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Research Report

Theory of mind in SLI revisited: links with syntax, comparisons with ASD

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Abstract

Background: According to the linguistic determinism approach, knowledge of sentential complements such as: *John says that the earth is flat* plays a crucial role in theory of mind (ToM) development by providing a means to represent explicitly people's mental attitudes and beliefs. This approach predicts that mastery of complements determines successful belief reasoning across explicit ToM tasks, even low-verbal ones, and across populations.
Aims: (1) To investigate the link between a low-verbal ToM-task and complements in Specific Language Impairment (SLI), (2) To determine whether this population shows similar ToM performance to that of children with Autism Spectrum Disorder (ASD) or those with Typical Development (TD) once these groups are matched on competency for complements, (3) To explore whether complements conveying a falsehood without jeopardizing the veracity of the entire sentence, such as complements of verbs of communication, are more crucial for belief attribution than complements which do not have this property, namely complements of verbs of perception, (?*John sees that the earth is flat*).
Methods & Procedures: Children with SLI ($n = 20$), with ASD ($n = 34$) and TD ($n = 30$) completed sentence–picture-matching tasks assessing complementation with communication and perception verbs, as well as a picture-sequencing task assessing ToM. Children were furthermore evaluated for general grammatical and lexical abilities and non-verbal IQ.
Outcomes & Results: Results reveal that competency on complements relates to ToM performance with a low-verbal task in SLI, and that SLI, ASD and TD groups of equivalent performance on complements also perform similarly for ToM. Results further suggest that complements with an independent truth-value are the only ones to show a significant relation to ToM performance after teasing out the impact of non-verbal reasoning.
Conclusions & Implications: This study suggests that clinical groups of different aetiologies as well as TD children perform comparably for ToM once they have similar complementation skills. Findings further highlight that specific types of complements, namely those with an independent truth value, relate in a special way to mentalizing. Future work should determine whether these specific structures could be effective in ToM remediation programmes.

Keywords: specific language impairment, autism spectrum disorders, complement sentences, false belief, linguistic determinism, theory of mind.

What this paper adds

What is already known on the subject

The linguistic determinism approach predicts that mastery of complements with an independent truth-value determines belief reasoning across explicit ToM tasks, even low-verbal ones, and across populations. However a statistically significant link between complements and a ToM task with low-verbal demand has not yet been shown in children with SLI, and their performance on such tasks has yet to be compared with performance of children with ASD of similar competency with complements. The impact of different types of complements on ToM also needs to be better understood.

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What this paper adds to existing knowledge
We report a link between a low-verbal ToM task and complements in SLI, and confirm that this population shows similar ToM performance to that of children with ASD and those with TD of similar competency for complements. Findings also suggest that complements conveying a falsehood without jeopardizing the veracity of the entire sentence, such as complements of verbs of communication ('John said that aliens landed in his backyard') are more crucial for belief attribution than complements which do not have this property, namely complements of verbs of perception (?John sees that the earth is flat).

What are the potential or actual clinical implications of this work?
This study suggests that clinical groups of different aetiologies as well as TD children perform comparably for ToM once they have similar complementation skills. Findings further highlight that specific types of complements, namely those with an independent truth-value, relate in a special way to mentalizing. Future work should determine whether these specific structures could be effective in ToM remediation programmes.

Introduction

One of the fundamentals for successful social interactions is the understanding that much of what others say and do is fuelled by their internal mental states, such as their intentions, desires and beliefs (Astington 1993, Astington and Dack 2008, Watson *et al.* 1999, Wellman 1990). The development of this 'theory of mind' (ToM) has been claimed to be significantly influenced by the emergence of a certain level of linguistic sophistication, including mastery of complement sentences such as 'John said/thought that aliens landed in his backyard'. These structures would enable children to explicitly reason about beliefs, which may conflict with reality (de Villiers and de Villers 2000, de Villiers and Pyers 2002). According to this view, performance on ToM tasks assessing explicit belief reasoning, even if they themselves are essentially non-verbal, should relate to proficiency with sentential complements. Moreover, ToM performance should be similar across various populations once their competency in complements is also held constant. This study tests these predictions by assessing the relationship between a belief attribution task involving minimal verbal demand and complements in children with specific language impairment (SLI), and by comparing their ToM performance with that of children with Autism Spectrum Disorder (ASD) of similar competency on sentential complements, taken from a previous study (Durrleman *et al.* 2016).[1] Comparing these populations is relevant because children with SLI present core delays in formal language (Leonard 1998) and also reportedly show delays in ToM development (Nilsson and de Lopez 2016) that may be a consequence of the verbal demand of the ToM tasks themselves (Miller 2004). Children with ASD display core difficulties in the realm of ToM which are arguably related to their well-documented social impairments (Baron-Cohen *et al.* 1985, Frith *et al.* 1991), and these difficulties would remain detectable even with tasks of low-verbal demand (Colle *et al.* 2007). As such, the current study teases apart the contributions of social and linguistic influences on ToM by comparing, for the first time, ToM performance of children diagnosed either with SLI or ASD matched on equivalent abilities for the specific linguistic capacity of complementation, thought to be crucial for enabling successful belief reasoning.

Sentential complements and ToM

The understanding of others' beliefs is an important milestone in ToM development, and is frequently assessed via 'false belief' (FB) tasks. These tasks require children to predict or explain a misinformed protagonist's behaviour, and in order to do so successfully they must appreciate that this behaviour will be determined by the protagonist's mental representation of the world, which may in fact be inaccurate. A common outline for this task involves a puppet (say Maxi) placing an object in location A before leaving the scene. In his absence, another puppet transfers the object to location B (Wimmer and Perner 1983). Upon puppet Maxi's return, the child is asked where Maxi will look for the object. While children aged 4 years and older grasp that Maxi will look in the location where he placed the object (i.e., location A), younger children reply he will look in the real location of the object, hence location B (Milligan *et al.* 2007, Wellman *et al.* 2001). Children with ASD experience persistent difficulty with such ToM tasks (Baron-Cohen *et al.* 1985, Happé 1995, Naito and Nagayama 2004, Yirmiya *et al.* 1998), and thus have been claimed to lack an intuitive understanding of others' mental states, which would explain several of their social impairments (Frith *et al.* 1991, Tager-Flusberg 2007).

In both typical development (TD) and ASD, links have been established between better language levels and success at FB (Astington and Baird 2005: 298–318, Fisher *et al.* 2005, Happé 1995, Tager-Flusberg 2000). Longitudinal studies have revealed that language skills predicted later FB performance in both of these populations, although not vice versa (for TD, see Astington and Jenkins 1999, de Villiers and Pyers 1997, 2002, and Slade and Ruffman 2005; for ASD, see Tager-Flusberg and Joseph 2005), implying that language plays a facilitating role in FB development. Some researchers have argued that specific subcomponents of language, such as the vocabulary of mental state terms, are important for belief reasoning (Olson 1988), while others have maintained that syntax, and in particular the syntax of complementation, plays a privileged role in acquiring this skill, because 'without (complements), the child cannot hold in mind the structures necessary for judging the truth and falsity of the content of beliefs' (de Villiers 2007). Consider the following example to illustrate the specific syntactic and semantic properties of complements which allow them to serve as tools for handling the possible worlds of other minds:

1) John says/thinks [that the earth is flat].

The content of the complement clause (in brackets) is false while the whole sentence may still be true. This property of having an independent truth-value would arguably render such sentences ideal for mental representations, as these may also be false. In line with this view, a predictive relation has been established precisely between mastery of complements and FB success in early TD (de Villiers and Pyers 2002) and training studies targeting complements in preschool TD children have yielded improved ToM scores (Lohmann and Tomasello 2003), even when the training included only complements of verbs of communication (e.g., *says*), thus avoiding mental-state verbs (e.g., *thinks*; Hale and Tager-Flusberg 2003). These findings have been interpreted to suggest that complement sentences serve as a tool for mentalizing, and they would be persistently useful for explicitly reasoning through the understanding of other's beliefs for individuals showing a delay in the realm of ToM development, such as children with ASD (Durrleman *et al.* 2016).

If linguistic competency, in particular with complements, plays a causal role in consolidating FB, then language-impaired populations even without a core mentalizing deficit should also be affected in this area of ToM. In line with this view, deaf children with language delay have been found to also display delays in FB reasoning (de Villiers and de Villiers 2003, Peterson and Siegal 2000, Schick *et al.* 2007). A large-scale study of ToM in deaf children with delay in American Sign Language (ASL) (i.e., those of hearing parents) compared with ToM of deaf children without delay in ASL (i.e., those of deaf parents) (total $N = 176$, age range = 4–8;3 years) revealed ToM to be specifically delayed in the language-delayed group, with competency on complements impacting ToM performance even when the ToM tasks were minimally verbal (Schick *et al.* 2007). Both ASL vocabulary and understanding sentential complements predicted ToM scores, underscoring the role of complements (and lexicon) as important representational tools for FB reasoning.

For children with SLI, a condition where 'specifically' language is affected while non-verbal IQ is not (Leonard 1998), FB delays were initially thought to be absent. However more recently doubt has been cast on this conclusion, given that those studies suggesting a separation between linguistic abilities and FB in this population were conducted with participants over the age of seven, which is older than when TD children succeed (Farmer 2000, Perner *et al.* 1989, Ziatas *et al.* 1998). It thus becomes conceivable that a delay in language development could lead to ToM delays during the critical period for passing these tasks, which is around 4 years old. In line with this, Holmes (2002) observed difficulties in FB acquisition for children with SLI aged 4–7, as did Tucker (2004) in children with SLI between 5 and 6;5 years of age and delayed by 12–18 months in FB performance. Delays in ToM were also observed in a study by Andrés-Roqueta *et al.* (2013) (participants with SLI aged 3;5–7;7) where linguistic competency was moreover the best predictor of FB success, accounting for most of the total variance (17% out of 41.2%) after controlling for the effects of age, non-verbal reasoning and attention. Language thus appears to be a critical variable to explain the FB delay in SLI, as confirmed by a very recent meta-analysis of 17 studies with 745 children between the ages of 4 and 12, reporting that children with SLI perform significantly below age-matched TD peers for ToM (Nilsson and de Lopez 2016), with linguistic skills predicting ToM abilities better than other abilities (e.g., such as sustained attention and working memory; Andrés-Roqueta *et al.* 2013, Holmes 2002).

However regarding the specific role of complement sentences in FB success in SLI, more work is still needed. Indeed, while children with language impairment, including SLI, have evidenced persistent difficulty in the mastery of complement-clauses (Tuller *et al.* 2012, Steel *et al.* 2016) and success on complement clauses specifically predicts success at verbal FB tasks in this population (de Villiers *et al.* 2003, Miller 2004), statistically detectible links are yet to be found between complements and non-verbal FB tasks. The confound in linguistic complexity between the FB and complements tasks may indeed explain the link between these measures to date, in particular since children with SLI, given their specific impairment on complex syntactic structures, perform differently on ToM tasks depending on their verbal demand (Cassidy and Balluramen 1997, Colle *et al.* 2007, Loukusa *et al.* 2014, Miller 2001, 2004). As such, the previously reported relationship between performance on verbal ToM tests and performance on complementation could be due to an experimental epiphenomenon, complex language being implied both in the ToM and the complementation assessments. For example, both tasks contain test questions of similar syntactic complexity. To recall, the task used to assess ToM frequently contains Wh-questions, such as *Where will X look for Y?* (Baron-Cohen *et al.* 1985, Wimmer and Perner 1983), a linguistic construction also present in complement tasks: 'X said that Y. [. . . more anecdote] *What did X say?*' (de Villiers and Pyers 2002, Miller 2004).

This flaw in the studies on the language–ToM interface in SLI has already been pointed out by Miller (2004), who attempted to shed light on this matter with a study of complements and FB assessed via a minimally verbal task. In that study, children were shown a video of two people acting out a change-of-location scenario, without dialogue or narration, and then asked to select which of two photographs showed 'what happens next'. The SLI data taken alone did not reveal significant correlations between FB and complements. However, this could possibly have been due to the rather small sample size ($N = 15$), so the issue is worthy of further investigation. Also, the complements evaluated included verbs of cognition (think, believe, know, guess etc.), which themselves require mental-state understanding, and thus in this respect confounds were again present between the ToM and complements tasks. More work is thus needed to elucidate the ToM–complements interface in SLI.

Aims of the present study

With this study, our first aim is to assess complements in a larger sample of children with SLI than in Miller (2004) and with a purer measure of complementation, teasing out the mental-state component, with the objective of determining if competency with these structures correlates with FB success when FB is assessed with minimal language.

Also, in light of the view that FB reasoning may be highly influenced by competency with complementation, it becomes conceivable that populations with comparable skills in complementation will perform comparably in FB tasks, even when these tasks are largely non-verbal. In this respect, it becomes interesting to compare performance between children with SLI and those with ASD, which is the second aim of our investigation. The results reported to date when these groups have been compared on non-verbal FB tasks have been contradictory, however groups were crucially not matched specifically for skills on complementation. Indeed an earlier study (Colle *et al.* 2007) found a significant difference in performance between children with SLI ($N = 15$) and those with ASD ($N = 12$) of comparable socio-economic status and sex, with language levels of around age 2 years or less. The authors consequently argued that such non-verbal ToM tasks serve as an excellent tool to distinguish between these populations, because ASD would be affected by a specific impairment in ToM, while ToM would be spared in SLI and performance would be normal providing the linguistic demands of the ToM task were kept low. However, a more recent study reports similar results on a minimally verbal ToM task, as well as on a verbal one, by groups of children with ASD ($N = 18$, 5;1–9;0 years) and SLI ($N = 14$, 5;0–7;7 years) (Loukusa *et al.* 2014). Both groups were within the norms for performance IQ, and those with ASD were also within the norms for verbal IQ, while those with SLI presented difficulties but 'all [. . .] were able to speak understandably using sentences' (Loukusa *et al.* 2014: 501). Still, Loukusa *et al.*'s study did not specifically assess FB attribution, in contrast to Colle *et al.* (2007), and instead applied the 'Contextual tasks of the ToM subtest of the NEPSY-II.' Therefore it remains to be determined if similar performance would arise between these populations specifically on FB, if they otherwise show similar competency with sentential complements. The current work compares, for the first time, the performance on low-verbal FB of children with SLI with that of children of ASD of similar competency specifically with respect to complementation. If complementation is critically linked to FB reasoning abilities, these groups are expected to perform similarly according to the view of linguistic determinism (de Villiers and de Villers 2000), even when the FB task is minimally verbal.

Finally, the complement–FB link in SLI has been established for complements of verbs that have a particular semantics, in that their complement has an independent truth-value. Given this, it remains to be determined whether it is the syntactic mechanism of complementation or rather the specific semantic characteristic of these complements which impacts FB success. It is therefore necessary to conduct work including assessments of complements of other types of verbs as yet unexamined in relation to FB in SLI, such as verbs of perception. These verbs can also occur with tensed complements, thus sharing the syntax of verbs of communication and cognition, however the truth-value of their complement is not independent of that of the matrix clause, thus they differ semantically. To illustrate, compare (2) with (3):

2) Many children with SLI *said/replied* [that the chocolate was in location A].
3) Many children with SLI *saw* [that the chocolate was in location A].

As noted above, the contents of the complement sentence in brackets in (2), like states of knowledge, may differ from reality without affecting the veracity of the entire sentence. However this does not carry over to (3), which would be false if the chocolate was not in location A. While complement sentences are generally produced early in development, preceding other instances of more complex embedding such as relative clauses (de Villiers *et al.* 1979, Friedmann *et al.* 2011), within the realm of complement sentences, those of perception verbs emerge earliest (Diessel and Tomasello 2001). The relationship between complements of verbs of perception and FB has yet to be tested in SLI, although one study on ASD suggests that these complements may also relate to FB success (Durrleman *et al.* 2016). With the current work, our third aim was to investigate the relationship between these sentences and FB in SLI. If links arise with these complements, this would suggest that FB success is also due to the structural properties of complementation, independently of the related semantic properties.

Methods

Populations

Participants included 20 children with SLI (6.5–11.7, mean age 9.2), 30 TD children (4.9–11.8, mean age 8.0) and 34 children with ASD (6.9–14.4, mean age 10.6). All groups were of similar non-verbal cognitive level (Leiter-R; Roid and Miller 1997), and the clinical populations were also of similar competency with complementation (de Villiers and Pyers 2002, Poltrock 2010) as illustrated by the analyses reported in the following section. Approval for this study was obtained from the Ethics Committee of the Comité de Protection des Personnes Sud Est II, France. Children with SLI were recruited through the Réseau Dys, Lyon, France, a network specialized in the diagnosis and treatment of various developmental disorders (SLI, dyslexia, ASD). Participants had all previously received a diagnosis of SLI through speech and language therapists within this network, applying the usual inclusionary and exclusionary criteria (i.e., 1.25 standard deviations below the norm for all language levels, scores within normal IQ range). Participants with ASD (from Durrleman *et al.* 2016), had also received a diagnosis of ASD by a qualified clinician according to DSM-IV-TR criteria as well as the ADOS-G and/or the ADI-R. In order to be included in this study, all children had to be able to form and understand simple sentences. The TD control group was recruited from local French schools and daycare centres. Parents of participants provided informed, written consent for their children to participate in the research.

Standardized assessments provided measures of expressive vocabulary and morphosyntax (BILO 3C; Khomsi *et al.* 2007). This task presented the advantage of being computerized, a particularly motivating format for clinical populations (Chen and Bernard-Opitz 1993, Huttinger 1996), and of yielding scores which would allow us to tease out the impacts of general linguistic abilities on ToM performance. We also administered the brief IQ of the Leiter International Performance Scale—Revised (Leiter-R; Roid and Miller 1997). This standardized intelligence task was chosen because it is essentially non-verbal and thus allowed us to control for the effects of non-verbal reasoning when using growth scores (GS).

Materials and procedure

Testing sessions were conducted in a quiet room that children were already familiar with (for therapy or school). Each session lasted between one hour and one hour and a half and included multiple breaks so as to maintain concentration and motivation. No time constraint was imposed. During these sessions, children were assessed for complements of verbs of communication (de Villiers and Pyers 2002) and perception (Poltrock 2010) as well as for non-verbal ToM via a picture-sequencing task (Baron-Cohen *et al.* 1986), as described below.

Complements of verbs of communication

The task assessing complement sentences with verbs of communication (adapted from de Villiers and Pyers 2002) contained 10 stories of two lines, illustrated via two photographs on a computer screen, followed by a test question (4). These were translated to French using the present tense instead of the past, since past tense has been found to be difficult for children with SLI and ASD (Leonard 2007, Roberts *et al.* 2004):

4) *La femme dit qu'il y a une araignée dans la baignoire (l'expérimentateur indique la première image). Mais regarde, c'est seulement des cheveux (l'expérimentateur indique la deuxième image). Qu'est-ce qu'elle dit qu'il y a dans la baignoire (l'expérimentateur re-indique la première image)?*
The woman says a spider is in the bathtub (experimenter points to the first picture). But look, it's only hair (experimenter points to the second picture). What does she say is in the bathtub (experimenter points back to the first picture)?

Children had to refer to the complement occurring with a tensed communication verb (i.e., *dire* 'say') in order to respond correctly. It is important to note that ToM is not necessary to succeed, as explained by de Villiers and Pyers (2002: 1043) since 'this task does not require the child to "read" the character's state of mind, but merely to represent it by holding the sentence in mind and then repeating the relevant piece back'.

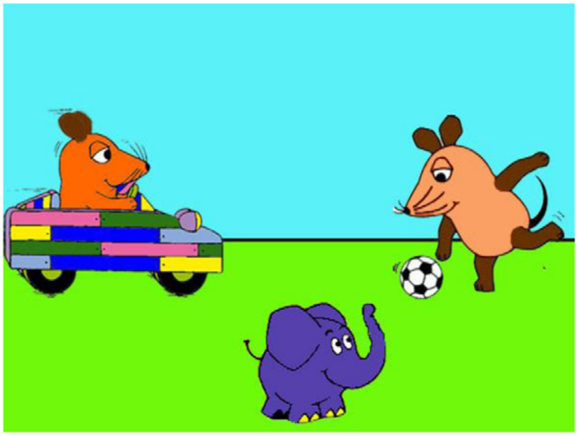

Figure 1. Picture from the test condition of the complements of perception verb task. [Colour figure can be viewed at wileyonlinelibrary.com]

Each correct response was awarded one point, yielding a maximum score of 10 points. Appendix A provides details of each story.

Complements of verbs of perception

Children were tested for their understanding of complement clauses occurring with the matrix verb *voir* ('to see') via a truth-value judgment task (Poltrock 2010). They were introduced to a puppet, Rodrigo, who could not speak French very well, and were asked to tell him 'yes' when he had said something right, and 'no' when he had said something wrong. There were a total of 12 sentences, with half the items accurately matching what was shown in the picture (as is the case for sentence 5 when accompanied by the picture shown in figure 1), and the other half not matching (e.g., when the picture in figure 1 was paired with the sentence in (6)). Correct answers were awarded one point, yielding a maximum of 12 points.

5) *L'éléphant voit que la souris joue au foot.*
   The elephant sees that the mouse is playing football.

6) *L'éléphant voit que la souris conduit une voiture.*
   The elephant sees that the mouse is driving a car.

The test phase was preceded by a warm-up presenting the characters in the task to the child and ensuring that s/he understood how to interpret the direction of the central characters' gaze independently of complementation (e.g., The duck sees the mouse). All children succeeded at this warm-up phase (see appendix B for the total list of stimuli used).

Low-verbal theory of mind

The task used to assess ToM with minimal verbal demand involved sequencing pictures to tell a story composed of four cards, with the first always being placed down by the experimenter (Baron-Cohen *et al.* 1986). The child was then given the three remaining cards in a predetermined order and told *Mets dans l'ordre*: 'Put into order.' We proposed two types of stories, one involving the 'mechanical' condition, depicting cause and effect occurrences and thus serving to ensure that children could sequence cards appropriately to tell a story regardless of belief reasoning. Children generally performed at ceiling for this task, and those two who did not were above chance (one TD child scored 5/6, one with SLI scored 4/6, and two with ASD scored 4/6 and 5/6). The other type of story, called the 'intentional' condition, was the critical test condition as in order to sequence the cards well, the child had to attribute a false belief to one of the characters (see appendix C for illustrations). Following the method used by Baron-Cohen *et al.* (1986), we scored the child's response as fully correct (2 points), or partially correct with the last picture placed at the end (1 point), or incorrect (0 point), yielding a maximum score of 6 points for each condition.

Results

Table 1 presents the global scores of our participants for the standardized measures.

Given that our data showed substantial variation in standard deviations and did not follow a normal distribution, non-parametric tests were used in R. Due to missing data for certain tasks, some of the statistical analyses were conducted on slightly reduced samples. For each analysis, the sample size is provided in brackets.

Kruskal–Wallis tests revealed that the SLI and TD groups differed significantly in chronological age (CA) ($\chi^2(1) = 4.93$, $p = 0.03$), with the SLI group being older than the TD group. Similarly, the SLI and ASD difference in CA was near significance ($\chi^2(1) = 3.41$, $p = 0.06$), with the ASD children being older than the SLI children. Crucially, however, according to Kruskal–Wallis tests, the SLI and TD groups did not differ significantly with respect to intellectual abilities as yielded by the growth scores ($\chi^2(1) = 1.95$, $p = 0.16$), and neither did the SLI and ASD groups ($\chi^2(1) = 0.67$, $p = 0.42$). They correspond to a mean non-verbal mental age of 8 years and 1 month. Thus the SLI children had similar non-verbal intelligence to the ASD children and to the TD children.

Children with SLI had significantly lower scores than TD children in morphosyntax ($\chi^2(1) = 8.05$,

Table 1. Participant characteristics (mean (SD) and median (scope))

Group N (male:female)		Chronological age	Non-verbal reasoning	Morphosyntax	Lexicon
TD	Mean (SD)	8.0 (1.9)	491.4 (8.5)	17.6 (5.6)	42.0 (8.0)
30 (16:14)	Median (scope)	7.7 (6.9)	491.0 (37.0)	16.5 (19.0)	39.5 (33.0)
SLI	Mean (SD)	9.2 (1.6)	487.0 (11.1)	12.5 (5.0)	33.5 (10.3)
20 (14:6)	Median (scope)	9.2 (5.2)	488 (37)	12.5 (16.0)	34.0 (43.0)
ASD	Mean (SD)	10.5 (2.4)	489.7 (12.3)	14.9 (6.9)	40.6 (11.2)
30 (28:6)	Median (scope)	10.1 (9.0)	489.5 (59.0)	13.5 (26.0)	41.0 (43.0)

Table 2. Participants' performance on communication complements (maximum: 10), perception complements (maximum: 12) and low-verbal ToM (maximum: 6)

		Low-verbal ToM	Communication complements	Perception complements
TD	Mean (SD)	5.2 (1.2)	8.0 (3.2)	10.7 (2.1)
	Median (scope)	6.0 (4.0)	9.0 (10.0)	12.0 (7.0)
SLI	Mean (SD)	5.1 (1.2)	6.9 (3.5)	10.7 (2.2)
	Median (scope)	5.5 (4.0)	8.0 (10.0)	12.0 (7.0)
ASD	Mean (SD)	4.7 (1.7)	6.2 (3.5)	10.3 (2.3)
	Median (scope)	6.0 (6.0)	7.5 (10.0)	12.0 (7.0)

$p = 0.005$) but they did not significantly differ from ASD children ($\chi^2(1) = 1.865$, $p = 0.17$). For lexicon, children with SLI had significantly lower scores than both TD ($\chi^2(1) = 8.97$, $p = 0.003$) and ASD groups ($\chi^2(1) = 4.75$, $p = 0.03$).

Comparisons between groups on experimental measures

Children with SLI performed similarly to their TD peers for understanding of complementation be it for communication verbs ($\chi^2(1) = 2.59$, $p = 0.11$) or perception verbs ($\chi^2(1) = 0.02$, $p = 0.88$) and low-verbal ToM ($\chi^2(1) = 0.52$, $p = 0.47$). Children with SLI also performed similarly to their ASD peers for understanding of complementation be it for communication verbs ($\chi^2(1) = 2.21$, $p = 0.65$) or perception verbs ($\chi^2(1) = 0.38$, $p = 0.54$) and low-verbal ToM ($\chi^2(1) = 0.16$, $p = 0.69$). The performance of the three groups for complements and low-verbal ToM is reported in table 2.

Links between low-verbal ToM and language in SLI, comparisons with ASD

In the SLI group the correlation with low-verbal ToM was non-significant for morphosyntax ($\tau(19) = 0.23$, $p = 0.20$) and approached significance for lexicon ($\tau(19) = 0.34$, $p = 0.06$). Low-verbal ToM significantly related to complements with verbs of communication ($\tau(18) = 0.42$, $p = 0.03$) and approached significance for complements with verbs of perception ($\tau(19) = 0.39$, $p = 0.05$).

Because there was also a significant correlation between non-verbal reasoning and lexicon ($\tau(19) = 0.47$, $p = 0.004$), complements with communication verbs ($\tau(18) = 0.35$, $p = 0.04$) and complements with perception verbs ($\tau(19) = 0.56$, $p = 0.002$) (although not with morphosyntax, $\tau(19) = 0.27$, $p = 0.10$)), we proceeded to conduct partial Kendall correlations controlling for non-verbal reasoning. The correlation between low-verbal ToM and lexicon then became statistically non-significant ($\tau(19) = 0.20$, $p = 0.22$), as did the correlation between low-verbal ToM and complements with perception verbs ($\tau(19) = 0.24$, $p = 0.15$). However, the correlation between low-verbal ToM and complements with communication verbs remained statistically significant after controlling for non-verbal reasoning ($\tau(18) = 0.33$, $p = 0.05$).

Thus low-verbal ToM and complements with communication verbs are significantly linked in SLI independently of non-verbal reasoning, as previously reported for ASD (Durrleman *et al.* 2016): $\tau(31) = 0.30$, $p = 0.02$). The link between complements of verbs of perception and low-verbal ToM became non significant in SLI after controlling for non-verbal abilities, in contrast to results for ASD ($\tau(30) = 0.26$, $p = 0.04$, as reported in Durrleman *et al.* (2016).

Discussion and conclusions

With this study, we set out to determine (1) whether knowledge of finite complements specifically relates to ToM independently of the verbal nature of the ToM task in SLI, (2) whether groups of similar abilities with complementation reveal similar ToM regardless of their diagnosis, and (3) whether complementation impacts ToM beyond its semantic component. To accomplish this, we assessed children with SLI for ToM using a minimally verbal task, and for two types of complements, those of verbs of communication and those of verbs of perception. We also conducted comparisons of ToM performance with a previously assessed group of children with ASD, as well as with a control group of TD children, ensuring that all groups had comparable performance on sentential complements.

In children with SLI, various language skills related to ToM when non-verbal reasoning was not controlled, such as abilities with lexicon, as well as complements with an independent truth-value (i.e., of verbs of communication) or without this semantic aspect (i.e., of verbs of perception). However only one skill related to ToM assessed with minimal language after teasing out the impact of non-verbal reasoning, and that is the skill of complementation with verbs of communication. This suggests that previous reports arguing in favour of a special relation between these specific complements and ToM is not due to a mere methodological epiphenomenon, either of language implied in the ToM task or ToM implied in the complements task (de Villiers *et al.* 2003, Miller 2004). Our results rather confirm that complement syntax, in particular that of complements with an independent truth-value, plays a privileged role in belief reasoning in SLI, unmediated by general language abilities, along the lines of that predicted by linguistic determinism (de Villiers and de Villers 2000, 2009).

The importance of complementation in ToM was also evident from the comparison of children with SLI and those with ASD. Indeed the SLI sample in this study was, for the first time, purposefully of similar levels of complementation with a previously assessed group of children with ASD (Durrleman *et al.* 2016) as well as with a group of TD children, and the performance of all groups in low-verbal ToM proved to be similar. ToM performance thus appears to be intricately related to the linguistic ability of complementation, regardless of the population.

One difference between the SLI group and the previously studied children with ASD is that complements of verbs of perception also correlated with low-verbal ToM in children with ASD after controlling for non-verbal abilities. The reason why perception complements did not relate could be a methodological issue. We chose to administer a task already used with preschool TD children (Poltrock 2010), although our population with SLI found having only to reply 'yes' and 'no' rather easy. This gave rise to high scores, yielding a near-ceiling effect, thus decreasing chances of highlighting a link with performance at other tasks. It is also important to note that our sample of children with SLI ($N = 20$) was less than that of the sample with ASD included in those analyses ($N = 31$). As such, a statistically significant correlation may not have emerged in our SLI group, while it did in the ASD group, because of our lesser sample size of SLI participants. Still, it would appear that perception verb complements contribute to ToM reasoning in a less central way than structures allowing the embedding of a false proposition. Indeed even in the group with ASD, where a correlation did emerge between complements of perception and low-verbal ToM, complements of verbs of communication were still the better predictors of low-verbal ToM performance in ASD as revealed by multiple regression analyses (Durrleman *et al.* 2016: 116–117). These latter structures thus appear to be the cognitive tools *par excellence* for representing FB (de Villiers and de Villers 2000, 2009).

While the correlational analyses conducted here between complements and FB do not themselves prove a causal relation, they are consistent with previous longitudinal work on both TD (de Villiers and Pyers 2002) and ASD (Tager-Flusberg and Joseph 2005), as well as with training studies on TD (Hale and Tager-Flusberg 2003, Lohmann and Tomasello 2003), showing that improved skills with complements influences ToM but not vice versa, as expected by the theoretical model of linguistic determinism (de Villiers 1995, de Villiers and de Villers 2000). The results of the current study further uphold the view that performance on ToM tasks requiring an explicit response, even minimally verbal ones, seem to imply an internal monologue allowing to explicitly reason through the representation of another person's subjective truth, and this would involve a certain level of linguistic sophistication, namely that of complementation. Interestingly, this appears to be the case regardless of the diagnosis. This could have important implications for clinical practice. Indeed the ability to understand the perspectives and beliefs of others influences the development of successful social interactions (Astington 1993, Astington and Dack 2008) and pragmatics (Sperber and Wilson 1986) and has been recently reported to be affected not only in children with a classical ToM deficit, such as ASD, but in also those with SLI during early phases of development (Andrés-Roqueta *et al.* 2013, Jester and Johnson 2016, Vissers and Koolen 2016). The reported difficulty attested by children in SLI to master complementation (Steel *et al.* 2016, Tuller *et al.* 2012), may thus be a good aspect to tackle in speech therapy programmes, also in view of enhancing their ToM and related delays in social skills (Maggio *et al.* 2014, McCabe 2005, McCabe and Marshall 2006) as well as their contextual use of language (Bishop and Norbury 2002, Ketelaars *et al.* 2009, Rapin and Allen 1983). As such, future work should seek to determine whether mentalizing delays stemming from different aetiologies, including SLI, could benefit from remediation programmes targeting the enhancing of specific forms of complementation.

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Note

1. This study included only one clinical population, ASD, and thus contained none of the comparisons with SLI reported here.

References

Andrés-Roqueta, C., Adriàn, J. E., Clemente, R. A. and Katsos, N., 2013, Which are the best predictors of Theory of Mind delay in children with specific language impairment? *International Journal of Language and Communication Disorders*, **48**, 726–737.

Astington, J. W., 1993, *The Child's Discovery of the Mind* (Cambridge, MA: Harvard University Press).

Astington, J. W. and Dack, L. A., 2008, Theory of mind. In M. M. Haith and J. B. Benson (eds), *Encyclopedia of Infant and Early Childhood Development*, Vol. 3 (San Diego, CA: Academic Press), pp. 343–356.

Astington, J. and Baird, J. (eds), 2005, *Why Language Matters for Theory of Mind* (Oxford: Oxford University Press).

Astington, J. W. and Jenkins, J. M., 1999, A longitudinal study of the relation between language and theory-of-mind development. *Developmental Psychology*, **35**, 1311–1320.

Baron-Cohen, S., Leslie, A. M. and Frith, U., 1985, Does the autistic child have a 'theory of mind'? *Cognition*, **21(1)**, 37–46.

Baron-Cohen, S., Leslie, A. M. and Frith, U., 1986, Mechanical, behavioural and intentional understanding of picture stories in autistic children. *British Journal of Developmental Psychology*, **4(2)**, 113–125.

Bishop, D. V. M. and Norbury, C. F., 2002, Exploring the borderlands of autistic disorder and specific language impairment: a study using standardised diagnostic instruments. *Journal of Child Psychology and Psychiatry and Allied Disciplines*, **43(7)**, 917–929.

Cassidy, K. and Balluramen, G., 1997, Theory of mind ability in language delayed children. Paper presented at the meeting of the Society for Research in Child Development, Washington, DC, USA.

Chen, S. H. and Bernard-Opitz, V., 1993, Comparison of personal and computer-assisted instruction for children with autism. *Mental Retardation*, **31(6)**, 368–376.

Colle, L., Baron-Cohen, S. and Hill, J., 2007, Do children with autism have a theory of mind? A non-verbal test of autism vs. specific language impairment. *Journal of Autism and Developmental Disorders*, **37(4)**, 716–723.

De Villiers, P. A., Burns, F. and Pearson, B. Z., 2003, The role of language in the theory of mind development of language-impaired children: complementing theories. In B. Beachley, A. Brown and F. Conlin (eds), *Proceedings of the 27th Annual Boston University Conference on Language Development* (Somerville: Cascadilla), pp. 232–242.

De Villiers, J. G., 1995, Steps in the mastery of sentence complements. Paper presented at the Biennial Meeting of the Society for Research in Child Development, Indianapolis, IN, USA.

De Villiers, J. G., 2007, The interface of language and theory of mind. *Lingua*, **117(11)**, 1858–1878.

De Villiers, J. G. and De Villiers, P. A., 2000, Linguistic determinism and the understanding of false beliefs. In P. Mitchell and K. Riggs (eds), *Children's Reasoning and the Mind* (Hove: Psychology Press), pp. 191–228.

De Villiers, J. G. and De Villiers, P. A., 2003, Language for thought: coming to understand false beliefs. In D. Gentner and S. Goldin-Meadow (eds), *Language in Mind: Advances in the study of language and cognition* (Cambridge, MA: MIT Press), pp. 335–384.

De Villiers, J. G. and De Villiers, P. A., 2009, Complements enable representation of the contents of false beliefs: the evolution of a theory. In S. Foster-Cohen (ed.), *Language Acquisition* (New York: Palgrave Macmillan), pp. 169–195.

De Villiers, J. and Pyers, J., 1997, Complementing cognition: the relationship between language and theory of mind. In E. Hughes, M. Hughes and A. Greenhill (eds), *Proceedings of the Twenty-first Annual Boston University Conference on Language Development*, Vol. 1 (Somerville: Cascadilla), pp. 136–147.

De Villiers, J. G. and Pyers, J., 2002, Complements to cognition: a longitudinal study of the relationship between complex syntax and false belief understanding. *Cognitive Development*, **17**, 1037–1060.

De Villiers, J. G., Tager-Flusberg, H., Hakuta, K. and Cohen, M., 1979, Children's comprehension of relative clauses. *Journal of Psycholinguistic Research*, **8**, 499–518.

Diessel, H. and Tomasello, M., 2001, The acquisition of finite complement clauses in English: A corpus-based analysis. *Cognitive Linguistics*, **12**, 97–141. doi:10.1515/cogl.12.2.97

Durrleman, S., Burnel, M., Thommen, E., Foudon, N., Sonié, S., Reboul, A. and Fourneret, P., 2016, The language cognition interface in ASD: Complement sentences and false belief reasoning. *Research in Autism Spectrum Disorders*, **21**, 109–120.

Farmer, M., 2000, Language and social cognition in children with specific language impairment. *Journal of Child Psychology and Psychiatry*, **41**, 627–636.

Fisher, N., Happé, F. and Dunn, J., 2005, The relationship between vocabulary, grammar, and false belief task performance in children with autistic spectrum disorders and children with moderate learning difficulties. *Journal of Child Psychology and Psychiatry*, **46(4)**, 409–419.

Friedmann, N., Aram, D. and Novogrodsky, R., 2011, Definitions as a window to the acquisition of relative clauses. *Applied Psycholinguistics*, **32**, 687–710.

Frith, U., Morton, J. and Leslie, A. M., 1991, The cognitive basis of a biological disorder: autism. *Trends in Neurosciences*, **10**, 433–438.

Hale, C. M. and Tager-Flusberg, H., 2003, The influence of language on theory of mind: a training study. *Developmental science*, **6(3)**, 346–359.

Happé, F. G. E., 1995, The role of age and verbal ability in the theory of mind task performance of subjects with autism. *Child Development*, **66(3)**, 843–855.

Holmes, A. M., 2002, Theory of mind and behavior disorders in children with specific language impairment [Abstract]. Dissertation Abstracts International: Section B: The Sciences and Engineering, 62(11—B).

Huttinger, P. L., 1996, Computer applications in programs for young children with disabilities: recurring themes. *Focus on Autism and Other Developmental Disabilities*, **11**, 105–114.

Jester, M., and Johnson, C. J., 2016, Differences in theory of mind and pretend play associations in children with and without specific language impairment. *Infant and Child Development*, **25**, 24–42.

KETELAARS, P., CUPERUS, M., VAN DAAL, J., JANSONIUS, K. and VERHOEVEN, L., 2009, Screening for pragmatic language impairment: the potential of the children's communication checklist. *Research in Developmental Disabilities*, **30(5)**, 952–960.

KHOMSI, A., KHOMSI, J., PARBEAU-GUENO, A. and PASQUET, F., 2007, *Bilan Informatisé de langage oral au Cycle III et au collège (BILO3C)* (Paris: Editions du CPA).

LEONARD, L. B., 1998, *Children with Specific Language Impairment* (Cambridge, MA: MIT Press).

LEONARD, L. B., 2007, Processing limitations and the grammatical profile of children with specific language impairment. In R. V. Kail (ed.), *Advances in Child Development and Behavior*, Vol. 35 (San Diego, CA: Elsevier), pp. 139–171.

LOHMANN, H. and TOMASELLO, M., 2003, The role of language in the development of false belief understanding: a training study. *Child Development*, **74(4)**, 1130–1144.

LOUKUSA, S., MÄAKINEN, L., KUUSIKKO-GAUFFIN, S., EBELING, H. and MOILANEN, I., 2014, Theory of mind and emotion recognition skills in children with specific language impairment, autism spectrum disorder and typical development: Group differences and connection to knowledge of grammatical morphology, word-finding abilities and verbal working memory. *International Journal of Language and Communication Disorders*, **49**, 498–507. doi:10.1111/1460-6984.12091

MAGGIO, V., GRANANA, N. E., RICHAUDEAU, A., TORRES, S., GIANNOTTI, A. and SUBURO, A. M., 2014, Behavior problems in children with specific language impairment. *Journal of Child Neurology*, **29**, 194–202.

MCCABE, P. C., 2005, Social and behavioral correlates of preschoolers with specific language impairment. *Psychol. Sch.*, **42**, 373–387.

MCCABE, P. C. and MARSHALL, D. J., 2006, Measuring the social competence of preschool children with specific language impairment: correspondence among informant rating and behavioral observations. *Topics in Early Child Special Education*, **26**, 234–246.

MILLER, C. A., 2001, False belief understanding in children with specific language impairment. *Journal of Communication Disorders*, **34(1)**, 73–86.

MILLER, C. A., 2004, False belief and sentence complement performance in children with specific language impairment. *International Journal of Language and Communication Disorders*, **39**, 191–213.

MILLIGAN, K., ASTINGTON, J. W. and DACK, L. A., 2007, Language and theory of mind: meta-analysis of the relation between language ability and false-belief understanding. *Child Development*, **78(2)**, 622–646.

NAITO, M. and NAGAYAMA, K., 2004, Autistic children's use of semantic common sense and theory of mind: a comparison with typical and mentally retarded children. *Journal of Autism and Developmental Disorders*, **34(5)**, 507–519.

NILSSON, K. K. and DE LOPEZ, J. K., 2016, Theory of mind in children with specific language impairment: a systematic review and meta-analysis. *Child Development*, **87**, 143–153.

OLSON, D. R., 1988, On the origins of beliefs and other intentional states in children. In J. W. Astington, P. L. Harris and D. R. Olson (eds), *Developing Theories of Mind* (New York, NY: Cambridge University Press), pp. 414–426.

PERNER, J., FRITH, U., LESLIE, A. and LEEKMAN, S., 1989, Exploration of the autistic child's theory of mind: knowledge, belief, and communication. *Child Development*, **60**, 689–700.

PETERSON, C. and SIEGAL, M., 2000, Insights into a theory of mind from deafness and autism. *Mind and Language*, **15**, 123–145.

POLTROCK, S., 2010, About the relation between implicit Theory of Mind & the comprehension of complement sentences (Doctoral dissertation, Universitätsbibliothek).

RAPIN, I. and ALLEN, D., 1983, Developmental language disorders: nosologic considerations. In U. Kirk (ed.), *Neuropsychology of Language, Reading and Spelling* (New York, NY: Academic Press), pp. 155–184.

ROBERTS, J., RICE, M. and TAGER-FLUSBERG, H., 2004, Tense marking in children with autism. *Applied Psycholinguistics*, **25**, 429–448.

ROID, G. H. and MILLER, L. J., 1997, *Leiter International Performance Scale—Revised: Examiners' Manual* (Wood Dale, IL: Stoelting).

SCHICK, B., DE VILLIERS, P., DE VILLIERS, J. and HOFFMEISTER, R., 2007, Language and theory of mind: a study of deaf children. *Child development*, **78(2)**, 376–396.

SLADE, L. and RUFFMAN, T., 2005, How language does (and does not) relate to theory of mind: a longitudinal study of syntax, semantics, working memory and false belief. *British Journal of Developmental Psychology*, **23**, 117–141.

SPERBER, D. and WILSON, D., 1986, *Relevance: Communication and Cognition* (Oxford: Blackwell).

STEEL, G., ROSE, M. and EADIE, P., 2016, The production of complement clauses in children with language impairment. *Journal of Speech, Language, and Hearing Research*, **59(2)**, 330–341.

TAGER-FLUSBERG, H., 2000, Language and understanding minds: connections in autism. In S. Baron-Cohen, H. Tager-Flusberg and D. J. Cohen (eds), *Understanding Other Minds: Perspectives from Developmental Cognitive Neuroscience*, 2nd edn (Oxford: Oxford University Press), pp. 124–149.

TAGER-FLUSBERG, H., 2007, Evaluating the theory-of-mind hypothesis of autism. *Current Directions in Psychological Science*, **16**, 311–315.

TAGER-FLUSBERG, H. and JOSEPH, R. M., 2005, How language facilitates the acquisition of false-belief understanding in children with autism. In J. W. Astington and J. A. Baird (eds), *Why Language Matters for Theory of Mind* (New York, NY: Oxford University Press), pp. 298–318.

TUCKER, L., 2004, *Specific language impairment and theory-of-mind: is normal language development an essential precursor for on time theory-of-mind development?* (Perth: Psychology, University of Western Australia).

TULLER, L., HENRY, C., SIZARET, E. and BARTHEZ, M. A., 2012, Specific language impairment at adolescence: avoiding complexity. *Applied Psycholinguistics*, **33(1)**, 161–184.

VISSERS, C. and KOOLEN, S., 2016, Theory of mind deficits and social emotion functioning in preschoolers with specific language impairment. *Frontiers in Psychology*, **7**, 1–7. doi.org/10.3389/fpsyg.2016.01734

WATSON, A. C., NIXON, C. L., WILSON, A. and CAPAGE, L., 1999, Social interaction skills and theory of mind in young children. *Developmental Psychology*, **35**, 386–391. doi:10.1037/0012-1649.35.2.386

WELLMAN, H., 1990, *The Child's Theory of Mind* (Cambridge, MA: MIT Press).

WELLMAN, H., CROSS, D. and WATSON, J., 2001, Meta-analysis of theory of mind development: the truth about false belief. *Child Development*, **72**, 655–684.

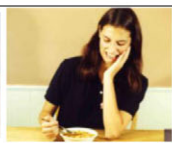
WIMMER, H. and PERNER, J., 1983, Beliefs about beliefs: representation and constraining function of wrong beliefs in young children's understanding of deception. *Cognition*, **13(1)**, 103–128.

YIRMIYA, N., EREL, O., SHAKED, M. and SOLOMONICA-LEVI, D., 1998, Meta-analyses comparing theory of mind abilities of individuals with autism, individuals with mental retardation, and normally developing individuals. *Psychobiological Bulletin*, **124(3)**, 283–307.

ZIATAS, K., DURKIN, K. and PRATT, C., 1998, Belief term development in children with autism, Asperger syndrome, specific language impairment, and normal development: links to theory of mind development. *Journal of Child Psychology and Psychiatry*, **39**, 755–763.

Appendix A: Material for complements of verbs of communication

  *La maîtresse dit que la fille a un insecte dans les cheveux. Mais en fait, c'est une feuille. Qu'est-ce qu'elle dit que la fille a dans les cheveux ?* "The teacher says that the girl has a bug in her hair. But really, it's just a leaf. What does she say that the girl has in her hair?"	  *La fille dit qu'elle lit un livre. Mais en fait, elle joue aux cartes. Qu'est-ce qu'elle dit qu'elle fait ?* "The girl says she is reading a book. But really she is playing cards. What does she say she is doing?"
  *La femme dit à son mari qu'elle a vu un fantôme. Mais regarde, c'est seulement un drap. Qu'est-ce qu'elle dit qu'elle a vu ?* "The woman tells her husband she sees a ghost. But look, it's only a sheet. What does she say she sees?'	  *Elle dit que son papa a une coupure à la main. Mais regarde, c'est juste du ketchup. Qu'est-ce qu'elle dit qu'il a à la main ?* "She says her Dad has a cut. But look, it is just ketchup. What does she say he has?"

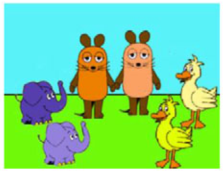
  *La fille dit qu'elle s'habille. Mais tu vois, elle regarde la télé. Qu'est-ce qu'elle dit qu'elle fait ?* "The girl says she is getting dressed. But look, she is watching TV. What does she say she is doing?"	  *La femme dit qu'il y a une araignée dans la baignoire. Mais regarde, c'est seulement des cheveux. Qu'est-ce qu'elle dit qu'il y a dans la baignoire ?* "The woman says there is a spider in the bathtub. But look, it's only some hair. What does she say there is?'
  *La fille dit qu'elle voit de l'argent par terre. Mais c'est seulement du papier. Qu'est-ce qu'elle dit qu'elle voit ?* "The girl says she sees money on the ground. But it's only paper. What does she say she sees?"	  *La fille dit à la maîtresse qu'elle dessine un visage. Mais ce n'est qu'un gribouillage. Qu'est-ce qu'elle dit à la maîtresse qu'elle dessine ?* "The girl says she is drawing a face. But it's just a scribble. What does she say she is doing?"
  *La dame dit qu'elle mange un œuf. Mais en réalité c'est une balle. Qu'est-ce qu'elle dit qu'elle mange ?* "The woman says she is eating an egg. But really it's a ball. What does she say she is doing?'	  *La fille dit qu'il y a un insecte dans son bol. Mais c'est juste un grain de raisin. Qu'est-ce qu'elle dit qu'il y a dans le bol ?* "The girl says there is an insect in her bowl. But it's only a raisin. What does she say it is in the bowl?"

Appendix B: Material for complements of verbs of perception

Consignes

Voici Rodrigue. Il ne parle pas très bien français, alors parfois il se trompe et dit des choses fausses. Tu vas me dire quand Rodrigue se trompe, et quand il a raison.

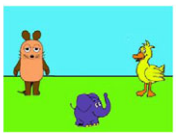
"Here is Rodrigo. He doesn't speak French well, so sometimes he says things wrong. You are going to tell me when Rodrigo makes a mistake and when he is right."



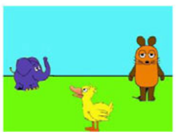
Montre-moi les canards.
Montre-moi la souris.
Montre-moi les éléphants.

"Show me the ducks.
Show me the mice.
Show me the elephants"

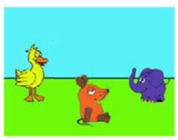
Entraînement



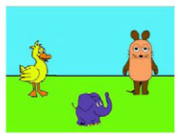
L'éléphant voit le



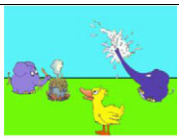
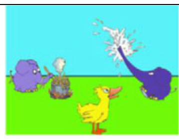
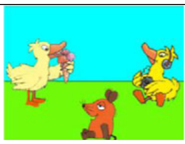
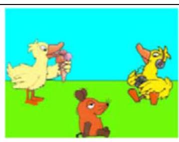
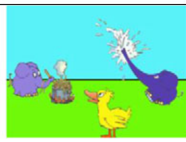
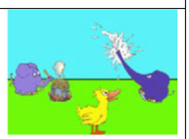
Le canard voit la



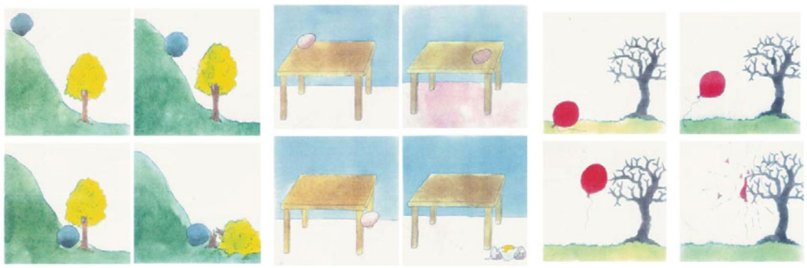
La souris voit



L'éléphant voit le

<table>
<tr><td>canard
The elephant sees the duck</td><td>souris
The duck sees the mouse</td><td>l'éléphant
The mouse sees the elephant</td><td>canard
The elephant sees the duck</td></tr>
<tr><td colspan="4">Items de test</td></tr>
<tr><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="2">1-7 : L'éléphant voit que la souris joue au foot
The elephant sees that the mouse is playing football</td><td colspan="2">2-8 : La souris voit que le canard mange une glace
The mouse sees that the duck is eating an ice-cream</td></tr>
<tr><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="2">3-9 : Le canard voit que l'éléphant crache de l'eau
The duck sees that the elephant is spouting water</td><td colspan="2">4-10 : L'éléphant voit que la souris conduit une voiture
The elephant sees that the mouse is driving a car</td></tr>
<tr><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="2">5-11 : La souris voit que le canard écoute de la musique
The mouse sees that the duck is listening to music</td><td colspan="2">6-12 : Le canard voit que l'éléphant fait cuire des pâtes
The duck sees that the elephant is baking pasta</td></tr>
</table>

Appendix C: Material for picture sequencing task (Baron-Cohen *et al.* 1986)



Mechanical

Intentional