison group ranged from 6;2-9;3, M = 7.5. Their mean of the standard score (SS) of KBIT was 114.8. Refer to Table 1 for the scores.

Table 1: Participants' ages and mean scores (standard deviations) on standardized tests of language and cognition.

	Autism (n = 10)	**Typical (n = 10)**
Mean Chronological Age in Years (SD)	10;5 (2;1)	7;5 (0;9)
Range	5;4-12;7	6;2-9;3
KBIT Matrices Standard Scores (SD)	98.6 (13.63)	114.8 (14.14)
Range	83-121	91-146
KBIT Matrices Raw Scores (SD)	28.6 (4.92)	28.1 (14.14)
Range	20-37	20-36
TROG 2 Raw Scores (SD)	12.3 (4.35)	-
Range	4-17	-
TROG 2 Standard Scores (SD)	86.1 (15.19101)	-
Range	55-104	-

3.1.1.2. Procedure

Each child was tested individually either in a quiet corner of a room at one of the above schools or at Language Acquisition Lab at Macquarie University. The testing session with each child lasted for approximately 1.5 hours. If the child had difficulty paying attention, the session was split into two parts.

Children were assessed for Principle C on a dynamic version of the TVJT. The task involves two experimenters; one experimenter manipulates toys and props and tells a story. The other experimenter plays the role of a puppet and at the end of the story, tries to say what happened. This is the presentation of the test sentence to the child. The task of the child is to judge whether the sentence delivered by the puppet is true or false in the context, that is, matches the story acted out by the first experimenter or not. The stories and critical questions were videotaped with two native English speakers and presented on a mini iPad[23] handled by just one experimenter. Principle C and Principle B stories were presented randomly to all participants.

[23] An IPad was used to engage the special population of children with autism due to anecdotal evidence for the strength of the visual modality (Quill, 1997). It also ensured that the sentences were presented by native speakers of English, who recorded the stories.

The presentation of the stories was random for each child. Stories were saved as separate clips on the iPad and the clips were then opened in no specified order by the experimenter for presentation to the child. All participants were instructed to watch short stories carefully and later evaluate whether the puppet was right or wrong. If the puppet was wrong, children were further asked why they thought that the puppet was wrong. The experimental items were preceded by two practice items. The experimenter then proceeded to the main task. Children's judgments of the test sentence were scored as 'Yes' (true) or 'No' (false). Percentages of correct rejections for particular items were calculated for each child. All the verbal responses of children were recorded on a small digital recorder for later analysis.

3.1.1.3. Stimuli

The target sentences for Part A included test sentences with pronouns in the subject position like *He washed Spiderman with water*. The sentences were formulated so as to make them similar to the test sentences used by Perovic and colleagues but with one modification. The modification included the addition of a Prepositional Phrase such as *with water* sentence-finally, to make the sentence seem more natural in a story context. There were 4 test sentences and four stories in total. The correct response was always a rejection of the test sentence spoken by the puppet, assessing the knowledge of Principle C. See Appendix 1 for a complete list of Principle C sentences.

In order to balance 'yes' and 'no' responses obtained from the children, children were presented with another test sentence for which the correct response was a 'yes' based on the events of the story, after they correctly rejected incorrect Principle C sentences. Children were further requested to give reasons after each rejection in order to ensure they rejected for correct reasons rather than lack of attention. In case the children accepted the Principle C sentences,

they were presented with another test sentence for which the correct response was a ‘no’ based on the events of the story.

To illustrate how the TVJT was adapted to test children, we will take an example from one of the test stories.

(10) “He washed Spiderman with water”

Meaning 1: *Spiderman washed himself with water

Meaning 2: Someone else washed Spiderman with water

Our experimental hypothesis is that all children including children with autism have Principle C as a constraint that is part of their innate linguistic knowledge. If that is the case, their grammars will not allow Meaning 1. The null hypothesis is that children lack the Principle C constraint. If that turns out to be the case then children should find (10) ambiguous; they would sometimes allow Meaning 1 and other times Meaning 2. In order to avoid Type 1 errors, the interpretation that favours the null hypothesis is set up as the interpretation aligned with a ‘yes’ response. To demonstrate knowledge of Principle C, children must say ‘no’. Both Meaning 1 and Meaning 2 are made available in the story. Consider the sample story in (11):

(11) A Sample Principle C Story

> Spiderman is wanted at a lake to save a kid from a wild crocodile. Since he is brave and helpful he agrees to help the kid and tells his friend Elmo about it. He asks Elmo whether he wants to come along but Elmo says that he needs to stay back to bake some cookies. Spiderman gets to the lake to

save the child and makes the crocodile run away. The mother and the child say thank you to Spiderman and Spiderman comes back to his friend Elmo. Elmo listens to the story and asks him how he got so dirty. Spiderman says because he was at the lake and asks for help to be washed. Elmo agrees to help and gets a bucket of water and a washcloth. Elmo then gets hungry and decides to eat a cookie. He says to Spiderman "Sorry, Spiderman. I'd like to help you get washed, but my stomach is rumbling and I need to go and have a snack." So Spiderman lifted the bucket of water, poured it over his head and used the washcloth like this <Spiderman washes himself>.

Kermit: Now that was a good story about Elmo and Spiderman. Spiderman saved people and came back dirty. And I know one thing that happened.

Test Sentence: "He washed Spiderman with water"

If children said "NO" then Kermit said 'A' if children said YES then Kermit said 'B'

"Let me try to say something else about the story"

A) "Spiderman went to save the kid"

B) "Elmo went to save people"

If the children understand the test sentence to mean that Spiderman washed himself then they would say "yes" to the test sentence as this is the actual outcome. If Principle C is in place, the children will understand the test sentence to mean that someone else washed Spiderman then they would say "no" to the test sentence. In order to balance the yes/no responses from children, we offered them another sentence that was true or false based on the events of the story. It is worth pointing out again that the reading or meaning ruled out by Principle C is an accurate description of the events of the story where Spiderman did wash himself in the end. The meaning where someone else (e.g. Elmo) washed Spiderman was under consideration in part of the story but it is not an actual outcome of the story.

There are three more important ingredients that deserve a mention for the sake of good experimental design. The design should satisfy the condition of falsification where the story context should make the negation of the test sentence a true description of the events transpiring in the story. In order to achieve this, a salient character is added to serve as a possible referent of the pronoun 'he', which is Elmo in this case. The design should also satisfy the condition of Plausible Dissent (Crain and Thornton, 1998). The story should be designed as such that the context does not lead children to perform erroneously due to the demands of the testing situation. For instance, if the Elmo never considered washing Spiderman, then this would violate the condition of Plausible Dissent because the proposition that turns out to be false would not have been under consideration. Finally it is important to remind the children about the final events of the story by situating the characters in a way that reminds them about what happened in the end taking care that the event corresponding to meaning '1' is acted out towards the end (refer to picture 1).

Picture 1: Final events of the Spiderman Story

This helps in two ways. First, if children do not have Principle C in place then the recency of the event should make the children say “yes”. On the other hand, if children go out of their way to say “no” then this is compelling evidence to show that children do not entertain meaning ‘1’. This strategy could be very important in testing children with autism who have been argued to show problems with complex reasoning (e.g. Ozonoff, Pennington, & Rogers, 1991). If these children go out of their way to say “no” then we can be confident of accepting our experimental hypothesis as opposed to null hypothesis.

Another manner in which our experimental set up meets the criterion of a stringent design is by the way of introducing a linguistic antecedent in such a manner that should not be

biased towards meaning '2'. This is achieved by the way of Kermit uttering the final lines where the focus is brought back on Spiderman.

3.1.1.4. Results

The main finding was that both the children with autism and the typically-developing control group all performed extremely well on the task. The data from the adult group showed that English-speaking adults correctly rejected the test sentences 100% of the time. The mean percentage of correct responses or correct rejections[24] for typically-developing children was 92.5% whereas for children with autism the mean percentage of correct rejections was 77.5%. Refer to Table 2 for group results and Appendix 2 for percentage of correct responses calculated for each child and averaged across all the four stories.

Table 2: Percentage of Correct Rejections (Group Mean) for ASD and Typical Controls for Principle C

Sentence Types	**ASD** (n = 10)	**Typical Control** (n = 10)	**Group Difference**
Principle C	77.5%	92.5%	Not Significant

A Mann-Whitney Test was used to compare the patterns of responses by children with autism and typically-developing children. The typically-developing children performed better than the autism group but the group difference was not significant ($Z = 1.4363$, $p = 0.14$). When children were asked why they rejected the test items, all the children from both groups gave correct justifying responses. For instance consider (10) where children's stated reason for rejecting it was that *Spiderman washed his own self or himself with water*.

It is important to state the results from our three ALI participants. The mean percentage of correct rejections for the non ALI or autism with no language impairment group was 78.57% while for the ALI group it was 75%. The figures show that the performance of the two groups is not likely to differ. Refer to Table 3 for individual scores from the ALI group on TROG and their performance on Principle C test sentences.

Table 3: Categorization of Children as ALI and their Performance Scores on Principle C

ASD Children	Percentile (TROG)	Age	Principle C (% Correct Rejections)
Participant 6	<1	12;0	75%
Participant 7	7	11;0	100%
Participant 9	4	11;9	50%

As is evident from the table, the ALI participants were not at chance performance as a group for the knowledge of Principle C. Only Participant 9 showed chance performance of 50%. At the same time results from the non ALI participants showed that Participants 2 and 10 also showed chance performance while none of the matched typically-developing children had a chance performance score.

3.2. Part B: Test of Principle B

3.2.1. Methods

3.2.1.1. Participants

The same 10 children on the autism spectrum and the matched typically-developing children who participated in Principle C were tested on Principle B too. The same 10 adults were also included in order to ensure the viability of the tasks.

3.2.1.2. Procedure

Part B of the experiment also used the dynamic TVJT (Crain & Thornton, 1998). Hence the testing procedure was essentially the same here as described for Principle C except for the stimuli which will be described below.

3.2.1.3. Stimuli

The target sentences for Part B included test sentences with pronouns in the object position like *John washed him with water*. The sentences were again formulated so as to make them similar to the test sentences used by Perovic and colleagues but with the addition of a Prepositional Phrase such as *with water* sentence-finally, to make the sentence seem more

[24] Each 'No' response for Principle C test sentences was scored as correct rejection.

natural in a story context. There were again 4 test sentences and four stories in total. The associated correct response was always a rejection of the test sentence spoken by the puppet, assessing the knowledge of Principle B. See Appendix 3 for a complete list of Principle B sentences.

In order to balance 'yes' and 'no' responses obtained from the children, they were presented with another test sentence for which the correct response was a 'yes' based on the events of the story, after they correctly rejected Principle B sentences. Children were furthermore requested for their reasons for rejecting the test sentences in order to ensure they rejected for correct reasons rather than lack of attention. In case the children accepted the Principle B sentences, they were presented with another test sentence for which the correct response was a 'no' based on the events of the story.

To illustrate how the TVJT was adapted to test children, we will take an example from one of the test stories.

(12) "John washed him with water"

Meaning 1:*John washed himself with water

Meaning 2: John washed someone else with water

Our experimental hypothesis was that all children including children with autism have Principle B as a constraint that is part of their innate linguistic knowledge. If that is the case, their grammars will not allow Meaning 1. The null hypothesis is that children lack the Principle B constraint. If that turns out to be the case then children should find (12) ambiguous; they would sometimes allow Meaning 1 and at other times Meaning 2. In order to avoid Type 1 errors, the interpretation that favours the null hypothesis is set up as the interpretation aligned with a 'yes' response. To demonstrate knowledge of Principle B,

children must say ‘no’. Both Meaning 1 and Meaning 2 should be made available in the story. Consider the sample story in (13):

(13) A Sample Principle B Story

> Mickey Mouse and John wake up in the morning to find their chair broken. Mickey Mouse tells John that he is needed at the sand pit to play with the kids. John says that he should stay back home to fix the chair so Mickey Mouse goes and plays with the kids in the sand pit and all of them have fun while John stays back and fixes the chair with some glue. Mickey Mouse says good bye to the kids and comes back home. He is happy to see the chair fixed. John asks him why is he so dirty. Mickey replies that he was playing with the kids in the sand pit. He asks John for help to be washed. John agrees to help and gets 2 buckets of water and washcloths. But just then John says, “Mickey Mouse, I am afraid I can’t help you because I have glue all over my hands. I need to use this washcloth to get clean. Here you can use this one. Mickey says “OK, thanks. I’ll get this sand off”. Both use water and a washcloth like this. <Both Mickey Mouse and John wash their own selves>
>
> Kermit: Now that was a good story about Mickey Mouse and John. Mickey Mouse got dirty and asked John for help. And I know one thing that happened.
>
> Test Question: “John washed him with water”

If children said "NO" then Kermit said 'A' if children said "YES" then Kermit said 'B'

"Let me try to say something else about the story"

A) "Mickey Mouse went to play with the kids"

B) "John went to play with the kids"

Along the Principle C lines, if children understand the test sentence to mean that "John washed himself" then they would say "yes" to the test sentence. If the children understand the test sentence to mean that "John washed someone else with water" then they would say "no" to the test sentence. In order to balance the yes/no responses from children, we offered them another sentence that was true or false based on the events of the story as shown above in the test story. It is worth pointing out again that the reading or meaning ruled out by Principle B is an accurate description of the events of the story where John did wash himself in the end. The meaning where someone else (e.g. Mickey Mouse) got washed was under consideration in part of the story but it is not an actual outcome of the story. The condition of falsification and plausible dissent are also integrated into the story context along with the other important ingredients as explained before for the Principle C context.

3.2.1.4. Results

The main finding was that both the children with autism and the typically-developing control group all performed extremely well on the task. The English speaking adults correctly rejected the test sentences 100% of the time. Typically-developing children rejected[25] the test sentences 97.5% of the time while the children with autism rejected the test sentences 75% of the time.

[25] Each 'No' response for Principle B test sentences was scored as correct rejection.

Refer to Table 4 for the group results and Appendix 4 for percentage of correct responses calculated for each child and averaged across all the four Principle B stories.

Table 4: Percentage of Correct Rejections (Group Mean) for ASD and Typical Controls for Principle B

Sentence Types	**ASD** (n = 10)	**Typical Control** (n = 10)	**Group Difference**
Principle B	75%	97.5%	Not Significant

A Mann-Whitney Test was used to compare the patterns of responses by children with autism and typically-developing children. Although the typically-developing children performed better than the autism group, the group difference was not significant ($Z = 0.8315$, $p = 0.40$). When children were probed for their correct rejections, all the children from both groups gave correct justifying responses. For instance consider (12), children rejected it by saying that the puppet was wrong as *John washed himself or his own self with water*. Results show that children on the autism spectrum are not likely to differ from their typically-developing peers even for Principle B.

It is helpful to state the results from the same three ALI participants. The mean percentage of correct rejections for the non ALI was 71.43% while for the ALI group it was 83.33%. Refer to Table 5 for individual scores from the ALI group on TROG and their performance on Principle B test sentences.

Table 5: Categorization of Children as ALI and their Performance Scores on Principle B

ASD Children	Percentile (TROG)	Age	Principle B (% Correct Rejections)
Participant 6	<1	12;0	100%
Participant 7	7	11;0	100%
Participant 9	4	11;9	50%

As is evident from the table, the ALI participants were not at chance performance as a group for the knowledge of Principle B. Only Participant 9 showed chance performance of 50%. This same participant gave a chance performance on Principle C. At the same time

results from the non ALI participants showed that Participants 8 and 10 showed 0% performance while none of the matched typically developing children had a chance performance score. Participant 8 is 12 years of age while Participant 10 is 5;4 indicating that the knowledge of Principle B in autism may be delayed in nature.

4. Discussion

The experimental findings revealed that the children on the autism spectrum who participated in our experiment did not show problems with syntactic functioning as others have argued (Pierce & Bartolucci, 1977; Bartolucci, Pierce & Streiner, 1980; Perovic et al., 2013a; 2013b). To the contrary, our participants' performance was not significantly different from the typically-developing children who formed the comparison group. Although the typically-developing children rejected the Principle B and C violations at a greater rate than the children on the autism spectrum, neither group showed any difference in their responses to the items testing Principle B and C. For these groups, then, there was no asymmetry between performance on Principles B and C that is usually reported in the literature (cf. Thornton and Wexler, 1999). At least for the typically-developing children, this is not surprising, given that they were age 6 and over, and the DPBE has normally disappeared by this age. Since both groups largely rejected both kinds of items, the findings also did not indicate any kind of pragmatic delay in either group of children. This suggests that children are responding by adhering to Principles B and C. This in turn suggests that these universal principles are in place in this group of children. Importantly, splitting the participants into ALI and non ALI groups did not hint at the possibility that the group with language impairment is likely to show any syntactic or pragmatic deficits on these principles. We turn to an exploration of these issues next.

4.1. Preserved Pragmatic Functioning in ASD

The 'Delay in Principle B Effect' (DPBE) is well documented in the language acquisition literature, though as noted above, it is really a delay in being able to compute Rule I, at least according to Grodzinsky and Reinhart (1993) and Reinhart (2011). According to these authors, the delay is not seen in experiments testing adherence to Principle C, perhaps due to directionality effects. Our first question, then, is why the delay in pragmatic knowledge or processing is not showing up in our two groups of children. This question is pertinent because Perovic et al. (2013a) showed that autistic children aged 6–16 years had difficulties and showed the DPBE as documented for typically-developing children up till age 6. The authors interpreted this in line with a delayed although normal pattern of language development[26].

The typically-developing children in our study did not show the DPBE, but this is to be expected, given that they were all 6 years or older, and children become adult like around this age. Our autism group was younger (5;4-12;7 years) than the previously studied groups of children by Perovic and colleagues who were between 6 to 18 years of age, so the expectation was that this group would accept the Principle B sentences like *John washed him with water* perhaps at chance. However, this was not the case. In our study, the autism group rejected Principle B sentences at a rate of 75%. Only 1 participant aged 11;9 who was categorized as ALI showed chance performance on Principle B. This same participant evidenced chance level performance on Principle C too. As mentioned before, our sample of ALI is too small to see any consistent patterns. Two non ALI children showed 0% performance on Principle B. Out of these one child was very young (5;4) and hence it may be argued that some very young children may not show adult like performance at this age, the result could be due to age. This is

[26] Since the literature differentiates between coreferential and bound reading, it is important to keep in mind that firm conclusions regarding pragmatic delays can only be deduced when sentences assessing both these readings are tested in the same population. To do this, quantificational antecedents would need to be compared with referential antecedents for the pronoun. Until then it can only be roughly concluded that if children with autism show DPBE, it could be attributed to delays of pragmatic development.

the same child who showed chance performance on Principle C. The second child was 12;0 years of age and appears to be the only case of delayed pragmatic knowledge in this regard.

It is not clear why the children in the autism group in our study did not show a DPBE. One possibility is that our dynamic TVJT methodology was more appropriate to this group than the picture-selection kind of TVJT administered by Perovic et al (2013a; 2013b). This certainly calls for a cross methodology comparison as it has already been shown that pronoun comprehension is affected with the TVJT (see Sanoudaki & Varlokosta, 2015). At any rate, it seems clear that the kind of pragmatic knowledge that is needed to understand these sentences is intact in this group of children. As long as we assume the fractionation of pragmatic knowledge into linguistic pragmatic knowledge and knowledge required by social rules (Schaeffer, 2003), we can safely say that the pragmatic knowledge which is concerned with ruling out illicit co-reference is not disturbed in at least children with high functioning autism.

4.2. Asymmetry between Principle C and B

Recall that Principle C states that a name cannot have the same reference as a pronoun that it is c-commanded and coindexed with. The constraint as a result has the effect of forcing the pronoun and the name to refer to different individuals that is to be 'disjoint' in reference. The results show that children on the autism spectrum are not likely to differ from their typically-developing peers with respect to Principle C constraints. As stated before, according to some theorists (Grodzinsky and Reinhart, 1993 and Reinhart, 2011), the pragmatic principle component of Principle C is disabled in these particular sentences perhaps due to directionality factor as the pronoun is in subject position. As a result, children obey syntactic constraints and perform better on these sentences as opposed to Principle B. Importantly if the directionality factor is not operative in the case of ASD then children with autism will show comparable problems on Principles B and C or at least they are not expected to do as well as the typically-developing children. The current results did not find any asymmetry between Principles B and

C. Furthermore there is no evidence of any deviance on Principle C or in other words there is no 'Delay of Principle C Effect' for children with autism. The children with autism, as a group, rejected these sentences 77.5% of the time. Above chance performance (more than 50% correct rejections) in the autism group suggests that if the pragmatic rule is disabled in these particular sentences due to directionality factors for typically-developing children, it is also disabled for children with autism.

4.3. Preserved Syntactic Functioning in ASD

Our experimental findings have not indicated that there is any kind of 'linguistic pragmatics' delay, and in turn, this suggests that the syntactic principles, Principles B and C are operational in children with autism as well as the typically-developing children. It is important to remember that c-command is an important part of the definition of these principles. There is no suggestion that children are not using the hierarchical relationship of c-command in their computation of these linguistic principles.

4.4. Other Factors

It is worth pointing out that our current sample of autistic children had high non verbal IQ as assessed by KBIT. A better non verbal IQ has been argued to be an important prognostic variable for clinical population in general and for autism in particular (Szatmari, Bartolucci, Bremner, Bond and Rich, 1989). Comparatively, lower functioning children in the spectrum are at a higher risk for language impairment irrespective of intellectual impairment (Kjelgaard & Tager-Flusberg, 2001). Our sample does not distinguish between individuals with higher versus lower functioning as assessed by non verbal IQ in order to establish the generalization of the current findings to lower functioning children. Furthermore, Perovic, Modyanova & Wexler (2013b) showed that children with autism who had concomitant language impairment (ALI) as assessed by standardized tests of language showed insensitivity in establishing referent relations as mediated by syntactic relations of c-command. Results from the current ALI children (n=3) showed that only 1 participant aged 11;9 showed chance performance on

Principle C. Our sample of ALI is too small to speak for any patterns. On the other hand, only one young ALN aged 5;4 showed chance performance on Principle C. In light of the young age, it may be argued that the chance performance may have been the outcome of age. This could be an important future direction in view of the heterogeneous linguistic profiles for children across the autism spectrum.

5. Conclusions

Results of the current experimental investigation on Principles B and C reveal two important issues. The ability to establish syntactic dependencies is not deficient in children with high functioning autism or high non verbal IQ, as they were sensitive to the c-command relation in choosing the correct referent for sentences governed by Principle C. Their pragmatic development also does not lag behind their typically-developing peers as assessed by sentences governed by Principle B. The better performance reported here as compared to previous studies may be, in part, due to the methodology, the Truth Value Judgment Task. The better performance on pragmatic linguistic knowledge and syntactic functioning requires further investigation with a larger sample size and autistic children with differing verbal and non verbal abilities. While further studies are needed, the current data on intact syntactic knowledge is indicative of the role played by innate mechanisms that support language acquisition in typical and atypical children in a similar manner (see Crain & Thornton, 2012).

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Appendices

Appendix 1: List of test sentences for Principle C

'Principle C' sentences: Pronoun in the subject position
She brushed Cinderella with a hairbrush
He covered Ironman with a sheet
She wiped the Princess with a cloth
He washed Spiderman with water

Appendix 2: Percentage of Correct rejections averaged across the four stories for the Autism and Matched Control Group

ASD Participants (Age)	**Principle C**	**Matched Participants (Age)**	**Principle C**
Participant 1 (10;11)	100%	Participant 1 (6;2)	75%
Participant 2 (12;7)	50%	Participant 2 (8;10)	100%
Participant 3 (9;7)	100%	Participant 3 (6;8)	75%
Participant 4 (10;9)	75%	Participant 4 (7;2)	100%
Participant 5 (8;9)	100%	Participant 5 (7;9)	100%
Participant 6 (12;0)	75%	Participant 6 (7;2)	100%
Participant 7 (11;0)	100%	Participant 7 (9;3)	100%
Participant 8 (12;0)	75%	Participant 8 (7;1)	100%
Participant 9 (11;9)	50%	Participant 9 (7;3)	100%
Participant 10 (5;4)	50%	Participant 10 (7;7)	75%

Appendix 3: List of sentences for Principle B

Sentences with pronouns in the object position
Mama Hedgehog brushed her with a hair brush
Scott covered him with a green bush
Jasmine wiped her with a cloth
John washed him with water

Appendix 4: Percentage of Correct rejections averaged across the four stories for the same Autism and Matched Control Group

ASD Participants (Age)	Principle B	Matched Participants (Age)	Principle B
Participant 1 (10;11)	100%	Participant 1 (6;2)	100%
Participant 2 (12;7)	100%	Participant 2 (8;10)	100%
Participant 3 (9;7)	100%	Participant 3 (6;8)	100%
Participant 4 (10;9)	100%	Participant 4 (7;2)	100%
Participant 5 (8;9)	100%	Participant 5 (7;9)	100%
Participant 6 (12;0)	100%	Participant 6 (7;2)	100%
Participant 7 (11;0)	100%	Participant 7 (9;3)	100%
Participant 8 (12;0)	0%	Participant 8 (7;1)	100%
Participant 9 (11;9)	50%	Participant 9 (7;3)	100%
Participant 10 (5;4)	0%	Participant 10 (7;7)	75%

Chapter 5

The Understanding of Logical Words in Autism

Abstract

This study investigates comprehension of logical words for disjunction ‘or’ and negation in children with autism. Previous work has shown that typically developing children are able to access the full range of truth-conditions that are associated with the corresponding words in classical logic (e.g. the disjunction operator ‘or’). Typically developing children are also able to derive the logical entailments for sentences in which negation takes scope over disjunction. But previous research has not investigated the comprehension of logical words in children with autism. The current paper seeks to help fill this gap using a dynamic task - the Truth Value Judgment Task. The findings demonstrate that children with autism interpret combinations of negation and disjunction in the same way as typically developing children, and their patterns of interpretation are in keeping with the principles of classical logic. The findings challenge claims about atypical developmental patterns in autism, at least in the area of logical reasoning. The findings suggest that children with autism draw upon the same concepts and principles of logic as typically developing children, and adhere to syntactic principles in establishing the scope relations between logical expressions.

Keywords: syntax, autism, logical development, disjunction

1. Introduction

Cognitive science continues to debate the nature of human logical reasoning. One school of thought contends that human beings reason using mental logic (Rips, 1994), whereas another school of thought contends that human reasoning is not guided by logic, at least for the most part (Johnson-Laird and Byrne, 2002) (see Crain, 2012). This debate extends to the realm of language where, again, there are two schools of thought. One approach argues that children's acquisition of language is largely dependent upon experience (Pullum & Scholz, 2002; Lieven, Salomo, & Tomasello 2009; Ambridge & Lieven 2011; Lieven, Behrens, Speares & Tomasello, 2003). We call this the experience-based or usage-based approach. This approach maintains that children acquire language in the same way as they acquire knowledge in any other cognitive domain. Advocates of this approach, therefore, deny the existence of domain-specific knowledge or special mechanisms that are recruited to acquire language (Tomasello, 2000; 2003). Rather, by attending to the linguistic input provided by their caregivers, children gradually learn to match their own sentence patterns with those they encounter in the environmental input. On the experience-based approach, therefore, children are free to adopt patterns of logical reasoning that are not based on classical logic. Children simply learn to reason using logical expressions in the same way as their caretakers.

The second approach to language acquisition acknowledges that experience has a part to play in language acquisition, but this approach contends that children also access a 'Universal Grammar' that guides their acquisition of language (e.g. Chomsky, 1986). The principles of Universal Grammar (UG) constrain the child's hypothesis space, such that only some of the logically possible sentence patterns can be learned. On this approach, UG is domain-specific, and doesn't involve learning in the same way as other cognitive domains. In addition to universal principles, UG contains a finite set of

parameters. These parameters provide children with a menu of linguistic choices for grammar formation. The choices available to children represent, at least in part, a theory of the differences among human languages. According to Crain (2012), UG also contains a set of logical principles and parameters that are used in assigning meanings to sentences. These principles and parameters of logic are fixed, and do not vary according to children's experience.

These two approaches to language acquisition make different predictions about children's interpretation of sentences containing logical words. The focus of the present study will be on the disjunction word 'or' in sentences with negation. The meaning of these sentences is not affected by pragmatic inferences, an area that children with autism find challenging. We will explore how children with autism interpret this combination of logical words, once pragmatic or contextual influences are not a factor. The findings of these investigations promise to provide some insight into the process of language acquisition in children with autism.

The paper is organized as follows. First, we give a brief introduction to the relevant logical expressions that we will be investigating, including disjunction and negation. We then review the previous literature on the acquisition of disjunction and negation in typically developing children, before turning to our experiment.

2. Language and Logic

Our study of logic in language in children with autism will focus mainly on the word for disjunction, English 'or'. Although 'or' is a small word, there is considerable disagreement on its basic meaning. The disagreement is over whether the 'or' used in English (and the corresponding expressions in other languages) corresponds to the expression for disjunction in classical logic, 'inclusive-or'. The alternative is 'exclusive-

or.' Some linguists and philosophers have concluded that the 'or' that appears in human language is exclusive-or, or is ambiguous between 'exclusive-or' and 'inclusive-or' (Kegley & Kegley, 1978; Richards, 1978). Others, in particular Crain and colleagues (Crain, 2008; Crain, Thornton & Khlentzos, 2009; Crain, 2012) have provided experimental evidence from child language that reaches the opposite conclusion. They conclude that the interpretation of disjunction is the same in human languages and in classical logic. More specifically, they claim that the meaning of disjunction in human language is unequivocally 'inclusive-or'. They base this claim on studies in which disjunction appears in the scope of negation, as in the present study. In order to better understand the experimental materials of the present study, therefore, it will be useful to expand on the logical interpretation of disjunction, both in positive and in negative sentences.

First, let us examine the interpretation that is assigned to disjunction in positive sentences. We will compare two interpretations of disjunction, exclusive disjunction (exclusive-or) and inclusive disjunction (inclusive-or). The truth conditions associated with 'exclusive-or' make statements of the form 'A or B' true if A is true, but B is false, or if B is true but A is false. Statements of the form 'A or B' are false, on the other hand, if both A and B are true, or if both are false. It is easy to come to the (mistaken) conclusion that disjunction in human language is 'exclusive-or'. Consider an everyday sentence like "You may have ice cream or cake for dessert." A parent who says this to their child is presumably informing the child that he or she may have either ice cream, or cake, but not both. Researchers who contend that disjunction is 'inclusive-or' in human languages readily agree that the sentence produced by the parent implies 'exclusivity', but they contend that this meaning is derived by an implicature, and does not reflect the basic truth conditions that are associated with disjunction in human languages. They

point to situations in which the implicature is cancelled, as in situations of uncertainty. For example, suppose John and Bill are discussing what Mary will bring to the party, and John makes the following bet: "Mary will bring ice cream or cake to the party". Suppose that Mary brings both ice cream and cake to the party. If so, Johns wins the bet. Although John had no reason to suppose that Mary would bring both the desserts, he had no reason to exclude this possibility. This example illustrates that affirmative sentences of the form (A or B) are true if only A is true, or only B, or if both A and B are true, at least in cases where the implicature of exclusivity is not operative, as in making a bet. However, when the implicature is operative, as in ordinary affirmative sentences, the use of disjunction when both disjuncts are true is pragmatically odd. However, the fact that disjunction is subject to pragmatic inference does not mean that the basic meaning is inconsistent with classical logic, according to many researchers (e.g., Crain & Khlentzos, 2010).

Next we will consider the truth conditions associated with the alternative interpretations of disjunction words, 'exclusive-or' and 'inclusive-or', in negative sentences. Crain and his colleagues point out that the 'exclusive-or' interpretation of disjunction yields unwanted properties in negative sentences. Recall that 'A or B' is true only if exactly one of the disjuncts, A or B, is true. It follows that sentences of the form 'Not A or B' are false only if exactly one of the disjuncts, A or B, is true. Sentences of the form 'Not A or B' are true, therefore, if both disjuncts are true, and they are also true if both are false. The fact that sentences of the form 'Not A or B' are true if both disjuncts are true is one of the unwanted consequences of 'exclusive-or', according to Crain and colleagues. Suppose that John says the following "Mary did not bring ice cream or cake to the party." If John's use of disjunction is interpreted as exclusive-or, then his assertion would be true if Mary brought both ice cream and cake to the party.

This is a counter-intuitive conclusion and, to our knowledge, no one has even attempted to show that children assign this meaning to disjunction in sentences with negation.

On the other hand, if disjunction is 'inclusive-or', then John's statement "Mary did not bring ice cream or cake to the party" is only true in circumstances in which Mary brought neither dessert to the party. Intuitively, this is the right result for English. In English, then, the meaning of negative sentence with disjunction corresponds to one of the laws of propositional logic, according to which a negated disjunction 'Not (A or B)' logically entails the negation of both disjunction. It entails 'Not A' and it entails 'Not B'. By conjunction introduction, we are logically entitled to infer the conjunctive statement "Not A and Not B.' The same logical entailment is made in propositional logic. That is, a negative statement with disjunction 'Not (A or B)' entitles us to infer the conjunctive statement 'Not A and not B'. In classical logic, this law is stated in one of De Morgan's laws: ¬ (A ∨ B) => (¬A ∧¬B)[27]. The following truth table shows that a 'conjunctive' entailment is licensed by disjunction in the scope of negation, just as long as disjunction is analyzed as 'inclusive-or' (Crain, 2008).

Table 1: Truth tables corresponding to the Truth conditions for ¬(A∨B) and (¬A ∧¬B)

A	B	A∨B	¬(A ∨ B)	¬A	¬B	¬A ∧ ¬B
0	0	0	1	1	1	1
0	1	1	0	1	0	0
1	0	1	0	0	1	0
1	1	1	0	0	0	0

Table 1 makes it clear that (A ∨ B) is true in three conditions, i.e., when only A is true, or only B is true, or when both A and B are true. It follows that the negation of (A ∨ B) is only true when both A and B are false.

[27] The symbols represent negation, disjunction and conjunction in classical logic, where ¬ is the symbol for negation, ∨ stands for disjunctive operator, ∧ conjunctive operator and => for entailment

We turn next to the empirical evidence from child language to see how well child language conforms to the alternative models of language acquisition. These models make different predictions about how children acquire the meanings of logical expressions, including disjunction. The question is how well the evidence accords with the claim that human languages draw on logical primitives, such that disjunction is interpreted as 'inclusive-or' across languages, as maintained by Crain and colleagues (see Crain, 2012; Crain, 2008; Crain, Gualmini & Pietroski, 2005; Crain & Khlentzos, 2007). The alternative hypothesis is that disjunction could be 'exclusive-or' or 'inclusive-or', depending on the evidence children encounter. This is the prediction of the experience-based approach, as we will see.

3. Disjunction in Child Language

Early studies of disjunction reached the conclusion that disjunction and conjunction were easily confused by young children (Paris, 1973). These studies compared children's responses to affirmative sentences with one or the other logical operator. If this finding had been maintained, it would have ruled out the possibility that children assign an 'exclusive-or' reading to disjunction words. However, subsequent studies showed that children did not confuse disjunction and conjunction. For example, a study by Crain, Gualmini & Meroni (2000) showed that children accepted sentences with disjunction if just one of the disjuncts was true, but rejected sentences with conjunction in the same contexts.

Another important finding was obtained by presenting children with sentences with disjunction in contexts where both disjuncts were true. For example, suppose Mary is holding a red balloon and a blue balloon, and John says "Mary is holding a red balloon or a blue balloon." Adults reject this description of the situation, because John would

have been more informative if he had used the corresponding statement with conjunction "Mary is holding a red balloon and a blue balloon." The fact that a sentence with conjunction is more informative than one where disjunction is the source of an implicature of exclusivity, entreats language users to use disjunctive statements in affirmative sentences only when the corresponding conjunctive statement is false. According to many researchers, this pragmatic inference is the source of the mistaken conclusion that disjunction is 'exclusive-or' in human languages. These researchers would distinguish the basic meaning of disjunction, 'inclusive-or', from the derived 'but not both' truth conditions.

On this theory, someone who lacked the pragmatic inference based on information strength would be expected to accept sentences with disjunction when both disjuncts were true. This is exactly what was found in studies that used the Truth Value Judgment Task to assess the interpretation that children assigned to sentences with disjunction. In contexts in which both disjuncts were true, children accepted affirmative sentences with disjunction, whereas adults did not. This finding was taken as compelling evidence that children's initial interpretation of disjunction is 'inclusive-or', since children were found to accept sentences with disjunction if just one of the disjuncts is true (Gualmini, Crain & Meroni, 2000), and if both of the disjuncts are true (Chierchia, Crain, Guasti, Gualmini & Meroni, 2001). These are exactly the truth conditions of disjunction in classical logic.

Some researchers, however, have reached other conclusions. A study by an advocate of the experience-based approach concludes that children initially interpret disjunction as 'exclusive-or', based on transcripts of the spontaneous productions of young English-speaking children (Morris, 2008). However, the study by Morris (2008) counted disjunctive sentences by either children or adults as evidence that they had

assigned ‘exclusive-or’ if these sentences were produced in situations in which only one disjunct was true. The problem with this analysis is that these situations are also compatible with the ‘inclusive-or’ interpretation of disjunction. Recall that ‘inclusive-or’ is not only true when both disjuncts are true, but also when just one disjunct is true. More specifically, ‘inclusive-or’ makes disjunctive sentences true in a superset of the circumstances that correspond to ‘exclusive-or’. So, whenever sentences with ‘exclusive-or’ are true, so are ones with ‘inclusive-or’ (unless the disjuncts are mutually exclusive). In view of this ‘counting error’, the findings from the Morris (2008) study are not inconsistent with the conclusion of previous research – that children initially assign an ‘inclusive-or’ interpretation to disjunction.

Assuming, then, that children had been found to interpret disjunction as ‘inclusive-or’, studies of the acquisition of logical words turned to another relationship that obtains between negation and disjunction in adult language. Researchers then investigated children’s knowledge of structural constraints on the interpretation of disjunction in sentences with negation. In the theory of UG, hierarchical structural relations must be established in order to enforce certain semantic interpretations. This is precisely the case with negation and disjunction. The conjunctive interpretation that is captured by De Morgan’s law, ‘Not (A or B’) entails ‘Not A and not B’ depends on the interpretation of disjunction as being within the scope of negation, where scope assignment corresponds to the structural notion of c-command in linguistic theory (see Crain, 2012).

This notion of scope is not embraced by the experience-based approach to language acquisition. On experience-based approaches, children are not endowed with the grammatical knowledge to compute hierarchical sentence representations. On the experience-based approach known as the constructivist approach, children learn various

'constructions', (which are types of sentence structures such as transitive sentences, passive sentences and so on), on the basis of the input (Goldberg 2003; Ambridge & Lieven 2011; Tomasello 2000, 2003). Constructions are linear representations, not hierarchical representations. Therefore, the hierarchical relationship of c-command is not a factor in determining the interpretation of a sentence containing logical words on experience-based approaches.

Children's interpretation of sentences containing two logical words, negation and disjunction was investigated in an experiment by Crain, Gardner, Gualmini, & Rabbin (2002). This experiment will be introduced in detail, as this is the experiment that is replicated in our study with children on the autism spectrum. In their study, Crain et al. tested sentences as in (1) and (2).

(1) The girl who stayed up late will not get a dime or a jewel

(2) The girl who didn't go to sleep will get a dime or a jewel

Both of these sentences contain negation ('not' or the negative auxiliary verb 'didn't') as well as the disjunction word 'or' and in each case, from a linear perspective, negation precedes disjunction. However, the two sentences have different interpretations. Let us consider these in detail.

In (1), negation c-commands disjunction, or put another way, disjunction is in the scope of negation. This can be seen in Figure 1[28]. Roughly, 'not' c-commands 'or' in the sentence representation because it is possible to go to the branching node above 'not', which is Neg', and then trace a path down the branches of the tree to reach disjunction. When disjunction is in the scope of negation, this gives rise to a conjunctive entailment. That is, (1) means that the girl who stayed up late will not get a dime **and** the girl who

[28] In Figure 1, TP refers to 'Tense Phrase' and is the same as 'Sentence'. The subject NP of the sentence is 'the girl who stayed up late'. This subject NP contains a relative clause 'who stayed up late' which is shown by the CP triangle in the structure. NegP is 'Negation Phrase' and contains the negative word 'not'.

stayed up late will not get a jewel. In (2), on the other hand, negation precedes disjunction in the sentence, but disjunction is not in the scope of negation. The negative auxiliary verb 'didn't' does not c-command disjunction. This is because the negative auxiliary verb 'didn't' is embedded inside the relative clause 'who didn't stay up late', and it is therefore not in a position to c-command disjunction. Consider Figure 2. In Figure 2, 'didn't' is inside the CP. It is not possible to trace a path from the first branching node above 'didn't' (which is not shown) down the tree to reach 'or'[29]. Because negation does not c-command disjunction, the sentence does not give rise to a conjunctive entailment. Rather, the sentence receives disjunctive truth conditions. This means that the sentence means the girl who didn't go to sleep will get a dime, or the girl who didn't go to sleep will get a jewel (or possibly both).

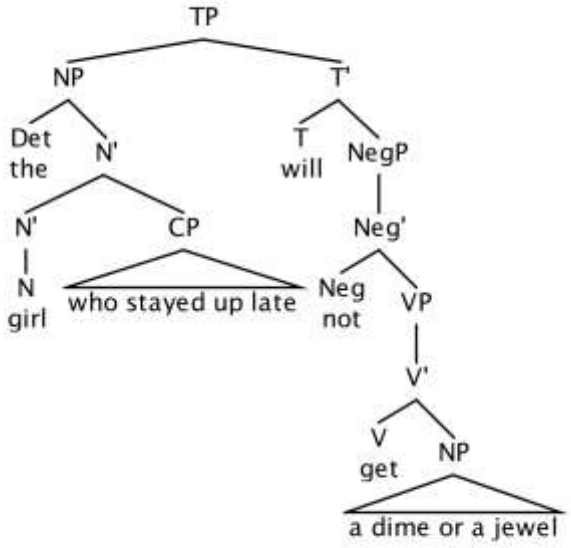

Figure 1: Negation c-commands Disjunction

[29] In Figure 2, the negative auxiliary verb 'didn't' is inside the CP. Although the internal structure of the CP relative clause is not shown, it is clear that it is not possible to go to the first branching node above it, and take a downward path to reach 'or'. Instead, one would have to travel upward, past several branching nodes to the TP at the top of the tree before it would be possible to take a path down the tree to reach 'or'. This means that there is no c-command relation between negation and disjunction.

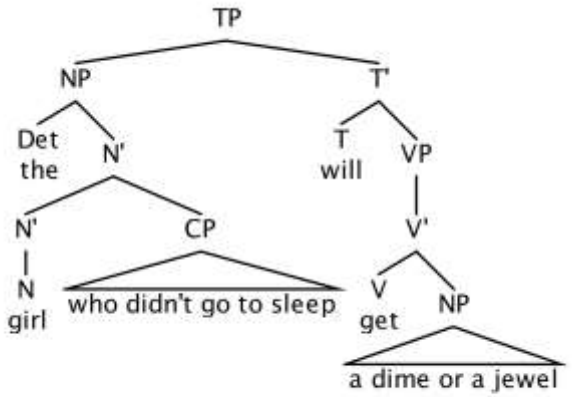

Figure 2: Negation does not C-command Disjunction

On the UG approach, the c-command relation is important in distinguishing the possible interpretation for the two sentences. On the experience-based approach, in both sentences, negation precedes disjunction. It is not clear what kind of input children might have received to inform them that (1) and (2) have different interpretations for disjunction.

The experiment conducted by Crain et al. (2002) used a Truth-Value Judgment Task (TVJT) to test sentences like (1) and (2) with children aged 3 to 5 years of age. The task used what is called a 'Prediction Mode'. Instead of having children judge the truth of a puppet's statement at the end of a story, prediction mode has the puppet make a prediction about an event at some point in the middle of the story (and the prediction is repeated again at the end). This innovation is to ensure that the use of disjunction is felicitous in the context. The design of the Crain et al. experiment was a between-subjects design; half of the subjects heard sentences like (1) and half heard ones like (2).

The TVJT comprised of a narrative activity in which two experimenters participated. One experimenter told a story by manipulating toys while the other

experimenter acted as a puppet uttering the test sentences. The experimental story narrated a tale of two girls waiting for a tooth fairy to arrive as they had both lost a tooth. The girls knew that tooth fairy would come during the course of the night and give them a reward in exchange for their lost tooth so one decided to go to bed but the other decided to stay awake as she wanted to know what the tooth fairy looks like. The tooth fairy duly arrived, bringing along two dimes and two jewels. At this juncture, the puppet predicted about what will happen next. Henceforth, the story resumed and the fairy gave both a jewel and a dime to the sleeping girl. The girl who was awake explained that she had stayed up so that she could meet the tooth fairy. The tooth fairy said that she was disappointed, as children are supposed to be asleep when she comes, but she decided to give one reward to the girl after listening to her explanation. She gave the girl a jewel, but not a dime.

At the end of the story, the puppet repeated the prediction made in the middle of the story, to remind the children of the events in the story. If children implement De Morgan's law and compute the conjunctive entailment, then (1) is false because in fact the girl who stayed up late did get something. Children rejected (1), 92% of the time. Children accepted sentences like (2) 87% of the time. The sentence was true because the girl who didn't go to sleep did get a jewel. In this case, the sentence received disjunctive truth conditions. The results suggested that children are computing hierarchical sentence representations in which there is a c-command relationship in place for (1) but not for (2). Children are clearly not relying on linear precedence to guide their interpretations of these sentences. If they were, it is likely that both sentences would have been interpreted in the same way and received disjunctive truth conditions.

4. Autism, Language and Logic

It has long been noted that children on the spectrum have difficulty with some aspects of language (Menyuk, 1978). There is consensus that all children, no matter how verbal, encounter some difficulty with social aspects of language use and pragmatics (Rutter, 1978). In recent times, there has been a strong interest to understand whether children with autism are able to learn the grammar of their local language. Learning of grammar is a multifaceted skill involving abilities to combine words into meaningful sentences, making sense of grammatical categories like noun, verb, (Bloom, Rocissano, & Hood, 1980) and learning to use basic grammatical words correctly for example morphemes marking tense (*ing, ed*) (Brown, 1973).

On these lines, Eigsti & Bennetto (2009) used a grammaticality judgment task with high functioning English-speaking children with autism, aged 9 to 17 and discovered that they had lower sensitivity to morphosyntactic violations than their typically-developing peers matched on age, verbal and non verbal abilities. Basically the deficits were significant for omitting the third person singular *–s* and progressive aspect *–ing*. Elicited productions of past tense *-ed* on verbs is also noted as an area of noted concern (Bartolucci and Alberts, 1974). Dalgleish (1975) suggested that syntactic deficits in autism are related to deficits in the ability to sequence stimuli. Another study found that children with autism differed from verbal mental age-matched children with typical development for the comprehension of transitive (e.g. *the child put the doll on the table*), but not intransitive (e.g. *the child arrived*) sentences (Prior & Hall, 1979). Relative clauses pose difficulty for children with autism too. Durrleman, Hippolyte, Zufferey, Iglesias & Hadjikhani (in press) showed that French speaking adult and adolescent participants with autism perform worse than their typically-developing age matched peers on interpreting object relative clauses (e.g. *Show me the cat that the dog*

is bitting) while participants on the spectrum who also had a history of language delay had difficulties with subject relative clauses (e.g. *Show me the dog that is biting the cat*).

However less is known about autistic children's knowledge of the distribution of pronouns. Recent studies by Perovic, Modyanova & Wexler (2013a, 2013b) have investigated comprehension of pronouns and reflexives in children with autism. Their studies were couched in the framework of 'UG' and investigated whether or not children with autism adhere to Principles A (that guide interpretation of reflexives) and B (that guide interpretation of pronouns) (Chomsky, 1986). The task was a picture selection task where participants had to choose the correct picture corresponding to the test sentences containing reflexives or pronouns. The experimental findings showed that the children with autism do quite well in interpreting sentences that are subject to Principle B, ones like 'Bart's dad washed him' even though there were some errors, and children sometimes interpreted the sentence to mean that Bart's dad washed himself/Bart's dad, but at a rate no greater than typically-developing children. In Perovic, Modyanova & Wexler (2013a), the children were not accurate in interpreting reflexives in sentences like 'Bart's dad washed himself'. The finding led the authors to propose that children with autism have more difficulty in understanding reflexives as they are not able to establish the hierarchical c-command syntactic dependency between the antecedent referent and the reflexive that is necessary for Principle A. Perovic et al (2013a) was followed up by a second study on children with autism (Perovic, Modyanova, & Wexler, 2013b) in which participants were categorized as those with concomitant language impairments[30] (ALI) and those with no language impairment (ALN). Using the same picture selection task, the authors found that reflexives were only a problem for ALI

[30] Language impairment is defined as a difficulty in the acquisition and use of spoken, written or signed language that causes a functional impairment and cannot be accounted for by deficits in general cognitive

children. They concluded that children with ALI are not able to use c-command to establish the correct referent for reflexives. The claim is not that c-command is deficient or not operational more generally, although it is not clear how this structural relation could be problematic only for reflexives.

A study by Noveck, Guelminger, Georgieff & Labryere (2007) investigated scope relations in typically-developing children and in participants with autism. The group with autism had a mean age of 16 years and 3 months. These researchers tested the participants' interpretation of sentences like *Every horse did not jump over the fence*. In English, the sentence is ambiguous. First, there is a reading on which 'every' takes scope over 'not.' On this reading, the interpretation is that none of the horses jumped over the fence. There is a second reading on which 'not' takes scope over 'every'. On this reading, the sentence is true if 'not every' horse jumped over the fence. Perhaps some of the horses jumped over the fence, but it is critical that at least some of the horses (or one) did not jump over the fence.

Previous findings have shown that adults typically prefer a 'not every' reading. For example, suppose that three horses are holding a contest to see which of them can jump over a fence. As the competition unfolds, one of the three horses jump over the fence, but two of them fail. Adult English speakers have been found to accept the sentence *Every horse did not jump over the fence* as an accurate description of this kind of context. By contrast, English speaking children reject *Every horse did not jump over the fence* as an accurate description of the context. Children justify their rejections by pointing out that one of the horses jumped over the fence. It seems, then, that children and adults initially adopt the reverse scope relation. For children, 'every' takes scope

ability (American Psychological Association, 2013). There is heterogeneity with respect to the severity of impairments ranging from mild to severe.

over ‘not’ in sentences like the one under discussion (Musolino, Crain & Thornton, 2000). This difference in interpretation between children and adults is difficult to reconcile with the experience-based approach to language acquisition, because children are expected to base their interpretations on experience.

Two acquisition scenarios have been offered to explain the interpretation assigned by adults. The first scenario is that children have a strong preference for the reading on which logical words are interpreted in the order in which they appear in sentences. On this analysis, children prefer the scope assignment with ‘every’ taking scope over ‘not’, simply because ‘every’ comes first. The second acquisition scenario is based on the truth conditions generated by the two scope assignments. When ‘every’ takes scope over ‘not’, the sentence is true in just one set of circumstance, namely one in which none of the horses jump over the fence. On the other scope assignment, the sentence is true in that circumstance, but it is also true in other circumstances as well. Logically speaking, it is true to assert that not every horse jumped over the fence if none of them did. This reading is difficult to access, however, because someone who knows that none of the horses jumped over the fence would use a sentence that expresses the “stronger” reading, such as *None of the horses jumped over the fence*. A speaker who asserts that *Not every horse jumped over the fence* is taken to be implying that some horses did jump over the fence. But, this is an implicature; it is not literally what the sentence means. This difference between the literal meaning and the implied meaning (or derived meaning) has been investigated in numerous studies. In any event, the alternative account of why children initially prefer the reading with ‘every’ taking scope over ‘not’ is based on the “strength” of the alternative readings. It is hypothesized that children initially assign the strongest scope relations. In the present case, the strongest scope assignment generates the ‘none’ reading, with ‘every’ taking scope over ‘not’.

Whatever the source of the difference between children and adults, it is clear that children have to learn, through experience with their language, to change their preference to the adult scope assignment, with 'not' taking scope over 'every'. To make the necessary change to their grammars, children must pay close attention to the context in which people make statements like 'Every horse did not jump over the fence'. Assuming that adults use such sentences only as descriptions of contexts in which the sentence is true, there will be an observable mismatch between the readings assigned by children and adults. The 'none' reading will make sentences false in the vast majority of contexts in which adults assert sentences with these logical operators, because adults will only use such sentence in circumstances corresponding to the 'not every' reading. In these contexts, children's scope assignment (with 'every' taking scope over 'not') makes the speaker's statement false.

Following proposals by Musolino and Lidz (2003, 2006), Noveck et al. assume that this change in scope assignments require the pragmatic ability to use the contexts they encounter to eliminate their initial scope assignment. To the extent that typically-developing children lack these pragmatic abilities, they will take considerable time before they align their scope assignments with those of adults. In view of the finding that children with autism often lack the requisite abilities to attend to the non-linguistic context, Noveck et al. predict that children with autism take considerably longer than typically-developing children to develop the necessary pragmatic abilities, so children with autism are predicted to generate non-adult scope assignments for several years after typically-developing children have re-aligned their scope assignment to be the same as adults. The findings of the study were not this clear-cut, however. Whereas adults showed the expected preference for the 'not every' reading, both the typically-developing child participants and the child participants with autism did not manifest a

clear preference. Noveck et al. take this to mean that both typically-developing children and children with autism are less skilled than adults at using contextual information to come up with the intended interpretation[31] – the scope assignment that matches the context for adult speakers.

Our study, like the Noveck et al. (2007) study, investigates children's interpretation of sentences containing two logical words. But the sentences used were not ambiguous. In contrast to the sentences used by Noveck et al., then, the sentences we presented to children were not subject to effects of pragmatics. The sentences we used contained negation and disjunction. The interpretation of these sentences is dictated by one of the laws of propositional logic, called De Morgan's laws. When this one of De Morgan's laws is operative, pragmatic effects are completely erased.

The current study is a replication of the study conducted by Crain, Gardner, Gualmini & Rabbin (2002). It investigates whether children with autism interpret sentences in line with the predictions of theory of UG. That is, the goal of the experiment was to determine whether or not, like typically-developing children, children with autism draw on c-command and logical primitives to interpret sentences with negated disjunction. Our study uses sentences with the same structure as the Crain et al. study, ones like (3) and (4).

(3) The boy who is on the bridge will not get a ball or a car

(4) The boy who isn't on the bridge will get a ball or a car

If children with autism can access c-command and logical primitives, they should respond to such sentences in the same way as typically-developing children. That is,

[31] Some evidence shows that individuals with autism are able to generate scalar inferences associated with

children should interpret (3) as the boy who is on the bridge will not get a car and the boy who is on the bridge will not get a ball. However, if children with autism cannot access the requisite grammatical and semantic knowledge, they may respond in line with the experience-based approach, potentially drawing no distinction in the interpretations assigned to sentences such as (3) and (4). In this case, they would be unlikely to enforce a conjunctive entailment for (3) and may potentially assign it disjunctive truth conditions, as appropriate for (4), where there is no c-command relation between the negative auxiliary verb 'isn't' and the disjunction word 'or'.

5. Experiment: Negation and Disjunction

5.1. Method

The present experiment used the dynamic version of the Truth Value Judgment Task (TVJT) (Crain & Thornton, 1998). This task has also been successfully employed recently in assessing children with Williams Syndrome (WS) (Musolino, Chunyo & Landau, 2010) [32].[33] The TVJT has been used here as picture matching or selection tasks tend to be less engaging for children, and in some cases, the pictures can be difficult for children to interpret. The task involves two experimenters where one experimenter manipulates toys and props and tells a story. The other experimenter acts as a puppet and presents a test sentence to the child at the end of the story, just like the study conducted by Crain, Gardner, Gualmini & Rabbin (2002). The task of the child is to judge the truth or the falsity of the given sentence spoken by the puppet. In order to make disjunction

"or" indicating that individuals with autism are able to take account of contextual information (Chevallier, Wilson, Happé & Noveck, 2010).

[32] The Musolino et al. (2010) study employed vignettes with outcomes from each declared at the end of each vignette without utilising a dynamic TVJT in a prediction mode.

[33] WS is characterized by spared linguistic abilities with deficits for number and spatial concepts processing (Mervis et al., 1999).

felicitous in the context[34], the TVJT was adapted to use in the prediction mode (see Chierchia et al., 1998). This is because it introduces uncertainty into the picture. If the puppet is not sure of the outcome between two events in the story context, it becomes natural to use 'or'. Thus, the story was interrupted half way through and the first experimenter acted as a dog and asked Kermit (second experimenter) what he thought would happen next. Kermit replied and the story resumes from that point onwards. At the end of the story, Kermit repeated his prediction. In the present experiment, the stories were videotaped, and presented to the children on an iPad. This step ensured consistent presentation, with story presentation by native speakers of English.

5.2. Participants

Sixteen children on the autism spectrum were tested. The sample included 2 girls and 14 boys. The children ranged in age between 5;4 to 12;7 with a mean age of 10 years and 3 months. Children clinically diagnosed with autism were recruited from special schools across Sydney and Melbourne. Children from Sydney were recruited from Macquarie University Special Education Centre (MUSEC), children from Melbourne were recruited from Northern School of Autism (NSA), Preston campus and children were also recruited from advertisements placed on Autism Spectrum Australia (ASPECT) website. Ten adults were also included in order to ensure the viability of the tasks. The typically-developing children for the comparison group and the adults were recruited from general advertisements across Macquarie University, Sydney. The children with autism were matched to the typically-developing children on the basis of non verbal cognition (IQ).

The autism group was tested on standardized tests of language and cognition. These tests included the matrices part of Kaufman Brief Test of Intelligence (KBIT)

[34] Some participants with autism are found to reason pragmatically (Pijnaker et al., 2009)

measuring non verbal IQ and Test for Reception of Grammar (TROG-2). The mean of the standard score (SS) of KBIT was 95.43 and the mean of SS for TROG was 79.06. Based on the scores of the KBIT, the autism group can be described as high-functioning as majority of children had a standard score of more than 80 (Norbury, 2005; Howlin, 2003). Therefore, the typically-developing children were matched to the children with autism within 2 points of KBIT raw scores. The age of the KBIT-matched comparison group ranged from 5;4 to 9;3 with a mean age of 7 years and 2 months. Their mean of the standard score (SS) of KBIT was 112.18. Refer to table 2 for the scores.

Table 2: Participants' ages and mean scores (standard deviations) on standardised tests of language and cognition.

	Autism (n = 16)	**Typical (n = 16)**
Chronological Age in Years (SD)	10;3 (2;2)	7;2 (0;10)
Range	5;4-12;7	5;4-9;3
KBIT Matrices Standard Scores (SD)	95.43 (13.10)	112.18 (13.44)
Range	74-121	91-146
KBIT Matrices Raw Scores (SD)	27 (6.28)	26.43 (6.30)
Range	15-37	16-36
TROG 2 Raw Scores (SD)	10.68 (4.86)	-
Range	3-17	-
TROG 2 Standard Scores (SD)	79.06 (16.31)	-
Range	55-104	-

The participants with autism were further classified as those with concomitant language impairment (ALI) based on their scores on TROG, along the lines suggested by Perovic et al. (2013b). Participants in their study were categorized as ALI if they scored below the 10th percentile on two of the three language measures (Whitehouse, Barry & Bishop, 2008). Our study had only one language measure but we categorized a child as ALI if he/she scored below the 10th percentile on the TROG as it tests for Reception of Grammar. As a result 8 or half of the participants from the sample were classified as ALI.

5.3. Procedure

Each child was tested individually either in a quiet corner of a room at one of the above schools or at the Language Acquisition Lab at Macquarie University. The testing session with each child lasted for approximately 1.5 hours where the experiment and the standardized tests were administered. If a child had difficulty paying attention, the session was split into two parts. As previously mentioned the children were tested with the TVJT, with all aspects of stories pre-recorded and presented on a mini iPad. All child participants were told that they would watch short stories and should keep in mind the predictions of the puppet as they would later be asked to judge whether the puppet was right or wrong. If the puppet was wrong, children were further requested for reasons about why they thought that the puppet was wrong. All the verbal responses of children were digitally recorded for analyses. Children's judgments of the test sentence were scored as 'Yes' or 'No'. Percentages of correct rejections or acceptance for particular items were calculated for each child.

5.4. Stimuli

The stimuli for this comprised of critical sentences presented for each story. In order to test and distinguish the knowledge of children for the interactions of negation and disjunction, two categories of sentences were presented. One category involved sentences where negation c-commands disjunction (C-command sentences) and the other where negation did not c-command disjunction but only precedes or comes before it (Non C-command sentences). In both categories of sentences, negation preceded disjunction in order to maintain the structure of critical sentences and to find out whether children rely more on the linear order of words in the sentences or the hierarchal relation of c-command between words for an interpretation. Each category had 4 stories. The correct response for C-command sentences was associated with rejections of the test sentence while the Non C-command sentences were associated with either rejection or

acceptance. All these stories were mixed and randomly presented to each child. The testing session started with two practice trials. See Appendix 1 for complete list of all sentences.

To take a detailed example here, consider one of the stories where negation precedes and c-commands disjunction. All the talking and manipulation for the story is done by one experimenter who acts as the dog puppet and the second acts as Kermit.

> The story is based on a scenario of a race organized at a school where there is a special judge and is introduced by the dog puppet. “The judge is Superman. Only two brothers are participating. Here is the older brother, here is the younger brother. Our judge Superman will fly over this bridge in the middle of the race to judge who is the winner. The prize for the winner is a ball. The other prize is a toy car. Brothers please make sure that you cross this bridge as quickly as possible in order to reach the finish line. The one who reaches the finish line first will be the winner of this race”. The race starts now. The older brother runs very fast [crosses the bridge] “I am the first to cross the bridge yay”. I made it!” The younger brother stops half way across at the bridge, “I have never seen Superman flying, if I finish the race first I will not be able to see a flying Superman. I will just stand here on the bridge”. Here comes the Superman flying over the bridge with the prizes in a special bucket.

At this stage story is interrupted and Dog Puppet asks the Kermit,

“What do you think will happen next Kermit?”

Kermit: “The boy who is on the bridge will not get a ball or a car”.

Story continues

Superman goes to the older brother at the finish line says, “You have done a good job,” gives him a toy car, and also gives a toy ball to him. “You are the winner”. The older brother is the winner. He goes back on the bridge, says to the younger brother, “Why are you still standing on this bridge”? The brother replies, “If I had crossed the bridge, I would not have seen you flying”. The Superman says, “Ok, then, you can have this toy car”.

Kermit’s critical sentence presented for evaluation: “I said that the boy who is on the bridge will not get a ball or a car”. Refer to picture 1 for the scene at the ending events of the story.

Picture 1: Final events of the Superman Story

Children should say “no” to the test sentence if they are able to generate a c-command relation between disjunction and negation. On the other hand, if they are unable to compute c-command relations, they could equally take the test sentence as true and say “yes” since this is what happened in the story. The meaning by which the boy on the bridge was supposed to get nothing was under consideration at one point in the story but it was not the actual outcome of the story.

To take a detailed example of a Non C-command story here, consider one of the stories where negation only precedes but does not c-command disjunction. Again all the talking and manipulation for the story is done by the experimenter who acts as the dog puppet.

This is the underwater treasure hunt at the Pacific Ocean. Here is the Magic man [introduced] who organized it. These two mermaids [introduced] are participating, the magic man announces some rules, “listen mermaids, I have hidden some treasure behind these sea-plants. The winner will be the one who finds the maximum amount of treasure. But the condition is that you cannot leave your plant island. You can move around on your islands.” One mermaid says, “This is so hard, we don’t have any legs”. Magician says, “This is the rule. The winner will get some seahorses, some crowns”. One mermaid hops around on the plant island, finds treasure, “yay”. The other mermaid says, “Well I will leave the island, it’s easier to swim rather than to hop around like this”.

At this stage story is interrupted and dog puppet asks the Kermit,

“What do you think will happen next Kermit?”

Kermit: “The mermaid who is not on the plant-island will get a crown or a seahorse”.

Story continues

At the end of the hunt, the magic man goes to the winner, “you have done a good job finding the maximum amount of treasure. You can have this sea horse. You

> can also have this crown." He goes to the other mermaid, "why are you not on your plant-island? The rules of the hunt were pretty strict." The mermaid explains "well I already said that I don't have legs. It was so hard for me. But I tried to find some treasure". Magic man says, "Ok, you can have this crown in this case".
>
> Kermit: "I said that the mermaid who is not on the plant-island will get a crown or a seahorse".

Now children can only say "yes" to the test sentence as this is what happened in the story.

5.5. Results

The main finding was that the group with autism correctly rejected the C-command sentences 91% of the time. They showed correct performance on the Non C-command sentences, 69% of the time[35]. The typically-developing matched group of children rejected the C-command sentences 100% of the time while they responded correctly to the Non C-command sentences 72% of the time. Adults responded as expected, rejecting the C-command sentences 100% and responding correctly to the Non C-command sentences 82.5% of the time. Appendix 2 shows the percentage of correct responses calculated for each individual child from both groups and averaged across the four stories for C-command and Non C-command sentences. Refer to Table 3 for group results.

[35] Each 'No' response for the C-command test sentence was scored as correct rejection while responses for the Non C-command test sentences were scored depending upon whether children correctly accepted or rejected the test sentences.

Table 3: Percentages of Correct Responses (group mean) for all three groups for C-command and Non C-command Phrases

Groups	C-command sentences	Non C-command sentences
Adults	100%	82.5%
Autism	91%	69%
Typical	100%	72%

When children were asked why they rejected the C-command sentences, the children from both groups gave similar justifications. For example for the sample sentence, *The boy who is on the bridge will not get a ball or a car,* a child would say that the puppet is wrong as the boy on the bridge got a car whereas he was not supposed to get anything.

A non-parametric Mann-Whitney Test was used to compare the patterns of responses by children with autism and typically-developing children for both between group comparison and within group comparison across the two types of sentences. The comparison between the two groups of children for different sentence types was not significant. For C-command sentences, a Mann-Whitney Test showed that the difference between typically-developing children and autism was not significant ($Z = 1.4887$, $p = 0.136$). The group difference was also not significant for Non C-command sentences ($Z = 6596$, $p = 0.509$). Within groups, there was a significant different between items. A Mann-Whitney Test conducted for the ASD group showed that there was a significant difference for performance on C-command and Non C-command sentences ($Z = 2.8078$, $p = 0.004$). Across sentence category comparison (C-command versus Non C-command sentences) was also significant for the typical matched group ($Z = 4.2023$, $p = 0$).

In addition, the performance data on C-command and Non C-command sentences for ALI versus ALN children were examined. The mean percentage of correct response for C-command was 84.37% and for Non C-command was 62.5% for the ALI

group. On the other hand, the mean percentage of correct response for C-command was 96.87% and for Non C-command was 75% for the non ALI group. This shows a similar response pattern, although the ALI group is not as accurate as the children who did well on the TROG. The individual results of the ALI group are shown in Table 4.

Table 4: Categorization of Children as ALI and their Performance Scores on C-command and Non C-command Sentences

ASD Participants	Percentile (TROG)	Age	C-command (% Correct Rejections)	Non C-command
6	<1	12;0	75	50
7	7	11;0	100	75
9	4	11;9	75	50
12	<1	6;7	50	75
13	<1	10;6	100	50
14	<1	7;5	75	75
15	7	12;4	100	50
16	7	10;10	100	75

As is evident, ALI participants were not at chance performance as a group for C-command and Non C-command sentences. Only Participant 12 gives a chance performance on C-command sentences while four participants showed chance performance for Non C-command sentences. At the same time, it is important to underscore that some children (n = 3) on the autism spectrum who are not classified as ALI (Participants 4, 10 & 11) also gave chance performance for only Non C-command sentences. Two of the matched typically-developing controls (Participants 3 and 10) showed chance performance on Non C-command sentences only. One matched typically-developing child (Participants 13) gave below chance performance (25% correct) on Non C-command sentences.

6. Discussion

The goal of the experiment was to see whether children with autism can interpret sentences containing disjunction and negation in a manner that requires the engagement

of core properties (c-command, entailment relations and De Morgan's laws) of language. As we have seen, in the UG approach, the c-command relation is important in distinguishing the possible interpretation. The experimental findings showed that the autism group did very well in distinguishing the two types of sentences. Although they did not respond as accurately as the typically-developing group, there was no significant difference in the performance of the two groups for both categories of sentences. This shows that the children with autism can successfully compute the scope relation between negation and disjunction (which depend on c-command) in order to determine the correct interpretation. As we noted, on experience-based accounts, it is unlikely that children's answers would differ for C-command and Non C-command sentences. Given that negation precedes disjunction in both sentence types, it is likely that considerable experience would be needed before children could accurately distinguish between them.

Another finding from the present investigation is that processing of relative clauses is within the reach of children with autism. This result contrasts with the findings of French speaking adults and adolescents as reported by Durrleman, Hippolyte, Zufferey, Iglesias & Hadjikhani (in press). The participants heard spoken sentences containing object or subject relative clauses and had to point to a corresponding picture. The results revealed that participants had problems interpreting these sentences as compared to a group of age matched participants. The present set of sentences only contains subject relatives and does not distinguish between object or relative clauses but nevertheless the children with autism performed well on our task. Although we acknowledge differences between French and English, this issue deserves more investigation.

There is another aspect of the results that deserves some more discussion. The autism group showed less accurate performance on 'Non C-command' sentences like

(4), (e.g. *The Mermaid who is not on the plant-island will get a crown or a seahorse*) where negation only preceded but did not c-command disjunction. The children with autism were 69% correct, as compared to 91% accuracy rate on the sentences where the conjunctive entailment had to be computed. Intuitively, one might think that sentences requiring this computation might be more difficult. A glance at the results from our typically-developing children and the adults show exactly the same pattern: more accurate performance on the C-command sentences than the Non C-command ones. It turns out that this pattern has been found in other studies too. In Crain et al.'s (2002) study with 4 and 5 year old typically-developing children, the pattern was similar to our study (better performance on C-command phrases than Non C-command), though there was less difference than in the results of the present experiment. These typically-developing children performed 92% correct on sentences where negation c-commanded disjunction but 87% correct on sentences where negation did not c-command disjunction. So, why is it that people are more accurate on the C-command sentences?

One possibility that was explored by Gualmini & Crain (2005) was that there is more length between the negation and disjunction in the Non C-command sentences. In one of the condition of their experiment, children were presented with sentences where negation c-commanded disjunction as in (5), although these two operators were further apart from each other than the sentences used in Crain et al. (2002). The study also presented sentences where negation only preceded disjunction but did not c-command it, as in (6). The study utilized a between group design where two different groups of children witnessed sentences like (5) and (6).

(5) Winnie the Pooh will <u>not</u> let Eeyore eat the cookie <u>or</u> the cake.

(6) Karate Man will give the Pooh Bear he could <u>not</u> lift the honey <u>or</u> the donut

The interpretation for (5) is that Winnie the Pooh would not let Eeyore eat the cookie and he would not let Eeyore eat the cake, or in other words the conjunctive interpretation is generated despite the number of words between negation and disjunction. Sentences like (6) were presented to know whether children would refrain from assigning conjunctive interpretation of disjunction because of the number of words between negation and disjunction. In addition, the two operators are close to each other and hence if proximity plays a role then children should assign a conjunctive interpretation to (6) as well. The experimental findings showed that children did not assign a conjunctive interpretation to (6), despite the proximity of the two operators. Thus the findings support the proposal that hierarchical structure is important rather than linear order of words. Therefore it seems that the length or the number of intervening words may not play a role in lower performance of participants in Non C-command sentences.

There is another possibility that may account for better accuracy on the C-command sentences in the study with children who have autism. This possibility hinges upon the differences between the present study and the studies conducted by Crain et al. (2002) and Gualmini & Crain (2005). The Crain et al. and Gualmini et al. studies used a between subjects design, with different groups of children judging the C-command and Non C-command sentences. Our experimental design was a within subjects design. Our participants heard both sets of sentences in the same session. This may have caused some confusion. In addition, some of the Non C-command sentences were true and one false, which again, may have meant the responses were less accurate for the Non C-command sentences.

Other than the performance variation between C-command and Non C-command sentences, it is unlikely that children or children with autism learn the notions of c-

command and De Morgan's law by rote memorizations or from parental input even though they may have well developed auditory perceptual abilities or auditory hypersensitivity (Gomot, Giard, Adrien, Barthelemy & Bruneau, 2002). Moreover as explained by Crain, Goro & Thornton (2006), the input provided to children is not conducive in this regard. For example, it has never been reported that parents explicitly instruct their children or point out for them that they should apply the De Morgan's law for interpreting a sentence when they notice that negation and disjunction appear in the same clause of the sentence (see Crain, 1991). In sum, the absolute performance that is above chance level shown by the autism group is reflective of typical development of logical reasoning in autism.

7. Conclusion

This chapter investigated children with autism's comprehension of complex sentences with logical operators. Although some studies have found deficits in linguistic knowledge in children with autism (Pierce & Bartolucci, 1977; Bartolucci, Pierce & Streiner, 1980, Rutter, 1978 & Tager-Flusberg, 1981; Perovic et al., 2013a; 2013b), our experimental findings reveal that children with autism show no deficit, and perform at a similar level to typically-developing children. This may be, in part, due to the makeup of the group of children with autism that we tested, but our choice of methodology may also have been optimal for such children with autism.

Our experiment, a replication of Crain et al. (2002), used a dynamic version of the Truth Value Judgment Task, as in their original experiment. Our view is that this task engages children's interest and minimizes performance limitations, giving the best chance of revealing children's linguistic knowledge (Crain & Thornton, 1998). The experiment investigated syntactically complex structures, as it contained a relative clause modifying the subject noun phrase, and, in addition, it contained both negation

and disjunction. Our experimental findings showed that the children with autism understood these complex sentences and were able to compute the scope relations between negation and disjunction. The findings showed no significant difference in the responses of the children with autism and the typically-developing comparison group. Sentences where negation c-commanded disjunction, the children computed the conjunctive entailment, leading to rejections of these sentences. And in the sentences in which negation was inside the relative clause and did not c-command negation, children did not compute the conjunctive entailment. The findings provide strong support for the view that our high-functioning group of children with autism has access to logical principles and the structural relationship of c-command that underpins the scope relations in human language. If children did not have hierarchical representations for these sentences, and were relying on the linear order of negation and disjunction, it might be expected that they would not differentiate the two types of sentences. This was not the case.

In sum, our experimental results support the view that children have available to them a 'Universal Grammar'. This gives them the ability to compute hierarchical sentence representations and structural relations such as c-command. It also contains a set of logical principles and parameters that are used in assigning meanings to sentences, such as the ones containing negation and disjunction that we have tested. Overall the findings suggest that children with autism draw upon the same concepts and principles of logic as typically-developing children (see Chierchia, Crain, Guasti & Thornton, 1998), and adhere to syntactic principles in establishing the scope relations between logical expressions.

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Appendices

Appendix 1: List of sentences for the two categories

No	**C-command Sentences**	**Correct Response** (character gets one of the objects mentioned)
1	The boy who is on the bridge will not get a ball or a car	Reject
2	The cat who is on foot will not get a fish or milk	Reject
3	The Dino who is on the building will not get a potato chip or peanut	Reject
4	The Penguin who is on the barrel will not get a coin or a jewel	Reject
No	**Non C-commanding Sentences**	**Correct Response**
1	The girl who is not on her bed will get cheese or salad	Reject
2	The mermaid who is not on the plant-island will get a crown or a seahorse	Accept
3	The thief who is not on the speed boat will get a blanket or tea	Accept
4	The gardener who is not on the barrel will get a hat or a seed-bottle	Accept

Appendix 2: Percentage of Correct C-command and non C-Commanding sentences averaged across the 4 stories for ASD and Matched Typical Group

ASD Participants (Age)	C-command Sentences	Non C-commanding Sentences	Matched Participants (Age)	C-command Sentences	Non C-commanding Sentences
Participant 1 (10;11)	100%	100%	Participant 1 (6;2)	100%	75%
Participant 2 (12;7)	100%	100%	Participant 2 (8;10)	100%	75%
Participant 3 (9;7)	100%	75%	Participant 3 (6;8)	100%	50%
Participant 4 (10;9)	100%	50%	Participant 4 (7;2)	100%	75%
Participant 5 (8;9)	100%	100%	Participant 5 (7;9)	100%	75%
Participant 6 (12;0)	75%	50%	Participant 6 (7;2)	100%	75%
Participant 7 (11;0)	100%	75%	Participant 7 (9;3)	100%	75%
Participant 8 (12;0)	100%	75%	Participant 8 (7;1)	100%	100%
Participant 9 (11;9)	75%	50%	Participant 9 (7;3)	100%	75%
Participant 10 (5;4)	100%	50%	Participant 10 (7;7)	100%	50%
Participant 11 (12;7)	75%	50%	Participant 11 (7;7)	100%	75%
Participant 12 (6;7)	50%	75%	Participant 12 (5;10)	100%	75%
Participant 13 (10;6)	100%	50%	Participant 13 (7;0)	100%	25%
Participant 14 (7;5)	75%	75%	Participant 14 (5;4)	100%	100%
Participant 15 (12;4)	100%	50%	Participant 15 (7;5)	100%	75%
Participant 16 (10;10)	100%	75%	Participant 16 (7;7)	100%	75%

Chapter 6

Conclusions

1. Conclusions

The current thesis investigated syntactic knowledge in children on the autism spectrum. The investigation was conducted within the framework of Universal Grammar (Chomsky, 1975; 1981; 1986), and investigated children's adherence to the principles of binding theory, namely Principles A, B and C, as well as children's knowledge of c-command in sentences containing negation and disjunction. The investigation was carried out within the theory of Universal Grammar (UG), in part because it makes precise testable predictions about aspects of children's grammatical knowledge. Our experiments probed whether or not children's knowledge of the distribution and meaning assigned to reflexives and pronouns within sentences is equivalent to the adult grammar.

The motivation for the investigation was a set of studies by Perovic et al. (2013a, 2013b) that investigated children's knowledge of two of the binding theory principles, namely Principles A and B. The experiments used a picture selection task based on Wexler and Chien (1985) in which children were required to point to the matching picture. The experiments both used simple sentences with possessive pronouns as the subject noun phrase to test adherence to Principle A or B; sentences such as '*Bart's dad is washing himself*' and *'Bart's dad is washing him'*. The possessive noun phrase meant that there was a choice of two potential referents for the pronoun or the reflexive within the clause. The larger noun phrase '*Bart's dad*' was the c-commanding antecedent while '*Bart*' was not. The first study by Perovic and colleagues demonstrated that children with autism showed the same 'Delay of Principle B Effect' (DPBE) as typically-developing children, but their performance on reflexives was much poorer than typically-developing children.

The authors summarized knowledge of Principle A as follows: "The principle is missing, or incorrectly represented, in the grammar of children with autism" (Perovic et al.

2013a, p.23). Furthermore, because the definition of Principle A rests on c-command, the authors go on to say that "children with autism do not show sensitivity to c-command in establishing the complex syntactic dependency of binding, where the antecedent of a reflexive must c-command the reflexive" (Perovic et al. 2013a, p.25). They do not commit to the position that c-command is missing altogether as this would clearly have serious repercussions in the grammar, and instead, Perovic et al. make their claims only for Principle A. The proposal that c-command is not in effect only for Principle A is not satisfying, however, as c-command is a very general relationship between nodes, or in this case, noun phrases in a hierarchical representation. This proposal motivated a replication of the study, with an independent c-command control, as well as further studies on Principle B and C.

The experiments in this thesis used a different methodology than the one followed by Perovic and colleagues for testing all the binding principles. The picture matching task using sentences with possessive noun phrase subjects was potentially confusing to children[36], especially children on the autism spectrum, and, for this reason, our experiments used the dynamic version of the Truth Value Judgment Task (Crain & Thornton, 1998). The stories were acted-out by native speakers of English and videotaped, and then the video clips were presented to the participants on an iPad. The stories ensured that plausible dissent was satisfied, so that children would have no difficulty in rejecting sentences as well as accepting them, thereby giving children the best chance of revealing their grammatical knowledge.

1.1. Summary of Findings

The main finding of this thesis is that children with autism as a group do not have difficulty with Principle A, Principle B, Principle C, or with c-command. While the children with autism did not perform as accurately as typically-developing children, their performance was, nevertheless, remarkably accurate. There was no significant difference between typically-

[36] Another study shows that a non-demanding task like eye tracking can reveal Dutch 4 year olds' correct interpretation of pronouns (Bergmann, Paulus & Fikkert, 2012).

developing children and children on the autism spectrum on any of the binding principles.

It is worth summarizing some details of the population tested in this thesis. All children in the current sample were considered high functioning as assessed by their non verbal scores on the KBIT (Norbury, 2005; Howlin, 2003). The children in the current sample were also categorized as either ALN or ALI based on their performance on the TROG[37]. However, data from ALI children did not show that they were at a particular disadvantage as compared to ALN due to their concomitant language impairment. In addition, the average age of the children studied here is much younger than the previously reported studies by Perovic et al. The average age was 10;3 (range 5;4-12;7 years) and the typically-developing children were of an average of 7;2 (range 5;4-9;3 years). Therefore, given the younger age of the children with autism, it is remarkable that the children performed as well as they did in these investigations.

The obtained findings are consistent with the findings obtained by Terzi, Marinis, Kotsopoulou & Francis (2014) comparing performance of Greek reflexives and pronouns in Greek speaking children diagnosed with autism for whom the authors showed that there was no deficient performance on reflexive binding. Our results also agree with the findings of typical like performance on Dutch strong and weak reflexives as shown by Dutch children diagnosed with autism (Geutjes, 2014). Although there are language specific differences between Greek, Dutch and English, which may introduce further variables, Principle A is nevertheless a universal principle, and so in effect, there should be no cross linguistic differences (see Thomas, 1991). Interestingly, a recent study conducted with British high functioning children with autism as reported by Janke and Perovic (in press) showed intact comprehension of reflexives. The authors furthermore classified the children as ALI based on their performance

[37] If children scored below the 10th percentile, they were categorized as ALI

on standardized language tests. Only three children in the ALI (n = 4)[38] group showed less than perfect performance on reflexives. This latest study assumes importance as intact performance for comprehension of binding relations was assessed by a two-choice picture selection task. In this regard, their methodology was patterned on the lines followed by Perovic et al. (2013a; 2013b). However, this does not undermine our results as their autistic participants (mean age = 12;02) were older than our participants and they also scored better on the KBIT as compared to our sample. Therefore a better result on the picture selection task may have been the result of age and a higher functioning sample as assessed by the KBIT. Next we turn to our specific results on each of the binding principles and tests of c-command.

1.1.1. Principle A

The children with autism as a group performed correctly on Principle A sentences 79% of time while typically-developing children matched on the KBIT performed correctly 94% of time. Our experiment also used possessive noun phrase subjects, so these were clearly not problematic for children. In the control sentences with possessive subjects and a predicate that did not contain a pronoun or reflexive, children with autism performed 85% correctly while typically-developing children performed 83% correctly. The results do not suggest any deficit in grammatical knowledge.

1.1.2. Principle B

The children with autism as a group performed correctly 75% of the time on sentences testing Principle B, while the typically-developing children correctly performed 97.5% of the time on Principle B[39]. The stories used in this particular Truth Value Judgment Task did not

[38] This effort to classify children as ALI based on their scores on two standardized language tests one of which included the TROG, parallels our efforts of classification. The authors did not take a prior decision to recruit children as ALI or ALN in order to assess for comprehension of reflexives.

[39] Individual results for Principle B from 2 children (aged 12;0 and 5;4) showed that only these participants with autism (performance rate = 0%) may display a delay of comprehension consistent with the reported pragmatic deficits in the literature as compared to any of the typically developing children who did not score below 50%. The current results could be considered in line with the widely reported delay of comprehending pronouns for typically developing children, an ability that appears to be in place by age 6;6 years much later than syntactic constraints due to later maturing pragmatic abilities. It could be possible that only some children diagnosed with

evoke any DPBE, even though the children were younger than in the Perovic et al. experiments. This may have been because the feature of plausible dissent was particularly salient in these stories, but this remains a question for the future. At any rate, in this experiment, apparently none of the children had any difficulty computing Rule I, assuming this knowledge was engaged in their responses. If children were not able to compute Rule I, at least on the theory as proposed by Grodzinsky & Reinhart (1993) and Reinhart (2011), they would have accepted coreference in sentences like '*Superman washed him with a sponge*', and shown a DPBE.

These group results should be carefully compared with the previously reported findings because:

- The current sample was also categorized as either ALN or ALI based on their performance on the TROG. Data from ALI children did not show that they were at a particular disadvantage as compared to ALN children due to their concomitant language impairment. However since the sample size of both the ALI and ALN groups were small, this line of research would benefit from future investigations with a larger sample size.
- All children in the current sample were considered high functioning as assessed by their non verbal scores on the KBIT (Norbury, 2005; Howlin, 2003). Thus, these results are not applicable to low functioning children with autism.
- The average age of children studied here is much younger than the previously reported studies. Considering the lower age ranges of the current sample, better performance on pronouns indicates that there is no difficulty with the relevant pragmatic development.

1.1.3. Principle C

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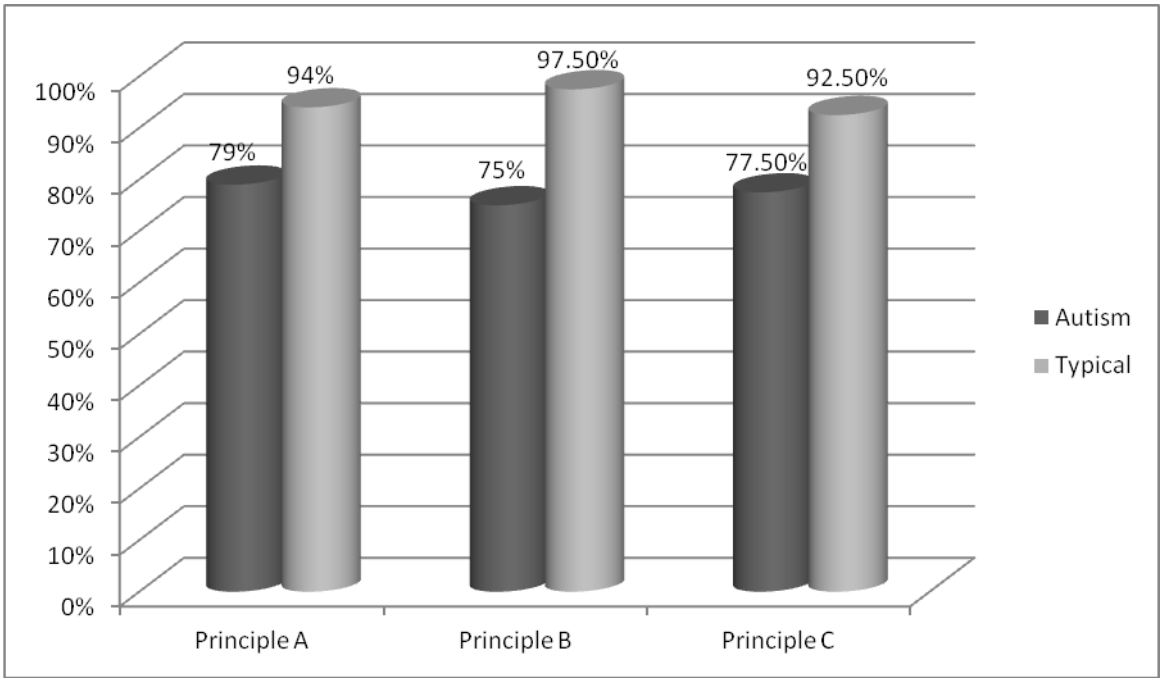
autism have more severe problems with pragmatics which further delays the development of the Principle B constraint. But since there are only two children with a very small sample size, this remains a conjecture at this

The children with autism as a group performed correctly 77.5% while the matched typically-developing children performed correctly 92.5% of the time. The difference was not significant between the two groups. Because the children performed well on Principle B, the performance asymmetry between Principles B and C that emerges in younger typically-developing children did not emerge in this experiment for children with autism. The children simply performed well on both of these principles. According to some theorists (Grodzinsky and Reinhart, 1993 and Reinhart, 2011), there is a pragmatic factor involved in the interpretation of Principle C sentences which is disabled due to directionality. We can assume that if directionality is causing typically-developing children to disallow coreference in Principle C sentences, it is also disallowing coreference in the group with autism. The graph in Figure 1 summarizes the results across the three binding principles. The graph shows remarkably stable performance across the binding principles in both children with autism and their typically-developing KBIT-matched peers.

Figure 1: Correct Mean Percent Performance of Children with Autism & their matched Typically-Developing Peers on Binding Principles



stage.

1.1.4. C-Command: Negation and Disjunction

The thesis also investigated children's knowledge of scope relations in complex sentences with negated disjunction. This experiment served as a c-command control outside the domain of binding for the Principle A experiment. Sentences in which negation has scope over disjunction, that is c-commands disjunction were compared with ones in which there is no c-command relation because negation is inside a relative clause. In the sentences in which negation scopes over negation, De Morgan's law is invoked, and as a result, the interpretation is not subject to the implicature of exclusivity. Thus, this experiment was also seen as a test of children's ability to compute scope relations in syntactically complex sentences containing relative clauses.

The experiment was a replication of Crain, Gardner, Gualmini, & Rabbin (2002) and included sentences as in (1), in which negation c-commands disjunction. In this sentence, De Morgan's Law is invoked, giving rise to a conjunctive entailment. In (2), in which there is no c-command relation between negation and disjunction, the sentence receives disjunctive truth conditions.

(1) The boy who is on the bridge will not get a ball or a car

(2) The boy who isn't on the bridge will get a ball or a car

The children with autism as a group performed 91% correctly for sentences like (1) and 69% correctly for sentences like (2)[40]. Their typically-developing matched peers performed 100% correctly for sentences from the former category while the correct performance rate for the sentences from the latter category was 72%. The slightly lower percentage of correct responses to (2) in this experiment may have been due to carry-over

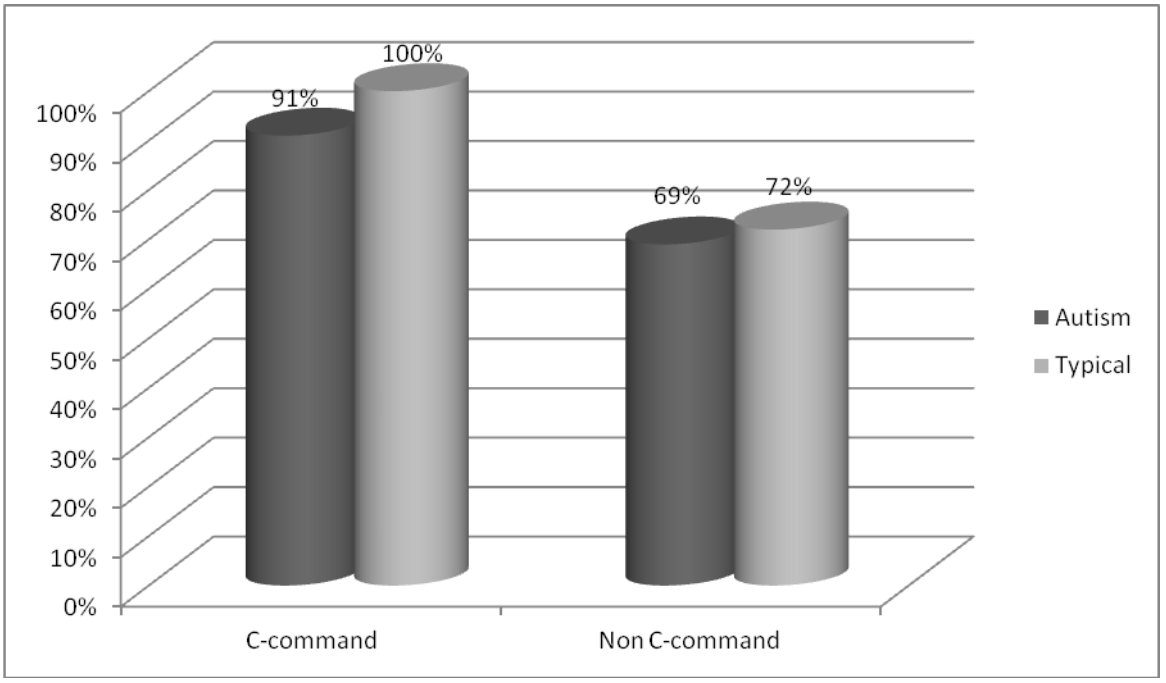
[40] The autism group showed less proficient performance on sentences where negation precedes but does not c-command disjunction. The performance rate is still higher than chance level (50%).

effects which resulted from our within-subject design. Children with autism may suffer from more interference due to working memory/executive functioning deficits. As an independent test that accounted for working memory or executive functioning was not incorporated in our study, this issue is open to future investigation (see Fortunato-Tavares, Andrade, Befi-Lopes, Limongi, Fernandes & Schwartz, 2015).

An alternative reason was explored by Gualmini & Crain (2005), according to whom typically-developing children may perform less efficiently on the Non C-command sentences as there is more distance between 'negation' and disjunction as compared to the C-command sentences. However, they showed that, at least for typically-developing children, the number of intervening words between the two operators does not affect the performance of children. Their performance is only affected by the presence or absence of a c-command relation between the relevant operators.

Whatever may be the reason for differential performance on the C-command versus Non C-command sentences, the children with autism are performing remarkably well and the overall pattern is the same as the typically-developing children, with better performance on the sentences governed by De Morgan's law. The results are summarized in Figure 2.

Figure 2: Mean Percent of Correct Performance of Children with Autism & their matched Typically-Developing Peers on Core Syntactic and Semantic Principles



Broadly, the obtained results could be situated within the central debate of whether language is acquired by experience or is it innately specified. Theorists favouring an experience based view of language acquisition consider environmental factors or parental input to play a very important role (e.g. Tomasello, 2006). On this account, general learning mechanisms that support learning in other domains also facilitate the acquisition of language or, in this case, the way a child understands syntactic dependencies relevant for the binding principles. Any process that interferes with the general learning mechanisms would be expected to disrupt learning in all cognitive domains and language is this regard would be no exception. Deficits of learning mechanisms (an example would be deficits of joint attention in autism, Baldwin et al., 1996) have been established for autism. Therefore such deficits would prove detrimental for acquiring syntactic dependencies. On the other hand, nativists claim that biological factors are more important (e.g. Chomsky, 1986) with minimal need for formal instruction. Accordingly, humans are naturally inclined to acquire language because they are endowed with a special biological module called the language acquisition device (LAD). The presence of this module makes it

easier for a child to work out the rules for language. Language acquisition as such is facilitated by a domain specific computational mechanism. Therefore language learning and the learning of other cognitive skills are treated differently under this approach. This helps to even out the process of language acquisition despite the differences of input that children may receive. Such a biological set-up would ensure adequate abstract linguistic knowledge to kick-start the acquisition process, even if deficits in the learning mechanisms (e.g. joint attention) make it difficult to take up input from the environment. Given that children with autism suffer from problems with learning that underpins the experienced based approach to language acquisition, our experimental results suggest that the innate approach to language acquisition better explains the findings. Refer to Figure 3 for proposed relations between the innate language module, joint attention, language and communication impairments in autism. Observable deficits or typicalities of language are assumed to be dependent upon the domains targeted by language assessment tasks. The TVJT is assumed to be tapping directly into the language capacity of children without an interference from other domains like learning mechanisms and social/pragmatic functioning.

The framework of nativism on language acquisition and nativism in general has been criticized by philosophers as overly speculative and lazy. But the nativism-empiricism (or leaning by experience/parental input) debate is concerned with psychological systems supporting the acquisition of psychological traits. The broad nature of the empiricist debate is construed in terms of domain general systems supporting learning of different psychological traits. Psychological outcomes are explained in terms of environmental conditions under which development occurs. Nativists on the other hand, posit different types of mechanisms and processes specialized for supporting learning in particular domains. Psychological outcomes are explained in terms of diversity of these systems (Margolis & Laurence, 2012).

The poverty of stimulus argument is the cornerstone of the nativism approach. This argument has been criticized by empiricists on the grounds that environment is not as impoverished and learning can go beyond the stimulus e.g. statistical learning methods. But the poverty of stimulus argument should be understood as contrasting the outcomes achieved by general learning vs. specialized learning systems. Strong support comes from biological experiments where animals like squirrels are isolated from other squirrels and removed from their natural habitat (Eibl-Eibesfeldt, 1989). Such squirrels still show the stereotypical behaviour of digging a hole in a solid floor where it is not possible to dig. This kind of behaviour cannot be learnt from the environment as the stimulus was impoverished providing strong support for specialized systems supporting learning.

Other than the arguments, there are many reasons for positing nativism. It is useful and beneficial when a psychological trait is very important and cannot just be left on the environmental input to be acquired. Secondly an innate system ensures acquisition of the trait even when the input is impoverished for instance avoidance of visual cliffs. Relying on environment may be too costly and dangerous in this regard. Thirdly it may take less cognitive effort to learn a trait if it is supported by a specialized system hence reducing cognitive cost (Margolis & Laurence, 2012).

Positing nativism for the topic under study is similarly construed for the current thesis. The results strongly support the existence of specialized language faculty embodying binding principles and hierarchical relation of c-command supporting language acquisition for a clinically diagnosed group.

1.2. Syntax (and Semantics) versus Pragmatics

The experimental findings show that our high functioning group of children with autism can generate syntactic representations for complex sentences containing subject relative

clauses. This result contrasts with the findings of French speaking adults and adolescents as reported by Durrleman, Hippolyte, Zufferey, Iglesias & Hadjikhani (in press). The participants heard spoken sentences containing object or subject relative clauses and had to point to a corresponding picture. The results revealed that participants had problems interpreting these sentences as compared to a group of age matched participants. The present set of sentences only contains subject relatives and does not distinguish between object or subject relative clauses but nevertheless the children with autism performed well on our task. Although we acknowledge differences between French and English, this issue deserves more investigation.

In addition, the children with autism can compute the scope relations in these sentences that give rise to meaning differences. When negation c-commands disjunction, they compute the conjunctive entailment and when it doesn't, they compute disjunctive truth conditions. These results reveal no syntactic or semantic impairment in this domain. Turning to pragmatics, as noted, the term 'pragmatics' is used quite broadly; there is a consensus of opinion that children with autism show deficits in everyday social skills and aspects of 'social pragmatics' (Baron-Cohen, 1988). Our experiments have tested how children fare on an aspect of pragmatics that is intimately related to computation of the binding principles that is Rule I (Grodzinsky & Reinhart 1993; Reinhart 2011). In this domain of 'linguistic pragmatics' (Schaeffer, 2003), our experiments have not uncovered any difficulty.

2. Future Directions

An investigation of the syntax/pragmatics divide in children with autism is a rich area for future research. In the experiments by Perovic et al. (2013a, 2013b) although the DPBE is in effect, but in fact, the usual paradigm for testing this has not yet been tested. The experiments by Perovic et al. tested sentences in which the pronoun had a referential antecedent such as '*Bart's dad'*, but to date, there has not been an experiment in which referential antecedents

are contrasted with quantificational ones, such as '*Every boy's dad'*. It will be useful to fill out the paradigm to see if the usual divide occurs, with acceptances of coreference in sentences like '*Bart's dad washed him'* and rejections of any anaphoric link in sentences like '*Every boy's dad washed him'*. It will also be useful to test development over time on the DPBE in a large sample of children with autism.

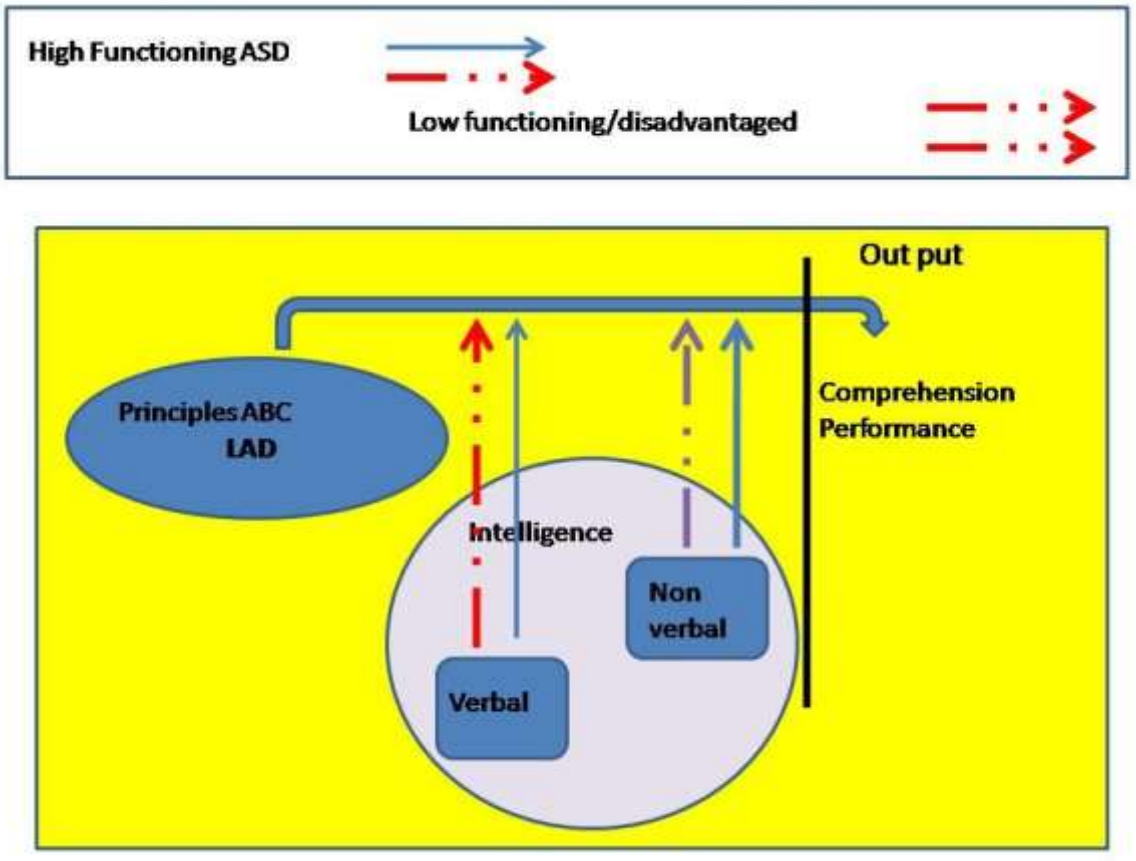
Furthermore, since the studies reported in this thesis employed the TVJT and showed findings that were in contrast to studies that deployed a picture matching task, it may be worthwhile examining performance of the same group of children on these different tasks aiming to study the same domain e.g. pronoun comprehension. Supporting this claim, a study conducted on preschoolers showed that tasks that require a response from young children put heavy demands on the limited cognitive resources of children. A non demanding task like eye tracking showed that Dutch 4 year olds could correctly interpret pronouns (Bergmann, Paulus & Fikkert, 2012).

Since the performance of the children on the spectrum show that their performance is almost adult-like, it motivates another future research direction. According to the innate approach, the adult state is considered the steady state of the language system and the child state is treated as the initial state. Therefore a developmental study on children with autism would helpfully answer any questions on possible delayed developmental trends. The knowledge of grammar is intact but what may possibly slow its manifestation (e.g. problems with working memory/executive functioning) is an interesting future research question.

Finally, in the present set of studies, the typically-developing children were only matched in terms of their KBIT scores. Previous studies have used different groups of matched typically-developing children in order to factor out the effects of non verbal and verbal variables. Children with autism may be more disadvantaged if they have lower scores

on both tests of verbal and non verbal IQs and in this case, a sensitive methodology such as the TVJT may be optimal to uncover their linguistic competence. Refer to Figure 3 for a sketch of a model on how (lower) verbal and non verbal IQ may interact with linguistic knowledge.

Figure 3: Role played by verbal and non-verbal intelligences as these interact with the language module (locus of binding principles) to determine the output that in turn is assessed as 'comprehension' by tasks like picture matching and TVJT. Low functioning children with autism may be more or 'doubly' disadvantaged due to their lower scores on verbal and non-verbal intelligence tests.



Ultimately more thorough cross-linguistic examination of children with autism would be beneficial in supporting the innate stance on this debate although there has been a bit of work comparing speakers of different languages as reported previously. For instance, children

speaking a different language but showing comparable or 'typical' performance on tasks assessing the binding principles and computations of c-command would strengthen the theorizing developed here.

3. Final Remarks

The investigation undertaken in this dissertation has investigated the linguistic competence of children with autism. The investigation has been undertaken in the framework of UG (Chomsky, 1975; 1981; 1986). The binding principles, Principle A, B and C are all assumed to constrain children's hypothesis space, such that they do not allow interpretations that are ruled out by these principles. Our experimental findings are that this knowledge is intact in our sample of high functioning children with autism. As we have pointed out, the range of facts that we have investigated would be very difficult to learn, given that constraints are negative statements, and children do not receive linguistic input informing them of the sentences and interpretations that are prohibited. The way to learn what sentences and interpretations are prohibited would be through corrective feedback, but it is unlikely that children receive any kind of direct teaching about the impossibility of sentences and interpretations (Brown & Hanlon 1970; Morgan & Travis, 1984). Furthermore, given the difficulties with general learning mechanisms or working memory/executive functioning that are reported for children with autism, it is likely that learning an intricate pattern about possible and impossible sentence meanings would be challenging. Our findings provide some support for the view that children with autism are engaging linguistic principles made available by UG. However, investigations of complex grammatical knowledge in children with autism are in their infancy, and there is no doubt a rich debate to follow in future years.

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7. Thesis Appendices

Thesis Appendix A

Age Equivalent Scores for TROG and KBIT

Table 1: Age equivalent scores of all the children on Autism Spectrum for TROG-2*

Participants	**Number of Blocks Passed**	**Chronological Age** (years; months)	**Age Equivalent** (years; months)
1	17	10;11	Above 12;0
2	16	12;7	10;10
3	16	9;7	10;10
4	5	10;9	4;5
5	12	8;9	6;6
6	6	12;0	4;9
7	12	11;0	6;6
8	15	12;0	9;0
9	11	11;9	6;2
10	4	5;4	4;0
11	13	12;7	7;0
12	3	6;7	Below 4;0
13	5	10;6	4;5
14	3	7;5	Below 4;0
15	12	12;4	6;6
16	12	10;10	6;6

Table 2: Age equivalent scores of all the children on Autism Spectrum for KBIT*

Participants	**Raw Scores (nonverbal)**	**Chronological Age** (years; months)	**Age Equivalent** (years; months)
1	37	10;11	16;0
2	31	12;7	10;8
3	28	9;7	9;3
4	30	10;9	10;4
5	20	8;9	6;3
6	30	12;0	10;4
7	34	11;0	13;8
8	26	12;0	8;6
9	26	11;9	8;6
10	24	5;4	7;9
11	34	12;7	13;8
12	18	6;7	5;8
13	20	10;6	6;3
14	15	7;5	5;0
15	32	12;4	11;8
16	27	10;10	8;9

*Age equivalents scores are not used for analysis in the thesis as these can sometime give misleading information. The scores for each participant on the autism spectrum are given here for illustrative purpose only.

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Thesis Appendix B

TROG profiles

Table 1: Individual profiles of ASD children on the TROG-II

Score of 1 indicates 'Pass' and 0 indicates 'Fail'

Participants (Age)	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	**Total**
1 (10;11)	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	0	0	**17**
2 (12;7)	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	0	0	0	**16**
3 (9;7)	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	**16**
4 (10;9)	1	1	1	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	**5**
5 (8;9)	1	1	1	1	1	1	1	1	1	1	0	0	1	0	0	0	1	0	0	0	**12**
6 (12;0)	1	1	0	0	1	1	1	0	0	1	0	0	0	0	0	0	0	0	0	0	**6**
7 (11;0)	1	1	1	1	0	1	1	1	1	1	1	0	1	0	1	0	0	0	0	0	**12**
8 (12;0)	1	1	1	1	1	1	1	1	1	1	0	0	1	1	1	1	0	1	0	0	**15**
9 (11;9)	1	1	1	1	1	1	1	0	1	1	1	0	1	0	0	0	0	0	0	0	**11**
10 (5;4)	1	0	0	0	1	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	**4**
11 (12;7)	1	1	1	1	1	1	1	0	1	1	1	0	1	1	1	0	0	0	0	0	**13**
12 (6;7)	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**3**
13 (10;6)	1	1	1	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	**5**
14 (7;5)	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**3**
15 (12;4)	1	1	1	0	1	1	1	0	1	1	1	0	0	1	1	1	0	0	0	0	**12**
16 (10;10)	1	1	1	1	1	1	1	0	1	1	1	1	1	0	0	0	0	0	0	0	**12**

* The TROG-II comprises of 17 blocks and each of these blocks is designed to test certain grammatical and non-grammatical comprehension abilities. The following description shows what each of these blocks assesses along with an example:

A: Two Elements (The sheep is running)

B: Negatives (The man is not sitting)

C: Reversible in and on (The cup is in the box)

D: Three elements (The girl pushes the box)

E: Reversible Subject-verb-object (the cat is looking at the boy)

F: Four elements (The horse sees the cup and the book)

G: Relative clause in subject (The man that is eating looks at the cat)

H: Not only X but also Y (The pencil is not only long but also red)

I: Reversible above and below (The flower is above the duck)

J: Comparative/absolute (The duck is bigger than the ball)

K: Reversible passive (The cow is chased by the girl)

L: Zero anaphor (The man is looking at the horse and is running)

M: Pronoun gender/number (They are carrying him)

N: Pronoun binding (The man sees the boy is pointing at him)

O: Neither nor (The girl is neither pointing nor running)

P: X but not Y (The cup but not the fork is red)

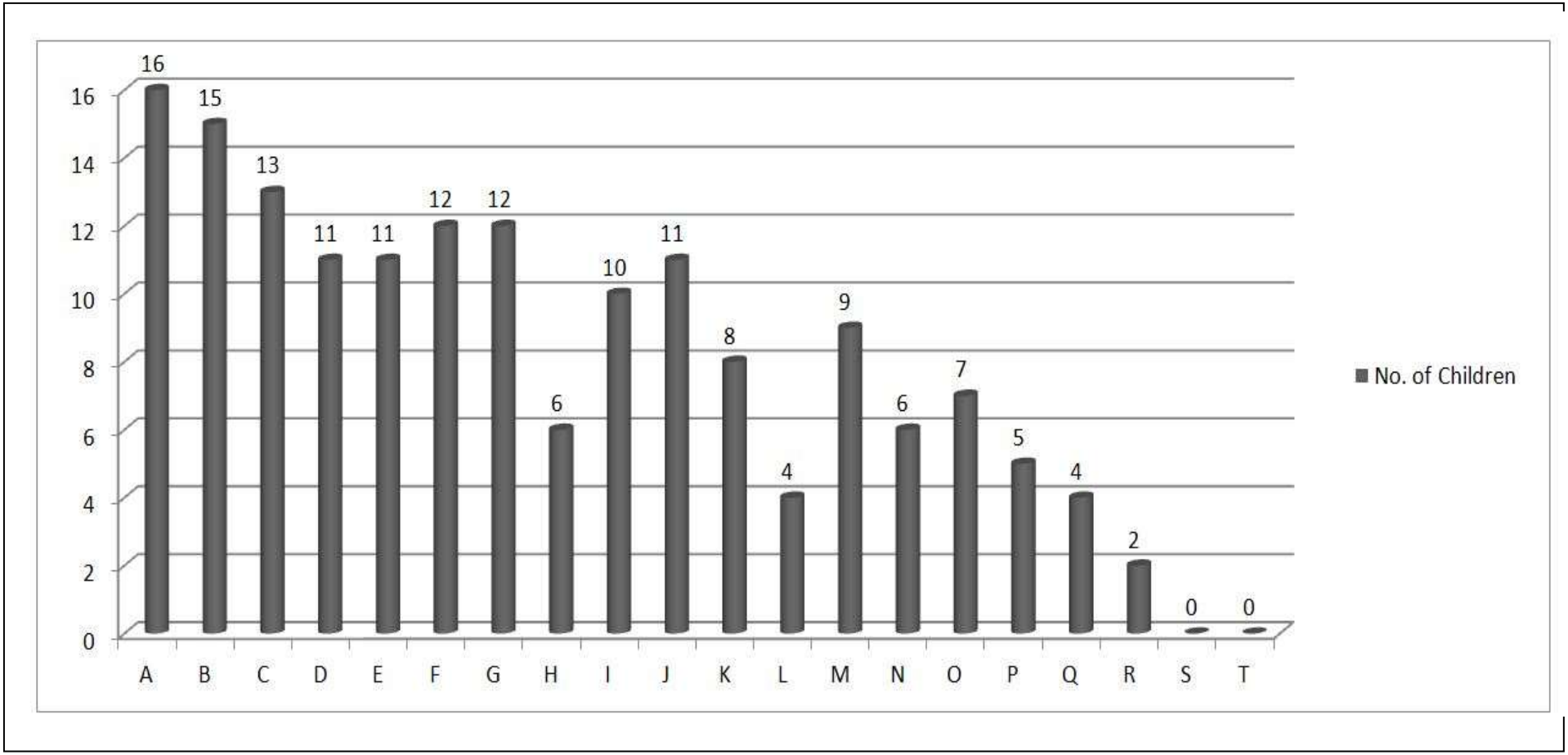
Q: Postmodified subject (The elephant pushing the boy is big)

R: Singular/plural inflection (The cows are under the tree)

S: Relative clause in object (The girl chases the dog that's is jumping)

T: Centre embedded sentence (The sheep the girl looks at is running)

Graph 1: Breakdown of the number of Autism Children who passed each of the TROG blocks



An overview of the individual performance of children[41] across the blocks shows that there was a decrease in the number of children who passed the blocks as the test went on. All of the children failed the final blocks S and T which tested the 'relative clause in object' construct the (e.g. 'the girl chases the dog that is jumping') and the 'centre-embedded sentence' construct (e.g. 'the sheep the girl looks at is running'). Furthermore, blocks A, D and F, that may indicate more general difficulties with remembering words, or integrating information from different parts of a sentence, rather than problems with grammatical comprehension (Bishop, 2003) and an inspection of the data shows that the majority of children passed these blocks and there were no children who failed all three blocks together. It is noteworthy that only 6 children passed block
'N', that tests for pronoun binding.

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[41] 8 children with autism were excluded at the beginning as they were distractive and did not sit through tests because of inattention.

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31 October 2012

A/Prof Rosalind Thornton
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Reference: 5201100880

Dear A/Prof Thornton,

FINAL APPROVAL

Title of project: "Language Acquisition in Autistic and Typically Developing Children"

The above project was approved by the Human Research Ethics Committee effective 9 March 2012. This research meets the requirements of the National Statement on Ethical Conduct in Human Research (2007). The National Statement is available at the following web site:

http://www.nhmrc.gov.au/_files_nhmrc/publications/attachments/e72.pdf.

The following personnel are authorised to conduct this research:

A/Prof Rosalind Thornton
Dr Jon Brock
Mrs Neha Khetrapal
Ms Kelly Rombough
Miss Shu Hui Yau
Mr Cory Bill
Mrs Anna Myra Notley

NB. STUDENTS: IT IS YOUR RESPONSIBILITY TO KEEP A COPY OF THIS APPROVAL LETTER TO SUBMIT WITH YOUR THESIS.

Please note the following standard requirements of approval:

1. The approval of this project is conditional upon your continuing compliance with the National Statement on Ethical Conduct in Human Research (2007).

2. Approval will be for a period of five (5) years subject to the provision of annual reports.

Progress Report 1 Due: 09 March 2013
Progress Report 2 Due: 09 March 2014
Progress Report 3 Due: 09 March 2015
Progress Report 4 Due: 09 March 2016
Final Report Due: 09 March 2017

NB. If you complete the work earlier than you had planned you must submit a Final Report as soon as the work is completed. If the project has been discontinued or not commenced for any reason, you are also required to submit a Final Report for the project.

Progress reports and Final Reports are available at the following website:

http://www.research.mq.edu.au/for/researchers/how_to_obtain_ethics_approval/human_research_ethics/forms

3. If the project has run for more than five (5) years you cannot renew approval for the project. You will need to complete and submit a Final Report and submit a new application for the project. (The five year limit on renewal of approvals allows the Committee to fully re-review research in an environment where legislation, guidelines and requirements are continually changing, for example, new child protection and privacy laws).

4. All amendments to the project must be reviewed and approved by the Committee before implementation. Please complete and submit a Request for Amendment Form available at the following website:

http://www.research.mq.edu.au/for/researchers/how_to_obtain_ethics_approval/human_research_ethics/forms

5. Please notify the Committee immediately in the event of any adverse effects on participants or of any unforeseen events that affect the continued ethical acceptability of the project.

6. At all times you are responsible for the ethical conduct of your research in accordance with the guidelines established by the University. This information is available at the following websites:

http://www.mq.edu.au/policy/

http://www.research.mq.edu.au/for/researchers/how_to_obtain_ethics_approval/human_research_ethics/policy

If you will be applying for or have applied for internal or external funding for the above project it is your responsibility to provide the Macquarie University's Research Grants Management Assistant with a copy of this email as soon as possible. Internal and External funding agencies will not be informed that you have final approval for your project and funds will not be released until the Research Grants Management Assistant has received a copy of this email.

If you need to provide a hard copy letter of Final Approval to an external organisation as evidence that you have Final Approval, please do not hesitate to contact the Ethics Secretariat at the address below.

Please retain a copy of this letter as this is your official notification of final ethics approval.

Yours sincerely

Dr Karolyn White
Director of Research Ethics
Chair, Human Research Ethics Committee