Syntax and Theory of Mind in Autism Spectrum Disorders

VALDES-LARIBI, Huarda

Abstract

Twenty 5 to 15-year-old children with Autism Spectrum Disorders (ASD) were assessed on their ability to understand complex syntactic structures and to attribute a false belief to a protagonist. Syntax tasks included relative clause and wh-question comprehension, as measured by participants’ correct designation of one of three characters. Complement clauses were measured with a truth-value judgment task requiring participants to assess the truth of a puppet’s utterance. These syntactic structures are situated in the highest layer of the syntactic tree (CP), and as such we expected ASD children to show difficulty in understanding them, because of a purported syntactic deficit stemming from prolonged truncation (Durrleman & Zufferey, 2009). Furthermore, we tested the hypothesis that ASD children’s syntax would follow the pattern predicted by a measure of syntactic complexity based on Relativized Minimality...

Reference

Master of Science in Speech and Language Therapy

Syntax and Theory of Mind in Autism Spectrum Disorders

Thesis supervisors: Dr. Stephanie Durrleman and Dr Julie Franck

Jury: Dr H. Delage, Dr S. Durrleman, Dr J. Franck

Huarda Valdés-Laribi
September 2012
Acknowledgments/ Remerciements

Tout d’abord, j’aimerais remercier les enfants et les familles qui ont participé à cette étude. Malgré un emploi du temps très chargé, vous avez donné de votre temps avec enthousiasme et générosité. Sans vous cette étude n’aurait jamais pu avoir lieu. Merci de nous avoir accueillies au sein de vos foyers, et d’avoir partagé votre quotidien avec nous.

This study would not have been possible without the help we received in finding participants. Amongst others, I would like to extend special thanks to M. Dimitri Gisin, psychologist, and Mrs Marie-Jeanne Accietto, president of the Autism Geneva Association. Many thanks to all the other professionals and parents who participated in the recruitment process, unfortunately I do not have the space to mention each one individually here.

I would like to express my gratitude to my two thesis supervisors, Julie Franck and Stephanie Durrleman, for allowing me to embark on this journey from the very beginning of the research process. The many discussions and brainstorming sessions that you led were enriching and exciting, offering precious insight into the processes involved in each step of a research project.

J’aimerais remercier très chaleureusement Sophie Tissot, qui a été ma collègue de recherche au cours de la première année de ce mémoire. Merci pour toute la précision et le sérieux de ton travail, pour les discussions éclairées à propos des tâches et bien entendu pour ton soutien moral.

Je remercie aussi Lola Nadel, Ines Themido, Elisa James et Virginie Boisier pour tout le travail qu’elles ont fourni pour voir les participants et pour l’élaboration de certaines tâches.

Finally, I would like to thank my family and friends for the support they have given me throughout this endeavour: my parents, for your valuable insight and advice and your unfaaltering support, Nathalie for being by my side, for your incredible patience and enthusiasm and your unconditional support. Milena et Amandine, merci d’avoir été là depuis le premier jour de ce mémoire jusqu’à la dernière minute, merci de votre écoute, de vos conseils, et de votre bonne humeur ! Et merci à vous que je n’ai pas pu nommer ici par faute de place, merci d’avoir su attendre, d’avoir su écouter, et de m’avoir soutenue depuis deux ans.
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### Abbreviations

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<thead>
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<th>Abbreviation</th>
<th>Description</th>
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<tbody>
<tr>
<td>AQ</td>
<td>Autism Quotient</td>
</tr>
<tr>
<td>ASD</td>
<td>Autism spectrum disorder</td>
</tr>
<tr>
<td>CARS</td>
<td>Childhood Autism Rating Scale</td>
</tr>
<tr>
<td>CP</td>
<td>Complementizer phrase</td>
</tr>
<tr>
<td>DCM</td>
<td>Derivational Complexity Metric</td>
</tr>
<tr>
<td>DoD</td>
<td>Deaf children of Deaf parents</td>
</tr>
<tr>
<td>DoH</td>
<td>Deaf children of hearing parents</td>
</tr>
<tr>
<td>DSM</td>
<td>Diagnostic and Statistical Manual of Mental Disorders</td>
</tr>
<tr>
<td>FB</td>
<td>False belief</td>
</tr>
<tr>
<td>ICD</td>
<td>International Classification of Diseases</td>
</tr>
<tr>
<td>IP</td>
<td>Inflectional phrase</td>
</tr>
<tr>
<td>IPSyn</td>
<td>Index of Productive Syntax</td>
</tr>
<tr>
<td>LR</td>
<td>Lexical restriction</td>
</tr>
<tr>
<td>MLU</td>
<td>Mean length of utterance</td>
</tr>
<tr>
<td>NP</td>
<td>Noun phrase</td>
</tr>
<tr>
<td>OR</td>
<td>Object relative clause</td>
</tr>
<tr>
<td>PDD</td>
<td>Pervasive developmental disorder</td>
</tr>
<tr>
<td>PDD-NOS</td>
<td>Pervasive developmental disorder not otherwise specified</td>
</tr>
<tr>
<td>RM</td>
<td>Relativized Minimality</td>
</tr>
<tr>
<td>Spec</td>
<td>Specifier</td>
</tr>
<tr>
<td>SR</td>
<td>Subject relative clause</td>
</tr>
<tr>
<td>TD</td>
<td>Typically developing</td>
</tr>
<tr>
<td>ToM</td>
<td>Theory of Mind</td>
</tr>
<tr>
<td>VP</td>
<td>Verb phrase</td>
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Abstract

Twenty 5 to 15-year-old children with Autism Spectrum Disorders (ASD) were assessed on their ability to understand complex syntactic structures and to attribute a false belief to a protagonist. Syntax tasks included relative clause and wh-question comprehension, as measured by participants’ correct designation of one of three characters. Complement clauses were measured with a truth-value judgment task requiring participants to assess the truth of a puppet’s utterance. These syntactic structures are situated in the highest layer of the syntactic tree (CP), and as such we expected ASD children to show difficulty in understanding them, because of a purported syntactic deficit stemming from prolonged truncation (Durrleman & Zufferey, 2009). Furthermore, we tested the hypothesis that ASD children’s syntax would follow the pattern predicted by a measure of syntactic complexity based on Relativized Minimality (Rizzi, 1990, 2004) and the Derivational Complexity Metric (Jakubowicz, 2004, 2011). Results favour both these hypotheses, although only a subgroup of better performing participants was subject to the effects of the most complex syntactic structures.

Theory of Mind (ToM) as measured by verbal and non-verbal tasks is impaired in most individuals with ASD (Baron-Cohen, 2000). Nevertheless a small proportion of ASD individuals succeed in verbal false-belief tasks, and some authors (Tager-Flusberg & Joseph, 2005; de Villiers, 2000; de Villiers and Pyers, 2002) suggest that knowledge of sentential complements allows these individuals to reason about another person’s false belief. However, only sentential complements with communication and cognition verbs were studied by these authors, and they used a memory-for-complements task involving memory load and ToM components. In this study we attempted to tease apart the cognitive components of the traditional complement comprehension tasks to establish whether the link between ToM and sentential complementation still holds when tasks involve a minimum of ToM and memory load. Our results do not follow those found in previous studies, as no correlation was found between participants’ comprehension of sentential complements using a perception verb, and their performance in verbal or non-verbal ToM tasks. In conclusion, children with ASD manifest a clear deficit in understanding complex syntactic structures, which follows a developmental complexity pattern. Deficits in ToM do not seem to be related to understanding of sentential complements where the matrix verb is a perception verb, thus pointing to a specific effect of sentential complements with communication or cognition verbs on ToM performance in children with ASD.
Introduction

The present study aims to investigate two main topics. The first topic centres on an area of language that has not been explored in detail in children with Autism Spectrum Disorders (ASD), syntax. Although there are many documented studies reporting deficits of language use and comprehension in individuals with ASD, very few of these have examined syntax, and even fewer have examined syntax in its more complex forms. Furthermore, these studies have been carried out in English, but not in French. It has been suggested by Durrleman and Zufferey (2009) that older children (and adults) with autism who have a minimum of language skills may have syntax that is reminiscent of young children. The syntactic structures understood and used by children with ASD may reflect a deficit that stems from the prolonged use of early childhood syntactic strategies such as pruning of the syntactic tree, thereby missing the critical period for language acquisition. These structures are then more likely to crystallise as immature syntactic structures, rendering language comprehension and production more difficult even for the higher functioning individuals. In this study, we examined ASD children’s understanding of three different syntactic structures, using linguistic theories such as truncation theory (Rizzi, 1993/1994) and Relativized Minimality (Rizzi, 1990, 2004) as working hypotheses. In particular, we developed a syntactic complexity metric with movement, intervention and similarity as factors of complexity. We then compared participants’ results to the predictions of the metric. This type of fine syntactic mapping could allow for more targeted speech and language therapy interventions in order to build on those structures that are easiest for children with ASD and develop those that are more complex.

The second topic investigated the relation between syntactic processing and Theory of Mind (ToM) in ASD. Several studies have found that children with ASD are not as proficient as their typically-developing (TD) peers in processing sentential complements such as “Thomas said that the sky was grey”. Moreover, ASD children’s processing of sentential complements has been found to correlate with their ability to pass verbal and non-verbal ToM tasks. A particular quality of sentential complements is that they can represent two levels of reality. The truth of the main clause is independent of the truth condition of the embedded clause. In the example above, the sky could be grey or not, but this would not change the fact that Thomas said it was. This particularity of complement clauses has led some authors to suggest that complement clauses provide a representational basis for ToM. Nevertheless, the studies that have linked ToM to complement clause understanding have used tasks that
involve several other cognitive components such as memory, but also ToM itself, and the semantics of certain classes of verbs that are more difficult for children with ASD. In this study, we analysed ASD children’s understanding of complement clauses in situations where memory and ToM components were not solicited as much. We then compared these results to their performance in non-verbal and verbal false belief (FB) tasks to establish whether the link between ToM and certain types of sentential complements can be extended to all sentential complements.

Studying the link between ToM and syntax in ASD could allow for the development of a tool to help children with ASD “learn” ToM through syntax, or at the very least to allow for a better understanding of the mechanisms underlying some of the core deficits in ASD.
Theoretical background

1. Syntax

The study of syntax in typically developing children has led to the development of theories accounting for apparently ungrammatical structures. One such theory is truncation theory (Rizzi, 1993/1994), which states that because of computational limitations and a tendency to choose the most “economical” structures, children’s early grammar tends to prune the syntactic tree of its more complex layers. The more mature the child’s grammar, the less layers they will truncate, and the more complex their syntax will be. For a general introduction to syntax and a detailed explanation of truncation theory, please refer to Appendix I.

Several theories have been proposed to tap into the mechanisms underlying principles of economy such as postulated by Rizzi (2000). These theories establish predictions pertaining to the types of syntactic structures that would be simpler or more complex for children to process. Relativized Minimality (Rizzi, 1990, 2004) and Derivational Complexity (Jakubowicz, 2005, 2011) are two of the most influential such theories, and form the basis for our hypothetical metric of syntactic complexity. They are of crucial relevance for this study, and are explained in detail in Appendix I.

1.1 Predictions arising from Relativized Minimality (RM) and the Derivational Complexity Metric (DCM)

In the Derivational Complexity Metric (Jakubowicz, 2005, 2011), the most important factor that influences complexity would appear to be movement. A structure containing the movement of an element will be more complex to process than a structure containing no movement.

In Relativized Minimality (Rizzi, 1990, 2004), two factors seem to influence the complexity of any given syntactic structure: intervention and similarity. A structure containing an intervener that is similar to the target will be more difficult to process than a structure containing an intervener that is different, and even more so than a structure containing no intervener at all.

Combined, these two theories could therefore lead us to postulate the existence of three factors determining syntactic complexity, and thereof children’s performance: movement,
intervention and similarity. Similarity arises only when the sentence contains an intervener, which can only appear when there is movement in the sentence. It is therefore possible to surmise the following metric of complexity, from most syntactically simple to most syntactically complex:

1. No movement
2. Movement only
3. Movement and intervention with a dissimilar intervener
4. Movement and intervention with a similar intervener

1.2 Sentential complements

Sentential complements are comprised in the highest level of the syntactic tree, as are wh-questions and relative clauses. A sentential complement is a subordinate clause embedded in a main clause, functioning as an argument of a verb in the main clause, such as in (5).

(5) She hoped [that it would soon end.]

In this example, “She hoped” is the main clause, and “that it would soon end” is the subordinate clause or sentential complement. A particular feature of sentential complements is the type of verb that is used in the main clause, or matrix verb. Matrix verbs comprise several types of verbs such as verbs of communication (e.g. “say”), verbs of perception (e.g. “see”) and mental state verbs (e.g. “hope”). These types of verbs can take complement clauses.

There are several kinds of complement clauses, that depend on the presence of complementizers such as “that” and whether or not the verb is finite. For example, the following sentence is a nonfinite complement clause, since its verb is nonfinite and it is missing a complementizer:

(6) Jane saw [the dog attacking].

Sentence (7) is a finite complement clause, since its verb is finite and it contains a complementizer.

(7) Jane thinks [that the dog ate the bone].
In this paper, we will be studying finite complement clauses, because of their purported role in theory of mind development (see below).

The matrix verb of a complement clause can belong to one of several different classes. Noonan (1985) categorised matrix verbs into different types according to their semantics (e.g. utterance, pretence, knowledge), and Kiparsky and Kiparsky (1970, cited by Poltrock, 2011) categorised matrix verbs into factive, nonfactive, or counterfactive according to the truth-value of the complement clause.

This is of particular interest to us, as the different types of verbs imply different truth values in the complement clause, which in turn interacts with the children’s cognitive abilities in order to understand the sentence. For example, factive verbs (such as verbs of knowledge, e.g. know, discover; and commentative verbs, e.g. regret, be sorry) are followed by a true embedded clause such as in “He regrets that the train left”, where the train must have left for the sentence to be pragmatically felicitous. Nonfactive verbs - such as propositional attitude verbs like think or believe- or communication verbs like say - can be followed by an embedded clause whose truth value is undetermined, such as in (6), where the dog may or may not have eaten the bone, and in either case the sentence is pragmatically felicitous. To understand a complement clause containing a nonfactive verb, the child (or adult) has to have understood that the truth value of the complement clause is undetermined, and not take it at face-value. A third category of matrix verbs is the counterfactive category. Counterfactive verbs, comprising pretence (e.g. pretend) and desiderative verbs (e.g. want, wish, desire), require the embedded clause to be false, such as in “He pretended that he was a fox”.

These different types of verbs appear at different stages of children’s development. It would seem that communication verbs are acquired before mental state verbs, perhaps because “the propositions embedded under verbs of communication can be evaluated with respect to their truth as acts of speaking are overt whereas acts of thinking are not.” (Poltrock, 2011).

Furthermore, certain types of mental state verbs have been found to be used more often by young children. What Bloom et al. (1989) label as “epistemic” verbs (e.g. think, know), are used more often in finite complement clauses than sensory verbs (e.g. see , look) (Bloom et al., 1989).

In a comprehension task where children had to answer yes/no/maybe to the truth of an embedded proposition under nonfactive, factive or counterfactive matrix verbs, Schulz (2000)
(cited by Poltrock, 2011) found that the 4 to 6-year-old children correctly interpreted the
different truth values depending on the type of verb presented.

The existing research pertaining to typical development of complement clauses in children’s
speech would seem to point to 3 and 4-year-old’s inability to embed the complement under
the matrix verb. Children of this age limit their sentence production to real states of affairs,
and do not seem to understand the potential to express false propositions (Poltrock, 2011).

2. Language in Autism and Autistic Spectrum Disorders (ASD)

Autism is a neurodevelopmental disorder present from infancy, affecting the individual’s
social and communicative skills, characterised by repetitive behaviours and restricted
interests. For a discussion on diagnostic criteria and prevalence of Autism Spectrum
Disorders, and a review of the findings related to general language development, phonology,
semantics, prosody, discourse and pragmatics, the reader can refer to Appendix II. Methodological
considerations when conducting studies with ASD children can also be found
in Appendix II. In the section below, we will briefly discuss the findings related to syntax in
autism, which is the main focus of this paper.

2.1 Syntax and morphology

There have been quite diverse findings in the area of syntax and morphology in ASD. The
few studies conducted in the area of morphology have yielded contrasting results (Eigsti et
al., 2011). Results vary depending on the type of control group used (language-impaired
controls or mental-age matched controls). While some have not found any significant
difference between ASD and language-impaired children in the use of certain morphemes
(Cantwell et al. 1978), others have found that children with ASD omit more obligatory
morphemes than their TD and developmentally delayed mental-age matched peers
(Bartolucci, Pierce, and Streiner, 1980). Eigsti et al. (2007) also reviewed the literature on
syntax acquisition in ASD children, and found that although pragmatics has been extensively
studied in autism, “there has not been a similarly in-depth exploration of the syntactic
development in autism, nor how it may relate to underlying cognitive impairments”. 
In a longitudinal study by Tager-Flusberg (1990) similar scores were obtained by children with autism, mental age-matched Down syndrome, and normal controls in the Index of Productive Syntax.

In a subsequent study with older ASD children (9 to 16 year-olds), Eigsti et al. (2009) found that the ASD participants obtained poorer results in grammatical judgment tasks testing understanding of third person singular and present progressive marking.

Certain studies indicate that children with ASD show rigid grammatical structures, including less variety of syntactic structures compared to control groups (Rapin & Allen, 1988; Shapiro 1977; Shapiro & Kapit, 1978 – all cited by Eigsti et al., 2007). Some authors such as Perovic, Modyanova and Wexler (2012) find that children with autism show impaired understanding of reflexive pronouns, a pattern that is not found at any point in typical development.

It is safe to conclude that although results vary, syntax in autism does indeed present with particularities and impairments that are worth studying in more detail. In the subsections below, we will review the main findings concerning certain complex syntactic structures that were mentioned in section 1 (syntax): wh-questions, complement clauses and relative clauses.

**Wh-Questions.** In a study of spontaneous speech in children with autism and Down syndrome, measured with the Index of Productive Syntax, Eigsti et al. (2007) found that children with autism produced less question and negation utterances than TD or developmentally delayed controls. Park et al. (2012) also found that children with autism obtained lower scores on the questions and negations subscale of the IPSyn, but this result was not significantly different to their TD and developmentally delayed controls. Eigsti et al. (2007) suggest that these poor results might not actually reflect limited syntactic knowledge, but conceptual limitations such as an inability to discuss people or events that are not present. These topics are usually expressed using more complex syntax.

In a longitudinal study comparing two small groups (n=6) of children with Down syndrome and autism, Tager-Flusberg et al. (1990) conclude that TD children, children with Down Syndrome, and children with autism have “similar developmental patterns in the emergence of syntactic and morphological structures”. MLU and IPSyn scores were analysed, and the only significant group difference was found in the highest MLU stage (>3.5), with the question/negation subscale of the IPSyn for the Autism group being lower than that of the
Down Syndrome group. This subscale evaluates the production of 11 types of syntactic structures (Scarborough et al., 1991) such as intonationally marked questions, wh-questions with inversion and inverted yes/no questions.

Durrleman & Zufferey (2009) furthered the analysis of Tager-Flusberg et al.’s 1990 corpus in order to establish which syntactic structures in the complementizer phrase were impaired. They chose to study the utterances of two children with an MLU above 2, so as to include only children who might use more complex syntactical structures. The findings point to an impaired CP layer, with few occurrences of spontaneous questions, and 25% of agrammatical questions, such as absence of auxiliary or absence of subject-auxiliary inversion.

Zebib et al. (in press) studied the production of wh-questions by French-speaking children. They found that children with ASD produce significantly less appropriate wh-questions, i.e. questions which contain the target wh-word and the target verb, which they interpreted in part as being due to pragmatic difficulties. The ASD children also tended to avoid the more complex wh structures, producing more in-situ questions than their TD controls (6 year-olds), but producing just as many as TD 4-year-olds.

**Relative Clauses.** There have been few studies examining ASD performance on relative clauses. Durrleman and Zufferey (in press) studied a population of normal IQ French-speaking adults with autism and Asperger’s syndrome, and found that they had more difficulty with object relatives than with subject relatives. As seen in the previous section, these difficulties are apparent in young children, but disappear in older children. These findings are particularly surprising given the claim that Asperger’s syndrome individuals do not display any language delay, and it follows the rationale for eliminating the difference between Autism and Asperger’s, as proposed by the DSM-5.

Riches et al (2010) studied a population of ASD teenagers with language impairment, compared to SLI and TD teenagers. The teenagers were asked to repeat object and subject relative clause sentences. The authors found that the ASD participants were better than the SLI group on overall repetition of relative clauses, but worse than the TD group. The ASD and SLI participants made more errors when repeating the object relatives than when repeating the subject relative, proportionally to TD participants.

**Complement clauses.** As we have seen in the first section of this chapter, complement clauses have certain semantic characteristics that could be difficult for children with autism to
fully master. In particular, the possibility of including a false proposition in the embedded clause while keeping the same truth value of the entire sentence could be problematic. As such, complement clauses in autism have been studied in relation to Theory of Mind (ToM) acquisition, as the property of representing false propositions is thought to be ideal for representing false beliefs. The details of the relationship found between ToM and complement clauses will be examined in the next sections, but we will briefly look at the results pertaining to ASD children’s results in complement clause understanding.

Tager-Flusberg (2000a) studied ASD children’s understanding of complementation, using 4 communication verbs and 4 cognition verbs. The children were told 8 short stories taken from de Villiers & Pyers (2002), with a communication verb in the matrix clause, such as “She told the girl there was a bug in her hair, but it was only a leaf”, and had to extract the complement “that it was only a leaf” in order to answer the question correctly: “What did she tell the girl?”. Those children with autism who passed a measure of false-belief (a component of ToM) were significantly more likely to interpret the complement clauses correctly. They did not perform as well as matched peers with mental deficiency on the complement clauses with cognition verbs, but performed just as well on the complement clauses with communication verbs. The link between ToM, syntax and autism will be further explored in the sections below.

Lind and Bowler (2009) conducted a study comparing ASD children with matched groups of children with learning disabilities and TD children. The matching procedure is not specified in their paper. According to the authors, the choice of communication verbs rather than mental state verbs meant that ToM skills were not needed to interpret the story correctly. The results show that all groups have similar understanding of syntactic complements, as the authors found no significant difference between the groups. These results would suggest that children with ASD do not have more difficulties than matched peers in understanding complement clauses when the matrix verb does not present a specific semantic difficulty, such as in cognition verbs.

*Limits of the previous studies.* As we have seen in the sections above, there have been relatively few studies examining the syntactic abilities of ASD individuals in detail. Most of the measures of syntactic complexity have been rather general, such as IPSyn or a simple calculation of MLU. There have not been many studies including experimental manipulations of specific syntactic structures, and practically none have studied the more
complex structures of the sentence, i.e. the structures in the Complementizer Phrase. When problems have been identified in syntax acquisition, they have often been underspecified, such as those identified in Eigsti et al. (2007) for \textit{wh}-questions. It is indeed not clear what type of differences were found in the utterances of the children with ASD in this study.

There is little data on relative clause acquisition in ASD, and no studies have examined complement clause comprehension with perception verbs. Furthermore, certain studies have not distinguished clearly between different components influencing children’s performance, in particular the difference between syntactic and conceptual processing. For example, in Tager-Flusberg’s (2000, 2005) study of complement clauses in ASD, the task required children to use certain components of Theory of Mind to understand the false proposition in the complement clauses as well as their syntactic structure. It is therefore not clear whether the children failed the tasks because of a lack of ToM knowledge or syntactic knowledge.

2.2 \textbf{Autism and truncation theory}

Following Durrleman & Zufferey (2009), the different outcomes of the studies above could be explained by applying truncation theory to ASD children’s speech. It would indeed seem plausible that ASD children strip off the higher layers of the syntactic tree, perhaps due to their limited cognitive resources. It is possible to surmise that children with ASD continue to truncate beyond the critical acquisition of language period, rendering subsequent development difficult. The result of this could be an impaired CP layer.”

3. \textbf{Theory of mind}

Theory of Mind (ToM) refers to the capacity of inferring mental states in others and oneself. For a detailed description of ToM and the tasks used to measure it, please refer to Appendix III.

3.1 \textbf{Theory of Mind and Language}

Many authors have argued that there are close links between ToM and language development. Intuitively, it is quite easy to imagine how the ability to attribute mental states to others contributes to social interactions, which in turn enriches and develops language skills. As Eigsti (2011) writes, “Because of the coupling of these processes, disentangling their unique contributions will provide a significant challenge”. Despite this challenge,
several authors have attempted to separate ToM from language in order to study each one in a separate manner, and establish the influences that ToM may have on language, and vice-versa. To this day, research in this field remains the topic of debate. In particular, it is very difficult to establish a specific causal direction between ToM and language, precisely because of the interaction between the two.

In the next paragraphs we will briefly overview a few of the more influential papers studying the relationship between ToM and language. Astington & Jenkins (1999) were some of the first to study children’s performance in false-belief and appearance-reality tasks in relation to their performance on standardized tests of syntactic and semantic ability. In a longitudinal study, they tested 59 TD 3-year-old children over a period of 7 months. They found that the children’s initial language scores predicted the later ToM scores, but that the initial ToM scores did not predict the later language scores. Furthermore, the syntactic scores were better predictors of ToM abilities than were the semantic scores.

In 2007, Schick et al. presented the findings of a study of deaf children. They compared three different groups: deaf children of deaf parents (DoD), deaf children of hearing parents (DoH), and hearing children of hearing parents. Having acquired a natural signed language during the same critical period, DoD typically show the same language abilities as hearing children of hearing parents. DoH on the other hand typically present delayed language, as they are not exposed to sign language at an early age. Other than this language delay, the DoH do not have cognitive impairments that could affect their ToM understanding. If language is necessary for ToM development, then the DoH children should not perform as well on the ToM tasks. If language is not necessary for ToM development, then the three groups should obtain similar results. Schick et al. (2007) chose ToM tasks with high verbal content (unexpected content stories, unseen change-in-location), but they also included tasks with low-verbal content. The DoH and TD children were also tested on their language abilities with standardized and experimental tasks. In particular, the authors used de Villiers and Pyers (2002) memory for complement clause task to test the comprehension of complement clauses. In this task, children were told four short stories accompanied by two photographs, followed by a question whose answer required the embedded clause to be extracted. Only communication verbs were used, as de Villiers and Pyers (2002) have claimed that communication verbs do not require any understanding of false beliefs. The authors found that DoH children did indeed perform below the level of TD and DoD children. They found
that the predictors of success in both low-verbal and high-verbal content tasks were vocabulary and syntactic complements.

Although the studies reported above claim to have found a causal relation between ToM and complement clauses, the memory-for-complements task still may contain a component of ToM and therefore does not completely separate the two domains being studied. Furthermore, San Juan and Astington (2012) report De Mulder (2011)’s findings where a measure of memory for complement was not found to show any correlation with explicit false-belief understanding.

Complement clauses are not the only complex syntactic structure to have been studied in relation to ToM. Smith et al. (2003) conducted a truth-value judgment task to evaluate TD children’s understanding of relative clauses. Relative clauses were found to be a good predictor of future ToM abilities. These results would point in favour of the view that language, and in particular embedded syntactic structures such as complement clauses or relative clauses, precede the development of ToM. According to the authors supporting this view, the acquisition of embedding could allow children to extract a false proposition from an embedded clause (such as in the memory for complements task), thus allowing them to reason about false-belief and ToM.

Authors such as Baillargeon et al. (2010) argue that the infants tested in nonverbal spontaneous tasks of ToM have developed full representations of belief. Since infants have not yet started producing language, this is taken as an indication that ToM development precedes the acquisition of grammar. Others (e.g. Perner) have claimed that the ToM abilities needed to pass implicit nonverbal ToM tasks are not as complex and developed as those needed to pass explicit ToM tasks.

Despite these diverging findings, evidence from training and longitudinal studies (such as Hale & Tager-Flusberg, 2003 or Lohmann and Tomasello, 2003’s training studies) points to a strong relationship between language and explicit FB understanding. However, more research is needed on the relationship between indirect, spontaneous-response false-belief measures and language.

A link between language and ToM has also been proposed in autism. ToM deficits have been used to explain the language impairments of children with ASD: pragmatics of course, but also the development of the lexicon. As children with ASD have difficulties in shared
attention, the cues that TD children use when learning to attribute a new word to an unknown object are not used by ASD children (Baron-Cohen, Baldwin & Crowson, 1997). A crucial finding in the links between language and ToM in autism is that certain language abilities such as complex syntax have been found to be good predictors of success at false-belief tasks. We will examine this notion in the sections below.

3.2 Theory of Mind, syntax and autism spectrum disorders

As Baron-Cohen writes, “One view is that the speech of many children with autism shows us what a pure “syntax organ” might look like, devoid of the normal overlay of pragmatics.” (Baron-Cohen, 1994). Shedding light on the link between syntax, ToM and ASD could help to tease apart the influences of ToM and syntax on one another. Studying this link could also be very useful in establishing educational and therapeutic guidelines to aid ASD individuals in both ToM and language.

Although most children with ASD do fail false-belief tasks, those who do not could provide valuable insights into the mechanisms behind false-belief understanding. If ToM impairment is indeed a core deficit in autism, these findings must somehow be explained. Happé (1995) found that the verbal abilities of those ASD children who succeeded in the false-belief tasks were higher than that of TD children when they first succeed in the false-belief tasks. Could it be that children with ASD are counting on their language abilities more than TD children to succeed in the false-belief tasks? Children with ASD may be using verbal strategies to reason about false-belief tasks, such as has been suggested by Bowler (1992) and Happé (1995). Some authors such as Tager-Flusberg & Joseph (2005) and de Villiers (de Villiers, 2000; de Villiers and de Villiers, 2000; de Villiers and Pyers, 2002) argue that children with autism might be bootstrapping on the ability to extract embedded clauses (such as in understanding complement clauses) in order to understand the false beliefs held by others. In particular, de Villiers suggests that it is the acquisition of mental state verbs that allow children with ASD to reason about other peoples’ mental states. As we have seen above, these verbs typically occur in complement phrase structures.

In a study using the memory-for-complements task with ASD children, Tager-Flusberg and Joseph (2005) found that performance on the complement clause task with communication verbs was a predictor of performance on ToM, but not mental state verbs. Nevertheless, given the difficulties that children with ASD show in understanding mental state verbs, and the fact
that communication in general poses a problem in ASD, it could be that had the authors tested memory for complements with verbs of perception they would have found different results.

As we have seen throughout this chapter, the fields of syntax, autism, and ToM are closely interlinked. Although all three areas have been studied, it is not yet clear what the relationship is between ToM and syntax in autism, in particular whether one specific syntactic structure (complement clauses with communication verbs) is linked to ToM abilities, or whether all structures in the Complementizer Phrase could be linked to ToM abilities. Indeed, Smith et al. (2003) found that relative clause performance, a structure that is also in the CP, was linked to ToM. Furthermore, *wh*-questions, which are also situated in the CP, must be understood correctly in order to answer the questions in verbal false-belief tasks such as the “Sally-Anne” task. Moreover, although verbal and non-verbal tasks have been used with TD and other atypical populations to study the relation between ToM and syntax, only verbal false-belief tasks have been used in ASD. It would be important to measure ToM ability in relation to language with other types of tasks, in particular with tasks involving little or no verbal content. If very young children succeed in these tasks, perhaps what is difficult for ASD children in the false-belief verbal tasks is the high verbal content.

In addition to these complex interactions between ToM and language in autism, there are still many open questions concerning the syntactic impairments that can be found in children with ASD. It could be that the ToM deficits in children who do not pass false-belief tasks are related to their more general impairments in the structure of the Complementizer Phrase. To date, there have been very few studies examining in close detail these higher layers of the syntactic tree in autism. By studying different structures comprised in the CP, such as relative clauses, *wh*-questions and complement clauses with other verbs, it might be possible to elucidate in part the types of mechanisms taking place in language development for ASD. It is also possible that the linguistic theories presented in the first part of this introductory chapter could be further developed in light of the results of ASD children on complex syntax tasks.

4. **Outline of the present study**

In this research, we propose to study French-speaking ASD children’s understanding of complex syntactic structures comprised in the CP. We will examine relative clauses and *wh*-questions with different degrees of syntactic complexity according to Relativized Minimality
(Rizzi, 1990, 2004) and the Derivational Complexity Metric (Jakubowicz, 2004, 2011) and in accordance with structural economy. These structures have been studied in production tasks, but not in comprehension tasks. Furthermore, testing ASD children’s understanding of in-situ questions could add to the data establishing a hierarchy of syntactic complexity for wh-questions, which is still under debate. We will also examine ASD children’s understanding of complement clauses using a perception verb, which has only been done with TD children (Poltrock, 2011), and a communication verb where the cognitive load has been reduced as much as possible and the biases of the original memory-for-complement task have been diminished. As well as exploring ASD children’s understanding of complex syntax, we will study the relationship between performance in verbal and non-verbal explicit ToM tasks.

### 4.1 Research Hypotheses

A. Children with ASD have a syntactic impairment whose manifestation is similar to early stages of language development in TD children. This is apparent in the truncation of the upper layers of the syntactic tree.


C. Deficits in memory should increase sensitivity to similarity-based intervention, following the hypothesis that RM stems from a performance constraint arising in the memory system.

D. The development of certain complex syntactic structures is related to the development of ToM in ASD children. In particular, because complement clauses allow the embedding of a false proposition independently of the truth of the main clause, they can be construed as a stepping-stone for ASD children in accessing ToM.
Method

1. General method

Participants’ knowledge of complex syntactic was assessed through tasks designed to evaluate understanding of relative clause structures, *wh*-questions or complement clause structures. In the *wh*-question and relative clause tasks, children were asked to point to one of three characters on the computer screen after having heard a target sentence. In the complement clause tasks, children were asked to judge the truth-value of a sentence uttered by a puppet.

Complexity of syntactic structures was operationalized via Type (Object/Subject for *wh*-questions and relatives), Restriction (Lexically Restricted/ Bare for *wh*-questions) and Situ (In-situ/Ex-situ for object *wh*-questions). As a measure of children’s understanding of complement clause syntax, we conducted two different experiments designed to exclude as much as possible the semantic difficulties of classic complement clause comprehension tasks, each using two verbs from different semantic classes: a communication verb and a perception verb.

ToM was assessed with two kinds of tasks: one task with high verbal content and two tasks with low verbal content. The high verbal content task required understanding of linguistic stimuli, a verbal response, and the ability to remember a short story, in order to attribute a false belief to a protagonist. The two low-verbal content tasks had little linguistic requirements, and the child was asked to give a non-verbal response. Participants’ ability to attribute a false belief to a protagonist was compared across the different tasks in order to assess the role of language in understanding of ToM tasks.

In addition to the syntax and ToM tasks, we administered memory tasks to assess the two storage systems of working memory as construed by Baddeley (2003): the phonological loop and the visuospatial sketchpad. Descriptions of the memory tasks we chose can be found in Appendix VII. Furthermore, the EVIP (Echelle de Vocabulaire en Images Peabody), a French adaptation of the Peabody Picture Vocabulary test-revised (PPVT-R, Dunn et al., 1993) was administered, but data was not analysed in this thesis as all children had not been tested at the time of writing.

Tasks were administered by Psychology or Speech and Language Therapy students who had previous experience with ASD children. All children were seen at their home. Each session
lasted around one and a half hours, with frequent breaks tailored to the child’s needs. Each child was seen over five to eight sessions.

2. Operational hypotheses

A. Our first research hypothesis was operationalized through the study of three different structures situated in the CP layer of the syntactic tree: wh-questions, relative clauses and complement clauses. Children with ASD were expected to perform poorly across all these tasks if the upper layers of the syntactic tree are indeed truncated.

B. The second research hypothesis predicted that ASD children’s results on syntax comprehension would follow a pattern that reflected the principles of Relativized Minimality and Derivational Complexity. Complexity was operationalized by Type (Object/Subject), Restriction (Lexically Restricted (LR)/Bare) and Situ (In-situ/Ex-situ). It was predicted that participants would obtain lower results in the Object conditions than in the Subject conditions, that they would obtain lower results in the LR condition than the Bare condition, and in the Ex-situ compared to the In-situ condition. These predictions also led to the development of the factors in table 1 (Movement, Intervention and Similarity). It was predicted that ASD participants would follow this hierarchy of hypothetical syntactic complexity. They were expected to obtain the highest results for structures with no Movement (a and b), followed by structures with Movement (c, d, and e), then with Movement and Intervention (f), and finally structures with Movement, Intervention and Similarity (g and h).

Table 1

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Object question, in situ, bare</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>b. Object question, in situ, lexically restricted</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>c. Subject question, bare</td>
<td>+</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>d. Subject question, lexically restricted</td>
<td>+</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>e. Subject relative, NP object</td>
<td>+</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>f. Object question, ex situ, bare</td>
<td>+</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>g. Object question, ex situ, lexically restricted</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>h. Object relative, NP subject</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
</tbody>
</table>
C. The hypothesis that RM stems from a performance constraint arising in the memory system can be operationalized through studying the relationship between participants’ results in memory tasks and their results in tasks involving similarity-based intervention. These two types of tasks should be closely correlated if deficits in memory increase sensitivity to similarity-based intervention. Although we did collect memory data, this aspect will not be presented in the current study as it is beyond the scope of the present thesis.

D. Our final research hypothesis linked ToM with complex syntactic structures, and in particular the syntax of complement clauses. The predictions arising from our hypothesis were that

i. ASD children’s results in the ToM FB verbal task would show a significant correlation with their results in complement clause comprehension.

ii. Complement clause comprehension should correlate with the ToM verbal task regardless of the semantics of the matrix verb (communication verb/perception verb), if it is indeed the syntax of the structure that allows children with ASD to solve false belief tasks.

iii. We expect no correlation between verbal ToM results and children’s understanding of wh-questions and relative clauses. Indeed, we have adopted the view that complement clauses have specific properties (namely the independence of the truth value of the main clause and the embedded clause) that allow children to access ToM, and that are not shared with relative clauses or wh-questions.

iv. If ToM in ASD children is facilitated by syntax, we expect no significant correlation between results in low verbal content ToM tasks and complement clause understanding, wh-question understanding or relative clause understanding.

v. The final predictions arising from hypothesis D concern the comparison of results across ToM tasks. If language play an important role in ASD children’s understanding of ToM tasks, we expect no correlation between the verbal ToM task and the low-verbal ToM tasks, although we do expect a correlation between the two low-verbal ToM tasks.
3. Participants

20 children (17 boys and 3 girls) were recruited through parent associations and psychologists. Two participants were excluded because of failure to understand and attend to the tasks. Ages ranged from 5 to 16 years old (mean = 115 months; SD= 35 months). Nine participants were French-speaking monolinguals, the others all spoke French at school. All participants had been diagnosed as being on the Autistic Spectrum by a specialist. Three children were diagnosed with PDD, two with PDD-NOS, nine with autism (one of whom also had Fragile X syndrome), three with Asperger’s syndrome, and one with childhood psychosis with autistic traits.

In addition to these official diagnoses, we conducted a parent questionnaire (the Autism Quotient for Children, Auyeung, Baron-Cohen, Wheelwright & Allisson, 2007) and a standardised clinical evaluation, the Childhood Autism Rating Scale (Schopler, Reichler, Rochen Renner, 1988). Results to these tests, as well as individual participants’ diagnoses and language status can be found in Appendix I.

Initial analyses included Age as a factor, where half of the participants were considered “Younger” (range= 66 –102 months; M= 85 months; SD= 14 months) and half were considered “Older” (range= 108 – 192 months; M= 137 months; SD= 25 months). This way of grouping children is commonly used for TD participants. However, given the great variability in ASD individuals’ cognitive profiles across all ages, Age was abandoned as a criterion to group our participants. We thus split the group in half based on syntactic performance in the wh-question task (Poor / Good). Indeed, those children who performed better on this task also had a tendency to perform better on the relative clause task and the complement clause task, thus justifying such a split. For a distribution of results, please see Appendix V. The age characteristics of these two groups are shown in table 2.

<table>
<thead>
<tr>
<th>Group</th>
<th>Age range</th>
<th>Mean age</th>
</tr>
</thead>
<tbody>
<tr>
<td>Good</td>
<td>66 - 192</td>
<td>120 (40)</td>
</tr>
<tr>
<td>Poor</td>
<td>69 - 151</td>
<td>108 (32)</td>
</tr>
</tbody>
</table>
4. Method: Syntax Tasks

4.1 Relative clause comprehension

4.1.1 Materials

The independent variable was the relative clause Type: Object vs Subject. There was an equal proportion of Object and Subject items, as seen in Figure 1.

Forty different pictures depicted three characters, of which the two external characters are of the same kind. Eight different verbs were used for the experimental items, distributed across the two experimental conditions (Object relative/ Subject relative). All items were semantically reversible, so that the child could not simply rely on understanding of the words alone to understand the sentence. Each session included six object relatives and six subject relatives, as well as eight filler items.

<table>
<thead>
<tr>
<th>Object relative</th>
<th>Subject relative</th>
</tr>
</thead>
</table>
| « Montre-moi le chat que les grenouilles arrosent »  
Show me the cat that the frogs wet. | « Montre-moi les cochons qui chassent le singe »  
Show me the pigs that chase the monkey |

Figure 2. Examples of experimental items.

The items were originally used for another task involving the effect of plural marking (Adani, 2011). The characters could be plural or singular, and this was counterbalanced across conditions to control for morphology of the verb. Each picture contained either two internal characters with singular external characters (e.g. one cat wetting two frogs wetting one cat) or
one internal character with plural external characters (e.g. two pigs chasing one monkey chasing two pigs). Throughout the two sessions, items were counterbalanced for audible vs inaudible plural marking, singular vs plural characters, agent vs subject positions, and spatial location of the expected answer (left or right). Seven out of twenty-five answers used singular stimuli (e.g. “Montre-moi le mouton”), and thirteen out of twenty-five of expected answers were central.

Four items were used to familiarise the children with the experimental task. The items were created using different elements from the experimental items. The filler items were simple NP sentences, such as “Show me the girl with the bow”, and ensured that children were not exposed to too many difficult items at once, as well as serving as a control for their general linguistic understanding.

Recordings were carried out in a quiet room, using an Olympus VN-6500PC recorder in high quality mode. Order if presentation was randomised through e-prime, and order of presentation was randomised, as was the position of the expected response (central, external right or external left).

4.1.2 Procedure

The task was presented on a 15” portable computer, covering the keyboard to avoid distracting participants. Due to the amount of items and the specificities of the population, the items were presented in two equal parts, to maximise children’s attention.

A lexical phase ensured that participants knew the names of the characters presented in the experimental stimuli. It was common to both the relative clause task and the wh-question task, and only administered once. The children were asked to point to each one of the characters named. This part of the task was conducted using the experimental stimuli, presented in powerpoint format.

All the characters used in the experimental phase of the wh-questions and relative clause tasks were tested. The instructions were said online by the experimenter (see Appendix IX for detailed protocols). When the child did not know the answer, they were given feedback, and the item was retested twice at the end of the list.

A familiarisation phase was administered to ensure participants’ understanding of what they were expected to do.
The only feedback given to participants referred to the efforts they had made (e.g. “Good listening!”), and never whether the answer was correct, except in the familiarisation phase.

### 4.1.3 Scoring and data analysis

The experimenter circled the answer given by the child online, using a printed table. The possible answers were: left character(s), middle character(s) or right character(s). The results were then transcribed to an excel table, mentioning the type of error (“shows the central character” or “shows the other external character”).

The criteria for exclusion were failure to learn the characters during the lexical phase and/or below or at-chance results in the filler items. All children succeeded in the lexical phase, but two children were excluded from analyses due to poor results in the filler items.

The dependent variable was accuracy rate, as measured by whether or not the character that the child pointed to after having heard the target sentence was correct. 2-factor ANOVAs were conducted, the first with factors Age (Younger / Older) and Type of relative (Subject / Object), and the second with factors Group (Good performance/ Poor performance) and Type of relative (Subject / Object). T-tests were calculated to compare contrasts within the Group factor for central errors.

### 4.1.4 Hypothesis for relative clause comprehension task

We expect our participants to show difficulties with Object relatives, which could be indicative of a deficit in movement within syntactic structures. Following the principle of RM, we expect children with ASD to obtain lower results for object relatives than for subject relatives.

### 4.1.5 Results

Results for each Performance group (Poor/Good) can be found in table 3 below.

**Table 3**

<table>
<thead>
<tr>
<th></th>
<th>Object relatives</th>
<th>Subject relatives</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Poor performance</td>
<td>36</td>
<td>60</td>
<td>48</td>
</tr>
<tr>
<td>Good performance</td>
<td>77</td>
<td>92</td>
<td>84</td>
</tr>
</tbody>
</table>

Mean 56 76 66
The Good performance group obtained significantly better results overall (84%) than the Poor performance group (48%), \(F(1,17) = 29.2, p<.01\). A significant main effect of relative Type was found, with better scores on subject relatives (76%) than on object relatives (56%), \(F(1, 17)= 8.0, p=.01\). No interaction between Group and relative clause Type was found \(F<1\).

Participants’ responses to experimental items could either be to show the central characters (never the right answer), the characters on the left or the characters on the right. Thus, errors could either be central or external.

The proportion of central errors in children’s incorrect responses was calculated, and found to correlate negatively with mean performance on both OR and SR \(r(17)=-.61, p<.01\). Thus, the more correct answers the children gave to all experimental items, the less central errors they made. Performance on OR alone also correlated negatively with the rate of central errors \(r (17) =-.44, p=.06\). No significant correlation was found between performance on SR and rate of central errors \(r (17) = -.33, p=.16\).

An effect of Group was found on central errors, with the Poor group obtaining a significantly higher rate of central errors (43%) than the Good group (18%) \(t (16)=2.79, p=.01\).

4.1.6 Discussion

The results support the hypothesis that children with ASD obtain better results in SR than in OR, in accordance with previous studies of TD children in several languages (e.g. Friedmann and Novogrodsky, 2004; Adani, 2011) and as predicted by RM constraints. Overall performance for subject relatives seems lower in our ASD participants than in TD peers. Indeed, in a study of relative clause comprehension using the same pictures as the current research, Franck, Rotondi and Guasti (2011) found that 5 year-olds’ performance is at 81% for SR and 96% for 7 year-olds. The results shown by our Poor performance ASD participants in SR (60%) seem much lower than the TD 5-year-olds, and even the Good performance group is not at ceiling level (92%). This gap is not as obvious for OR, as the TD children in Franck et al.’s study obtained similar results to our ASD population (45% correct for the 5 year-olds and 77% for the 7 year-olds, as compared to 36% for the Poor ASD group and 77% for the Good ASD group). These results should therefore be further investigated in order to establish whether there is a similar or different pattern of results between ASD and TD children.
4.2 Wh-question comprehension task

4.2.1 Materials:

The independent variables were Wh-question Type (Object vs Subject), Restriction (Lexically Restricted vs Bare), and Situ (Ex-situ vs In-situ) for Object questions. There was an equal proportion of Object and Subject items, as well as LR and Bare items, as seen in Figure 3.

Figure 3. Schematic representation of the experimental conditions (in bold).

There were six experimental conditions: six lexically restricted object in-situ questions, six lexically restricted object ex-situ questions, twelve lexically restricted subject questions, six bare object ex-situ questions, six bare object in-situ questions and twelve bare subject questions

<table>
<thead>
<tr>
<th>Lexically restricted object in-situ question</th>
<th>Lexically restricted object ex-situ question</th>
</tr>
</thead>
<tbody>
<tr>
<td>« Dis-moi les poules arrosent quel lapin ? »</td>
<td>« Montre-moi quelle fée les fantômes poussent »</td>
</tr>
<tr>
<td>Tell me the chickens wet which rabbit?</td>
<td>Show me which fairy the ghosts push.</td>
</tr>
</tbody>
</table>
Lexically restricted subject question
« Montre-moi quelles vaches chassent le cheval »
Show me which cows chase the horse.

Bare object ex-situ question
« Montre-moi qui le chat sent »
Show me who the cat smells.

Bare object in-situ question
« Dis-moi le fantôme montre qui ? »
Tell me the ghost shows who?

Bare subject question
« Montre-moi qui poursuit les lapins »
Show me who follows the rabbits.

Figure 4. Examples of experimental items.

As in the relative clause task, forty different pictures each depicted three characters. The pictures were taken from the same set as for the relative clause experiment (Adani, 2011), so morphology of the plural marking of the verbs was controlled in the same way, and the items were also counterbalanced for audible vs inaudible plural marking, singular vs plural characters, and spatial location of the expected answer (left or right). Sixteen different verbs were used. As with the relative clause task, all items were semantically reversible.

Six items were created to familiarise the children to the experimental task. The items were constructed using different elements from the experimental items and respected the same proportions for Type of question, Restriction and Situ. The filler items were all simple wh-questions with the following structure: “Where is/are NP”, e.g. Where is the standing cow? All items were recorded in the same conditions as for the relative clause task.

4.2.2 Procedure

The task was presented in four equal parts. Each session included six object relatives, six subject relatives, and eight filler items. Familiarisation and experimental items were
presented to participants on the same computer as for the relative clause task. The lexical
task was carried out once for both the wh-question task and the relative sentence task.

Following the same procedure as for the relative clause comprehension task, the stimuli were
presented in a random order. The children were given instructions orally by the experimenter. Please refer to Appendix IX for detailed instructions.

4.2.3 Scoring and data analysis:

The results were transcribed in the same way as for the relative clauses, mentioning error
type. Criteria for exclusion were identical to those in the relative clause task, and the same
two children had to be excluded from analyses. As in the relative clause task, accuracy rate
was the dependent variable. A 3-factor ANOVA was conducted with factors Group (Poor vs Good), Type of question (Subject vs Object) and Restriction (LR vs Bare).

4.2.4 Hypotheses for wh-question comprehension task

Following the principles of Relativized Minimality and Derivational Complexity, we expect
children with ASD to obtain lower results for Object questions than for Subject questions,
lower results for Lexically Restricted questions than for Bare questions, and lower results for
Ex-situ questions than for In-situ questions.

4.2.5 Results

Groups were defined based on performance, with half of the children in the Poor group
(N=9), and half in the Good group (N=9).

Table 4
Percentage of correct responses for Type and Restriction (LR=lexically restricted).

<table>
<thead>
<tr>
<th></th>
<th>Object</th>
<th>Subject</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Bare</td>
<td>LR</td>
</tr>
<tr>
<td>Poor</td>
<td>52</td>
<td>51</td>
</tr>
<tr>
<td>Good</td>
<td>91</td>
<td>84</td>
</tr>
<tr>
<td>Mean</td>
<td>71</td>
<td>68</td>
</tr>
</tbody>
</table>

A main effect of Group was found, with the Good group obtaining significantly better results
overall (89%) than the Poor group (49%), ($F(1,16) = 33.8, p<.01$). A near significant
interaction was found between Restriction and Group \( (F(1,16)=3.8, p=.07) \). This interaction was further explored through unilateral Student \( t \)-tests, comparing the Restriction conditions for each of the two Groups.

**Table 5**

*Percentage of correct responses (and standard deviations) for restriction conditions and performance groups.*

<table>
<thead>
<tr>
<th></th>
<th>Bare</th>
<th>LR</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Poor</td>
<td>47</td>
<td>51</td>
<td>49</td>
</tr>
<tr>
<td>(10)</td>
<td>19.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Good</td>
<td>93</td>
<td>85</td>
<td>89</td>
</tr>
<tr>
<td>(8.3)</td>
<td>21.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>70</td>
<td>68</td>
<td>69</td>
</tr>
</tbody>
</table>

Student \( t \)-tests show a significant effect of Restriction in the Good group, with 85% correct for Lexically Restricted items and 93% for Bare items \( (t(8)=2.45, p=.02, \) unilateral test). In contrast, the Poor group shows no effect of Restriction, with 51% for Lexically Restricted items compared to 47% for Bare items \( (t(8)=-.74, p=.48) \).

No main effect of Restriction was found, with 68% correct answers in the Restricted items, and 72% in the Bare items \( (F<1) \). No main effect of question Type was found, with 68% correct answers for Object questions, and 68% for Subject questions \( (F<1) \). No interaction was found between Restriction, question Type and Group \( (F<1) \).

Given the lack of main effect of question Type, and the fact that it does not interact with other variables, Subject and Object questions were collapsed together, as shown in table 5. Student \( t \)-tests show that the Good performance group performed significantly above chance for each condition \( (p<.001) \). The Poor performance group did not perform significantly above chance for any of the conditions in table 4.

Student \( t \)-tests show that the Good performance group performed significantly above chance (defined as 33%) for each condition \( (p<.001) \). The Poor performance group performed significantly above chance only for the Lexically Restricted condition \( (t(8)=-2.45, p=.04) \).
An analysis of variance was conducted to study the effects of the Situ variable with the Group variable (table 6.). A main effect of Situ was found, with better performance in the In-situ condition (81%) than in the Ex-situ condition (57%) \((F(1, 16)=15.6, p<.01)\). A main effect of Group was also noted, with the Good group performing significantly better (88%) than the Poor group (51%) \((F(1, 16)=26, p<.01)\). No interaction was found between the Situ and the Group variables \((F(1, 16)=208, p=.65)\), indicating that both groups are equally sensitive to whether the Object question is In-situ or Ex-situ.

Student t-tests show that the Good performance group performed significantly above chance (defined as 33%) for In-situ \((t(8)=-5.07, p=.001)\) and for Ex-situ \((t(8)=-3.54, p=.008)\) but not in the Ex-situ condition \((t(8)=-1.18, p=.27)\).

As with the relative clause task, participants’ errors could be either central or external. The proportion of central errors in children’s incorrect responses was found to correlate negatively with mean performance on the task \((r(16)=-.706, p=.01)\), as well as with each of the following conditions: Subject questions \((r(16)=-.704, p=.01)\), Object In-situ questions \((r(16)=-.574, p=.01)\), and Object Ex-situ questions \((r(16)=-.516, p=.03)\). Thus, the more correct answers the children gave to all experimental items, the less central errors they made.

A Student t-test reveals an effect of Group on central errors, with the Poor group (17%) obtaining a significantly lower rate of central errors than the Good group (48%) \((t(16)=-2.45, p=.026)\).

### 4.2.6 Discussion

Participants obtain lower results for Ex-situ questions than In-situ questions, which was predicted by our hypothesis. However, contrary to our hypothesis, no effect of question Type was found. The lack of effect of this variable cannot be explained by a ceiling effect, as even
for the Good group performance is not very high (mean = 89%). However, the Poor group may be showing a floor effect, as their results were above chance only for Lexically Restricted items and In-situ items. Furthermore, the Situ variable may simply be masking the effect of Type. Results are characterised by variability, even within performance Groups. For LR conditions, the standard deviations are 19.5% for the Poor group and 21.5% for the Good group. This reduces chances of finding any significant effect, and may point to the need for a larger sample size to counter the differences between ASD individuals.

No significant effect of Lexical Restriction was found when all participants were considered, contrary to our hypothesis. However, once the two performance groups were defined, an effect of Lexical Restriction was found in the Good group. This could be because the Poor group displayed a floor effect, masking any fine differences in more complex structures such as those requiring intervention. Therefore, the only effects that can arise are the ones involving simple syntactic operations, such as the presence or absence of movement. According to the DCM (Jakubowicz, 2011), in-situ *wh*-questions will be easier to process than ex-situ questions, as the former requires no movement but the latter does. Perhaps participants in the Poor performance group find it extremely difficult to process syntactic structures involving movement, which is present in all but one (in-situ) of the *wh*-question structures we tested.

### 4.3 Complement clause comprehension: Communication verb

#### 4.3.1 Materials

The dependent variable was the child’s number of correct yes/no responses when judging the truth value of the puppet’s utterance.

The independent variables were the truth value of the embedded complement clause (true/false), and the structure of the main clause (complex/simple).

There were 12 experimental items. Six simple complement clauses, and six longer complement clauses (see examples in figure 5). Half of the items in each condition contained false propositions in the embedded clause, with the correct answer being “no”. Each character always appeared on the same side of the screen and order of presentation of characters in the first two screens was counterbalanced.
**4.3.2 Procedure**

The items were presented on the same computer as for the other syntax tasks and in two equal parts to ensure children’s attention to the task. For the detailed protocol, please refer to Appendix IX. The initial phase of the task introduced the characters to participants, ensuring that they had been memorised. Participants were then introduced to the puppet and told that they would help it learn French. The participants then had two practice trials where they were given feedback by the experimenter, who ensured any misunderstandings were resolved at this point. The six simple items followed by the six complex items were then presented in the same pre-assigned random order to each participant.

**4.3.3 Scoring and data analysis**

The experimenter circled the answer (yes or no) given by the child online, using a printed table. The criterion for exclusion was an inability to remember the characters in the initial phase of the task, no participants were excluded.
4.3.3.1 Hypotheses

We expect participants to have difficulties understanding complement clause structures, in accordance with the hypothesis that the higher layers of the CP are truncated. Furthermore, we expect participants’ results to differ from those found in previous complement clause comprehension tasks (e.g. the memory for complements task by Tager-Flusberg and Joseph, 2005). Indeed, the memory load required of participants in the current task was significantly reduced, while still tapping into understanding of complement clauses using communication verbs.

4.3.4 Results

Table 7

<table>
<thead>
<tr>
<th>Expected answer</th>
<th>Simple</th>
<th>Complex</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>No</td>
<td>15</td>
<td>21</td>
<td>18</td>
</tr>
<tr>
<td>Yes</td>
<td>94</td>
<td>96</td>
<td>95</td>
</tr>
<tr>
<td>Mean</td>
<td>55</td>
<td>57</td>
<td>56</td>
</tr>
</tbody>
</table>

Participants answered “no” correctly in only 18% of the items, whereas they answered “yes” correctly for 95% of items. This is probably due to the fact that there were only two familiarisation items, which required the children to answer “yes”. This is a crucial phase of truth-value judgment tasks. Indeed, children must be taught that they can say that the puppet is wrong, because they are biased towards giving positive answers (Crain & Thornton, 1998, cited in Poltrock, 2011). In the present study they had not been trained in answering “no”, which renders the data invalid.

4.4 Complement clause comprehension: perception verb

In this task, we tested children’s understanding of complement clauses whose matrix verb was voir (to see). Complement clause comprehension using perception verbs had never been tested with an ASD population, and could allow to eliminate the added difficulty of the semantics of mental state or communication verbs. This task was adapted from Poltrock’s complement clause comprehension task (Study 1, page 66) with TD German-speaking children. We added a series of control items to ensure that children were interpreting the
character’s gaze properly. Indeed, given the documented difficulties ASD children display in interpreting gaze, and given the important role that gaze played in this task, it was essential to exclude those participants whose incorrect responses were due to inability to interpret gaze rather than an inability to understand the complement clause question. The data from the current study with ASD participants was compared to the data that Poltrock (2011) collected with TD German-speaking 3 to 5 year-olds.

4.4.1 Materials

The dependent variable was the child’s number of correct yes/no responses when judging the truth value of the puppet’s utterance. The independent variable was the truth condition of the proposition contained in the embedded clause (true / false), requiring a “yes” or a “no” answer.

The stimulus sentences were composed of complement clause sentences, all using the matrix verb voir (see). Six different verbs were each used for two embedded clauses: conduire, cracher, écouter, cuire, jouer, manger (drive, spray, listen to, cook, play, eat). Each participant was assigned to a version (A or B) which differed in the direction of gaze of the central character. The examples below illustrate one example for each truth condition in each version.

L’éléphant voit que la souris joue au foot.  
The elephant sees that the mouse is playing football.  
Expected answer: no

L’éléphant voit que la souris joue au foot.  
The elephant sees that the mouse is playing football.  
Expected answer: yes
In Poltrock’s study, there were four experimental picture configurations, to which we added a further two using the same characters in different orders, so as to reduce the possibility of children giving the same response for the same picture. The six pictures of the experimental items depicted three characters, with one central character turned towards one of two external characters. The two external characters were the same type of animal (e.g. two elephants), and each one was undertaking a different action. The direction of gaze of the central character was counterbalanced. The six pictures were each used for two embedded clauses, for each true/false condition.

Because failure to respond accurately to this task could be due to children’s misinterpretation of the central character’s gaze, we introduced a series of control items where the children were tested on their interpretation of the character’s gaze. The pictures of the six control items differed in that the external characters were not carrying out any action, and there were three different kinds of animal. Participants were exposed to three sentences and six different pictures. Half of the sentences corresponded to the central character’s direction of gaze, with an expected “yes” answer, and the other half did not correspond, with an expected “no” answer.
Puppet's sentence:
“L’éléphant voit le canard”
*The elephant sees the duck*
(expected answer: **yes**)

Figure 7. Example of control item

All pictures were taken from the complement comprehension task devised by Poltrock (2011). The pictures were modified with Adobe Photoshop Elements 8 in order to create the familiarisation images, the two extra control items and the two extra experimental items.

### 4.4.2 Procedure

This truth-value judgment task was administered using a hand puppet (a monkey or a pig), and the stimulus pictures were presented in powerpoint format on the same computer as for the other syntax tasks (Poltrock’s stimuli were presented on paper). Although Poltrock’s procedure did not require the children to respond verbally, we decided to ask the children to answer “yes” or “no”. Poltrock’s procedure seemed more complicated and abstract for our participants to understand, as they would have had to first learn that they had to give a particular wooden fruit in case the puppet was right and another in case it was wrong. In all phases except for the lexical phase, the children were asked to say whether or not the puppet was right when making assertions about the picture on the screen.

The lexical task was administered first, to verify the children’s knowledge of the characters. The experimenter repeated this task until all the characters were correctly identified. The children were then introduced to a hand puppet, and were told that it would need their help to learn French.

Given the bias towards positive responses generally shown by TD children, we controlled for this by introducing a training phase that had not been included in Poltrock’s task (the “familiarisation” phase in Poltrock’s task corresponds to our “control” phase). For these items, children had to judge whether the puppet’s statement was true or false, but it simply
required them to process the noun of the sentence in order to answer. Feedback was given after each of the training items.

In the control phase, the stimulus sentences were simple SVO sentences, so that the child’s ability to interpret the character’s gaze could be assessed separately from complex syntax understanding. No feedback was given in this phase, except for positive encouragement.

In the experimental phase, the children were again asked to judge the truth-value of the puppet’s statements. They were not given any feedback other than positive encouragement. One of the two versions of the experimental items (A or B) was attributed to each participant, so that half of the group would be exposed to version A and the other half to version B. The items were assigned a random order, and all items were administered in the same order for all children.

Poltrock (2011) studied 48 monolingual German-speaking children, aged between 3 and 4 years. 25 children were attributed to a “younger” group (mean age 3;3 years) and 23 were attributed to an “older” group (mean age 3;9 years). 29 5-year-olds were also tested on this task. Analyses were conducted using only the correct “no” answers, as these are considered a more valid measure by the author, because of the bias in truth-value judgment tasks to give positive answers, as shown by Crain and Thornton (1998) (cited by Poltrock, 2011).

4.4.3 Scoring and data analysis

The experimenter circled the answer (yes or no) given by the child online, using a printed table. The criterion for exclusion from analyses was participants’ failure in the control phase, as this would suggest an inability to interpret gaze correctly, thus rendering the results of the experimental phase invalid.

The dependent variable was participant’s number of correct rejections or acceptances of the puppet’s utterances. Student t-tests were conducted to compare participants’ rate of correct rejections with their rate of correct acceptances.

4.4.4 Hypotheses

Following the hypothesis of a deficit in the higher syntactic layers of the CP, we expect children with ASD to obtain lower results than the TD German-speaking children from Poltrock (2011) in the understanding of complement clauses.
We expect to find no significant difference between complement clause understanding with the verb “to say” or with the verb “to see”.

4.4.5 Results

The mean percentage of correct responses for both Yes and No conditions was 84%. Performance was significantly better in the Yes condition (98%) than in the No condition (71%) ($t(14)=-2.82, \, p=.01$). Both the Yes and the No condition were nonetheless significantly above chance-level (Yes, $t(14)=31.5, \, p<.001$; No, $t(14)=2.15, \, p=.05$).

Three out of the 18 participants performed at chance level (defined as 50%) for the control condition (M=50%). They were therefore excluded from consequent analyses. All other participants performed above chance in the control condition, with a mean of 93% correct answers.

4.4.6 Discussion

As the results for the communication verb complement clause task cannot be analysed, we will not be able to address the hypothesis that perception verbs and communication verbs are equally difficult to understand for children with ASD.

There is a clear trend pointing in favour of the prediction that children with ASD obtain lower results than TD children from Poltrock’s study.

Table 8

<table>
<thead>
<tr>
<th></th>
<th>Correct acceptance (“yes”)</th>
<th>Correct rejections (“no”)</th>
<th>Total correct</th>
</tr>
</thead>
<tbody>
<tr>
<td>ASD</td>
<td>98</td>
<td>71</td>
<td>84</td>
</tr>
<tr>
<td>TD 3;3 year-olds</td>
<td>89</td>
<td>56</td>
<td>74</td>
</tr>
<tr>
<td>TD 3;9 year-olds</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>(at chance-level)</td>
<td></td>
</tr>
<tr>
<td>TD 5-year olds</td>
<td>96</td>
<td>99</td>
<td>98</td>
</tr>
</tbody>
</table>

Although statistical analyses cannot be carried out without Poltrock’s detailed data set, it the ASD group’s performance is lower (71%) than TD 5-year-olds (99%), and perhaps lower
even than the older three-year olds (85%) when only the correct rejections are taken into account. Correct rejections seem to be quite low in the ASD population, with only 71% compared to 83% for TD 3;6-4 year-olds. Correct acceptances seem on the other hand to be as high (98%) as TD 5-year-olds (96%). Furthermore, $t$-tests show a significant difference between performance in the No condition and performance in the Yes condition, as mentioned in section 4.4.5. This gap between the two conditions could be due to a specific difficulty for ASD children to reject the puppet’s utterance, despite the extra training items.

5. Method: Theory of mind tasks

We conducted two different kinds of tasks: one task with high verbal content and two tasks with low verbal content. The high verbal content task required understanding of linguistic stimuli, a verbal response, and the ability to remember a short story, to attribute a false belief to a protagonist of the story. The two low-verbal content tasks had little linguistic requirements, and the child was asked to give a non-verbal response. Comparing the two types of task (verbal / low-verbal) will allow to assess the role of language in understanding false belief tasks. The dependent variable for these tasks was the children’s attribution of a false belief to a protagonist.

5.1 Theory of Mind: False-belief verbal task

The items of this task were adapted from the original “Sally-Anne” test developed by Baron-Cohen, Leslie, and Frith (1985). This task was a “Verbal” FB task. For details of each of the four stories told to the children, please refer to Appendix IX.

5.1.1 Scoring and data analysis

The dependent variable was participants’ answers to each of the three final questions. Children could answer one out of two locations for each of the three questions. When participants answered at least one of the two control questions incorrectly, the item was eliminated from the data to be analysed. After elimination of this data, the mean percentage of correct answers to the false-belief questions was calculated for all participants.

5.1.2 Hypotheses

We expect children with ASD to perform poorly in the FB question of this task, in accordance with previous studies (e.g. Baron-Cohen, Leslie and Frith, 1985) where 20 to 30% of children with ASD have been found to succeed (Baron-Cohen, 1990).
5.1.3 Results

Children answered at least one of the two control questions incorrectly in 35% of all items. These were eliminated, leaving 65% of initial data for analysis (54 items distributed across 18 participants). Of the data that was analysed, mean accuracy for the false-belief question was 63%. Patterns of response varied across individuals, with seven children failing all FB questions, two children correctly answering 50% of the FB questions, two answering 75% of the FB questions correctly, and seven answering 100% of the FB questions correctly.

Further analyses were conducted with only those children whose scores in the Autism Quotient and the CARS were high enough to meet the cut-off for autism or referral to a specialist (see Appendix IV for details of these scores). When considering only these 11 children, there were 29 items left, i.e. 35% of the original data set. Mean accuracy in the FB question was 39% for this subset of children.

5.1.4 Discussion

Contrary to our predictions, results do not follow previous findings in the literature. Indeed, our participants performed well above reported scores for ASD children, with mean accuracy at 63% as compared to 20 to 30% in other studies (Baron-Cohen, 1990).

Interestingly, when we considered only the participants with higher scores on the Autism Quotient and the CARS, results were closer to those expected (39% for the current study, compared to 20-30% in previous studies). The subgroup of children whose scores are high enough to classify them as “mildly autistic” in the CARS or that situate them above the cut-off for referral in the AQ would probably correspond to the strict diagnostic criteria for autism that were followed until very recently in most studies. Perhaps our participants, although situated on the Autism Spectrum, would not have been considered in less recent research where autism was still defined according to the narrower DSM-IV-TR criteria. The purported core deficit in ToM might be specific to the subgroup of children who correspond to the criteria for “autism”, and not to those who were diagnosed as having Asperger’s or PDD-NOS, as was the case for many of our participants. It could also be that our participants are better at this ToM task because their language skills allow them to reason about the events taking place. Indeed, the participants in our study only included children whose language skills were not massively impaired, as they needed to understand at least part of the more
complex linguistic tasks. Thus, it could be that our participants are form part of a subgroup of individuals with ASD who perform well in both language and ToM.

5.2 Theory of Mind: False-belief low-verbal content task

This task was adapted from Colle, Baron-Cohen and Hill (2007), who in turn adapted their task from Call and Tomasello (1999)’s non-verbal theory of mind task for great apes and children. The only adaptation we made to the task was in the formulation of the instruction given to the child. Instead of using the *wh*-question “Where is the sweet?”, we gave the instruction “Find the sweet”. This simple canonical syntactic structure ensures that the children’s understanding of complex syntax does not interfere with the results.

5.2.1 Materials

The materials necessary for the task are listed below:

- Two identical opaque boxes, large enough to contain the desired object.
- An opaque foldable screen, dimensions 77cm x 30cm
- A table large enough for three people to sit in the configuration illustrated in Figure 10.
- At least 24 exemplars of a desired object (sweet, sticker, piece of straw, etc.)

The experiment was divided into three main parts, of which two were in turn divided into three phases, with three trials for each phase of the test:

1. Pre-test (x3)
2. Screening phase:
   2.1. Visible displacement (x3)
   2.2. Invisible displacement (x3)
   2.3. Ignore the communicator (x3)
3. Test phase:
   3.1. False belief (x3)
   3.2. True belief (x3)
   3.3. Control condition (x3)

The dependent variable was the proportion of correct responses given by the child (pointing).
There were 4 independent variables, though not all applied for all phases:

- B’s Belief: experimenter B’s belief on the location of the desired object; False/True.
- Visibility: the participant’s view of the boxes when the desired object was placed into one of the two; Visible / Non-visible.

When the boxes were visible, the participant did not need to count on B to find the object. When the boxes were hidden from view, the participant had to count on B to find the object.

- B’s Behaviour: Pointing / No pointing.
- Switching of the boxes: switch / no switch

Table 9

*Specification of the independent variables for each phase of the non-verbal FB task.*

<table>
<thead>
<tr>
<th>Phase</th>
<th>Independent variables</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>B’s belief</td>
</tr>
<tr>
<td>Pre-test</td>
<td>true</td>
</tr>
<tr>
<td>Screening: visible displacement</td>
<td>true</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Screening: invisible displacement</td>
<td>true</td>
</tr>
<tr>
<td>Screening: ignoring the communicator</td>
<td>true</td>
</tr>
<tr>
<td>Test: false belief</td>
<td>false</td>
</tr>
<tr>
<td>Test: true belief</td>
<td>true</td>
</tr>
<tr>
<td>Test: control</td>
<td>true</td>
</tr>
</tbody>
</table>

The controlled variable was the box in which the desired object was hidden (left or right) and was quasi-randomised. Following Colle et al. (2007) the object was not hidden more than twice in a row in the same box.
5.2.2 Procedure

This experiment required the presence of two adults. The experiment was conducted in a quiet room in the child’s home, where adult B could easily move to the next room for the trials when this was necessary. From beginning to end, the task lasted approximately half an hour, with some children needing breaks and others completing the whole task in one sitting.

In each trial, the child had to find a desired object (usually a sweet) in one of two identical boxes. There were three trials per phase. A child was considered to have succeeded in each of the conditions of the pre-test and screening phases when they answered correctly (i.e. pointed to the box containing the desired object) in all three trials. When one trial was failed, the experimenter administered trials of the same condition again until three consecutive correct responses were obtained, or until two consecutive incorrect responses were given. When two consecutive incorrect responses were given, the condition was considered to be failed, and the testing was interrupted. This was because the following phases could not be interpreted if the child did not have the prerequisite skills to understand the task.

The first part, or pre-test phase, ensured that participants understood that experimenter B would help them find the object by pointing to one of the two boxes. The desired object was placed into one of the two boxes in full sight of both the participant and B. B was asked by A “Trouve le [object]” (Find the [object]). B pointed to the correct box, and A asked the child to find the object. After the child’s answer, the experimenter opened the box in front of the child and B and showed them its contents. If the child had pointed to the box containing the object, they would immediately be given the object. If the child had pointed to the other box, they were shown the empty box, the other box was opened and they received the object.

The second part, or screening phase, ensured that participants had the necessary prerequisite skills for the test phase. There were three parts each containing three trials:

1. Visible displacement, i.e. the ability to follow a visible object that is transferred from one box to the other by A.
2. Invisible displacement, i.e. the ability to understand that an object contained in a box has been moved with its container while A switches the two boxes. Experimenter B does not point in this condition.
3. Ignoring the communicator i.e. the ability to give a different response to experimenter B when experimenter B is clearly mistaken. In this condition, the object was hidden in one
of the two boxes in view of both the experimenter and the child. B left the room, and while they were away A switched the boxes in front of the child. When B returned, she was asked to find the object. B pointed to the empty box because she had not seen the switch. The participant had to take into account only what they knew about the object, i.e. that it had been placed in one box and then moved.

The third part, or test phase, was also divided into three parts each containing three trials. In this phase, an opaque screen was placed between the child and experimenter A, so that only the two adults could see the boxes and their contents. The screen was removed before asking experimenter B to point to the box with the object. Each test phase is detailed below:

1. **False belief.** The object was placed in one of the two boxes, with the screen in place. B left the room, and A removed the screen so that the child could now see the boxes. Experimenter A switched the two boxes in front of the child. B returned after the switch, and was asked to point to the box containing the desired object. As B was “unaware” of the switch, they pointed to the box with no object. The child was then asked to point to the box containing the object. If the child had realised that experimenter B held a false belief because they were not in the room at the time of the switch, then the child would point to the box containing the desired object (i.e. the opposite of the one B showed). If the child had not attributed a false belief to experimenter B, then they would point to the same box as B (i.e. the empty box).

2. **True belief.** This part was introduced by Colle et al. in their 2007 task to make sure that the child was not simply applying the rule “when the boxes are switched, B always points to the wrong box”. In this condition the boxes were switched, but in the presence of both B and the child, unlike in the FB condition where B was unaware of such a switch. The child had to nonetheless count on the information given by B’s pointing, unlike in the third screening condition (ignoring the communicator), because they had not seen where the object had been placed.

3. **Control condition.** This condition was also introduced by Colle et al. (2007). It ensured that the child was not simply applying the rule “when B goes away, B will always point to the wrong box”. This condition was identical to the False belief condition but there was no box switch, so B still held a correct belief.
We compared our results to those obtained by ASD children in Colle et al. (2007). Their sample was composed of 12 children with autism (mean chronological age 8;1 years, and mean mental age 4;9 years). Criteria for inclusion were a language production level of under two years, and a maximum score in verbal comprehension equivalent to two years of age.

5.2.3 Scoring and data analysis
Experimenter A ticked the child’s response online, on a printed response sheet. Children who failed the pre-test or screening phase were excluded from the analyses for this task. For all other children, the mean percentage of correct responses for each of the test conditions was calculated. Student t-tests were conducted to compare correct responses between the false belief and the true belief conditions, and between the false belief and the control condition.

5.2.4 Hypotheses
We expect children to obtain similar results to those obtained by Colle et al. (2007) with their ASD population. We expect this task to correlate with the picture sequencing task, but not with the ToM verbal FB task.

5.2.5 Results
Of the 21 children tested, six did not pass the screening tests, and were therefore not included in the test conditions (control, false and true belief), following Colle et al’s procedure.
Table 10

<table>
<thead>
<tr>
<th></th>
<th>Control</th>
<th>False belief</th>
<th>True belief</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean present study</td>
<td>78 (37)</td>
<td>64 (37)</td>
<td>56 (37)</td>
</tr>
<tr>
<td>Mean Colle et al. (2007)</td>
<td>86</td>
<td>14</td>
<td>78</td>
</tr>
</tbody>
</table>

After presenting analyses of our results, I will compare the data with Colle et al.’s findings. Student t-tests showed no significant difference between the two belief conditions ($t(14)=0.54$, $p=.60$), nor between the control condition and the false belief condition ($t(14)=-1.10$, $p=.29$), or between the control condition and the true belief condition ($t(14)=-1.63$, $p=.13$).

As illustrated in Figure 12, and shown by the large standard deviations for each condition (37%) performance is characterised by great variability. Certain participants perform well in the false belief condition and poorly in the true belief, and others show the opposite pattern, while one performs at ceiling in both conditions and a final group performs poorly in both conditions.
The 15 participants to whom the test conditions were administered performed above chance (defined as 50%) for the control condition, with 78% correct responses ($t(14)=2.90, p=.01$). The two belief phases rendered performances no different from chance: false belief 64% correct ($t(14)=1.53, p=.15$); true belief 56% correct ($t(14)=.58, p=.57$).

Results obtained by Colle et al. (2007) were very different to ours, with higher results in both the control condition (86% vs 78%) and the true belief condition (78% vs 56%), but much lower results in the FB condition (14% vs 64%).

5.2.6 Discussion

Our hypothesis that results would mirror those found by Colle et al. (2007) was not verified. Participants’ results in both the false belief and true belief phases were low and the control condition was not succeeded by all. The heterogeneous results in the test condition could be due to the many possible strategies that can be used to attempt to solve it. A couple of children spontaneously shared their reasoning with the experimenters while undertaking the task, thus allowing for insight into their strategies. For a detailed description of the various possible strategies, please refer to Appendix IX. At least some participants seem to have applied their own strategies that were not based on any kind of ToM reasoning, but rather on rules that they tried to extract from previous trials, and others may have answered randomly. Given the amount of strategies arising from this task and the great variability of responses, one is tempted to question its validity. Indeed, if participants are led in so many different directions in their attempt to solve the task, it might not be tapping directly into the cognitive construct of ToM.

5.3 Theory of Mind: picture sequencing task

This task is a low-verbal content task, taken from Baron-Cohen, Leslie, and Frith (1986). It aims to test participants’ understanding of physical events, and two types of social events: one requiring understanding of other people’s mental states, and the other requiring no understanding of other’s mental states.

5.3.1 Material

The independent variables are summarised in the figure below:
The first independent variable was the Type of event taking place. Events represented on the picture sequences could either be Mechanical, Behavioural or Intentional. A second independent variable applied only to the Mechanical conditions. We named this variable Entity, where either a Person or an Object can be the main “actors” of the story. The last independent variable applied only to the behavioural conditions. We named this variable Social interaction, where the story could either represent a scene with social interaction (Yes), or no social interaction (No).

The dependent variable was the child’s sequence of response for the three pictures, which could either be correct (2 points), partially correct when the last picture was well positioned (1 point), or incorrect (0 points).

Fifteen stories were presented, with five types of stories overall, three stories per condition:

- Mechanical 1 (Entity: Object): an object was depicted interacting causally with another object.
- Mechanical 2 (Entity: Person): a person was depicted interacting causally with an object.
- Behavioural 1 (Social interaction: No): one person was depicted in an everyday scene which did not require attribution of mental states to understand.
- Behavioural 2 (Social interaction: Yes): two people were depicted interacting in an everyday scene which did not require attribution of mental states to understand.
- Intentional: two people were depicted interacting in a scene where one held a false-belief.
5.3.2 Procedure
The experimenter placed the first picture on the first square of the cardboard strip. The other three pictures were placed above the cardboard strip in the same incorrect semi-random order as described in Baron-Cohen et al. (1986).

The child’s task was to find the correct order of the three remaining illustrations. The experimenter then asked the children to tell them the story and recorded it for further spontaneous speech analysis (spontaneous speech data was not analysed in this thesis).

The items were administered in the following order: Mechanical 1, Mechanical 2, Behavioural 2, Intentional, and Behavioural 1.

5.3.3 Scoring and data analysis
The experimenter wrote the child’s sequence of images immediately after they had placed all the pictures on the cardboard strip. One point was attributed when the child had placed the last picture correctly but the second and third were incorrect. Two points were attributed when the whole sequence was correct. Total number of points and mean scores (ranging from 0 to 2) were calculated for each of the five conditions, and for each of the three types of story (Intention, Mechanic and Behaviour).
Mean performances for each of the five experimental conditions were compared through Student t-tests, for all participants and for the subgroup of participants whose AQ and CARS scores fall above the cut-off for autism or referral.

### 5.3.4 Hypotheses
Baron-Cohen, Leslie and Frith (1986) hypothesised that children with autism would display the following pattern of results:

\[
\text{M Object} > \text{M Person} > \text{B No social interaction} > \text{B Social interaction} > \text{Intention}
\]

Results found by Baron-Cohen et al. only partially supported this hypothesis, as their participants with autism obtained similar results in both conditions of the Behaviour stories and in both conditions of the Mechanic stories. Performance was high in the Mechanic stories (1.91), good in the Behaviour stories (1.48), but poor in the intentional stories (0.59). We expect to replicate the results found by Baron-Cohen et al..

### 5.3.5 Results

#### Table 11

*Mean performance (and standard deviations) for all participants on each of the five experimental conditions (range 0-2).*

<table>
<thead>
<tr>
<th></th>
<th>Mechanic 1</th>
<th>Mechanic 2</th>
<th>Behaviour 1</th>
<th>Behaviour 2</th>
<th>Intention</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mean</strong></td>
<td>1.78 (.48)</td>
<td>1.89 (.36)</td>
<td>1.62 (.61)</td>
<td>1.16 (.73)</td>
<td>1.02 (.66)</td>
</tr>
</tbody>
</table>

Student t-tests show that Entity has no effect in the two Mechanic conditions \((t(20) = -.98, p = .34)\). We can therefore collapse these for further analyses.

Student t-tests show that Social interaction has an effect on performance in the Behaviour conditions, with significantly better results in the No social interaction condition (1.62) than in the Social interaction condition (1.16) \((t(20)= 4.22, p< .001)\).

Performance on the collapsed Mechanic condition (1.83) is significantly higher than performance on the Behaviour condition with No social interaction (1.62) \((t(20)=2.49, p=.02)\). Performance on the collapsed Mechanic condition (1.83) is also significantly higher than performance on the Behaviour condition with Social interaction (1.16), with \(t(20)=4.86, p<.001\).
Performance is significantly lower in the Intention condition (1.02) than in the Behaviour condition with No social interaction (1.62) \((t(20)=4.33, p<.001)\). However, performance in the Intention condition (1.02) is not significantly different from the Behaviour condition with Social interaction (1.16) \((t(20)=.873, p=.39)\).

Following Baron-Cohen, Leslie, and Frith (1986), we also collapsed both Behaviour conditions and compared this to the intention condition. We found that children’s performance was significantly better in the behaviour condition (1.34) than in the intention condition (1.01) \((t(20)=2.63, p=.02)\).

Furthermore, we analysed a subset of results from those participants whose scores on the AQ and the CARS were below cut-offs (“autism” subgroup).

**Table 12**

*Mean performance (and standard deviations) for the 13 participants in the “autism” subgroup, for each of the five experimental conditions (range 0-2).*

<table>
<thead>
<tr>
<th>Mechanic 1</th>
<th>Mechanic 2</th>
<th>Behaviour 1</th>
<th>Behaviour 2</th>
<th>Intention</th>
</tr>
</thead>
<tbody>
<tr>
<td>Entity: object</td>
<td>Entity: person</td>
<td>No social interaction</td>
<td>Social interaction</td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>1.64</td>
<td>1.90</td>
<td>1.51</td>
<td>1.15</td>
</tr>
<tr>
<td></td>
<td>(0.74)</td>
<td>(0.45)</td>
<td>(0.79)</td>
<td>(0.96)</td>
</tr>
</tbody>
</table>

As with previous analyses including all participants, a significant effect of Social interaction was found between the two Behaviour conditions \((t (13) =3.09, p = .009)\). Student \(t\)-tests show that Entity has no effect in the two Mechanic conditions \((t (13) = -1.64, p = .13)\). The Mechanic conditions were therefore collapsed for further analyses.

Performance on the collapsed Mechanic condition (1.77) was significantly higher than on the Behaviour condition with No social interaction (1.51) \((t (13) =3.73, p = .003)\).

Contrary to results obtained with all participants, performance on the Behaviour with Social interaction condition (1.15) was significantly higher than performance on the Intention condition (0.87) \((t (13) =3.30, p = .006)\)

### 5.3.6 Discussion

We expected participants’ results to follow the pattern found by Baron-Cohen et al (1986), as summarised below (M= Mechanical; B= Behavioural):
M Object = M Person > B No social interaction = B Social interaction > Intention

Instead, our participants displayed the following pattern of results:

M Object = M Person > B No social interaction > B Social interaction = Intention

The children in Baron-Cohen et al. (1986) obtained lower results (0.59) than the children in our study (1.02) for the Intention condition. This could be because our sample includes all children on the autism spectrum, whereas children in Baron-Cohen et al.’s study corresponded to the diagnostic criteria for autism of the time. Children with Asperger’s syndrome could be performing very well because their verbal reasoning skills may be allowing for a more advanced interpreting of the sequences. This would need to be examined with a larger sample and diagnostic subgroups.

The pattern of results for only those participants whose AQ and CARS are above the cut-offs for referral is shown below:

M Object = M Person > B No social interaction > B Social interaction > Intention

These results fit Baron-Cohen et al.’s initial hypothesis better, as the only difference between our pattern of results and the pattern of results expected by Baron-Cohen et al. was the lack of effect of the Entity variable in the Mechanic condition.

6. General discussion

In this section, we will discuss the fit between our results and our main operational hypotheses stated in section 2 of the present Method.

6.1 Performance on tasks situated in the CP

In hypothesis A, children with ASD were expected to perform poorly across all syntax tasks. Although we did not collect data for TD control children, the results point strongly in favour of this hypothesis. Indeed, when compared with results of TD children from a previous study using similar stimuli to our relative clause task (Franck, Rotondi & Guasti, 2011), participants in the Poor group obtained lower results than TD 5 year-olds (48% vs. 63%) and participants in the Good group obtained similar results to TD 7 year-olds (84% vs.87%), despite higher mean chronological ages in the ASD sample. Furthermore, the results obtained by our ASD participants in the wh-question task were low, with the Poor
performance group obtaining 49% correct responses for all tasks and the Good performance group obtaining 89%. Finally, ASD participants’ correct rejections in the complement clause comprehension task were lower than the TD 3;9 year-olds in Poltrock’s (2011) study(71% vs 85%). It would therefore seem that children with ASD show a deficit in understanding structures situated in the left periphery of the syntactic tree.

6.2 Syntactic complexity

In the first part of hypothesis B, we made a series of predictions for conditions in the wh-question task and the relative clause task. Two of our three predictions were verified by our results. A main effect of Situ was found in all participants’ results in the wh-question task, with better performance in the In-situ (81%) than in the Ex-situ condition (57%) ($F(1, 16)=15.6, p<.01$). Furthermore, an effect of Restriction was found in the wh-question task, though only in the Good group, who obtained significantly better results for LR items (93%) than for Bare items (85%) ($t(16) = 2.45, p=.02$ with a unilateral test).

Contrary to predictions, participants did not obtain significantly lower results in the Object conditions of wh-questions and relative clauses (65%) than in the Subject conditions of wh-questions and relative clauses (72%), however the trend points in the right direction.

Results were also examined for their fit with the hypothetical syntax complexity metric based on RM and DCM, as predicted by the second part of hypothesis B.

Table 13

<table>
<thead>
<tr>
<th>Level of hypothetical metric</th>
<th>Mean correct responses per level (%)</th>
<th>Conditions in each level</th>
<th>Mean correct responses (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. No movement</td>
<td>82</td>
<td>Object in-situ wh-questions</td>
<td>82 ns</td>
</tr>
<tr>
<td>2. Movement</td>
<td>72</td>
<td>Subject relatives</td>
<td>76 ns</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Subject wh-questions</td>
<td>69 ns</td>
</tr>
<tr>
<td>3. Movement + intervention</td>
<td>56</td>
<td>Object ex-situ wh-questions</td>
<td>57 ns</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Object relatives</td>
<td>55 ns</td>
</tr>
</tbody>
</table>
As predicted by our hypothesis, Student t-tests showed that performance on level 1 (82%) was significantly higher than performance on level 2 (72%) (\( t (17) = -2.16, p = .05 \)), which was significantly higher than performance on level 3 (56%) (\( t (17) = -2.64, p = .02 \)). Also as predicted, no significant difference was found between subject relatives (76%) and subject \( wh \)-questions (69%) (\( t(17) = -1.52, p = .15 \)), both part of the same level. Significant differences were found between each of the two conditions in level 2 and each of the two conditions in level 3, as predicted by our hypothesis. Subject relative performance was significantly higher than object ex-situ \( wh \)-question performance (\( t (17) = -2.92, p = .01 \)). Subject relative performance was significantly higher than object relative performance (\( t (17) = -2.88, p = .01 \)).

Subject \( wh \)-question performance was not significantly higher than object ex-situ \( wh \)-questions performance (\( t(17) = -1.73, p = .10 \)). Subject \( wh \)-question performance was not significantly higher than object relative performance (\( t (17) = 1.74, p = .10 \)), although for both these measures the trend follows our hypothesis.

When comparing individual conditions separately rather than grouped within theoretically-motivated levels, t-tests reveal that there is no significant difference between the group’s results in object in-situ \( wh \)-questions (82%) and their results in subject relatives (76%) (\( t (17) = 1.04, p = .31 \)), although they are situated in two different levels of the syntactic complexity metric. This is contrary to our hypothesis that results would not be significantly different if part of the same level.

Given the small sample, grouping all results together is the most relevant way to consider them. With all participants, the three-level syntactic complexity metric (with factors movement and intervention) is supported by the results. The significant differences found between conditions belonging to different levels further corroborates this metric, although the lack of significant difference between object in-situ \( wh \)-questions and subject relatives has yet to be accounted for. These two conditions are purported to differ in that the latter contains movement in its syntactic structure, whereas the former does not. We had therefore expected our participants to perform better in the condition with no movement (object in-situ questions). In the following section, I will examine how the data fit the predictions for each of the two performance groups, starting with the Good performance group.
Table 14
Distribution of correct responses for the Good group on the levels defined by the complexity metric (significant results are signalled by *, non-significant by “ns”).

<table>
<thead>
<tr>
<th>Level of hypothetical metric</th>
<th>Mean correct responses per level (%)</th>
<th>Conditions in each level</th>
<th>Mean correct responses per condition (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. No movement</td>
<td>98</td>
<td>Bare object in-situ wh-questions</td>
<td>98</td>
</tr>
<tr>
<td></td>
<td></td>
<td>LR object in-situ wh-questions</td>
<td>98</td>
</tr>
<tr>
<td></td>
<td>ns</td>
<td>Bare subject questions</td>
<td>95</td>
</tr>
<tr>
<td></td>
<td></td>
<td>LR subject questions</td>
<td>86</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Subject relatives with NP object</td>
<td>93</td>
</tr>
<tr>
<td>2. Movement</td>
<td>92</td>
<td>Bare ex-situ object questions</td>
<td>83</td>
</tr>
<tr>
<td></td>
<td>ns</td>
<td>LR ex-situ object wh-questions</td>
<td>70</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Object relatives with NP subject</td>
<td>68</td>
</tr>
</tbody>
</table>

The statistics for the Good performance group partly fit our hypothesis. Student \(t\)-tests show that performance in level 3 (83%) was significantly higher than performance in level 4 (76%) \((t(8)=-2.86, p=.021)\). Contrary to our hypothesis, no significant difference was found between performance in level 1 (98%) and performance in level 2 (92%) \((t(8)=-1.72, p=.12)\), nor between level 2 and level 3 for the participants in the good performance group \((t(8)=.349, p=.74)\). The trend is nonetheless in the expected direction.
Table 15

Distribution of correct responses for the Poor group on the levels defined by the complexity metric. (significant results are signalled by *, non-significant by "ns")

<table>
<thead>
<tr>
<th>Level of hypothetical metric</th>
<th>Mean correct responses per level (%)</th>
<th>Conditions in each level</th>
<th>Mean correct responses per condition (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. No movement</td>
<td>65</td>
<td>Bare object in-situ wh-questions</td>
<td>67</td>
</tr>
<tr>
<td></td>
<td></td>
<td>LR object in-situ wh-questions</td>
<td>63</td>
</tr>
<tr>
<td></td>
<td>ns</td>
<td>Bare subject questions</td>
<td>43</td>
</tr>
<tr>
<td></td>
<td></td>
<td>LR subject questions</td>
<td>50</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Subject relatives with NP object</td>
<td>58</td>
</tr>
<tr>
<td>2. Movement</td>
<td>53</td>
<td>Bare ex-situ object questions</td>
<td>37</td>
</tr>
<tr>
<td></td>
<td>ns</td>
<td>LR ex-situ object wh-questions</td>
<td>39</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Object relatives with NP subject</td>
<td>43</td>
</tr>
</tbody>
</table>

Student $t$-tests show that results in level 1 (65%) are not significantly higher than in level 2 (53%) ($t(8)=-1.53, p=.16$), although there is a trend in this direction. Results are not significantly different between level 2 and level 3 ($t(8)=-1.03, p=.33$), nor between level 3 and level 4 ($t(8)=-.068, p=.95$).

For the more detailed four-level complexity metric (with factors Movement, Intervention and Similarity), results vary depending on performance Group. The Good performers are sensitive to Similarity, as their results are significantly higher in the conditions involving Movement and Intervention with dissimilarity (level 3) than in those involving Movement and Intervention with Similarity (level 4). They show a tendency to sensitivity to Movement, with near significantly different results in understanding of structures containing Movement (level 2) compared to those containing No movement (level 1). However, they did not show sensitivity to Intervention, which was the distinguishing feature between levels 2 (Movement) and 3 (Movement and Intervention). This is not what RM would predict. Under RM, similarity does not arise without intervention. Therefore, we would expect a condition with intervention to differ from a condition without intervention. Although no significant difference was found between relevant conditions, there was a clear tendency in the right direction (92% vs 83%). Our results may lack power, as they are characterised by great variability and a small sample size. With a larger sample size the results might fit the hypothesis.
Another explanation for our results stems from models of sentence comprehension suggesting that similarity plays a role in any situation involving memory, not only in the case of intervention. An example of such a model is the cue-based parsing model (e.g. Lewis, Vasishth & Van Dyke, 2006). This model would predict an effect of similarity in relation to memory constraints, and might be more appropriate to consider when attempting to explain the results found in the present study.

The Poor performers only show a tendency to being sensitive to Movement, with near significant differences only between syntactic structures containing movement (level 2) and syntactic structures containing no movement (level 1). A possible explanation for this is that when the syntactic structure contains movement, Poor performers are equally as bad, whether or not intervention or similarity factors are added. It is only when performance is above a certain level, such as in the Good performance group, that differences start to appear between the finer syntactic levels.

### 6.3 Relationships between all tasks

In hypothesis D, ToM was linked with complex syntactic structures, and in particular the syntax of complement clauses. Correlations were calculated between different tasks to test our hypotheses concerning the link between syntax and ToM.

In hypothesis D.i we expected to find significant positive correlations between the verbal false-belief task and complement clause understanding. It has indeed been found in other studies (Astington and Jenkins, 1999; Shick, de Villiers, de Villiers, Hoffmeister, 2007) that complement clause understanding predicts performance on false-belief tasks in TD children and children with impairments such as deafness. This link has been shown with communication verbs and mental state verbs in children with ASD (Tager-Flusberg & Joseph, 2005; Lind & Bowler, 2009). Poltrock (2011) also found significant positive correlations between TD 3-year-old children’s performance on false belief tasks and complement clause comprehension using the perception verb *to see.*
Table 16
Correlations between the different syntactic and ToM tasks. Significant correlations are marked by ** when p<.001, and * when p=.05.

<table>
<thead>
<tr>
<th></th>
<th>ToM non-verbal “false belief”</th>
<th>ToM sequencing “intention”</th>
<th>ToM verbal “false belief”</th>
</tr>
</thead>
<tbody>
<tr>
<td>Complements perception correct rejection</td>
<td>.104</td>
<td>.273</td>
<td>.314</td>
</tr>
<tr>
<td>All wh-questions</td>
<td>.710**</td>
<td>.705**</td>
<td>.338</td>
</tr>
<tr>
<td>Subject wh-questions</td>
<td>.559*</td>
<td>.638**</td>
<td>.553*</td>
</tr>
<tr>
<td>Object wh-questions</td>
<td>.725**</td>
<td>.685**</td>
<td>.222</td>
</tr>
<tr>
<td>In-situ wh-questions</td>
<td>.401</td>
<td>.434</td>
<td>.091</td>
</tr>
<tr>
<td>Ex-situ wh-questions</td>
<td>.723**</td>
<td>.699**</td>
<td>.260</td>
</tr>
<tr>
<td>All relatives</td>
<td>.709**</td>
<td>.685**</td>
<td>.674**</td>
</tr>
<tr>
<td>Complexity Metric1</td>
<td>.472</td>
<td>.500*</td>
<td>.124</td>
</tr>
<tr>
<td>Complexity Metric2</td>
<td>.683*</td>
<td>.647**</td>
<td>.635**</td>
</tr>
<tr>
<td>Complexity Metric3</td>
<td>.688**</td>
<td>.704**</td>
<td>.413</td>
</tr>
<tr>
<td>Complexity Metric4</td>
<td>.615*</td>
<td>.692**</td>
<td>.546*</td>
</tr>
</tbody>
</table>

Our results show no significant correlation between complement clause understanding with a perception verb and responses on the verbal false-belief tasks (r = .314, p=.30).

Furthermore, hypothesis D.ii predicted that the ToM verbal task would correlate with complement clause comprehension regardless of the semantics of the matrix verb. Given that our results show a lack of correlation, this should be accounted for. Perhaps only verbs allowing the expression of misrepresentation of reality, such as mental state verbs, somehow allow children with ASD to succeed in understanding verbal FB tasks. The correlations found by Poltrock could be suggesting that TD children develop ToM in a way that is linked to all sentential complements, and our results could suggest that ASD children follow a different developmental route for ToM understanding. Our hypothesis that it is the syntax of the complement clause that allows children with ASD to access a representation of a false belief, and not its semantics, is therefore not verified by our results. Another explanation for the lack of correlation could lie in the format of the task. The complement clause task
differed from the two other tasks, in that it was a truth-value judgment task using a puppet. As mentioned in section 4.4.6, children with ASD may have a more pronounced difficulty in rejecting the puppet’s utterance, thereby affecting results and masking any link between ToM and complement clauses.

In hypothesis (D.iii), we expected no correlation between the verbal ToM task and children’s understanding of *wh*-questions and relative clauses. In accordance with our hypothesis, no significant correlation was found between results in all conditions of the *wh*-question task and results in the false-belief question of the ToM verbal task \((r=0.338, p=0.20)\). However, relative clause understanding significantly correlates with the false-belief ToM verbal task \((r=0.674, p<0.001)\). Although this is contrary to our initial hypothesis, an explanation for these results may lie in an alternative hypothesis stating that ToM is linked to the ability to embed, such as in complement and relative clauses. Smith, Apperly and White (2003) had indeed found that relative clause comprehension is linked to ToM performance. Our results would support the hypothesis that embedding plays a role in understanding ToM verbal false-belief tasks. As no significant correlation was found between understanding of all *wh*-questions and the verbal false-belief task, perhaps embedding is the crucial component of the CP that allows for ToM to develop. However, as we found no correlations between complement clause comprehension and the verbal false-belief task, there is probably another component accounting for the relationship found in previous studies between ToM and complex syntax (complement clauses and relative clauses).

Hypothesis D.iv predicted no significant correlation between results on low-verbal content ToM tasks and complement clause understanding. In accordance with our hypothesis, no correlation was found. However, contrary to our prediction, the Intention condition of the picture sequencing task, although requiring little use of language, was found to correlate significantly with all the relative clause and *wh*-question tasks, except for the in-situ condition which was nearly significant \((p=0.07)\). This could point to a general developmental relation between the two tasks, i.e. that general cognition underlies results to both tasks. It could also be indicative of the presence of a specific component that is necessary to process both the sequencing task and the syntax tasks.

In accordance with our prediction, the two conditions in Level 1 of the syntactic complexity metric do not correlate with the ToM low-verbal FB task. However, contrary to our prediction, the results on the overall group show that the low-verbal ToM false-belief
condition correlates significantly with overall performance on *wh*-questions and overall relative clause comprehension. There are significant positive correlations between the three highest levels of the syntactic complexity metric and the non-verbal ToM false-belief condition. These findings point to a link between the understanding of complex syntactic structures requiring movement and ability to attribute a false-belief to an agent even in the absence of verbal directions.

Our final hypothesis, D.v, pertaining to the relationships between ToM tasks, was verified by our results. As predicted, the False-belief question of the verbal ToM task did not correlate with either the Intention condition of the picture sequencing task \((r (14) = 0.271, p=0.31)\), or the False belief condition of the low-verbal ToM task \((r (10) =.477, p=.12)\).

Furthermore, statistics show that the Intention condition of the picture sequencing task correlates significantly with the False belief condition of the low-verbal false-belief task \((r(11)= .63, p=.02)\). This is in keeping with our hypothesis that both low-verbal ToM tasks would correlate with each other.

### 6.4 Methodological considerations and future perspectives

#### 6.4.1 Syntax tasks

The complement clause tasks required children to judge the truth value of a sentence uttered by a puppet. The main pitfall of the communication verb task was the insufficient amount of familiarisation items, and especially the lack of familiarisation items requiring the child to answer “no”. In the perception verb task, where additional familiarisation items had been added to control for children’s bias towards positive response, children with ASD still found had difficulty answering “no”. It could be that truth-value judgment tasks do not optimally reflect ASD children’s ability. Furthermore, taking into account what a puppet says requires skills in symbolic play, which is a documented difficulty in ASD children (Tager-Flusberg, 2000). Although no problems with the symbolic use of the puppet arose for our participants during administration of the test, it is possible that the symbolic aspect of the task interfered with the syntactic aspect.

Future tasks with ASD participants should take into account the need for an extensive familiarisation phase when using truth-value judgment tasks.
6.4.2 ToM tasks

It was mentioned in section 5.2.5 that the low-verbal false-belief task rendered results that were not expected given data from previous studies. The task may not show sufficient validity given the amount of possible response strategies.

It would have been interesting to conduct a detailed analysis of participants’ oral production in the picture-sequence task, as this may have provided insight into participants’ reasoning, namely whether they attributed a false belief to the protagonists.

Further research could delve into the distinction between implicit and explicit ToM measures, as all our tasks involved explicit ToM measures. Implicit ToM requires use of material that was not possible to use in participants’ homes (e.g. eye-tracking devices).

6.4.3 General considerations

Several issues can be raised concerning our population. Although they were all diagnosed as being on the Autism Spectrum in their childhood, diagnostic nomenclature varied greatly, including “psychosis”, “severe autism”, “Asperger’s” and “PDD”. Furthermore, parental reports of their child’s autism varied, and may have reflected an evolution of their child from when the diagnosis had been given. Although experimenters’ clinical training did not allow for it, it would have been ideal to conduct standardised clinical testing such as the ADOS or ADI-R to control for this.

Another issue related to the population is sample size. Although our sample was initially composed of 20 participants, which is a substantial number given the difficulties encountered to recruit participants, the inter-individual differences in age and cognitive abilities were such that a larger sample size would have increased the statistical power of analyses, possibly showing effects that we did not find for lack of statistical power.

Finally, our sample was constituted of 10 bilingual children. Some of the bilingual children had first been exposed to another language before their parents were advised to speak only in French to their child, even if their own dominant language was not French. Therefore, bilingualism may have affected participants’ responses. Namely, a link has been found between early bilingualism and a better ability in ToM (see for example Kovacs, 2009), which is of particular relevance to this study. Further analyses could be carried out to tease out the contribution of bilingualism on participants’ results.
A series of tasks measuring non-verbal IQ, memory and vocabulary were administered but not reported on in this thesis. It will therefore be of paramount importance to analyse data in light of results to these tasks, and to form several subgroups subsequently. In addition, individual participants’ answers across tasks would be interesting in order to identify response profiles.
Conclusion

This exploratory study aimed to examine ToM, syntax and ASD. Through various tasks studying ASD children’s comprehension of complex syntactic structures arising in the CP, it was suggested that children with ASD truncate the upper layers of the syntactic tree well beyond the expected age. Certain syntactic structures such as subject relatives, which are acquired at an early age in TD children, posed difficulty to the ASD group, even though ages ranged from 5 to 15, above the expected age for understanding SR in TD children. Furthermore, the pattern of response indicated that children with ASD follow a developmental pattern that can be explained in part by Relativized Minimality (Rizzi, 1990, 2004) and Derivational Complexity (Jakubowicz, 2004, 2011). Although a subgroup of participants showed no effect of intervention or similarity, we interpreted this as a consequence of their poor results in all syntactic structures involving movement. The subgroup of children who performed better showed both an effect of movement and an effect of similarity, but no effect of intervention, contrary to what has been predicted by RM. We mention the possibility of a similarity effect in the absence of intervention, as proposed by cue-based parsing. Results could be analysed in light of data from the basic memory tasks such as the Corsi block-tapping test and the phonological loop test that we administered but did not analyse for this thesis. If correlations were to be found between results on the memory tests and the syntactic structures belonging to the higher levels of the syntactic complexity metric, this could allow to identify the kind of link that has been reported between working memory and syntax.

Several studies (e.g. Tager-Flusberg & Joseph 2005; Lind & Bowler 2009) have reported that ASD children’s ToM performance as measured by FB tasks is correlated with their correct understanding of sentential complements, in particular using verbs of communication. We delved into this by studying ASD children’s understanding of sentential complements using a verb of communication and a perception verb, which to our knowledge had never been tested in this population. Furthermore, we aimed to reduce the memory component of Tager-Flusberg and Joseph’s (2005) memory for complements task, by accompanying sentences with pictures. We then studied the link between understanding of sentential complements using a perception verb and understanding of ToM as measured by false belief tasks. Contrary to the only previous study to our knowledge with TD children, which had studied the link between ToM and sentential complements with a perception verb (Poltrock, 2011), no significant correlation was found between these two measures. One explanation for this is
that the correlation is only found in TD children, and that ASD children benefit only from understanding of communication or cognition verbs in sentential complements in order to understand ToM. Similar tasks with these two types of verbs should be administered to test this hypothesis.

Contrary to our predictions, correlations were found between measures of ToM and understanding of different types of relative clauses and *wh*-questions. However, relative clauses have been found to correlate with ToM (Smith, Apperly and White, 2003), and *wh*-questions are part and parcel of traditional verbal FB tasks, which could explain this correlation. It is surprising that a correlation was found between relative clause comprehension and ToM, but not between complement clause comprehension and ToM. Indeed, it has been suggested that the characteristic of complement clauses that allows children with ASD to access ToM is embedding, thus explaining the correlations found with relative clauses in previous studies (Smith et al. 2003). Yet our results do not concur with this view, because if embedding were linked to ToM development, both complement clauses and relative clauses would correlate with false-belief tasks.

We expected ToM low-verbal measures to be independent from syntax in ASD children. Indeed, if the ASD children who succeed on ToM false-belief tasks do so by using their knowledge of complex syntax (and in particular embedding) to understand the stories and the questions and to reason about them, then the low-verbal ToM measures should probably not be influenced by this knowledge. Our results go against this view, as correlations were found between relative clause and *wh*-question comprehension and all ToM measures, including the low-verbal content ones.

In sum, the present study has contributed to exploring the field of syntax in autism by examining structures that had not yet been studied in French-speaking children with ASD, and by combining several types of ToM measures to separate possible factors of success in FB tasks. Given the purported link between syntax and memory, analyses should be carried out to study this link in our population. In addition, it would be interesting to examine the relationship between Executive Functions such as inhibition, and ASD children’s ability to process complex syntax. Indeed, certain authors claim that Autism Spectrum Disorders are characterised by a core deficit in Executive Functions (e.g. Pennington & Ozonoff, 1996), which could explain the poor results in syntactic processing of complex structures, if Executive Functions influence syntax processing.
Future research with TD control children should allow to refine our knowledge of syntactic and ToM development in ASD. Furthermore, subgroups of ASD participants based on standardised vocabulary and/or IQ measures could allow to rule out a general cognitive delay across the board, and to establish finer profiles of ASD categories. Finally, subgroups based on specific diagnostic criteria could allow for identification of characteristic functioning in ASD children according to severity of the disorder.
References


Appendix I: Syntax and truncation theory

1. Syntax

“Syntax is the study of the principles and processes by which sentences are constructed in particular languages” (Chomsky, N. (2002) [1957]. Syntactic Structures. p. 11).

A sentence is made up of words which are configured in a particular way following certain rules, and varies in complexity. Syntacticians have conceptualized sentence structure in the form of a tree, with the lower branches representing the most basic structures, and the upper ones representing more complex sentence structures. According to Rizzi (1997) the structure of the sentence or clause is composed of three layers. Below, I will briefly describe a simplified version of Rizzi’s definition of the clause, illustrated in figure 15. The lowest layer of the syntactic tree is the lexical layer or verb phrase (VP), comprising verbs and their arguments. The second layer is the inflectional layer (IP), comprising inflections, negations, auxiliaries and clitics, and the uppermost layer is called the complementizer layer, or complementizer phrase (CP). The CP contains the syntactic material necessary to form questions, complement clauses and relatives.

![Figure 15. Schematic representation of a syntactic tree.](image-url)

The syntactic tree described in Figure 15 is a universal structure hypothesised to exist for both adults and children. How, then, can one explain the seemingly very different structures that are observed in child speech? For example, how can we explain the production of infinitival clauses, or declarative root infinitives such as (1) below, if children use the same syntactic tree as adults to structure their sentences?

(1) voir l’auto papa  
    see the car daddy 
(Wexler, 1994; Rizzi, 1994)

Although adults also use main-clause infinitives when the syntactic contexts allow them, such as certain questions or embedded declaratives (see Rizzi, 1994), they do not produce such infinitives in declarative clauses. This observation suggests that adults and children follow different syntactic rules to construct their sentences.

Truncation theory provides one explanation for this apparent discontinuity between child and adult syntax. Rizzi (1994) has proposed that the language of young children involves pruning the syntactic tree of its more complex layers, perhaps to reduce cognitive load. This view supports a continuity theory of child to adult language development, in that the structures observed in young children can be explained by truncated adult syntactic trees. Unlike adults, children have the option of “stripping off external clausal layers” (Rizzi, 1994), leading to structures such as root infinitives or null subjects.

An important aspect of this theory is that it predicts that certain lower-layer phenomena such as root infinitives will not occur with higher-layer structures such as *wh*-questions (these will be further explored in section 1.2.2 below). This is because a child will “strip off” the layers of the syntactic tree from top to bottom, as shown in Figure 16. If the CP is truncated for a particular utterance, then the child cannot produce a *wh*-question in the presence of a root infinitive. Several studies (see Rizzi, 1994, for a review) have indeed shown that young children’s utterances do not contain *wh*-question clauses with root infinitives. When a child uses a *wh*-question structure, they will be using the entire projection of their syntactic tree, reaching up to the highest layer, i.e. the Complementizer Phrase. As the CP cannot exist on its own without the inflectional and lexical levels, the properties of the three layers will be used, and the root infinitive therefore cannot be produced.
Several predictions arise from truncation theory. For example, if for a particular utterance a child truncates their syntactic tree just above the lexical level ((1) in figure 2), they will not produce an auxiliary, negation or clitic (situated in IP), nor will they produce a question, relative or complement clause (situated in the CP layer). Their sentence will most likely be a root infinitive. If a child truncates at the specifier (Spec) of the inflectional level ((2) in figure 16), they will not use a more complex structure of the CP layer such as a question or relative clause. Their sentence could contain a subject omission with an inflected verb, a negation and an auxiliary. Finally, when a child truncates the highest level of the syntactic tree, their sentence might not contain an inflected verb if they are a V2 language speaker (mainly Germanic languages).

As a child develops more and more complex language, they will truncate their syntactic structures less and less, until their syntactic tree is no longer truncated and is used in the same was as adults use it. Truncation theory enables the syntactic errors produced by children to be explained, and is in keeping with the principles of generative grammar and a continuity theory of child to adult grammar.

Figure 16. Illustration of the layers that are truncated first.

Furthermore, Rizzi has proposed the existence of the principle called “structural economy”, guiding children’s early grammar. On the assumption that children have limited processing capacities or working memories (Hamman, 2006; Bloom, 1990), the structural economy principle states that the child will “use the minimum of structure consistent with well-formedness constraints” (Rizzi, 2000), i.e. whenever possible children will use a minimal
structure requiring less processing capacities rather than a more complex one. This principle leads to the prediction that children with more limited processing capacities, because of younger age, underlying mental deficiency or specificities of a particular disorder, would have a tendency to use more minimal structures.

3. Syntactic complexity

3.1 Relativized minimality

The principle of Relativized Minimality (RM) can be used to explain phenomena of early grammar such as root infinitives or null subjects, and it gives a measure for syntactic complexity. Relativized Minimality (RM) was proposed by Rizzi (1990, 2004), and states that in a structure such as X.....Z.....Y, “a local relation cannot hold between X and Y when Z intervenes, and Z is somehow a potential candidate for the local relation” (Rizzi, 1990). A local relation is defined as “one which must be satisfied in the smallest environment in which it can be satisfied” (Rizzi, 2004). RM guides the parser in order to reduce ambiguity whenever two elements of a phrase (X and Z) are both competing for one local relation with a third element (Y). Whenever the parser encounters an element of the same class as the one forming the chain, it blocks the dependency and the parser has to reanalyse the sentence.

To illustrate this principle, I have chosen to use the example of subject relatives (SR) and object relatives (OR). A relative clause is a subordinate of a main clause, which is introduced by a relative pronoun such as who or that, such as in (2)a):

(2a) Show me the dog [that____bites the cow].

In this sentence, the relative clause “that bites the cow” is a subject relative, as it arises from the transformation and adjunction of the two sentences (2b) and (2c), where “the dog” is the subject of (2c). The movement of the subject “the dog” is from the embedded subject position (the underlined gap in (2a).

(2b) Show me the dog.

(2c) The dog____bites the cow.
Sentence (3a) is an object relative, where the movement of “the dog” is from the object position (the underlined gap). An object relative arises from the transformation and adjunction of (3b) and (3c), where the dog is no longer the subject of (3c) but its object:

(3a) Show me the dog [that the cow is biting _____].

(3b) Show me the dog.
(3c) The cow is biting the dog.

Whereas in English OR and SR can both be introduced by that, in French OR are introduced by the relative pronoun que and SR are introduced by qui. In the example above, the subject relative would be:

Montre-moi le chien [qui _____ mord la vache].
Show me the dog that _____ bites the cow.

The object relative would be:

Montre-moi le chien [que la vache mord _____].
Show me the dog that the cow bites _____.

Research into OR and SR acquisition has shown that there is a developmental asymmetry in the acquisition and processing of these two types of structures. Friedmann & Novogrodsky (2004) studied children’s comprehension of OR and SR in Hebrew, and found that 4-year-olds did not perform well on OR (and performed well on SR), but 6 year-olds performed well on both OR and SR.

Adani (2011) studied Italian-speaking 3 to 7-year-old children’s performance on comprehension of subject relatives, and two types of object relatives. They found that the 3-year-olds performed at chance-level for comprehension of object relatives (53% and 36% correct for each type of object relative), but understood subject relatives well (90% correct). The difficulties shown by children in understanding these particular structures were explained using Relativized Minimality (Rizzi, 1990, 2004) as a measure of syntactic complexity.

What makes OR more complex to process than SR, according to RM? In any sentence, the parser attempts to postulate a dependency between the two closest potential candidates: in the examples above, it “knows” it has to look for a NP and analyses the first one it encounters, going for the “easiest” possible answer to the dependency. In subject relatives this strategy...
works well but in object relatives with the same structure as in (3a), an intervener, in this case the subject noun phrase “the cow”, separates the terms that the parser tries to connect in the dependency (the NP “the dog” and the verb “bites”). In this type of object relatives therefore, the parser has to reanalyse its initial postulate, resulting in longer reaction times in adults (e.g. Frauenfelder, Segui, and Mehler, 1980) and a failure of the task in children (e.g. Brown, 1972). In Adani’s (2011) study, the type of object relative influenced children’s performance. Children of all ages performed less well on the object relatives where the subject Determiner Phrase (DP) was placed after the verb. Thus, their performance was poorer when an intervener of same syntactic nature perturbed the local relation between X and Z, such as observed in Relativized Minimality.

Friedmann, Belletti and Rizzi (2009) found similar results with 3;6 to 5-year-olds. They tested subject and object relatives with different types of interveners to establish which intervening structures would be more difficult for the parser to process (requiring reanalysis of the sentence). They found that children had even lower results in OR comprehension when the two competitors for the dependency were of similar syntactic nature, more specifically with a lexical NP restriction. Friedmann, Belletti and Rizzi (2009) were the first to show that Relativized Minimality could account for the asymmetry between SR and OR in children, and proposed that children’s RM was more rigid than adults’, given their cognitive immaturity and their working memory limitations. It is surmised by the authors that it is only when the two competitors are of distinctly different syntactic nature that children’s parsers do not encounter difficulties in establishing the dependency.

Another example of the effect of distance between two dependent structures is that of lexically restricted and bare \textit{wh}-questions. A \textit{wh}-question is an interrogative clause headed by a \textit{wh}-word such as \textit{what}, \textit{when}, \textit{why}, or \textit{who}. \textit{Wh}-questions occur within the CP, like complement clauses and relatives.

A lexically restricted question is a structure such as “What monkey is the boy hugging?”. A bare, or non-lexically restricted question is a structure such as “Who is the boy hugging?”. In the first case, “what monkey” and “the boy” are both noun phrases, and as such they are both potential candidates for the relation with the verb. The NP “what monkey” therefore blocks the relation between “the boy” and “is hugging”. In contrast, in a bare \textit{wh}-question there is no obstacle to the formation of the dependency, as there is only one potential candidate, in
this case “the boy”. Following the principle of Relativized Minimality, lexically restricted questions should therefore be more difficult to parse.

Friedmann et al. (2009) studied children’s understanding of who and which subject and object questions, and found that it was only when “both the crossing element and the intervener included a lexical NP restriction” that object questions were more difficult. This finding was interpreted in light of the Relativized Minimality Theory.

In sum, the two structures mentioned above (relative clauses and wh-questions) can both be subject to the principle of Relativized Minimality. Both structures can be object A’ dependencies or subject A’ dependencies. The object A’ dependencies always involve an intervener placed between the target and the origin. This intervener can become problematic when it is similar in syntactic structure to the target, as it is competing for one same dependency, leading to a RM effect.

How the similarity between the two structures is defined is still under study. In the examples above, Friedmann et al. (2009) found that when the two structures where noun phrases the intervention effect arose. Hence, two noun phrases can be considered as being two similar syntactic constructions that could compete for the same local relation. This is not the only type of similarity that can lead to the intervener perturbing the local relation. Rizzi (2004) has proposed that two elements can be considered similar when they belong to the same featural class. Furthermore, the features that are taken into account for establishing similarity of classes are only those that trigger movement. These are the general guiding principles to establish whether or not the intervener and target are similar. The precise categories and definitions of similarity are currently under study, and intervention effects have yet to be examined in more syntactic structures to gain a more comprehensive understanding of the kind of similarity which is needed in order to lead to intervention effects.

The constraints imposed by RM on grammar may stem from memory constraints (see for example Ortega-Santos, 2011). Indeed, memory retrieval is influenced by similarity constraints, which could then be reflected in RM constraints. The link between RM and current theories of memory is under scrutiny in many other studies, but the scope of the present study does not allow us to delve further into this literature, as this would be the subject of yet another thesis.
3.2 Derivational complexity

Following from the idea that children prefer using more economic syntactic structures, and similarly to Rizzi (2007), Jakubowicz (2011) has proposed that children’s language development was “affected by developmental constraints such as the capacity of working memory, that are sensitive to the computational complexity of the derivation.” (Jakubowicz, 2011). The computational complexity of the derivation has been defined by Jakubowicz in the form of a Derivational Complexity Metric (DCM) (Jakubowicz, 2005, 2011). This metric was established by studying the acquisition of *wh*-questions by French-speaking TD and SLI children.

*Wh*-questions in French are particularly interesting to study, as unlike many other languages, French offers the option to move the *wh*-element, and the option to move the auxiliary or verb, while conserving the same semantic qualities. The examples below, taken from Hamman (2006), illustrate the possible structures:

(4)  

a.  

<table>
<thead>
<tr>
<th>Structure</th>
<th>Description</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Il va où? <em>in-situ, colloquial French</em></td>
<td>he goes where</td>
<td>‘where does he go?’</td>
</tr>
<tr>
<td>b. Où il va? <em>fronted Wh without inversion, colloquial French</em></td>
<td>where he goes</td>
<td>‘where does he go?’</td>
</tr>
<tr>
<td>c. Où va-t-il? <em>fronted Wh with inversion of a clitic subject</em></td>
<td>where goes-t-he?</td>
<td>‘where does he go?’</td>
</tr>
<tr>
<td>d. Où va la maman? <em>fronted Wh with inversion of a lexical subject</em></td>
<td>where goes the mommy</td>
<td>‘where does mommy go?’</td>
</tr>
<tr>
<td>e. Où est-ce qu’il va? <em>periphrastic</em></td>
<td>where is it that he goes</td>
<td>‘where does he go?’</td>
</tr>
</tbody>
</table>

Structures (4)a, b, c, and f all have the same meaning, but differ in syntactic complexity. According to Jakubowicz (2011, 2004) and Hamman (2006), the complexity of these sentences increases from a to f, with in-situ questions being the most simple as its surface structure is the same as a declarative sentence and it contains no overt movement. This view of the in-situ question being the simplest to process has been debated, with certain authors
such as Huang (1982) arguing that although in-situ questions contain no overt movement, covert movement still takes place in the syntactic tree, thereby maintaining its complexity.

In a study comparing the production of three TD children, Hammann (2006) studied spontaneous speech samples. The data points to a preference for the more simple structures over the more complex ones, in accordance with the principle of structural economy. The children in Hammann’s study preferred using in-situ questions rather than fronted wh-questions. In addition, the fronted wh-questions were rarely ever inverted, which also shows a preference for the simpler non-inverted structures. It would therefore seem that the scale of complexity proposed by Jakubowicz (2011, 2004) and Hammann (2006) is indeed found in children’s utterances.

Zuckermann and Hulk (2001) used a question-elicitation task to establish whether children (ages 4 to 5;9), follow the hierarchy of wh-question described above, and apply the principle of structural economy. After analysing the existing spontaneous speech data in combination with their experimental data, the authors conclude that children do follow the developmental order mentioned above. They first acquire wh in-situ questions, then fronting, wh+est-ce que and inversion structures.
Appendix II: Autism and Autism Spectrum Disorders

1. Diagnostic criteria

The exact aetiology of autism is still unknown, though there are strong genetic underpinnings and environmental influences (e.g. Plauché et al, 2007). The main classification systems (ICD-10 [WHO, 1992] and DSM-IV-TR [American Psychiatric Association, 2000]) consider autism as being included in the broader category of Pervasive Developmental Disorders (PDD), which is an umbrella term for the five following disorders: Autism, Asperger’s syndrome, Childhood Disintegrative Disorder, PDD Not Otherwise Specified, and Rett’s Syndrome. In most current research, the term “Autistic Spectrum Disorders” (ASD) replaces PDD, following the proposed revision of the Diagnostic and Statistical Manual, to be published in May 2013. The DSM-5 will no longer have distinct categories for the five disorders mentioned above. Instead, they will fall on a continuum of severity on the Autistic Spectrum. This revision reflects recent findings showing that distinctions between the PDDs are not as clear as previously thought, and individuals could be found to have different diagnoses across their lifespan. In this paper, we have adopted this more recent classification, and will therefore mostly be referring to Autism Spectrum Disorders.

An individual is considered to be on the Autism Spectrum when he/she meets the following four diagnostic criteria (from DSM-5, APA, proposed revision 2011):

A. Persistent deficits in social communication and social interaction across contexts, not accounted for by general developmental delays.
B. Restricted, repetitive patterns of behaviour, interests, or activities.
C. Symptoms must be present in early childhood
D. Symptoms together limit and impair everyday functioning.

ASD is diagnosed by a specialised mental health professional, through clinical observation and thorough standardised testing. The diagnostic methods vary from country to country, with certain countries having better access to trained professionals. In Switzerland, where we conducted this study, the systematic use of standardised testing in clinical settings was only recently introduced, and it is now starting to become more widespread. As such, many children with ASD in Switzerland have been diagnosed using a range of diagnostic tools, varying from an hour of clinical observation to clinical observation over a couple of days, parent questionnaires and standardised measures.
Several measures are considered to be reliable enough for diagnosing ASD. They include thorough assessments requiring professional training in tests, such as the Autism Diagnostic Observation Schedule (Lord et al., 1989; Lord et al., 2000), which is a semi-structured, standardised assessment of communication, social interaction, and play; the Autism Diagnostic Interview- Revised (ADI-R) (Cox et al., 1999; Lord et al., 1994), which is a standardised, semi-structured diagnostic interview for use with the parents or caregivers of people with autism or other Pervasive Developmental Disorders; the Childhood Autism Rating Scale (Schopler et al.), which requires clinical expertise and knowledge of general child development, and parent questionnaires such as the Autism Quotient (Baron Cohen et al.). Until the development of these standardised tests in the 1990s, researchers included a variety of children in their studies, and this has been used by certain authors to explain the contradicting results between the most recent studies and earlier studies (e.g. Durrleman & Zufferey, 2009).

2. Prevalence

Following an extensive survey of various epidemiological studies around the world, Elsabbagh et al. (2012) have estimated the global prevalence of PDD/ASD to be 62/10’000. As one of the most common neurodevelopmental disorders, ASD is becoming widely recognised as an important health issue in most developed countries. Although more and more research is being carried out in order to develop a better understanding of this disorder, there are still many areas of ASD that are poorly understood or subject to controversy. The need to continue research in this field is therefore of paramount importance.
Appendix III: Theory of mind

1. Definitions and tasks measuring Theory of Mind

The term Theory of Mind (ToM) was first coined by Premack & Woodruff (1978). Their research examined the possibility that chimpanzees were capable of inferring mental states when shown videos of humans in problematic situations. This capacity to infer mental states in others and oneself was referred to as “theory of mind”:

« In saying that an individual has a theory of mind, we mean that the individual imputes mental states to himself and to others » (Premack & Woodruff, 1978).

ToM allows us to interpret and predict behaviours in light of mental states that we attribute to the author of the behaviour. It is because we have this ability that we are able to understand everyday social interactions. ToM can be construed as a single cognitive process, such as in Premack & Woodruff’s seminal paper, but it has more recently been accepted that ToM is composed of several cognitive processes that follow a developmental path (Wellman & Liu, 2004). Since Premack & Woodruff’s research, the literature on ToM has flourished, and more recently the proposed definitions include an array of finer skills that evolve gradually into a fully developed theory of mind.

It is commonly accepted that FB tasks are a good indicator of ToM, as they require the individual to attribute a mental state (false belief) to another individual in order to predict that individual’s behaviour correctly. Since the earliest research on ToM, the tasks used required children to attribute a false belief to the protagonist of a story they were told. Two types of false belief tasks are traditionally used: location change (Wimmer & Perner, 1983) and unexpected contents (Perner, Leekam, & Wimmer, 1987). These tasks are elicited-response, verbal false belief tasks. A classic example of this kind of task is the story of Maxi and the chocolate (Wimmer & Perner, 1983). The child is told the following story (from Wimmer & Perner’s original task):

[Scene with match boxes fixed high on the wall; boy-doll present; representing Maxi waiting for his mother.]

“Mother returns from her shopping trip. She bought chocolate for a cake. Maxi may help her put away the things. He asks her: ‘Where should I put the chocolate?’ ‘In the blue cupboard’, says the mother. ‘Wait I’ll lift you up there, because you are too small.’ Mother lifts him up.
Maxi puts the chocolate into the blue cupboard. [A toy chocolate is put into the 'blue match box.) Maxi remembers exactly where he put the chocolate so that he could come back and get some later. He loves chocolate. Then he leaves for the playground. [The boy doll is removed.] Mother starts to prepare the cake and takes the chocolate out of the blue cupboard. She grates a bit into the dough and then she does not put it back into the blue but into the green cupboard. [Toy chocolate is thereby transferred from the blue to the green match box.] Now she realizes that she forgot to buy eggs. So she goes to the neighbour for some eggs. There comes Maxi back from the playground, hungry, and he wants to get some chocolate. [Boy doll reappears.] He still remembers where he had put the chocolate."

The crucial phase is the following one. The experimenter asks a question whose response will indicate whether the child has understood that Maxi does not know what the mother knows, because Maxi was not a witness to the change of place of the chocolate:

['BELIEF' question] 'Where will Maxi look for the chocolate?'
[Subject has to indicate one of the 3 boxes. The box indicated is opened.]
If the child answers that Maxi will look for the chocolate in the blue cupboard, they have attributed a false belief to Maxi, i.e. the child has understood that Maxi believes that the chocolate is where he left it, and not where the child knows it to be, and will furthermore act on his beliefs. If the child answers that Maxi will look for the chocolate in the green box, they have not attributed a false belief to Maxi and are answering what they know to be true. The next type of question allows to control for the possibility that the child hasn’t understood the story or doesn’t actually remember it well enough, which would mean that her results cannot be taken into account to evaluate her attribution of false belief to others.

['REALITY' question (asked only if the box opened is found empty)] 'Where is the chocolate really?'
['MEMORY' question] 'Do you remember where Maxi put the chocolate in the beginning?'

This task has been adapted and used in many consequent studies of false belief (for a review, see Wellman et al., 2001), with some variants manipulating whether the character wants to find something or would like to avoid something, or the words used to ask the questions. For example, certain variants used the term “first” in the belief question: “Where will Maxi look for the chocolate first”. This seems to help TD children’s responses, by increasing the salience of the location they are supposed to be targeting in their answer, and reducing the cost of inhibition of the first answer (Leslie et al., 2004).

Until late last century, it was widely accepted that ToM only developed at around 4 years of age. This view was based on studies showing that children started succeeding elicited-
response false-belief tasks such as the *Maxi and the chocolate* task only at around age 4 (see Wellman et al., 2001, for a review). Nevertheless, verbal elicited-response false-belief tasks are only one way of measuring the ability to attribute false-beliefs to others, and false-belief is only one of the different processes involved in ToM. Wellman & Liu (2004) developed a scale based on a meta-analysis of the age of performance in different kinds of theory of mind tasks in TD children. Their description of each of the stages is reported below, from least complicated to most complicated:

1. Diverse desires: The individual judges that two people have different desires about the same objects
2. Diverse beliefs: The individual judges that two people have different beliefs about the same object, when the individual doesn’t know what is true or false.
3. Knowledge access: The individual sees what is contained in a recipient, and judges (yes/no) the knowledge of the other person who does not see.
4. Contents false belief: The individual judges the other person’s false belief about what is in a distinctive container (the individual knows the true content).
5. Explicit false belief: The individual judges how someone will search, given the person’s mistaken belief.
6. Belief-emotion: The individual judges how a person will feel, given a belief that is mistaken.
7. Real vs apparent emotion: The individual judges that a person can feel one thing but display another.

Other types of experiments assessing ToM are non-verbal and/or do not require the child’s explicit response, thus reducing the requirements and cognitive load on children. These experiments have found that when children are required to respond spontaneously, and when the task is nonverbal or using very little language, they manifest behaviour that points to a very early understanding of false-belief in others, as young as 13 months old (Surian et al., 2007). Several authors found that young infants were capable of attributing false-beliefs about location to actors or characters, by using a paradigm of violation of expectation and measuring children’s looking times, therefore tapping more directly into their cognitive processes without requiring inhibition or explicit actions. The studies were carried out with 13-month-olds (Surian et al., 2007), 15-month-olds (Onishi & Baillargeon, 2005), 18 months (Song & Baillargeon, 2008) and 25-month-olds (Southgate et al., 2007). Song & Baillargeon (2008) studied 14.5-month-olds’ reasoning about others’ false perception using a violation of
expectation task, and Scott & Baillargeon (2009) conducted a study exploring 18-month-olds’ understanding of FB about identity. All these studies found results pointing to the existence of a ToM in young infants.

Other studies included indirect-elicited-response tasks, i.e. tasks that rely on infants’ natural tendency to help adults (Buttelman et al., 2009) or requiring them to act out to obtain something themselves (Southgate et al., 2010). 17-month-old children were found to be able to represent the adult’s false belief in order to determine his/her goal and his/her referential communication (Southgate et al., 2010), and 18-month-old children were found to understand that the experimenter held a false belief about the location of a desired object (Buttelman et al., 2009).

These findings have proven controversial. In particular, authors such as Perner & Ruffman (2005) have suggested that children simply associate the experimenter (agent), the toy and its location, and have not actually understood the beliefs held by the agent. Others have argued that children are simply responding to an unusual event, and are using physical reasoning to realise that there has been a change in the visual scene (Buttelman et al, 2009). San Juan and Astington (2012) point out that implicit paradigms such as the ones described above have yet to be tested on a wider range of tasks, since they have only been tested in situations where forced-choice looking paradigms would work. Furthermore, these authors mention the need for repeated measure designs in order to measure the extent of the children’s knowledge generalization. It is nevertheless quite intriguing that infants between 13 months and 25 months appear to have been found to succeed in what appears to be a less demanding task tapping into ToM.

2. Theory of mind and Autism Spectrum Disorders

Several theories have been proposed to explain the symptoms of autism. Some of the more influential ones are the Theory of Mind deficit (Baron-Cohen, 1990; Frith, 1989; Leslie, 1987), the Executive Functions deficit (e.g. Pennington & Ozonoff, 1996) and the Central Coherence deficit (Happé, 1994). All these theories have been empirically studied, but so far not one of them has sufficient support to explain all the symptoms of autism. In this paper, we have adopted the view that Theory of Mind difficulties are a core primary impairment in ASD. According to Baron-Cohen (2001), “Difficulty in understanding other minds is a core cognitive feature of autism spectrum conditions”.
Baron-Cohen, Leslie and Frith (1985) were the first to show that children with autism fail a false-belief task significantly more frequently than TD matched controls. Using a variation of the Maxi and the chocolate story (the now well-known Sally-Anne task), Baron-Cohen et al. (1985) tested 11-year-old ASD children and TD 4-year-olds. They found that 15% of the TD 4-year-olds failed (corresponding to previous findings), and that 80% of the ASD 11-year-olds failed. Similar results have been found in many other studies using Sally-Anne type tasks since then.

Using a low verbal content false-belief task, Colle et al. (2007) tested children with ASD and specific language impairment (SLI) whose language development was equal to or below 2 years of age. The children had to find an object that had been moved into one of two boxes. A series of competence tests made sure that the children had the skills required to understand the more complex false-belief task. The children had to attribute a false belief to an adult to obtain an object. This experiment is explained in detail in Chapter 3 (Method). The authors found that despite the minimal verbal content of the task, 86% of ASD 8-year-olds failed the false-belief question, whereas 24% of the SLI 8-year-olds and 44% of the TD 4-year-olds failed. Therefore, even though the task required very little understanding of language, the ASD children still did not manage to attribute a false belief to the experimenter.
## Participant information

<table>
<thead>
<tr>
<th>Participant n°</th>
<th>Age in months</th>
<th>Age in years</th>
<th>Age of first meaningful word combinations</th>
<th>Languages</th>
<th>Diagnosis</th>
<th>AQ score</th>
<th>Below/above AQ cut-off for referral</th>
<th>CARS score</th>
<th>CARS description</th>
</tr>
</thead>
<tbody>
<tr>
<td>14</td>
<td>66</td>
<td>6</td>
<td></td>
<td>Monolingual</td>
<td>Asperger’s Syndrome</td>
<td>72</td>
<td>below</td>
<td>16</td>
<td>non autistic</td>
</tr>
<tr>
<td>29</td>
<td>69</td>
<td>6</td>
<td>After 24 months</td>
<td>Monolingual</td>
<td>PDD and autism</td>
<td>69</td>
<td>below</td>
<td>19.5</td>
<td>non autistic</td>
</tr>
<tr>
<td>27</td>
<td>72</td>
<td>6</td>
<td>After 24 months</td>
<td>Monolingual</td>
<td>PDD</td>
<td>66</td>
<td>below</td>
<td>23</td>
<td>non autistic</td>
</tr>
<tr>
<td>26</td>
<td>77</td>
<td>6</td>
<td>10 words at 24 months</td>
<td>Bilingual</td>
<td>Autism</td>
<td>82</td>
<td>above</td>
<td>39.5</td>
<td>severe autism</td>
</tr>
<tr>
<td>30</td>
<td>91</td>
<td>8</td>
<td>42 months</td>
<td>Bilingual</td>
<td>Autism</td>
<td>77</td>
<td>above</td>
<td>mild autism</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>94</td>
<td>8</td>
<td></td>
<td></td>
<td></td>
<td>55</td>
<td>below</td>
<td>21.5</td>
<td>non autistic</td>
</tr>
<tr>
<td>3</td>
<td>97</td>
<td>8</td>
<td>4 years</td>
<td>Bilingual</td>
<td>Autism</td>
<td>100</td>
<td>above</td>
<td>31</td>
<td>mild autism</td>
</tr>
<tr>
<td>13</td>
<td>101</td>
<td>8</td>
<td>After 30 months</td>
<td>Monolingual</td>
<td>PDD with mild autistic traits</td>
<td>73</td>
<td>below</td>
<td>36.5</td>
<td>mild autism</td>
</tr>
<tr>
<td>18</td>
<td>102</td>
<td>9</td>
<td>4 years</td>
<td>Monolingual</td>
<td>Mild atypical autism</td>
<td>87</td>
<td>above</td>
<td>37.5</td>
<td>severe autism</td>
</tr>
<tr>
<td>5</td>
<td>102</td>
<td>9</td>
<td>After 24 months</td>
<td>Monolingual</td>
<td>ASD, Attention deficit and hyperactivity disorder</td>
<td>98</td>
<td>above</td>
<td>30</td>
<td>mild autism</td>
</tr>
<tr>
<td>6</td>
<td>121</td>
<td>10</td>
<td>Bilingual</td>
<td>Asperger’s Syndrome</td>
<td>67</td>
<td>below</td>
<td>mild autism</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>126</td>
<td>11</td>
<td>5 years</td>
<td>Bilingual</td>
<td>Autistic traits and psychosis</td>
<td>75</td>
<td>below</td>
<td>19.5</td>
<td>non autistic</td>
</tr>
<tr>
<td>2</td>
<td>128</td>
<td>11</td>
<td>4.6 years</td>
<td>Bilingual</td>
<td>Severe autism</td>
<td>119</td>
<td>above</td>
<td>32.5</td>
<td>mild autism</td>
</tr>
<tr>
<td>23</td>
<td>146</td>
<td>12</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>148</td>
<td>12</td>
<td></td>
<td>Bilingual</td>
<td>Autism</td>
<td>35</td>
<td>mild autism</td>
<td></td>
<td></td>
</tr>
<tr>
<td>28</td>
<td>148</td>
<td>12</td>
<td></td>
<td>Bilingual</td>
<td>Autism and Fragile X syndrome</td>
<td>42</td>
<td>above</td>
<td>severe autism</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>150</td>
<td>13</td>
<td>5.6 years</td>
<td>Bilingual</td>
<td>PDD-NOS</td>
<td>39</td>
<td>above</td>
<td>36</td>
<td>mild autism</td>
</tr>
<tr>
<td>15</td>
<td>162</td>
<td>14</td>
<td>24 months</td>
<td>Monolingual</td>
<td>PDD-NOS</td>
<td>68</td>
<td>below</td>
<td>19</td>
<td>non autistic</td>
</tr>
<tr>
<td>21</td>
<td>192</td>
<td>16</td>
<td>12 months</td>
<td>Bilingual</td>
<td>Asperger's Syndrome</td>
<td>70</td>
<td>below</td>
<td>22.5</td>
<td>non autistic</td>
</tr>
</tbody>
</table>
Appendix V: Language and Autism Spectrum Disorders

The study of language in autism can lead to a better understanding of the mechanisms underlying Universal Grammar. Following Rizzi (2007), we will consider that syntax, “is constrained by its immersion in a rich and diverse structure of cognitive and sensorimotor aptitudes” (my translation). As such, we shall consider that the development of grammar is “partially determined by the demands of the systems with which the faculty of language interacts”. It is therefore conceivable that when those systems are impaired, such as in developmental disorders affecting areas other than language only, the manifestation of syntax, “the motor of language” (Rizzi, 2007), may be different to that of TD individuals. When specific systems are identified as being impaired, it is conceivable to study the impact of these systems on syntax. The current study focuses on a particular set of developmental disorders, known as Autism Spectrum Disorders (ASD).

The disorders on the Autism Spectrum are characterised by impairments or delays in communication and language, so it is not surprising that one of the first concerns mentioned by parents of children with an ASD is language delay, lack of language or loss of meaningful word utterances (Plauché et al., 2007).

Studies in the United States in the early 90s (Prizant, 1996; Rapin, 1991) suggested that only half of ASD individuals ever acquire functional language, but with the development of intensive therapies such as Applied Behavioural Analysis (ABA), these numbers have risen to around 75% (Tager-Flusberg, Paul & Lord, 2005). In Switzerland, therapies such as ABA are not yet widely recognised or used, and no studies in this field have been conducted to our knowledge. However, it is possible to surmise that half of the children on the Autism Spectrum in Switzerland are non-verbal, assuming the situation is similar to the one in the USA in the early 90s.

One of the best predictors of later language development in children with ASD is the presence of functional language before 5 years old. In young children with autism, language and communication prerequisites are often absent or delayed, with poor or inexistent joint attention and proto-declarative pointing. Clinically, language in ASD is characterised by a series of abnormalities, such as immediate or delayed echolalia, idiosyncrasies, pronoun inversion, pragmatic difficulties and atypical prosody.
In the following section, I will present a brief review of the research pertaining to ASD language performance in areas other than syntax.

1. Pragmatics and discourse
Pragmatic and discursive impairments are central to Autism Spectrum Disorders, and are in fact the most consistently impaired domains. It has been proposed that “whatever the level of syntactic or semantic skill in autism, the level of pragmatic skill will be lower” Frith (1989/2003:118). Even individuals diagnosed as ASD in their infancy, but who no longer meet the diagnostic criteria, remain impaired (Kelley, Paul, Fein & Naigles, 2006). Children with ASD have difficulty maintaining or initiating conversations, do not respond as adequately as their TD peers, and do not interpret conversational cues as well as their TD peers. Gricean maxims tend not to be respected, and their speech has been described as pedantic (Eigsti et al., 2007). As we shall see in later sections, the close link between theory of mind and pragmatics provides a clue as to why impairments in this area of language exist. Baron-Cohen (1994) has even described pragmatics as “interaction of language and mindreading”.

2. Prosody
The intonation, rhythm and stress patterns in individuals with ASD have been described as ‘odd’, with early clinical observations (e.g. Kanner, 1943) pointing to a robotic tone, deficits in volume control and pitch, and odd stress patterns. Most recent studies do find impairments in prosody production and comprehension, though there is no current consensus, due to methodological differences in studies examining prosody, and the little research that has been devoted to prosody in ASD (McCann & Peppé, 2003; Shriberg et al., 2011). Not surprisingly, the most robust finding is that it is the affective and pragmatic component of prosody that is most affected, with grammatical prosody seemingly less impaired (Shriberg et al., 2001).

3. Semantics and the lexicon
Conflicting results have been found regarding the size of the lexicon: Howlin et al. (2003) conclude that adults on the ASD have significantly smaller lexicons. This could be due to their limited and repetitive interests that do not expose them to many different new words and concepts and limit the development of their lexicon. Lord & Paul (1997) on the other hand,
note that adults on the spectrum often have a larger lexicon than neurotypical adults with the same general language abilities.

Most studies do however converge in the view that lexical knowledge is a strength for individuals on the Autism Spectrum (Eigsti et al., 2011), relative to other language domains. For example, Tager-Flusberg (2001) studied a large cohort of children with autism and found that their receptive vocabulary measured by the Peabody Picture Vocabulary Test was relatively stronger than their syntactic scores on standardized tests. They suggest that this is due to their good short-term memory, which is hypothesised to be characteristic of ASD. Studies have found that individuals with autism obtain similar results to matched TD peers in their capacity to sort objects according to categories (Tager-Flusberg, 1985; Ungerer & Sigman, 1987).

Other studies have shown that when one delves into finer aspects of semantics, ASD children do seem to display semantic impairments. In particular, children with ASD obtain poor results in understanding mental state verbs such as “know, think, wonder, etc.” (see Eigsti et al., 2011, for a review). This will be of particular interest to us in the understanding of complement clauses whose matrix verb is a mental state verb.

Some oddities that have been clinically observed, such as the use of non-prototypical words, have also been experimentally shown in word fluency tasks (Dunn, Gomes & Sebastian, 1996).

Although children with ASD seemingly perform well on standardized tests of vocabulary and manage the basic categorization tasks, it would appear that their semantic organisation and understanding of certain classes of words such as mental verbs is altered.

### 4. Phonology

As with most other areas of language development in ASD, phonology studies have yielded diverging results. Although some studies show that phonology is once again a relative strength for children with ASD, others have found that ASD children show significant phonological impairments (Eigsti et al., 2011).

It would nonetheless seem that it is mostly in low-functioning individuals with autism, and in early childhood, that phonological and articulatory deficits are found. (Eigsti et al., 2011).
Rapin et al. (2009) and Tager-Flusberg et al. (1997) have suggested the existence of subgroups within the autism spectrum with phonological deficits.

As we have seen above, children with ASD show atypical use and development of language and communication. The profiles are nonetheless very heterogeneous, with some individuals being completely non-verbal and others having no other apparent impairment other than discourse and pragmatic difficulties.

5. **Methodological considerations when studying language in autism**

As with many developmental disorders, there are certain methodological hurdles that one may come across when studying individuals with autism. This is particularly true for the study of language, an aspect of cognition that is always altered in some way with ASD individuals.

Echolalia, the imitation of language heard in the environment, can lead to under or over-estimations of the child’s language development. What may be interpreted as the child’s own production can in fact be a rote memorisation process, that is not appropriate to the context and whose grammatical structure has not been integrated by the child. It is therefore important to differentiate echolalia from spontaneous speech when studying ASD children’s utterances. It has been hypothesised that echolalia may actually allow children with ASD to develop more complex syntax. Although most behavioural educational methods rely on children’s imitation skills to build their language, echolalia does not seem to help in syntactic development (Tager-Flusberg & Calkins, 1990).

Related to these echolalic tendencies, children with ASD often show better production than comprehension. Miniscalco et al (2012) studied a population of ASD toddlers, and compared their results on expressive word production and comprehension of words. Relatively to TD children, the ASD toddlers showed better results in production than in comprehension, although they did understand more than they produced. This could lead to an overestimation of their overall language development, if their comprehension results are not carefully studied. Despite this finding, “most research on the language of individuals with autism centres on their productive capacities” (Tager-Flusberg et al., 2005).
Studying the language profiles of children with ASD poses a further challenge (Tager-Flusberg, 2000). The very characteristics of the disorders make it difficult to obtain spontaneous speech, as children with ASD do not respond well to situations where they have no external constraints. In standardised testing, individuals with ASD often fail to understand what is asked of them simply because they may not understand the pragmatics of a testing situation (Tager-Flusberg, 2000). Administration of tests must often be adapted to the particular characteristics of the children, with frequent breaks or positive feedback often being the only way to obtain results (Sparrow, 1997, cited in Tager-Flusberg, 2000).
## Appendix VI: Distribution of results on the *wh*-question task

<table>
<thead>
<tr>
<th>Age in months</th>
<th>Percentage of correct responses</th>
<th>Performance group</th>
</tr>
</thead>
<tbody>
<tr>
<td>148</td>
<td>23%</td>
<td>Poor (N=9)</td>
</tr>
<tr>
<td>148</td>
<td>29%</td>
<td></td>
</tr>
<tr>
<td>101</td>
<td>33%</td>
<td></td>
</tr>
<tr>
<td>151</td>
<td>40%</td>
<td></td>
</tr>
<tr>
<td>102</td>
<td>46%</td>
<td></td>
</tr>
<tr>
<td>69</td>
<td>60%</td>
<td></td>
</tr>
<tr>
<td>94</td>
<td>67%</td>
<td></td>
</tr>
<tr>
<td>91</td>
<td>69%</td>
<td></td>
</tr>
<tr>
<td>72</td>
<td>75%</td>
<td></td>
</tr>
<tr>
<td>108</td>
<td>77%</td>
<td>Good (N=9)</td>
</tr>
<tr>
<td>77</td>
<td>79%</td>
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<tr>
<td>128</td>
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<td>97</td>
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<td>121</td>
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<td>126</td>
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</tr>
<tr>
<td>66</td>
<td>96%</td>
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</tr>
<tr>
<td>162</td>
<td>96%</td>
<td></td>
</tr>
<tr>
<td>192</td>
<td>100%</td>
<td></td>
</tr>
</tbody>
</table>
Appendix VII: Memory tasks

1. Phonological loop: non-word repetition task

This task was taken from Poncelet & Van der Linden (2003). The authors elaborated a task to test the phonological stock of working memory in francophone individuals. They established normative data on the basis of ninety-eight children’s results, ages 3 to 12 and attributed to one of four different age groups. 24 adults were also tested to establish norms for children and adults.

1.2 Materials

The independent variables of this test were the syllable structure of the items: complex (CCV) vs simple (CV) and the amount of syllables in each item: two to eight syllables. The dependent variable was the child’s correct repetition of the syllables said by the experimenter.

Each item was composed of non-words with two to eight syllables. The items were constructed following the phonotactic rules of French (Poncelet & Van der Linden, 2003).

The test’s thirty-two items were distributed as follows:

- 24 items with simple CV syllable structures, e.g. “zu”. The simple CV list contained non-words with two to eight syllables. For each number of syllables, there were three items.
- 18 items with complex CCV syllable structure (e.g. “pra”). The complex CCV list contained non-words with two to six syllables, as complex syllable structures are harder to repeat. For each number of syllables, there were three items.

An example for each condition can be found below:

<table>
<thead>
<tr>
<th>Syllable complexity</th>
<th>Number of syllables</th>
<th>Example of item</th>
</tr>
</thead>
<tbody>
<tr>
<td>Simple (CV)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>befo</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>bofenan</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>bunfonagu</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>zingumunchonlé</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>pemédakinvoreu</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>bunfenangutozèleu</td>
</tr>
<tr>
<td></td>
<td>8</td>
<td>pémeudakinvoreuchonpin</td>
</tr>
</tbody>
</table>
1.3 Procedure

The children were told that they were going to be asked to repeat a series of words “that don’t mean anything”. Four one-syllable words were first used as training items to ensure that the child had understood the type of response expected.

The experimenter then read out each of the test items, making sure that they were read as one word for each item (no breaks between syllables). All the stimuli were presented to the child even when they were making many mistakes. All items were presented online orally by the experimenter, and the child’s response was recorded. A break was inserted between the two lists. The items were presented from the shortest to longest non-word, and the simple list was administered before the complex list. The items were printed out on a sheet of paper that was then used for scoring. They were not written in phonetic alphabet on the stimulus sheet, as the authors chose to spell the words as a francophone would spell them, but the corresponding pronunciations were detailed in Poncelet & Van der Linden’s paper.

1.4 Scoring and data analysis

The child’s answers were recorded using an Olympus VN-6500PC recorder in high quality mode, without an external microphone. An item was considered as correct when all of the syllables had been repeated, or when one or two of the syllables contained a phoneme differing by no more than one articulatory feature (for consonants), or was acoustically similar (for vowels). A list of allowed variations per phoneme was included by Poncelet & Van der Linden in their original paper. The data was not analysed for this thesis.

2. Visuo-spatial memory: Corsi block-tapping task

This task is designed to measure participant’s visuo-spatial memory span, one of the components of working memory as construed by Baddeley (2003).
The Corsi block-tapping task has been used in many clinical and experimental settings since it was first developed by Corsi (1972). Despite this, the exact specifications of the apparatus to be used are difficult to find and vary across studies. We chose to follow the specifications given by Pagulayan, Busch, Medina, Bartok and Krikorian (2006), where normative developmental data for children had been collected and more details concerning the apparatus were given.

### 2.1 Materials

Following Pagulayan et al. (2006), our apparatus was composed of nine black 3.2 cm wooden cubes that had been screwed into a 20 cm by 25 cm black wooden board. The placement of the cubes is shown below:

![Image of Corsi block-tapping apparatus]

Each cube had a number on the experimenter’s side, so that the experimenter but not the child could keep track of the cubes to be touched.

The dependent variable was the sequence of blocks that was touched by the child. The independent variable was the length of the sequence of blocks touched by the experimenter.

Each sequence was pre-determined following the same quasi-random order as in Pagulayan et al. (2006). Forty-five items distributed over nine levels of difficulty could be administered depending on the participant’s performance. Each level corresponded to the number of blocks to be touched (one to nine blocks). For each level, four items were obligatory, and the fifth was administered only if at least one of the previous items of that level was incorrect.

### 2.2 Procedure

The experimenter explained to the child that they would have to point to the blocks in exactly the same order as shown by the experimenter. Before each level, the child was told that there
would be one more block to show. The experimenter then proceeded to point to the blocks in the corresponding sequence, at a rate of one block per second.

When the first four items of each level were answered correctly, the fifth item was not administered. This follows Pagulayan et al. (2006) who considered “that accuracy of reproduction on the first four items at a level indicated mastery of that level and that such performance demonstrated adequate ability to sustain attention at that level.”

When one or more of the four items was answered incorrectly, the fifth item was administered. When the child gave incorrect responses for all five items of one level, the task was stopped.

### 2.3 Scoring and data analysis

After each sequence shown by the child, the experimenter wrote down the sequence of numbers of blocks on an answer sheet. The span capacity was defined as “the highest level at which the participant correctly reproduced at least one sequence”, ranging from 0 to 9. The data was not analysed for this thesis.
Appendix VIII: Theory of Mind Verbal task: “Sally-Anne”

1. Materials
The stories were told to the children by the experimenter, using figurines to act out the different scenes. Unlike in Baron-Cohen et al.’s original test, four different scenarios were used in order to obtain more than one measure. All scenarios involved protagonist A displacing an object without protagonist B being aware of this, which meant that the child had to attribute a belief to protagonist B that did not correspond to what the child knew had actually happened.

The dependent variable was the child’s response to the memory, reality and false belief questions: correct or incorrect.

2. Procedure
The experimenter acted out each of the four stories using figurines. In each story, a different object was displaced, with a different scenario, initial and final location. For details of each of the stories, please refer to Appendix VIII. The false belief question, “Where will A look for the object” was slightly modified from Baron-Cohen’s initial question. Following Surian and Leslie (1999), we decided to add the term “first” (“en premier” in French) at the end of the question, because this enhances TD children’s performance on the task.

The children were introduced to the two characters, A (e.g. “This is Sally”) and B (e.g. “This is Anne”). The experimenter ensured that the names had been learnt by the child before proceeding.

The experimenter then acted out the story with the figurines, following the general outline below:

1. A and B are both placed in the scenario at the beginning.
2. “A puts the [object] into [location 1].”
3. “A goes out to play/shop.” The experimenter hides A from the child’s view.
4. “B takes the [object] and puts it in [location 2].”
5. “A comes back.” The experimenter brings A back into the child’s view.
6. “A wants the [object].”
7. Test question: “Où est-ce que A va chercher [objet] en premier?” (Where will A look for the [object] first?)
8. Reality question “Où est [objet] en réalité?” (Where is the [object] now?)
9. Memory question “Où était [objet] au début?” (Where was the [object] at the beginning?)

The two control questions (steps 8 and 9 above) ensured that the child had remembered where the object was at the beginning, and that they could say where the object had been displaced to.

Figure 8 depicts the “Billy and his mother” scenario, where protagonist A is Billy’s mother, protagonist B is Billy, the object is a mug, and the two locations are a cupboard and a toy box.

<table>
<thead>
<tr>
<th>Step 2</th>
<th>“La mère de Billy va ranger la tasse dans l’armoire”.</th>
<th>Billy’s mother puts the mug in the cupboard.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Step 4</td>
<td>« Billy met la tasse dans le coffre à jouets ».</td>
<td>Billy puts the mug in the toy box.</td>
</tr>
</tbody>
</table>

**Figure 9.** Illustrations of steps 2 and 4 in the “Billy and his mother” scenario.
Appendix IX: Protocols for each task, in French

1. Syntax

1.2 Relative clause comprehension

**Procédure**

*Lexique.* À chaque diapositive du diaporama, demander à l’enfant de montrer un animal. Tous les personnages figurent dans le diaporama, avec un rappel de l’animal cible en commentaire. Dans les cas où l’enfant donne une mauvaise réponse, reprendre l’item avec lui et faire remarquer les différences entre les personnages. Continuer cette partie jusqu’à ce que l’enfant ait retenu les personnages, ou interrompre la tâche si cette partie s’avère trop difficile.

Pour les parties suivantes, lancer e-prime et dire à l’enfant :

« Maintenant on va faire un jeu avec ces images. Des images vont apparaître à l’écran et une voix va te demander de montrer des personnages. Tu devras montrer soit à droite soit au centre soit à gauche de l’écran. Tu n’as pas besoin de te dépêcher. Tu as compris? Tu as des questions? Pour l’instant on va s’entraîner. Tu es prêt? »

*Familiarisation.* Si l’enfant se trompe pendant cette phase, reprendre l’item et lui montrer ce qui est attendu.

*Partie 1 et 2.* Ces deux parties peuvent être passées l’une après l’autre avec ou sans pause. Ne jamais corriger l’enfant ou lui dire s’il a fait juste ou faux. Il faut par contre toujours l’encourager à continuer bien évidemment. Noter ses réponses sur la feuille de passation, et rajouter un commentaire lorsque l’enfant a répété la phrase de façon erronée ou lorsqu’il ne semblait pas attentif.

1.3 Wh-question comprehension

**Procédure**

*Lexique.* Le lexique est vérifié une seule fois pour relatives et questions wh.

*Familiarisation.* Même procédure que pour la phase de familiarisation des relatives.

*Parties 1, 2, 3 et 4.* Même procédure que pour les parties 1 et 2 des relatives.
1.4 Complement clause comprehension : perception verb

1.4.1 Matériel :
- Ordinateur
- Fichier ppt correspondant à la version qui a été attribuée à l’enfant (Perception Version A ou Perception Version B)
- Marionnette
- Feuille de passation : l’avoir sous les yeux pour vérifier les stimuli et pour noter les réponses du participant.

1.4.2 Procédure

*Familiarisation avec les images et les personnages (lexique).* Lancer le diaporama de la présentation powerpoint (version A ou B selon ce qui aura été préalablement attribué à l’enfant). Présenter la première image (diapositive 3).

Dire « *Regarde, voici des canards, des souris et des éléphants.* » (ne pas montrer les personnages) Marquer un petit temps d’arrêt pour s’assurer que l’enfant a regardé tous les personnages.

Dire ensuite chacun des items suivants, en notant la réponse de l’enfant sur la feuille de passation.

- ‘*Montre-moi les canards!*’
- ‘*Montre-moi les souris!*’
- ‘*Montre-moi les éléphants!*’

*Introduction à la marionnette et vérification de la compréhension de la consigne.* Attention, cette partie de la tâche est la seule où l’on doit donner un feedback à l’enfant. Ceci permet de s’assurer que l’enfant a bien compris la consigne, et de la lui réexpliquer le cas échéant.

Sortir la marionnette et la montrer à l’enfant :

« *Voici Pim le singe/ Paf le cochon. Il apprend le français et ne parle pas encore très bien. Il faudra que tu l’aides. Nous allons lui montrer des images et il va les décrire, il va dire ce qu’il y a dessus. Parfois il va se tromper, et toi tu devras dire s’il s’est trompé.* »
Vérifier que l’enfant ait bien compris la consigne, avec les 4 images d’entraînement : « On essaye alors ? Pim/Paf, dis-nous ce qu’il y a sur cette image ! »

Avant chaque phrase dite par la marionnette, marquer un petit temps d’arrêt afin de s’assurer que l’enfant a bien regardé l’image. L’encourager à regarder la totalité de l’image si nécessaire. L’expérimentateur dit ensuite chacun des items ci-dessous en faisant parler la marionnette.

Après chaque item, demander à l’enfant (avec la voix de l’expérimentateur) si la marionnette a dit vrai :

- (marionnette) « Il y a un éléphant. » (expérimentateur) Est-ce que c’est vrai ?
- (marionnette) « Il y a une souris. » (expérimentateur) Est-ce que c’est vrai ?
- (marionnette) « Il y a une voiture. » (expérimentateur) Est-ce que c’est vrai ?
- (marionnette) « Il y a un canard. » (expérimentateur) Est-ce que c’est vrai ?

*Items contrôle.* Ces stimuli ont pour but de contrôler si le participant parvient à déterminer la direction du regard des personnages, condition préalable à la compréhension des items test.

Dire à l’enfant

« C’est bien, tu as pu aider Paf/Pim ! Il est content ! Maintenant nous allons continuer avec d’autres images. Comme avant, Paf/Pim va décrire les images. Toi, tu vas dire si Paf/Pim a raison, s’il dit vrai. »

Présenter chaque item successivement en faisant parler la marionnette. Comme au préalable, laisser à l’enfant le temps de bien regarder l’image avant de dire la phrase.

- (marionnette) « L’éléphant voit le canard. » (expérimentateur) Est-ce que c’est vrai ?
- (marionnette) « Le canard voit la souris. » (expérimentateur) Est-ce que c’est vrai ?
- (marionnette) « L’éléphant voit le canard. » (expérimentateur) Est-ce que c’est vrai ?
- (marionnette) « La souris voit l’éléphant. » (expérimentateur) Est-ce que c’est vrai ?
- (marionnette) « Le canard voit la souris. » (expérimentateur) Est-ce que c’est vrai ?
- (marionnette) « La souris voit l’éléphant » (expérimentateur) Est-ce que c’est vrai ?

Entourer sur la feuille de passation la réponse de l’enfant.
Ne pas donner de feedback sur la réussite de la tâche. Des commentaires sur l’effort que fournit l’enfant l’aideront à rester motivé, p.ex. « tu écoutes bien, bravo ! » ou « Paf est content ! » ou « tu es bien concentré ! ».


1. Le canard voit que la souris joue au foot.
2. La souris voit que le canard mange une glace.
3. La souris voit que l’éléphant crache de l’eau
4. L’éléphant voit que la souris conduit une voiture.
5. L’éléphant voit que le canard écoute de la musique.
6. La souris voit que l’éléphant fait cuire des pâtes.
7. L’éléphant voit que la souris joue au foot.
8. L’éléphant voit que le canard mange une glace.
9. Le canard voit que l’éléphant crache de l’eau
10. Le canard voit que la souris conduit une voiture.
11. La souris voit que le canard écoute de la musique.
12. Le canard voit que l’éléphant fait cuire des pâtes.

Entourer sur la feuille de passation la réponse de l’enfant. Ne pas donner de feedback sur la réussite de la tâche, l’encourager.

*Commentaires généraux.* Si nécessaire, il est possible de faire une pause entre chacune des grandes parties de la tâche (familiarisation, contrôle, test). Si possible, ne pas faire de pause au sein d’un même bloc.

La version A et la version B se différencient par les images et les réponses attendues dans la phase test. Les phrases stimuli sont les mêmes.

Attention à garder une prosodie aussi naturelle que possible en faisant parler Paf. L’expérimentateur peut changer de voix pour la marionnette, ce qui peut aider le participant à déterminer que c’est la marionnette qui parle. Cependant l’on veillera à ne pas trop exagérer le changement de voix, car une voix trop caricaturale risque de distraire l’enfant et de l’exposer à des stimuli moins écologiques.
1.5 Complement clause comprehension : communication verb

*Procédure (réalisée par Lola Nadel et Ines Themido)*

*Présentation des personnages.* Cette tâche comporte 4 personnages différents, les 5 premiers items sont dédiés à leur présentation. Pour les 4 premiers items, dire: « *Je vais te présenter les 4 personnages de ce jeu. »*

Item présentation 1: « Voici Marie! Tu vois elle a de longs cheveux noir et une jolie robe verte. C'est Marie. »

Item présentation 2: « Là c'est la sœur de Marie. C'est rigolo elle a les cheveux orange. Elle a aussi une belle robe rose. C'est la sœur de Marie. »

Item présentation 3: « Voici Thomas! On dirait un marin avec son t-shirt rayé! Il a les cheveux bruns. C'est Thomas »

Item présentation 4: « Et là c'est le frère de Thomas. Il est blond et a un beau short jaune! »

Au 5ᵉ item de présentation, demander à l'enfant de nommer chaque personnage en le pointant du doigt : « Maintenant arrives-tu à me montrer chaque personnage en me disant leurs prénoms? » Demander si nécessaire, personnage par personnage: « ça c'est qui? »

S'il ne se souvient plus, recommencer la présentation jusqu'à ce que les noms soient connus.

*Entraînement.* Dire à l’enfant « Maintenant tu vas entendre les personnages dire des choses; tu verras, ils ne sont jamais d'accord! »

Sortir la marionnette et expliquer à l’enfant: « Alors ça c'est Paf le cochon/Nim le singe. Lui aussi il veut jouer, hein Paf/Nim? »

« Oui je veux jouer! » *(faire une petite voix)*

« Paf/Nim il va essayer de retenir ce que Marie, Thomas et leurs frère et soeur ont dit. Mais il ne comprend pas très bien de français donc parfois il se trompe. Toi, tu devras l’aider en lui disant s’il a bien compris, donc tu dois dire si Paf/Nim dit juste ou s'il se trompe. Tu as compris? »

Si l’enfant montre une incompréhension de la procédure, le corriger. Ne pas le corriger si son erreur porte sur la compréhension de la complétive.
Présenter le premier item d’entraînement. Quand on arrive à la diapositive avec les deux personnages dire:

Item 1. Voix marionnette : « Marie dit qu'il y a un lapin ».
   Voix expérimentateur: Est-ce que c’est vrai ?

Item 2. Voix marionnette : « Thomas dit qu'il a soif ».
   Voix expérimentateur: Est-ce que c’est vrai ? Super, maintenant tu es prêt pour le grand jeu !

*Début de la tâche.* On fait défiler les items de la présentation powerpoint, à chaque fois qu'apparaît la diapositive avec les deux personnages ensemble, la marionnette dit l'affirmation à laquelle l'enfant doit répondre par vrai ou par faux. Si l’enfant n’a pas entendu on répète la phrase de la marionnette une fois. On ne lui donne aucun feedback, juste des encouragements généraux à continuer.

Marionnette : *Marie dit qu'il fait beau* Est-ce que c’est vrai ?
Marionnette : *Thomas dit que la fleur est moche* Est-ce que c’est vrai ?
Marionnette : *Marie dit que la chaise est grande* Est-ce que c’est vrai ?
Marionnette : *Thomas dit qu'il y a des bonbons* Est-ce que c’est vrai ?
Marionnette : *Marie dit que le bâton est court* Est-ce que c’est vrai ?
Marionnette : *Thomas dit que la voiture est rouge* Est-ce que c’est vrai ?

**PAUSE**

Marionnette : *Le frère de Thomas dit qu'il y a des étoiles* Est-ce que c’est vrai ?
Marionnette : *La sœur de Marie dit qu'il y a des oiseaux* Est-ce que c’est vrai ?
Marionnette : *Le frère de Thomas dit que le livre est gros* Est-ce que c’est vrai ?
Marionnette : *La sœur de Marie dit qu'il y a une fourmi* Est-ce que c’est vrai ?
Marionnette : *Le frère de Thomas dit que la tour est haute* Est-ce que c’est vrai ?
Marionnette : *La sœur de Marie dit que le ciel est gris* Est-ce que c’est vrai ?

*Encodage des réponses:*

Si l'enfant dit vrai puis faux pour un même item, le noter: coche avec 1 à côté pour sa première réponse et coche avec 2 à côté pour la seconde.
2 Theory of mind

2.1 False-belief verbal task

En plus de l’histoire de Sally et Anne, imaginée par Baron-Cohen et al. (1985) nous avons créé trois histoires sur base de celle-ci :

3. Sally, Anne et la bille.

Remarques générales. Pour chacune des histoires, l’expérimentateur joue toute l’histoire avant de poser les trois questions à l’enfant. Certains enfants voudront poser des questions pendant que l’expérimentateur raconte/joue l’histoire, il est donc important de veiller au maximum à ce que l’enfant pose ses questions à la fin. On pourra le laisser jouer avec les personnages, de préférence à la fin de l’histoire afin qu’il ne leur attribue pas déjà des caractéristiques lors de son jeu.

Ci-dessous, les procédures pour chacune de ces histoires.

2.1.1 Billy, sa maman, et la tasse.

Matériel

- Personnage playmobil femme (maman de Billy)
- Personnage légo garçon (Billy)
- Tasse légo
- Armoire légo montée sur un bloc légo
- Coffre légo
- Deux chaises et une table légo pour créer le décor de la cuisine
- Base support légo (planche verte)
- Deux petites barrières légo pour séparer la pièce avec l’armoire de la pièce avec le coffre à jouets
- Feuille de résultats"
**Procédure**

Au préalable, préparer le matériel en suivant la disposition de la figure ci-dessus.

Dire à l’enfant qu’on va lui raconter une histoire, et qu’on lui posera ensuite des questions se rapportant à l’histoire. S’assurer à ce moment-là que l’enfant a bien compris qu’il pourra jouer avec les personnages à la fin de l’histoire.

**Présentation des personnages à l’enfant** : prendre les deux personnages chacun dans une main, et en avançant chaque personnage concerné vers l’enfant, dire :

« Voici Billy et voici la maman de Billy ».

**Contrôle de la connaissance des personnages** : poser les deux personnages sur la table, et demander : « Montre-moi Billy », puis « Montre-moi la maman de Billy »

En cas d’échec à cette partie, répéter la procédure afin de s’assurer que l’enfant ait bien retenu les personnages.

**Histoire racontée** : tout en manipulant les personnages appropriés, raconter l’histoire à l’enfant :

« La maman de Billy boit son café. Elle a fini son café, elle va ranger la tasse dans l’armoire. La maman de Billy va au travail [s’assurer que le personnage de la maman est bien hors de vue de l’enfant également]. Billy a soif, il prend la tasse, boit, puis met la tasse dans le coffre à jouet. La maman de Billy rentre du travail. Elle a soif et elle veut la tasse »

**Questions** : remettre les personnages sur la table, et poser les questions suivantes (attention, les questions doivent être posées exactement de la même façon qu’ici), sans pointer ni porter son regard sur un lieu en particulier.

« Où est-ce que la maman va aller chercher la tasse en premier ? » (question de fausse croyance)

« Où est la tasse en réalité ? » (question de réalité)

« Où était la tasse au début ? » (question de mémoire)
Noter les réponses de l’enfant sur la feuille de réponses, y compris lorsque celui-ci montre plusieurs endroits à la fois. Dans ce cas, reposer exactement la même question en précisant qu’il faut dire un endroit, et noter que la réponse a été donnée en deuxième.

2.1.2 Max, Daniel, et le balai.

Matériel

- Personnage légo d’un âne (Daniel)
- Personnage légo d’un singe (Max)
- Balai légo
- Suffisamment de blocs légo pour construire une maison, avec fenêtres, porte d’entrée et toit.
- Fleurs et petites barrières légo pour mettre dans le jardin
- Feuille de résultats

Procédure

Au préalable, préparer le matériel en suivant la disposition illustrée dans la figure ci-dessous.

Dire à l’enfant qu’on va lui raconter une histoire, et qu’on lui posera ensuite des questions se rapportant à l’histoire. S’assurer à ce moment-là que l’enfant a bien compris qu’il pourra jouer avec les personnage à la fin de l’histoire.

Présentation des personnages à l’enfant : prendre les deux personnages chacun dans une main, et en avançant chaque personnage concerné vers l’enfant, dire : « Voici Max et voici Daniel ».

Contrôle de la connaissance des personnages : poser les deux personnages sur la table, et demander : « Montre-moi Max » puis « Montre-moi Daniel ». En cas d’échec à cette partie, répéter la procédure afin de s’assurer que l’enfant ait bien retenu les personnages.

Histoire racontée : tout en manipulant les personnages appropriés, raconter l’histoire à l’enfant :

« Max et Daniel sont dans le jardin. Max est en train de balayer. Il met le balai à côté de la maison et il part acheter des fleurs. [s’assurer que Max est complètement hors de vue]
Daniel prend le balai, il rentre dans la maison, il balaye dans la maison. Il laisse le balai dans la maison. Il ressort dans le jardin. Max revient de ses courses. Il veut le balai.

**Questions** : remettre les personnages sur la table, et poser les questions suivantes (attention, les questions doivent être posées exactement de la même façon qu’ici), sans pointer ni porter son regard sur un lieu en particulier.

« Où est-ce que Max va aller chercher le balai en premier ? » (question de fausse croyance)

« Où est-ce que le balai est en réalité ? » (question de réalité)

« Où est-ce que le balai était au début ? » (question de mémoire)

Noter les réponses de l’enfant sur la feuille de réponses, y compris lorsque celui-ci montre plusieurs endroits à la fois. Dans ce cas, reposer exactement la même question en précisant qu’il faut dire un endroit, et noter que la réponse a été donnée en deuxième.

![Figure](image.jpg) Illustrations du scénario de Max et Daniel

### 2.1.3 Sally, Anne et la bille.

**Matériel**

- Poupée couleurs (Sally)
- Poupée noir et blanc (Anne)
- Bille
- Petit sac
- Petite boîte
- Feuille de résultats
**Procédure**

Au préalable, préparer le matériel en suivant la disposition de la figure ci-dessous. Dire à l’enfant qu’on va lui raconter une histoire, et qu’on lui posera ensuite des questions se rapportant à l’histoire. S’assurer à ce moment-là que l’enfant a bien compris qu’il pourra jouer avec les personnages à la fin de l’histoire.

*Présentation des personnages à l’enfant*: prendre les deux personnages chacun dans une main, et en avançant chaque personnage concerné vers l’enfant, dire : « Voici Sally et voici Anne ».

*Contrôle de la connaissance des personnages*: poser les deux personnages sur la table, et demander : « Montre-moi Sally » puis « Montre-moi Anne ». En cas d’échec à cette partie, répéter la procédure afin de s’assurer que l’enfant ait bien retenu les personnages.

*Histoire racontée*: tout en manipulant les personnages appropriés, raconter l’histoire à l’enfant :

« Sally range sa bille dans la boîte puis Sally quitte la pièce. [s’assurer que Sally est complètement hors de vue] Pendant que Sally est absente, Anne met la bille dans le sac. Sally revient et veut sa bille. »

*Questions*: remettre les personnages sur la table, et poser les questions suivantes (attention, les questions doivent être posées exactement de la même façon qu’ici !), sans pointer ni porter son regard sur un lieu en particulier.

« Où est-ce que Sally va aller chercher la bille en premier ? » (question de fausse croyance)

« Où est-ce que la bille est en réalité ? » (question de réalité)

« Où est-ce que la bille était au début ? » (question de mémoire)

Noter les réponses de l’enfant sur la feuille de réponses, y compris lorsque celui-ci montre plusieurs endroits à la fois. Dans ce cas, reposer exactement la même question en précisant qu’il faut dire un endroit, et noter que la réponse a été donnée en deuxième.
2.1.4 Julie, son papa, et le nœud.

Matériel

- Personnage playmobil fille (Julie)
- Personnage playmobil homme (le papa de Julie)
- Petit nœud playmobil
- Commode à tiroirs playmobil
- Valise playmobil
- Feuille de résultats

Procédure

Au préalable, préparer le matériel en suivant la disposition illustrée dans la figure. Dire à l’enfant qu’on va lui raconter une histoire, et qu’on lui posera ensuite des questions se rapportant à l’histoire. S’assurer à ce moment-là que l’enfant a bien compris qu’il pourra jouer avec les personnages à la fin de l’histoire.

Présentation des personnages à l’enfant : prendre les deux personnages chacun dans une main, et en avançant chaque personnage concerné vers l’enfant, dire :« Voici Julie et voici le papa de Julie ».

Contrôle de la connaissance des personnages : poser les deux personnages sur la table, et demander : « Montre-moi Julie » puis « Montre-moi le papa de Julie ». En cas d’échec à cette partie, répéter la procédure afin de s’assurer que l’enfant ait bien retenu les personnages.

Histoire racontée : tout en manipulant les personnages appropriés, raconter l’histoire à l’enfant.
«Julie rentre de l’école et range son nœud dans le tiroir. Puis elle va jouer dehors. [s’assurer que Julie est complètement hors de vue] Pendant que Julie joue dehors, son papa prend le nœud et le met dans la valise. Julie revient et veut son nœud.»

Questions : remettre les personnages sur la table, et poser les questions suivantes (attention, les questions doivent être posées exactement de la même façon qu’ici !), sans pointer ni porter son regard sur un lieu en particulier.

«Où est-ce que Julie va aller chercher le nœud en premier ?» (question de fausse croyance)

«Où est-ce que le nœud est en réalité ?» (question de réalité)

«Où est-ce que le nœud était au début ?» (question de mémoire)

Noter les réponses de l’enfant sur la feuille de réponses, y compris lorsque celui-ci montre plusieurs endroits à la fois. Dans ce cas, reposer exactement la même question en précisant qu’il faut dire un endroit, et noter que la réponse a été donnée en deuxième.

Figure Illustration du scénario de Julie et son papa

2.2 False-belief low verbal content task

Cette expérience a été reprise de celle décrite par Colle et al (2007), et nécessite deux expérimentateurs.

Matériel

- Ecran en carton pliable, dimensions 77cm x 30cm
- Deux petites boîtes opaques identiques
- Une table rectangulaire ou carrée suffisamment grande pour que trois personnes puissent s’y asseoir en vis-à-vis (c.f. illustration ci-dessous)
• Au moins 24 morceaux d’un renforçateur alimentaire ou non-alimentaire approprié pour l’enfant testé (à vérifier auparavant avec le parent). Par souci de clarté, nous ferons référence au renforçateur comme « X » dans ce document.
• Si possible, une pièce séparée pour que l’expérimenter B puisse sortir de la salle complètement

**Procédure**

Cette tâche est composée de plusieurs tests, chacun comportant trois essais. Pour chaque essai l’enfant doit trouver un renforçateur caché dans une boîte en pointant. Il est important de faire tous les essais de chaque test. Pour tous les tests, sauf les tests de croyance, on ne pourra passer au test suivant qu’après réussite de trois essais consécutifs. Ainsi, si l’enfant échoue à deux ou trois des trois essais, on arrêtera la passation. Si l’enfant échoue à un seul essai, ou si l’on remarque que l’attention a baissée, reprendre le même niveau de test pour arriver aux trois essais consécutifs réussis.

Il est important de noter que l’emplacement du renforçateur pour chaque essai a été randomisé, et figure sur la feuille de passation:

- G → cacher le renforçateur dans la boîte de gauche.
- D → cacher le renforçateur dans la boîte de droite.

Certaines conditions se déroulent avec écran. Pour ces conditions, s’assurer que l’enfant ne voit pas ce qui se passe de l’autre côté de l’écran.

Ne pas sortir le matériel tout de suite. S’installer aux places attribuées. L’expérimenter B doit s’asseoir à équidistance de l’expérimenter A, afin de pouvoir voir à la fois l’enfant et les manipulations des boîtes lorsque l’écran est placé au centre.

Dire à l’enfant que l’on va jouer à trouver un bonbon/paille/autre renforçateur dans une boîte. Sortir les deux boîtes, les montrer à l’enfant, et montrer les renforçateurs que nous avons prévus. S’assurer encore à ce moment-là que ce sont des renforçateurs assez puissants pour que l’enfant ait la motivation de continuer la tâche jusqu’au bout. Il est possible de changer le goût du bonbon ou d’utiliser deux bonbons différents au fil de l’expérience, et de demander quels bonbons l’enfant aimerait parmi ceux proposés. Il les aura ainsi au fur et à mesure de l’expérience.
Expliquer à l’enfant qu’il ne faudra montrer la boîte où se trouve le bonbon qu’une fois qu’on le lui demandera, car l’expérimentateur B doit aussi jouer à trouver X.

A partir de maintenant, l’ensemble des conditions se fera sans parler (sauf pour donner les quelques consignes suivantes), si possible.

**Pré-test (sans écran)**

Buts du pré-test :

- Montrer à l’enfant que l’expérimentateur B peut l’aider à trouver la réponse,
- Lui signifier que la réponse doit être donnée sous forme de pointage.

On s’assurera donc que l’enfant ne manipule pas les boîtes et ne fasse pas un geste imprécis lors du pointage. Si nécessaire, reprendre les règles avec l’enfant : « tu ne touches pas les boîtes, tu montres seulement avec ton doigt ».

Lors du prétest, l’enfant et l’expérimentateur B peuvent voir toutes les manipulations effectuées par l’expérimentateur A.

**Déroulement**

1. A ouvre les deux boîtes, les montre à l’enfant.
2. A cache le renforçateur dans la boîte de gauche (refermer les deux couvercles), en s’assurant au préalable d’avoir le regard de l’enfant (agiter légèrement le renforçateur avant de le mettre dans la boîte peut aider).
3. A demande à B « trouve le/la X »
4. A montre la boîte de gauche (correcte) en pointant, après s’être assurée d’avoir l’attention de l’enfant.
5. A demande à l’enfant « trouve le/la X ». L’enfant doit montrer la boîte correcte en pointant.
6. A ouvre la boîte pointée et la montre à l’enfant.
7. A donne X à l’enfant.
8. B note la réponse donnée par l’enfant.
9. Reprendre à l’étape (1) jusqu’aux trois essais réussis, en changeant la boîte où est caché X selon les instructions sur la feuille de passation.
Tests de compétences pré-requises (sans écran)

But : vérifier que l’enfant possède les compétences requises pour traiter les informations de la tâche de fausse croyance. Ces compétences sont :

- Le déplacement visible : la capacité à suivre le déplacement d’un objet que l’on voit.
- Le déplacement invisible : la capacité à suivre le déplacement d’un objet que l’on ne voit pas (suivre le déplacement de son récipient).
- La capacité à ne pas prendre en compte la réponse de l’adulte dans sa prise de décision.

Déplacement visible:

1) A ouvre les deux boîtes et les montre à l’enfant
2) A cache X dans la boîte de droite selon la feuille de passation, puis referme les deux boîtes.
3) B sort de la pièce, afin que l’enfant ne puisse plus la voir.
4) A montre le contenu des deux boîtes à l’enfant.
5) A prend ensuite X et le déplace dans la boîte de gauche (dans l’autre boîte).
6) A referme les deux boîtes.
7) Selon un signe prédéterminé (e.g. léger toussotement de A), B sait qu’elle peut revenir dans la salle. Elle revient.
8) A demande à l’enfant « trouve X ».
9) L’enfant pointe la boîte.
10) A ouvre la boîte pointée et la montre à l’enfant.
11) A donne X à l’enfant, même si la réponse est erronée.
12) B note la réponse donnée par l’enfant.
13) Reprendre à l’étape (1) jusqu’aux trois essais réussis, en changeant la boîte où est caché X selon les instructions sur la feuille de passation.

Déplacement invisible

1) A ouvre les deux boîtes et les montre à l’enfant
2) A cache X dans la boîte de gauche selon la feuille de passation, puis referme les deux boîtes.
3) B sort de la pièce, afin que l’enfant ne puisse plus la voir.
4) A intervertit les deux boîtes, afin que la boîte contenant le renforçateur soit maintenant à droite (l’enfant ne voit pas le bonbon ! il voit uniquement le déplacement des boîtes !).

5) Selon un signe prédéterminé (e.g. léger toussotement de A), B sait qu’elle peut revenir dans la salle. Elle revient.

6) A demande à l’enfant « trouve X ».

7) L’enfant pointe une boîte.

8) A ouvre la boîte pointée et la montre à l’enfant.

9) A donne X à l’enfant, même si la réponse est erronée.

10) B note la réponse donnée par l’enfant.

11) Reprendre à l’étape (1) jusqu’aux trois essais réussis, en changeant la boîte où est caché X selon les instructions sur la feuille de passation.

Non prise en compte de l'aide

1) A ouvre les deux boîtes et les montre à l’enfant

2) A cache X dans la boîte de droite selon la feuille de passation, puis referme les deux boîtes.

3) B sort de la pièce, afin que l’enfant ne puisse plus la voir.

4) A montre le contenu des deux boîtes à l’enfant.

5) A prend ensuite X et le déplace dans la boîte de gauche (dans l’autre boîte).

6) A referme les deux boîtes.

7) Selon un signe prédéterminé (e.g. léger toussotement de A), B sait qu’elle peut revenir dans la salle. Elle revient.

8) A demande à B « trouve X »

9) B pointe la boîte de droite (là où elle a vu A cacher le renforçateur)

10) A demande à l’enfant « trouve X ».

11) L’enfant pointe une boîte.

12) A ouvre la boîte pointée et la montre à l’enfant.

13) A donne X à l’enfant, même si la réponse est erronée.

14) B note la réponse donnée par l’enfant.

15) Reprendre à l’étape (1) jusqu’aux trois essais réussis, en changeant la boîte où est caché X selon les instructions sur la feuille de passation.
Tests de croyance (AVEC ECRAN)

Fausse croyance

2) A cache X dans la boîte de gauche selon la feuille de passation, puis referme les deux boîtes. L’enfant ne peut ni voir ni entendre là où se trouve le renforçateur, mais doit pouvoir voir que B a regardé les boîtes.
3) B sort de la pièce, afin que l’enfant ne puisse plus la voir.
4) A enlève l’écran.
5) A ne montre pas le contenu des boîtes à l’enfant (autrement ce ne serait plus une tâche de fausse croyance)!
6) A intervertit les deux boîtes devant l’enfant, afin que la boîte contenant le renforçateur soit maintenant à droite
7) Selon un signe prédéterminé (e.g. léger toussotement de A), B sait qu’elle peut revenir dans la salle. Elle revient.
8) A demande à B « trouve X »
9) B pointe la boîte de gauche (là où elle a vu A cacher le renforçateur)
10) A demande à l’enfant « trouve X ».
11) L’enfant pointe une boîte.
12) A ouvre la boîte pointée et la montre à l’enfant.
13) A donne X à l’enfant, même si la réponse est erronée.
14) B note la réponse donnée par l’enfant.
15) Reprendre à l’étape (1) jusqu’aux trois essais réussis, en changeant la boîte où est caché X selon les instructions sur la feuille de passation.

⇒ Continuer à l’étape suivante même si les trois essais sont ratés.

Croyance correcte (B ne sort pas)

But : s’assurer que lors de la tâche de fausse croyance l’enfant n’a pas conclu que quand on intervertissait les boîtes, B donne toujours une réponse erronée.

2) A cache X dans la boîte de droite selon la feuille de passation, puis referme les deux boîtes. L’enfant ne peut ni voir ni entendre là où se trouve le renforçateur, mais doit pouvoir voir que B a regardé les boîtes.

3) A enlève l’écran.

4) A ne montre pas le contenu des boîtes

5) A intervertit les deux boîtes devant l’enfant et devant B, afin que la boîte contenant le renforçateur soit maintenant à gauche

6) A demande à B « trouve X »

7) B pointe la boîte de droite (là où elle a vu A cacher le renforçateur)

8) A demande à l’enfant « trouve X ».

9) L’enfant pointe une boîte.

10) A ouvre la boîte pointée et la montre à l’enfant.

11) A donne X à l’enfant, même si la réponse est erronée.

12) B note la réponse donnée par l’enfant.

13) Reprendre à l’étape (1) jusqu’aux trois essais réussis, en changeant la boîte où est caché X selon les instructions sur la feuille de passation.

Continuer à l’étape suivante même si les trois essais sont ratés.

Condition contrôle

But: vérifier que pendant le test de fausse croyance, l’enfant n’a pas conclu qu’à chaque fois que B partait, son pointage était erroné.

A place un écran entre l’enfant et elle, afin de cacher les boîtes. B doit pouvoir voir des deux côtés de l’écran, et l’enfant ne doit pas pouvoir voir les boîtes.

1) A cache X dans la boîte de gauche selon la feuille de passation, puis referme les deux boîtes. L’enfant ne peut ni voir ni entendre là où se trouve le renforçateur, mais doit pouvoir voir que B a regardé les boîtes.

2) B sort de la pièce, afin que l’enfant ne puisse plus la voir.

3) B revient.

4) A demande à B « trouve X »

5) B pointe la boîte de gauche (là où elle a vu A cacher le renforçateur)

6) A demande à l’enfant « trouve X ».
7) L’enfant pointe une boîte.
8) A ouvre la boîte pointée et la montre à l’enfant.
9) A donne X à l’enfant, même si la réponse est erronée.
10) B note la réponse donnée par l’enfant.
11) Reprendre à l’étape (1) jusqu’aux trois essais réussis, en changeant la boîte où est caché X selon les instructions sur la feuille de passation.

2.3 Picture-sequencing task

Matériel :

Cinq types d’histoire se répartissent sur 15 histoires composées chacune de 4 images de format 5x5 cm en couleur. Il y a 3 histoires différentes pour chaque condition.

2.3.2 Procédure :


L’expérimentateur donne les instructions à l’enfant : « Tu vas devoir me raconter une histoire avec des images. C’est moi qui pose la première image et tu vas mettre les trois autres dans les cadres en essayant de faire une histoire. Une fois que tu auras mis les images en ordre tu vas devoir me raconter ce qu’il se passe dans cette histoire. »

Il est possible de redonner des éléments de la consigne en cas d’oubli ou de distraction. Si l’enfant ne répond pas, l’expérimentateur peut décrire la première image et demander « quelle est l’image qui vient ensuite ? ».

Une fois que l’enfant a positionné les images sur la bande, on note l’ordre. L’enfant a une seule tentative par histoire et il n’y a aucune correction. Si au bout de 10 minutes l’enfant n’a toujours pas construit l’histoire, la séquence est considérée comme échouée et on passe à la suivante.
Notation des résultats : 2 points pour une séquence complète, 1 point quand la dernière image est bien positionnée : 1 point, 0 points pour les autres cas de réponses. Pour chaque condition le score maximum est de 6 points.
Appendix X: Possible strategies for the low-verbal ToM task.

Participants’ explanations as to how they had reasoned about the task led us to imagine the possible strategies that other participants may have used. These strategies are explored below.

Since the first test condition was the false belief condition, those participants who did not understand that B was pointing to the incorrect box were exposed to three consecutive incorrect responses because they would point to the same box as B. After the third trial, it would seem that at least some of these children then decided to change their strategy by pointing systematically to the opposite box to that shown by B. As the condition after the false belief condition was the true belief condition, this strategy proved to be erroneous as well, and some children quickly changed their strategy again after one or two incorrect answers. This pattern of reasoning could yield results such that when participants changed their strategy quickly (i.e. after one or two trials) they obtained low scores in both true and false belief conditions, and when they changed strategies more slowly, they gave only incorrect answers in both conditions. At least two children probably had difficulty changing strategies, as they pointed to the opposite box to the experimenter throughout the false and the true belief conditions, thus obtaining 100% correct responses for the false belief condition, and 0% for the true belief condition. Yet others may either have correctly understood that experimenter B held a false belief, or they may simply have decided to show the same box as B throughout the six trials of false and true belief, thus obtaining 0% correct responses for the false belief condition, and 0% for the true belief condition. The results on the control condition allow us to at least partly verify this hypothesis. Those children who used the same strategy throughout the three test conditions would probably obtain the following pattern of results.

Table 17.
Purported strategies and expected results if children did not use ToM to answer.

<table>
<thead>
<tr>
<th>Strategy used for all test conditions</th>
<th>False belief expected results (% correct)</th>
<th>True belief expected results (% correct)</th>
<th>Control condition expected results (% correct)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Point to the same box as B</td>
<td>0</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>2. Point to the other box</td>
<td>100</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>
When individual results are analysed, no participant shows the pattern of results predicted with strategy 2 (point to the other box). Only two participants show the pattern of results predicted with strategy 1 (point to the same box), but this would also be predicted for participants who had poor ToM skills.

The profiles that we have gleaned from participants’ responses are shown in the table below.

Table 18
Participant profiles after analysis of patterns of response

<table>
<thead>
<tr>
<th>1.False belief (%)</th>
<th>2.True belief (%)</th>
<th>3.Control belief (%)</th>
<th>Possible response strategy</th>
<th>Number of participants</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>100</td>
<td>100</td>
<td>Good skills in ToM and general understanding of the task</td>
<td>1</td>
</tr>
<tr>
<td>100</td>
<td>100</td>
<td>0 or 33</td>
<td>“When B leaves, always point to the opposite box.”</td>
<td>4</td>
</tr>
<tr>
<td>100</td>
<td>67</td>
<td>33</td>
<td>Applied a strategy “always answer the opposite of B” then changed strategies then changed again.</td>
<td>1</td>
</tr>
<tr>
<td>67</td>
<td>100</td>
<td>100</td>
<td>Did not attend for one item but otherwise good skills in ToM and general understanding.</td>
<td>1</td>
</tr>
<tr>
<td>0 to 67</td>
<td>0 to 67</td>
<td>100</td>
<td>1.”Point to the same box as B” → strategy fail, so change 2.”point to the opposite box” 3. Good understanding so no need for strategy OR Lack of ToM</td>
<td>2</td>
</tr>
<tr>
<td>0 to 67</td>
<td>0 to 67</td>
<td>0 to 67</td>
<td>Random response</td>
<td>4</td>
</tr>
<tr>
<td>0</td>
<td>100</td>
<td>100</td>
<td>“Point to the same box as B”, OR Poor ToM</td>
<td>2</td>
</tr>
</tbody>
</table>

Nevertheless, individual results also point to another possible profile. Those children who obtain varying results between 1/3 and 2/3 correct answers may simply be lost as to how they can answer, and have not found any strategy that works. If they had very poor ToM skills, they would at least be answering correctly in the control condition, where no ToM skills are necessary. However, four children obtain poor results in the control condition as well as the false and true belief conditions. These children may be answering randomly.
Appendix XI : Consent form

RECHERCHE
Etude du développement de la syntaxe chez l’enfant atteint d’autisme.

Responsables du projet de recherche :

| Julie Franck, MER | Laboratoire de psycholinguistique expérimentale |
| Stephanie Durrleman, MA | Département de Linguistique |

*(Dans ce texte, le masculin est utilisé au sens générique ; il comprend aussi bien les femmes que les hommes.)*

CONSENTEMENT DE PARTICIPATION A LA RECHERCHE

Information aux parents

- **Engagement du chercheur** (voir ci-après)

- **Objectifs généraux de la recherche** : Etude fine des compétences syntaxiques des enfants atteints d’autisme, ainsi que la relation entre ces compétences et d’autres fonctions cognitives, en particulier la théorie de l’esprit et le contrôle exécutif.

- **Procédure** :

Les expérimentateurs prendront le temps de faire connaissance et de s’assurer que votre enfant est à l’aise avant de commencer les séances de test. Ils auront au préalable discuté avec vous pour connaître les intérêts de votre enfant, ses besoins spécifiques et les situations qui pourraient être plus difficiles.

Au cours d’environ quatre séances, votre enfant alternera des moments de jeu et des moments de tests (décrits ci-dessous). Les expérimentateurs effectueront un enregistrement audio des séances afin d’analyser les réponses de votre enfant par la suite.

Tâches de théorie de l’esprit :
1) Nous demanderons à votre enfant de trouver dans quelle boîte se cache un renforçateur (objet motivant pour l’enfant). Il est toujours récompensé, même lorsqu’il ne trouve pas la bonne réponse.
2) Expériences classiques de théorie de l’esprit : À l’aide d’images ou de poupées, nous raconterons une histoire à votre enfant. Nous lui poserons ensuite trois questions visant à évaluer sa compréhension de la situation.
3) Séquences d’images : nous demanderons à votre enfant de remettre dans l’ordre 4 images représentant une suite d’événements.

Tâches de syntaxe : Compréhension de phrases relatives (par exemple « Montre-moi le chien qui mouille le chat ») et complétives (par exemple « Jean dit que le camion est rouge »), et de questions. Votre enfant indique sa réponse en pointant, ou en verbalisant une réponse courte.

Tâche de vocabulaire : Nous montrerons des planches d’images à votre enfant, qui devra
pointer vers l’image nommée.

**Tâche de contrôle exécutif** : Des formes de couleurs différentes seront présentées à l’écran. Nous demanderons à votre enfant de répondre soit en fonction de la couleur, soit en fonction de l’emplacement de la forme.

**Tâches de mémoire** : Nous demanderons à votre enfant de répéter des mots de longueur croissante, portant sur la mémoire phonologique (auditive), et des séquences d’actions portant sur la mémoire visuo-spatiale.


- **Protection des données** (mesures d’archivage/destruction des données) : Anonymat et archivage des données sur cd-rom, conservées pendant 10 ans puis détruites.
- **Avantages et bénéfices pour les participants** : Situation ludique de jeu, contribution à la socialisation et informations sur le niveau syntaxique.
- **Inconvénients et risques éventuels pour les participants** : Aucun.
- **Durée du projet** : environ 6-8 semaines, à prolonger d’une ou deux semaines en cas de besoin.
- **Durée des expériences et des pauses** (bloc d’expériences et durée minimale des pauses s’il y a lieu) : Chaque séance durera 90 minutes au total. Les expériences individuelles dureront 20 minutes scindées par une pause si l’enfant en montre le besoin. Il faut toutefois prévoir un temps durant lequel votre enfant se familiarisera avec l’expérimentateur.
- **Accès aux résultats de la recherche** : Vous pouvez à tout moment prendre contact avec le chercheur pour disposer des résultats ou de l’article qui les résumera.
- **Personnes à contacter** : Stephanie Durrleman, Rue de Candolle 2, Département de linguistique, 1205 Genève. Stephanie.durrleman@unige.ch

Sur la base des informations qui précèdent, le-la soussigné-e consent à ce qu’il-elle et son enfant (prénom/nom de l'enfant) participe à la recherche « Etude du développement de la syntaxe chez l’enfant atteint d’autisme », et autorise :

- l’utilisation des données à des fins scientifiques et la publication des résultats de la recherche dans des revues ou livres scientifiques, étant entendu que les données resteront anonymes et qu’aucune information ne sera donnée sur notre identité ;

  □ OUI □ NON

- l’utilisation des données à des fins pédagogiques (cours et

  □ OUI □ NON
séminaires de formation d’étudiants ou de professionnels soumis au secret professionnel).

- la mise à disposition à des fins scientifiques des transcriptions des productions orales de mon enfant sur la base de données du Child Language Data Exchange System (système d’échange de données de langage oral), étant entendu que les données resteront anonymes et qu’aucune information ne sera donnée sur notre identité.

J’ai choisi volontairement de participer à cette recherche. J’ai été informé-e du fait que je peux me retirer en tout temps sans fournir de justifications et que je peux, le cas échéant, demander la destruction des données nous concernant.

Ce consentement ne décharge pas les organisateurs de la recherche de leurs responsabilités. Je conserve tous mes droits garantis par la loi.

<table>
<thead>
<tr>
<th>Prénom Nom du(des) parent(s)</th>
<th>Date</th>
<th>Signature(s)</th>
</tr>
</thead>
</table>

OUI  NON