Chapter 41

Talking about beliefs about beliefs without using recursion

Denise Zijlstra
University of Groningen

Marieke Wijnbergen
University of Groningen

Margreet Vogelzang
University of Groningen

Petra Hendriks
University of Groningen

It has been argued by Roeper and colleagues that second-order beliefs (beliefs about beliefs) can only be represented using an overt recursion device, such as sentence embedding. We investigated this claim in a comprehension experiment with Dutch adults. For sequences of three simplex sentences linked by demonstrative pronouns (e.g., "Computers are intelligent. John thinks that. Mary knows that"), participants frequently accepted a second-order belief ("Mary knows that John thinks that computers are intelligent"). As predicted, they did so more often when the two demonstrative pronouns differed in form (*this* vs. *that*) than when they had the same form (either *this* or *that*). We conclude that second-order beliefs do not require syntactic recursion and can be constructed and understood via pronominal reference.

1 Introduction

Children have been found to master *first-order Theory of Mind* (ToM), which is the ability to attribute mental states (such as beliefs) to other persons, by the age of 4 or 5 (e.g., Wellman, Cross & Watson 2001; Wimmer & Perner 1983). One view is that children's development of first-order ToM depends on their mastery of the grammar of syntactic complementation (de Villiers & Pyers 2002). According to this

language-first view, the development of the syntactic means to embed a possibly false proposition (e.g., "Computers are intelligent") under a mental state verb (as in "John thinks that computers are intelligent") or verb of communication (such as *says*) is necessary to mentally represent another person's false belief. *Second-order ToM*, or the ability to attribute beliefs about beliefs to other persons, is mastered much later and perhaps not before the age of 8 or 9 years old (Hollebrandse et al. 2008). However, if second-order ToM merely involves a second application of ToM, then why are children so much delayed in their development of second-order ToM? Roeper (2007) argues that this delay is due to the additional difficulty of second-order beliefs caused by syntactic recursion.

Roeper's argument is based on the following observation (2007: 265): suppose we said to you that "John told a lie. The Statue of Liberty was turned upside down," and we would ask you whether the Statue of Liberty was turned upside down. You would probably answer "no", because it was a lie that John told. In this case, it is possible to infer that the sentence expressing the false belief is subordinate to the sentence referring to John telling a lie, because "it is possible to convey an embedded meaning across a sentence boundary" (Hollebrandse et al. 2008: 269). Thus, this sequence of two simplex sentences yields the same interpretation as the complex embedded structure "John lied that the Statue of Liberty was turned upside down". An alternative way of expressing a first-order belief is by using a demonstrative pronoun such as *that* (Hollebrandse et al. 2008; Hollebrandse & van Hout 2015):

(1) a. Computers are intelligent. John thinks that.
    b. John thinks that computers are intelligent.

Here, *that* in the second clause of (1a) refers to the situation expressed by the first clause of (1a). In other words, the sequence of two simplex clauses in (1a) can effectively make the same claim as an embedded proposition (1b). This means that, to express a first-order belief, a speaker can use a recursive rule system involving sentence embedding, as well as a non-recursive rule system (Hollebrandse et al. 2008; Hollebrandse & van Hout 2015). For second-order (false) beliefs, however, things are argued to be different. Consider the following example:

(2) Mary told a lie. John told a lie. The Statue of Liberty was turned upside down.

Here, it is much more difficult to make a guess, or inference, about what Mary was lying about. When asked what these sentences assert, all people consulted by Roeper (2007: 265) answered with confusion and uncertainty and mostly concluded that Mary and John told the same lie. The difficulty here lies in putting a guess inside a guess without an overt recursion device such as sentence embedding. However, if we would say to you that "Mary lied that John lied that the Statue of Liberty was turned upside down," you would understand the second-order belief, because this belief was expressed explicitly by using two sentence embeddings. The same appears to be the case for sequences of three simplex sentences linked by demonstrative pronouns:

(3) a. Computers are intelligent. John thinks that. Mary knows that.
b. Mary knows that John thinks that computers are intelligent.
c. Mary knows that computers are intelligent.

It is claimed (Hollebrandse et al. 2008; Hollebrandse & van Hout 2015) that the third sentence in (3a) can be interpreted as (3c), but not as (3b). On the basis of the patterns of interpretation in (2) and (3), it is argued that the representation of second-order beliefs requires syntactic recursion. Only by syntactically embedding the false belief inside a proposition inside another proposition, a listener will understand that Mary knows that John thinks that computers are intelligent. Thus, in contrast to first-order beliefs, second-order beliefs require an overt recursion device, such as sentence embedding, and are therefore considered to be syntactically different from first-order beliefs (Roeper 2007; Hollebrandse et al. 2008; Hollebrandse & van Hout 2015).

According to the above reasoning put forward by Roeper (2007) and colleagues, the second-order false belief interpretation is not available for (3a) because of the absence of an overt recursion device in this sentence. However, an alternative explanation for the unavailability of the second-order false belief interpretation in (3a) is that this interpretation is strongly dispreferred due to the two identical demonstrative pronouns. When a language has different pronominal forms, these different forms tend to refer to different referents (e.g., personal versus demonstrative pronouns in Dutch and German, see Ellert 2010, and null versus overt pronouns in Italian, see Carminati 2002). According to Diessel (1999), all languages have at least two demonstrative forms that are deictically contrastive and allow speakers to refer to referents nearby versus referents at some distance. For example, Dutch distinguishes between the proximal demonstrative pronoun *dit* ('this'), which is used for near deixis, and the distal demonstrative pronoun *dat* ('that'), which is used for remote deixis. So when the speaker uses two identical demonstrative pronouns, these pronouns can be expected to refer to the same referent. It is thus conceivable that the second-order belief interpretation for the second demonstrative pronoun in (3a) is blocked by the interpretation assigned to the first demonstrative pronoun. If the first pronoun is interpreted as referring to the situation denoted by the first clause, the second pronoun, which has the same form as the first pronoun, is perhaps preferably interpreted as referring to this same situation and hence the third clause is interpreted as representing a first-order belief as well.

In this study, we investigate whether it is possible to represent a second-order belief without an overt recursion device in examples such as (3a). Additionally, we investigate whether it is easier to represent a second-order belief when the demonstrative pronouns differ in form, compared to when the demonstrative pronouns are identical. To investigate these questions, we carried out a comprehension experiment with adult speakers of Dutch.

2 Methodology

2.1 Participants

29 unimpaired Dutch adults (fourteen men, fifteen women) participated in this study, with a mean age of 22 years old (age range 19-31). They were all students of the University of Groningen or the Hanze University of Applied Sciences.

2.2 Materials

To investigate whether it is possible to represent a second-order belief without sentence embedding, we used a referential choice task. In this task, participants read sequences of three simplex sentences. An example is given in (4a). The first sentence expresses a proposition that is, or could be, false. The second and third sentence each consist of a referential subject, a mental state verb (such as *thinks* or *knows*) and a potentially ambiguous demonstrative object pronoun (either *dit* 'this' or *dat* 'that'). The subject of the third sentence is always someone with authority, in (4a) a dentist, to increase the plausibility of the arguably more complex second-order belief. We did this as we were interested in the possibility of the second-order false belief interpretation, rather than in a preference for either the first-order or second-order belief interpretation. If a second-order belief can be represented without sentence embedding, it should be possible for the sequence of simplex sentences in (4a) to receive the same interpretation as the complex sentence in (4b).

(4) a. Snoep is gezond. Marie denkt dat. De tandarts weet dit.
'Candy is healthy. Mary thinks that. The dentist knows this.'

b. De tandarts weet dat Marie denkt dat snoep gezond is.
'The dentist knows that Mary thinks that candy is healthy.'

The participants were asked to indicate what the underlined demonstrative pronoun in the third sentence refers to. They should indicate their interpretation by selecting an answer out of three answer possibilities: an answer corresponding to a *second-order belief*, e.g., that the dentist knows that Mary thinks that candy is healthy (5a), an answer corresponding to a *first-order belief*, e.g., that the dentist knows that candy is healthy (5b), and an answer corresponding to a plausible but non-mentioned belief, such as that the dentist knows that Mary eats candy (5c). Participants were allowed to select more than one answer.

(5) a. Dat Marie denkt dat snoep gezond is.
'That Mary thinks that candy is healthy.'

b. Dat snoep gezond is.
'That candy is healthy.'

c. Dat Marie snoept.
'That Mary eats candy.'

The second and third sentence in each item contain one of the two demonstrative pronouns *dit* 'this' or *dat* 'that' and one of the three mental state verbs *denken* 'to think', *geloven* 'to believe' (both non-factive verbs), and *weten* 'to know' (a factive verb). The three verbs were selected for their high frequency. The four different combinations of demonstrative pronouns *dit-dit* 'this-this', *dit-dat* 'this-that', *dat-dat* 'that-that', and *dat-dit* 'that-this' were equally divided over the 36 test items in our experiment, resulting in nine items per demonstrative pronoun combination. Additionally, we used all nine possible combinations of the three mental state verbs. Each verb combination was used once with each of the four demonstrative pronoun combinations, and therefore was used four times in total. On the basis of these materials, four different lists were construed such that for each sentence the lists only differed in the pronoun combination used. Each participant only received one list.

The 36 test items were preceded by two practice items, which were identical for each of the four lists. Practice items consisted of a sequence of two clauses, the second one containing a mental state verb and a demonstrative pronoun (e.g., *Het regent. Jan denkt dat.* 'It is raining. John thinks that.'), and were included to ensure that participants understood the task.

2.3 Procedure

All participants were tested individually at the university. Participants received the referential choice task on paper. They were instructed that participation was voluntary and that they could stop the experiment at any moment. As a token of gratitude, the participants received a small reward upon completion of the task.

2.4 Data analysis

Three participants were excluded from the analysis because they failed to respond to all items. The responses of the remaining 26 participants were analysed.

3 Results

Table 1 shows the number of responses per belief response type on the referential choice task. The most frequently chosen response type was the second-order belief response (326). This type of response was chosen more often than the response type according to which both a second-order belief and a first-order belief are possible (313), which was chosen more often than the first-order belief response (277). As expected, the other belief response and further responses including the other belief were hardly ever selected. On the 936 items in total, participants selected an answer corresponding to the second-order belief 654 times (326 + 313 + 3 + 12), an answer corresponding to the first-order belief 603 times (277 + 313 + 1 + 12), and an answer corresponding to the other belief 20 times (4 + 1 + 3 + 12). Thus, the participants found a second-order belief response to be possible more than two-third of the time.

Table 1: Distribution of responses per response type in absolute numbers.

Response type	Number of responses
second-order belief	326
first-order belief	277
other belief	4
second-order + first-order belief	313
second-order + other belief	3
first-order + other belief	1
second-order + first-order + other belief	12
Total	936

For analysis, we excluded all responses which contained an other belief interpretation. In total, 20 responses were excluded, so that 916 responses remained for analysis. Next, we looked at the effect of the forms of the two demonstrative pronouns on the response type (i.e., whether a second-order belief, a first-order belief or both were chosen, see Table 2). As we used two demonstrative pronouns (*dit* 'this' and *dat* 'that'), there were four different pronoun combinations.

Table 2: Distribution of responses (second-order vs. first-order vs. both first- and second-order belief) per demonstrative pronoun combination in absolute numbers.

Pronoun combination	Second-order belief	First-order belief	Both beliefs	Total number of responses
dat-dat	56	87	84	227
dat-dit	99	50	79	228
dit-dit	69	90	74	232
dit-dat	103	50	76	229
Total	326	277	313	916

A Pearson's Chi-squared analysis was carried out to investigate the effect of the forms of the two demonstrative pronouns on the participants' belief responses. The analysis indicated that the form of the demonstrative pronouns significantly influences the participants' responses ($\chi^2(6, N = 916) = 41.820$, $p < .001$). Post-hoc pairwise chi-square analyses with Bonferroni corrections were done to compare all combinations of pronouns. The results show that responses to the conditions in which the two demonstrative pronouns were the same (i.e., *dat-dat* and *dit-dit*) did not differ ($\chi^2(2, N = 459) = 1.791$, $p = .408$). Moreover, the two conditions in which the two demonstrative pronouns were different (i.e., *dat-dit* and *dit-dat*) also showed no dif-

ference (χ^2(2, N = 457) = 0.135, p = .935). All other comparisons showed differences between pronoun combinations (all p < .008). So, there is indeed a difference in interpretation of our simplex sentences when the demonstrative pronouns differ in form, compared to when the demonstrative pronouns are identical.

To investigate this difference between pronoun combinations, we analysed the distribution of first-order and second-order belief responses in more detail. McNemar tests show that when the two pronouns were the same (i.e., *dat-dat* and *dit-dit*), participants selected the first-order belief response more often than the second-order belief response (p = .003). In contrast, participants selected the second-order belief response more often than the first-order belief response when the pronouns differed (i.e., *dat-dit* and *dit-dat*, p < .001).

Table 3: Distribution of responses (second-order vs. first-order vs. both first- and second-order belief) per verb combination in absolute numbers.

Verb combination	Second-order belief	First-order belief	Both beliefs	Total number of responses
denken-denken	34	36	32	102
denken-geloven	45	24	35	104
denken-weten	26	39	36	101
geloven-denken	42	29	32	103
geloven-geloven	47	26	31	104
geloven-weten	39	22	35	96
weten-denken	33	37	32	102
weten-geloven	30	32	41	103
weten-weten	30	32	39	101
Total	326	277	313	916

Finally, although it was not the aim of our study, we wanted to see whether the different mental state verbs had a different effect on the participants' belief responses. Three mental state verbs were used in the study (*denken* 'to think', *geloven* 'to believe' and *weten* 'to know'), resulting in nine different verb combinations. The responses per verb combination are shown in Table 3.

A Pearson's Chi-squared analysis revealed that the choice of verbs did not influence the participants' responses (χ^2(16, N = 916) = 23.452, p = .102).

4 Discussion and conclusion

It has been argued that an overt recursion device such as sentence embedding is required for representing second-order beliefs, but not first-order beliefs, and that this explains children's delayed development of second-order ToM compared to first-order ToM (e.g., Roeper 2007; Hollebrandse et al. 2008; Hollebrandse & van Hout

2015). This study investigated the first part of this reasoning, namely whether syntactic recursion is truly necessary for second-order beliefs. Using a referential choice task, we tested whether second-order beliefs can also be represented by a sequence of simplex sentences linked by demonstrative pronouns.

Our study first of all shows that Dutch readers allow a demonstrative pronoun that is the object of a mental state verb in a simplex sentence to refer to a first-order belief referred to by a demonstrative pronoun in the preceding simplex sentence, resulting in the representation of a second-order belief. Thus, it is possible to represent a second-order belief without a syntactic recursion device such as sentence embedding. In our study, participants selected this referential option in more than two-third of the cases. This shows that the representation of second-order beliefs by non-recursive pronominal reference rather than recursive sentence embedding is a viable option in languages such as Dutch. This finding contradicts the earlier claim that overt syntactic recursion is necessary for the representation of second-order beliefs (Roeper 2007). Additionally, this finding sheds doubt on the explanation of children's late development of second-order ToM as resulting from the complexity of syntactic recursion (Hollebrandse et al. 2008).

As hypothesized, participants' selection of a second-order belief response was influenced by the form of the two demonstrative pronouns used. The participants in our study were more likely to choose a second-order belief response if the two demonstrative pronouns differed in form. At the same time, participants were less likely to choose a second-order belief response when the two demonstrative pronouns were identical in form. This finding is in accordance with the view that pronouns that have the same form tend to refer to the same thing, while pronouns that have a different form (such as *this* versus *that*) tend to refer to different things. This feature of pronominal reference may explain why previous studies on the representation of second-order false beliefs, using sentences with identical demonstrative pronouns (e.g., Hollebrandse et al. 2008) incorrectly concluded that it is impossible to express second-order beliefs without syntactic recursion.

In our study, we used three different mental state verbs for introducing the two beliefs in the sequences of three sentences: two non-factive verbs (*denken* 'to think' and *geloven* 'to believe') and one factive verb (*weten* 'to know'), which were evenly distributed across the second and third sentences of the test items. As the first sentence of each item always expressed a proposition that is false or could be false, it might be expected that using a factive verb instead of a non-factive verb in the third sentence, as in "Candy is healthy. Mary thinks that. The dentist knows this." would lead to mainly second-order belief responses. Factive verbs such as *know* presuppose the truth of their sentential complement (e.g., Karttunen 1971), meaning that it is impossible to know something that is false. Thus, if the third sentence contains a factive verb, a first-order belief interpretation (e.g., "The dentist knows that candy is healthy") should be practically impossible. However, the verbs used did not influence the participants' belief responses, suggesting that verb factivity did not play a role in the participants' interpretation of the demonstrative pronouns. Three possible explanations come to mind. One possibility is that the subject of the third sentence

being someone with authority (e.g., a dentist) has a similar effect on interpretation as having a factive verb in the third sentence and, by increasing the plausibility of the second-order belief response across the board, masks potential effects of verb factivity. A second possibility is that readers not always agreed on the falsity of the first sentence (e.g., Candy is healthy). Finally, a third possibility is that the verb *weten* ('to know') perhaps is not strictly factive in ordinary language use and may allow uncertainty regarding the truth of its sentential complement (cf. Hazlett 2010). However, more research is needed to clarify this issue.

To conclude, our study shows that the expression of second-order false beliefs does not require the presence of an overt recursion device such as sentence embedding. Like first-order beliefs, second-order beliefs can also be expressed by a sequence of simplex sentences linked by demonstrative pronouns. This suggests that first-order ToM and second-order ToM are not fundamentally different.

References

Carminati, Maria Nella. 2002. *The processing of Italian subject pronouns.* Amherst, USA: University of Massachusetts PhD thesis.

de Villiers, Jill G. & Jennie E. Pyers. 2002. Complements to cognition: A longitudinal study of the relationship between complex syntax and false-belief-understanding. *Cognitive Development* 17(1). 1037–1060.

Diessel, Holger. 1999. *Demonstratives: form, function and grammaticalization.* Amsterdam: John Benjamins.

Ellert, Miriam. 2010. *Ambiguous pronoun resolution in L1 and L2 German and Dutch.* Nijmegen: Max Planck Institute PhD thesis.

Hazlett, Allan. 2010. The myth of factive verbs. *Philosophy and Phenomenological Research* 80(3). 497–522.

Hollebrandse, Bart, Kathryn Hobbs, Jill G. de Villiers & Thomas Roeper. 2008. Second order embedding and second order false belief. In A. Gavarró & M. J. Freitas (eds.), *Proceedings from GALA 2007: Language acquisition and development*, 270–280. Newcastle, UK: Cambridge Scholar Press.

Hollebrandse, Bart & Angeliek van Hout. 2015. Comprehension and production of double-embedded structures: A kindergardenpath in long-distance dependencies in Dutch school-aged children? In C. Hamann & E. Ruigendijk (eds.), *Proceedings from GALA 2013: Language acquisition and development*, 190–204. Newcastle, UK: Cambridge Scholar Press.

Karttunen, Lauri. 1971. Implicative verbs. *Language* 47(2). 340–358.

Roeper, Thomas. 2007. *The prism of grammar: how child language illuminates humanism.* Cambridge, UK: MIT Press.

Wellman, Henry M., David Cross & Julanne Watson. 2001. Meta-analysis of Theory of Mind development: the truth about false-belief. *Child Development* 72(3). 655–684.

Wimmer, Heinz & Josef Perner. 1983. Beliefs about beliefs: representation and constraining function of wrong beliefs in young children's understanding of deception. *Cognition* 13(1). 103–128.