

First and second-order false-belief reasoning: Does language support reasoning about the beliefs of others?

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1 Introduction¹

We understand and act upon the beliefs of other people, even if these conflict with our own beliefs. Children's development of this ability, known as Theory of Mind, has been extensively studied over the past twenty-five years, starting with the seminal study of Wimmer and Perner (1983). Theory of Mind (ToM) development involves various aspects of reasoning about others, including social awareness, joint attention, and anticipation of other people's behavior. Reasoning about false beliefs—the ability to handle the contrast between true and false beliefs—seems to develop rather late. It is typically not until the age of four that children understand that, for instance, *John thinks that it is raining outside* contains a belief about the weather attributed to John, and know that John may be incorrect in his belief, thus attributing a false belief to another person (Astington, 1993; Wellman & Bartsch, 1988). Our study involves more complex false-belief reasoning adding another belief layer, for instance, *Tom believes that John thinks that it is raining outside*. We investigated when children succeed at complex false-belief reasoning as tested with a verbal story task at the age

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of 7, whereas they pass a similarly complex task with non-verbal movie clips not until the age of 8 or 9.

Why does false-belief reasoning develop so late? De Villiers (2005) argues that the acquisition of the syntax of linguistic embedding, with verbs like *say* (*Mom said that it was raining*), is a prerequisite for developing the cognitive representations required for false beliefs. The child has to be able to embed sentential complements before she can represent a false belief in a cognitive embedding and reason about it accurately. Recent work, however, found that toddlers as young as 15 months old are able to pass a false-belief task. In a non-verbal version of the so-called Sally-Ann task, Onishi and Baillargeon (2005) showed toddlers movies in which a toy is hidden in one location while the actor is watching; when the actor's view is blocked by a screen, the toy is hidden in another location. When the screen opens again and the actor is about to reclaim the toy, the toddlers looked longer at the location where the toy was initially hidden (i.e., where the actor thinks that the toy is), than at the location where the toy was hidden now. The children's looks reveal their expectation of the actor's behavior on the basis of that person's belief about the hiding place of a toy, which is different from their own beliefs about it (cf. Southgate, Senju & Csibra, 2007, who replicated this finding with 25-month-old children). The children thus seem to track the actor's false belief about the location of a toy vis-à-vis their own, true beliefs.

Although one may doubt whether these tasks, which measure expectation, test the actual reasoning involved in considering false beliefs (see Apperly & Butterfill, 2009; De Bruin, 2011), the Onishi and Baillargeon findings undoubtedly show that 15-month-olds effectively represent false beliefs. Toddlers develop implicit knowledge of false-belief attribution well before they can verbalize that knowledge explicitly,

which suggests that they have some form of cognitive representation of false beliefs that does not rely on language. These young learners pass this ToM test before they pass any of the verbal false-belief tasks and before they have acquired any complex syntax, thereby refuting the basis of De Villiers's (2005) hypothesis.

In this study we present a more complex case of false-belief reasoning with older children that finds just the opposite: 7-year-olds pass a verbal false-belief reasoning task, but fail on an equally complex non-verbal task. It is not until the age of 8 or 9 that children pass this non-verbal task as well. The case under investigation involves two layers of belief representations: the ability to understand one person's belief (the first layer) about a belief attributed to another person (the second layer), as in *Tom believes that John thinks that it is raining outside*, where Tom entertains the knowledge that John holds a certain belief about the weather. Perner and Wimmer (1985) claim that this latter type of ToM development—second-order reasoning—is not mastered until the age of 7 or 8 (see also Sullivan, Zaitchik & Tager-Flusberg, 1994). We probed second-order ToM reasoning in 6-9 year-olds with a verbal and a non-verbal task. We argue that for such complex false-belief tasks, language may support the development of the cognitive representations of reasoning required to perform these tasks, reviving De Villiers' hypothesis about the role of language in false-belief reasoning.

2 Participants

43 Dutch children were tested, divided over two age groups: twenty-one 6 and 7 year-olds (mean age = 6;9, range = 6;2 – 7;3) and twenty-two 8 and 9 year-olds (mean age = 8;10, range = 8;2 – 9;11). We also tested a control group of seventeen adults.

3 Method

We used two tasks to test false-belief (FB) reasoning at first-order and second-order levels, the designs and materials of which were taken from the study of Hollebrandse, Hobbs, De Villiers and Roeper (2008) with English children. The essence of both tasks is that the protagonists in the stories and video clips have beliefs about situations that are different from the participants' beliefs (first order), as well as from the beliefs of others (second order). The two tasks differ as to how the clues for the beliefs were presented. In the verbal task, participants were told a story about four characters which provided the necessary clues for FB reasoning (see Appendix 1 for an illustration). In the non-verbal task, participants watched silent movies with one or two actors. The experimenter occasionally pointed out some features in the movies, but, crucially, no language clues about beliefs were given. Instead, the clues for the beliefs of the different actors had to be deduced from the visual context (see Appendix 2 for an illustration).

All subjects participated in both tasks. The data was collected in two sessions. The order in which the tasks were conducted was balanced across participants.

3.1 Verbal false-belief task

In the verbal task an elaborate story was told in which the beliefs of various people in the story were manipulated. The stories were accompanied by pictures, which were presented one by one and served as a memory aid. The stories were modeled after Wimmer and Perner's (1985) "ice cream truck story", but in contrast to their stories, we made sure that there were no overlapping beliefs, not only at the second-order

level, but also at the first-order level: each protagonist had his or her own distinct belief which was different from those of the other protagonists.

All the stories have the same set up. Protagonist 1 and 2 initially share the same belief. In the sample story in Appendix 1, both main characters (Sam and Maria) initially think that there are chocolate-chip cookies at the bake sale of the church. Then character 1's belief changes without character 2 knowing about it (Sam's mom tells Sam that they are selling pumpkin pie). Next, character 2 learns that the reality is different, without character 1 knowing about this (Maria finds out that there are only brownies left). At this point character 1 has a first-order belief which differs from his initial belief and also from the reality (Sam now thinks they're selling pumpkin pie, not chocolate-chip cookies; he doesn't know that in reality they're selling brownies). Character 2 knows the reality which is different from her second-order belief about character 1 (Maria knows they're selling brownies, but thinks that Sam still thinks that they sell chocolate-chip cookies).

We did not use any second-order embedding constructions of the type *Maria thinks that Sam thinks they are selling cookies at the bake sale* in the story. Instead we elicited a second-order answer by asking a "double" first-order question. The mailman asks Maria a first-order question *What does Sam think they are selling at the bake sale?* The experimenter then asks the participant what Maria answered to the mailman (see also Sullivan, Zaitchik & Tager-Flusberg, 1994). The child thus did not need to process second-order embedding structures in language, but was still required to do a second-order reasoning task.

There were eight stories with this format, each containing one second-order question and two first-order ones. One first-order question was asked in the middle of the

story and the second one was asked at the end of the story. The purpose of asking the same first-order question once more at the end of the story was to check whether children had difficulties with the length and complexity of the story. The second first-order question thus effectively served as a control of how well participants were able to keep track of the different beliefs despite the length and complexity of the story.

3.2 Non-verbal false-belief task

For the non-verbal task, participants also had to keep track of the different beliefs of different protagonists in the same situation. Whereas the former task was a fully verbal one, this one limited the use of language as much as possible. The experimenter only drew attention to the contents of a box and pointed out whether or not the observers in the movies were watching the changes of the content. This was done without using any propositional-attitude verbs (such as *think* or *believe*), and without referring to thoughts or beliefs in any other way.

Participants watched short movies. In half of the movies the contents of a box were changed once or twice (the Unknown-Change-of-Content set-up), and in the other half an object was moved between two or three different locations (the Unknown-Change-of-Location set-up). The task was presented as a game in two parts. In the first part the participant himself was the player of the game and had to keep track of what the observer in the movie knew about the changes of the contents of a box (or the different locations in the change-of-location variant of this task). These were the first-order trials (see Appendix 2a).

In the second part participants were told that it was the same game, but now there was a different player: an additional observer in the movie (i.e., the man in the win-

dow on the right in Appendix 2b). The task of the participant was to keep track of what this observer knew about the contents of the box and what he knew about the other observer (the woman)'s beliefs, which involves second-order reasoning. The set of events in the second-order movies was essentially the same as in the first-order movies, except that here we introduced a second-order false belief for the man about the woman. For example, the man would incorrectly believe that the woman thinks there is an apple in the box, whereas she actually believes that there is small basket in the box; in reality, however, there is a turtle in the box.

Four movies tested first-order FB reasoning and four others tested second-order FB reasoning. For the younger children, a first-order question was added to the end of the second-order trials to check whether they were able to follow the complex series of events.²

In both tasks then, participants had to reason about first-order and second-order false beliefs in a setting in which none of the protagonists' beliefs overlapped. In both tasks participants had to keep track of two first-order beliefs and one second-order belief. In the story task they had to keep track of Sam's and Mary's first-order beliefs as well as Mary's second-order belief about Sam's first-order belief. In the movie task they had to keep track of the first-order beliefs of the protagonist in the right window and the protagonist in the left window, and the second-order belief of

² The second first-order question was not asked with the older children as they were tested before the younger children. At that time, we feared that adding another question would make the task too demanding. However, as the older children turned out to be quite successful with the second first-order question in the verbal task, our fears appeared to be unwarranted. Hence, we decided to add the second first-order question to the non-verbal task for the younger children.

the protagonist in the right window about the belief of the other protagonist in the left window.

The tasks differed in whether the clues about who believes what about whom were presented verbally, or whether they had to be deduced from the movies, hence our labels verbal versus non-verbal task. Note that even though we call the movie task non-verbal, it is not completely non-verbal, as the experimenter draws verbal attention to the changes of the contents of the box; moreover, the test questions were also verbal. Conversely, the verbal task was supported with pictures. The two tasks also differed in the number of protagonists; the non-verbal task has only two protagonists (the woman and the man), whereas the verbal task has four (Sam, Maria, the mom and the mailman). Having more protagonists adds to the complexity of the mental representations involved and potentially makes the verbal task more demanding. However, as we will see in the next section, this is not reflected in the results. Children are more accurate in the verbal task than in the non-verbal task.

4 Results

Figures 1 and 2 present the children's scores on the verbal and non-verbal tasks. For both, the results show a sharp difference between first-order and second-order questions. Moreover, for the second-order items, children performed better in the verbal task than in the non-verbal task. The adults performed nearly at ceiling at all test questions, with 96% correct responses on the second-order question in the verbal task and 91% in the non-verbal task.

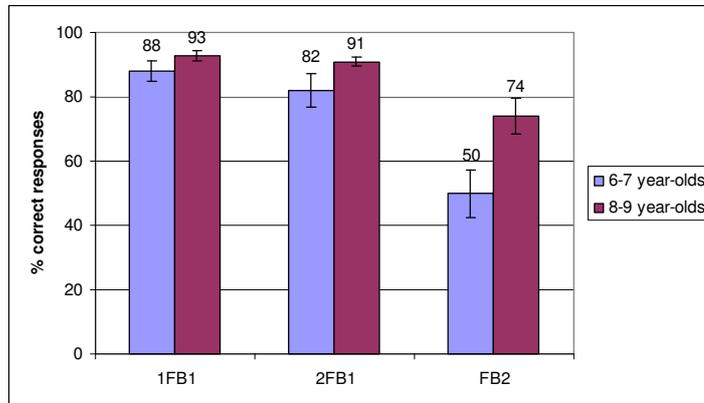


Figure 1: Verbal false-belief task: Percentage of correct responses for both age groups (error bars show standard errors) on 1FB1 (first first-order FB question), 2FB1 (second first-order FB question) and FB2 (second-order FB question).

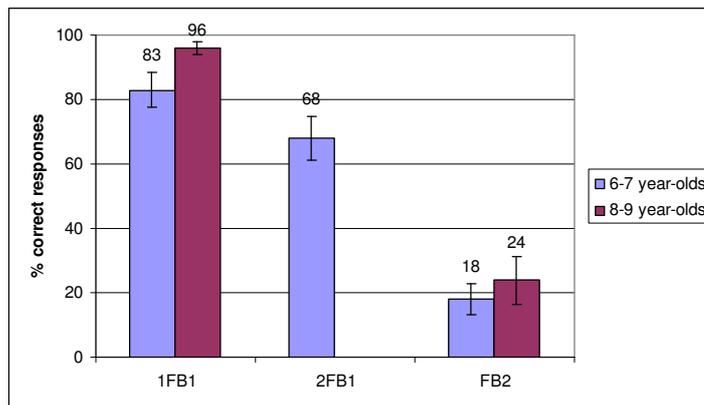


Figure 2: Non-verbal false-belief task: Percentage of correct responses for both age groups (error bars show standard errors) on 1FB1 (first first-order FB question), 2FB1 (first-order FB question in the second-order trial) and FB2 (second-order FB question). Note that the older children did not receive the 2FB1 question.

Repeated Measures ANOVAs were performed with Verbal Level (verbal – non-verbal) and False Belief Order (first order – second order) as within-participants factors, and Age (younger children – older children) as the between-participants factor. There were main effects for Verbal Level, $F(2,43) = 51.4; p < 0.001$) and False Belief Order, $F(2,43) = 160.7; p < 0.001$), and a significant interaction between the two ($F(2,43) = 37.4; p < 0.001$). The children performed better on the verbal than on the

non-verbal task and they also performed better on first-order questions than on second-order questions. There was a difference between performance on first-order and second-order questions in the non-verbal but not in the verbal task.

Taking a closer look at these effects, we performed paired-sample t-tests. These only revealed significant differences between the verbal and the non-verbal second-order responses, both for the younger group ($t(20) = 4.1$; $p = 0.001$) and the older group ($t(20) = 6.5$; $p < 0.001$). Importantly, there were no significant differences between any of the first-order false-belief responses, except for one: in the non-verbal task the younger group showed a significant difference between the first and second first-order question ($t(20) = 2.6$; $p = 0.015$). This general lack of effect at first-order level indicates that participants had no problem at this level of reasoning. The difficulties lie instead at the second-order level of reasoning.

Furthermore, Age was also significant ($F(2,43) = 7.9$; $p = 0.008$). The younger group performed worse than the older group. Paired sample t-tests reveal that this difference mostly lies in the difference between the two age groups on the verbal second-order false belief question ($t(20) = 2.1$; $p = 0.050$). Moreover, there was a trend for Age for the first first-order FB question in the non-verbal task ($t(20) = 2.0$; $p = 0.056$).

5 Discussion

Onishi and Baillargeon (2005) show that implicit non-verbal FB reasoning is accomplished at a very young age, which suggests that language is not required for the implicit representation of first-order false beliefs. Explicit verbal FB reasoning is acquired around the age of four, possibly with the help of language (de Villiers,

2005). In this study, we investigated second-order reasoning about false beliefs with a verbal and a non-verbal task. Children's success on the first-order false-belief items in the two tasks indicates that they were able to keep track of the different beliefs despite the complexity of the tasks with several protagonists, each with their own beliefs. Their performance on these first-order items contrasts with their much poorer performance on the second-order items. Importantly, children pass a verbal second-order task before they pass a non-verbal second-order task. We thus find a strong effect of language at the second-order level, as the verbal second-order FB task turned out to be easier than the corresponding non-verbal task. What does this suggest about the relation between language development and false-belief reasoning? And why is the verbal task easier for children?

A first possibility is that children's different performance on the two tasks is a task effect that does not relate to their capacity for FB reasoning. Retrieval of the relevant belief representations from memory in order to respond to the test question may be aided by the manner in which these representations have been processed and stored during the task. In the verbal task the story was presented verbally. Moreover there were probe questions at various moments throughout the story which were designed to prompt participants to verbalize their knowledge about false beliefs. In the non-verbal task, on the other hand, the story was presented purely visually and no probe questions were asked. It is conceivable that the explicit nature of the verbal task makes this task easier for children. However, this is at odds with the observed difference between toddler's early good performance on implicit false-belief tasks and young children's difficulty with explicit false-belief tasks (see Section 1).

An alternative explanation in terms of task effects is that the mismatch between mode of presentation and mode of response may make the non-verbal task more difficult for children. In both the verbal and the non-verbal task a verbal response was required in response to the test question. If this explanation is correct, we predict that children will perform better on a non-verbal task if performance is measured by looking behavior, as one can do in an eye-tracking study. Also, if this explanation is correct, it is expected that in implicit higher-order reasoning tasks (such as Meijering, Van Maanen, Van Rijn & Verbrugge's (2010) marble task) that do not rely on language either in their presentation or for the response, children may not experience the same difficulty as in our non-verbal task. However, even for adults implicit second-order reasoning does not come readily, as Hedden and Zhang (2002) have shown.

An third possibility is that children perform better on the verbal task because grammatical representations help them in their FB reasoning. Second-order FB reasoning requires embedding of beliefs in a way similar to how language structures syntactic embedding. The recursive linguistic representations involved in syntactic embedding may therefore provide the scaffolding to perform the recursive step of a second-order FB reasoning task (Hollebrandse & Roeper, submitted). This explanation extends the ideas of De Villiers (2005) about the role of language in acquiring explicit FB representations to second-order FB reasoning (see also Hollebrandse, 2000).

We conclude that a verbal second-order FB task is easier for children than a corresponding non-verbal FB task. This suggests that language supports explicit reasoning about beliefs, perhaps by facilitating the cognitive system that keeps track of beliefs attributed by people to other people.

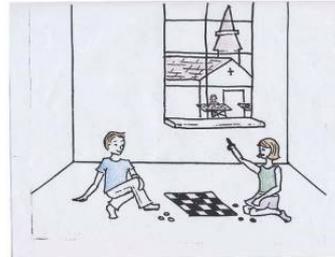
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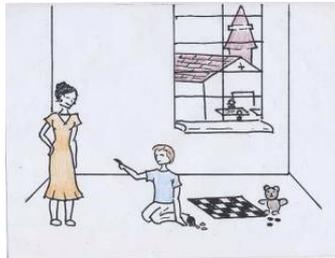
Appendix 1: Illustration of verbal false belief task: the *Bake Sale* Story

Abbreviations: Q1FB1 = first first-order false-belief question; Q2FB1 = second first-order false-belief question; QFB2 = second-order false-belief question.

Sam and Maria are playing together. They look outside and see that the church is having a bake sale. Maria tells Sam: "I am going to buy chocolate chip cookies for us there," and she walks away.



Mom comes home and she tells Sam that she just drove past the bake sale. "Are they selling chocolate chip cookies?" Sam asks. "No," mum says, "they are only selling pumpkin pie." "Maria will now probably get pumpkin pie at the bake sale," Sam says.



Probe 1: Does Maria know they are selling pumpkin pie at the bake sale?

Maria has arrived at the bake sale. "I would like to buy chocolate chip cookies," she says. "All we have left are brownies," says the lady behind the stall. Since Maria also likes brownies, she decides to get some brownies.



Probe 2: Does Sam know that Maria bought some brownies?

Q1FB1: What does Sam think they are selling at the bake sale? Why does he think that?

On her way back, Maria meets the mailman. She tells the mailman: "I have just bought some brownies. I am going to share them with my brother Sam. It is a surprise". "That is nice of you," says the mailman. Then he asks Maria: "Does Sam know what you bought him?"



Ignorance: What does Maria tell the mailman?

Then the mailman asks: "What does Sam think they are selling at the bake sale?"

QFB2: What does Maria tell the mailman? Why does she say that?

Q2FB1: What does Sam think they are selling at the bake sale? Why does he think that?

Appendix 2: Illustration of non-verbal false-belief task (Unknown-Change-of-Content set-up)

Abbreviations: Q1FB1 = first first-order false-belief question; Q2FB1 = second first-order false-belief question; QFB2 = second-order false-belief question.

a. Non-verbal first-order task



First order trial

Q1FB1: Remember you are the player. Now, what does she think is in the box?
(experimenter points to the woman)

b. Non-verbal second-order task



Second order trial

QFB2: Remember, first you were the player, but now he (experimenter points to the man in the right window) is the player and we are going to ask him the same question as we asked you: "What does she think is in the box?" What will he answer?

Q2FB1: What does she herself think is in the box?

Examples of non-verbal movies can be found at:

<http://www.let.rug.nl/hollebr/FB-movies/1stOrderNonVerbal.wmv>

<http://www.let.rug.nl/hollebr/FB-movies/2ndOrderNonVerbal.wmv>