Three-year-olds' understanding of *know* and *think*

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Abstract: This study investigates three-year-olds' representations of the attitude verbs *think* and *know*, in attempt to assess children's understanding of factivity. *Know* is factive and is therefore used in contexts where the complement is taken to be true. *Think*, although non-factive, is still often used in situations where the complement is taken to be true. Are children able to recognize the difference between *know* and *think* and to understand that the truth of the complement is presupposed in one case but not the other? Acquisition studies on *know* and *think* find that children do not have an adult-like understanding of these verbs and their (non-)factivity before the age of four, but these tasks are often inappropriate for testing preschoolers' understanding of factivity for independent reasons. We designed an interactive game to implicitly evaluate children's knowledge of these verbs in a task that more directly targets factivity. Our results show that some three-year-olds are able to distinguish *think* and *know*, particularly in ways that suggest they understand that *know* presupposes the truth of its complement, and that *think* does not. The remaining three-year-olds, however, seem to treat both as non-factive. This suggests that early representations of *know* may be non-factive, and raises the question of how children come to distinguish the verbs.

Keywords: factivity, presupposition, acquisition, semantics-pragmatics interface, attitude ascriptions

1. Introduction

Children's understanding and use of pragmatics poses several observational and theoretical challenges. On the one hand, children seem quite competent in this domain. They make inferences about the goals and desires that drive people's behavior as young as one year of age (e.g., Gergely *et al* 1995; Warneken & Tomasello 2006; Woodward 1998). Moreover, early word learners seem to be able to use such inferences in determining the intended meaning of novel nouns (Merriman & Bowman 1989; Bloom 2002; Halberda 2003). Similarly, in the domain of language use, we often find evidence that children are exquisitely sensitive to the felicity conditions of a given grammatical expression (Hamburger & Crain, 1982; Thornton & Crain 1999; Gualmini *et al* 2008; Musolino & Lidz 2006). On the other hand, children are notoriously susceptible to pragmatic errors in making inferences about a speaker's communicative intent when this goes beyond the literal meaning of the expression (Noveck

Draft, Fall 2013. Submitted for inclusion in: Schwarz, Florian (ed.) Under Contract. *Experimental Perspectives on Presuppositions*, edited volume for Springer's *Studies in Theoretical Psycholinguistics* Series.

2000; Papafragou & Musolino 2002; Huang & Snedeker 2009; Papafragou, *in press*). And, they fail to use pragmatic information to guide parsing decisions, even when they appear to use the very same information to shape their own productions (Trueswell *et al* 1999; Hurewitz *et al* 2000). Together, these literatures highlight a tension between children's abilities to make inferences about the goals and intentions that underlie what people do and between those that underlie what people say.

In this paper, we explore this tension in the domain of attitude verb learning. This class of verbs presents an interesting puzzle from the perspective of the semantics-pragmatics interface. While attitude verbs tend to be used in association with rich pragmatic content, that content is sometimes packaged into the verb and sometimes not. For example, the verb *know* is factive, in that it presupposes the truth of its complement and is therefore likely to be used in contexts where the speaker takes the complement to be true. The verb *think* is non-factive, but it is nonetheless often used in contexts where the speaker takes the complement to be true. How is a learner to recognize that the truth of the complement is encoded as a presupposition in the *know* case but not the *think* case? As a first step towards addressing that question, this paper examines the age at which children distinguish *know* from *think* with respect to factivity.

2. *Know* and *think*

Think and *know* both report the beliefs of a subject. For example, (1) and (2) both convey that John has the belief that Mary is at the office.

(1) John knows that Mary is at the office

(2) John thinks that Mary is at the office

They differ however in that (1), unlike (2), can only be true if Mary is in fact at the office. *Know* is factive. Factive verbs like *know* are typically taken to presuppose, as opposed to entail, the

truth of their complements (Kiparsky & Kiparsky 1970; Karttunen 1971; Hooper & Thompson 1973; Hooper 1975). The truth of the complement seems to project out of p-family contexts like negation (Chierchia & McConnell-Ginet 1990) with *know* sentences like (3), but not with the equivalent *think* sentences like (4).

(3) John doesn't know that Mary is at the office

(4) John doesn't think that Mary is at the office

Because *know* and *think* differ in the presuppositional status of their complements, their uses license different inferences. Taken in isolation, (1) and (3) both indicate that the speaker takes it for granted that Mary is at the office. On the other hand, (2) and (4) are consistent with Mary either being at the office or not: we cannot draw inferences about her actual location without further assumptions about John and the speaker. In contexts where the speaker could have uttered "John knows that Mary is at the office", or simply "Mary is at the office", we might infer, via Gricean reasoning, that if the speaker instead uttered "John *thinks* that Mary is at the office", she is indicating that she doesn't believe that Mary is at the office. However, in contexts where the speaker takes John to be a reliable source of information, and the competing sentences are irrelevant or no accessible, her use of (2) might invite the inference that Mary actually is at the office, and her use of (4) that she isn't[1]. Thus, in contexts where speakers and hearers take John to be a reliable source of information, both (1) and (2) will invite the inference that Mary is at the office. However, we expect divergent inferences for their negated counterparts: (3) still indicates that Mary is at the office (and John simply isn't aware of this fact), while (4) indicates that she isn't.

[1] The reason why the inference for (4) is that Mary is not at the office, rather than agnosticism about Mary's actual location is that *think* is a neg-raising predicate: "John doesn't think that Mary is at the office" implies that John thinks that Mary is not at the office. If John is a reliable source, we will infer that Mary isn't at the office.

Do children recognize that sentences with *know* presuppose the truth of their complements, even in negated contexts, but that *think* sentences do not? As we will see in the next section, previous research shows that young children behave as though *think* sentences report true beliefs: across various tasks, their responses seems to suggest that they take both sentences like (1) and (2) to indicate that Mary is in the office. If speakers use sentences like (2) to implicate that they do not believe that Mary is in the office, children seem to be unaware of this fact. This pattern could result from children not differentiating *think* and *know* at all, or from a failure to derive implicatures using these verbs (either due to difficulty with quantity implicatures in general, or in realizing that *think* and *know* can be relevant alternatives to each other). To test whether young children can differentiate *think* and *know*, it is thus important to look at their understanding of negated sentences like (3) and (4): do they realize that (3) presupposes that Mary is at the office, but that (4) does not?

While we cannot directly probe children's representations of verbs like *know* and *think* (or adults' for that matter), we can use behavioral methods to assess the kinds of inferences they make upon hearing such sentences and then try to reconstruct the semantic representations that underlie such inferences. Specifically, we ask whether three-year-olds can demonstrate recognition of the factivity of *know* and the non-factivity of *think*. Once we know the answer to this question, we will be in a better position to address further questions about (a) the nature of the target (adult) representation of these verbs (e.g., how is factivity encoded?), (b) how children eventually reach such representations, and (c) how children come to associate a presupposition with certain lexical items, but not others.

3. Past acquisition studies

3.1 Studies on children's understanding of *think* and their developing Theory of Mind

Previous studies show that children have difficulty with *think* until at least four years of age. Unlike adults and older children, three-year-olds typically reject a sentence like (2) in contexts where Mary is not at the office, even if John thinks that she is (Johnson & Maratsos 1977; Wellman *et al* 2001; de Villiers & Pyers 2002; de Villiers 2005; Sowalsky *et al* 2009; Lewis *et al* 2012; a.o.). For example, consider the scenario in (5):

(5) False belief scenario: Mary has already made it home for the day, but John wrongly believes that she is at the office.

a. John thinks that Mary is at the office

b. Mary is at the office

In this scenario, adults and older children assent to (5a), but three-year-olds reject it. Three-year-olds seem to respond based on the truth of the complement clause (5b) (false in this scenario), instead of the entire sentence. There are at least four possible explanations for three-year-olds' non-adult-like responses in contexts like (5).

1. Conceptual Hypothesis. Children's initial difficulty with *think* reflects difficulty with the belief concept that *think* expresses. They reject sentences like (5a) because of their inability to attribute a false belief to John. This failure could either be due to a lack of understanding that people can have false beliefs or because they cannot deal with a belief representation that conflicts with their own (cf. Johnson & Maratsos 1977; Tardif & Wellman 2000; Perner *et al* 2003; a.o.).
2. Complement-only Hypothesis. Three-year-olds only attend to the embedded clause because they do not understand the matrix clause and thus ignore it altogether. This could

be due to a lack of understanding of the verb *think*, or an inability to embed a finite complement clause (cf. de Villiers 1995; Diessel & Tomassello 2001)

3. Pragmatic Hypothesis. Children's difficulty with *think* is not semantic, syntactic, nor conceptual, but pragmatic in nature (Lewis *et al* 2012, *in progress*; Lewis 2013). The reason children respond to the truth of the complement clause in (5) is the same reason adults sometimes respond to the truth of the complement of *think*. Verbs like *think* are sometimes used to proffer the content of its complement, in which case the complement clause carries the main point of the utterance, and the matrix clause get demoted to parenthetical status (cf. Urmson 1952; Hooper 1975; Rooryck 2001; Simons 2007; a.o). Children's failures could be due to a tendency to assign such parenthetical readings for *think*, even in situations where adults do not.
4. Factive-*think* Hypothesis. Children's non-adult responses could be due to a failure to recognize the non-factivity of *think* and instead they treat it in essentially the same way adults treat *know*. (Johnson & Maratsos 1977; Abbeduto & Rosenberg 1985).

Lewis *et al* (2012, *in progress*), and Lewis (2013), provide initial evidence against the first two hypotheses. They show that three-year-olds are not attending solely to the complement clause, and argue that children respond to the truth of the complement clause only in contexts in which they assume that it is being proffered by the speaker. In contexts in which parenthetical interpretations are blocked, three-year-olds can respond to the truth of the entire clause, in an adult-like way, even in false belief scenario. Consider the variant of scenario (5) in (6):

(6) False belief scenario 2: Mary *is* at the office, but John wrongly believes that she is at home.

   a. John thinks that Mary is at the office

b. Mary is at the office

In this scenario, the sentence (6a) is *false*, even though the complement clause (6b) is true. In such cases, three-year-olds, rejected sentences like (6a), just like adults. Lewis and colleagues argue that the reason three-year-olds' performance improves in this kind of false belief scenario is that parenthetical interpretations in which the speaker endorses the reported belief are blocked: the speaker cannot endorse a belief of John's that John does not hold. These results argue against the Complement-only Hypothesis. Indeed, children's adult-like responses are unexpected if children merely respond to the truth of the complement: they should accept the sentence, since the complement is true. Furthermore, it shows that three-year-olds are able to provide adult-like responses, even in contexts in which the subject has a false belief, suggesting that their difficulty is not conceptual, contra the Conceptual Hypothesis.

Lewis's results, however, are still consistent with the last two hypotheses: children's difficulty with *think* could either be due to a (cancelable) tendency to assume that speakers typically endorse the truth of the complement, or to a factive interpretation of *think.* Note that in the scenario in (6), we would typically reject the sentence "John knows that Mary is at the office". Perhaps three-year-olds' responses then reflect a factive understanding of *think*.

3.2 Past studies on children's understanding of *know*

Previous research suggests that children do not differentiate verbs like *know* and *think* until at least age four (Macnamara *et al* 1976, Johnson & Maratsos 1977, Abbeduto & Rosenberg 1985, Moore & Davidge 1989, Moore *et al* 1989). Some authors even argue that children might not have a fully adult-like understanding of *know* well into the grade school years (Harris 1975, Hopmann & Maratsos 1978, Scoville & Gordon 1980, Falmagne *et al* 1994, Léger 2008). However, many of these studies involve complex tasks that could be independently difficult,

especially for three-year-olds. Moreover, many of these tasks require children to make metalinguistic judgments or to compare the relative acceptability of two sentences. Consequently, these tasks may underestimate children's knowledge. Studies involving more naturalistic use of the verbs could serve as a better probe of children's knowledge.

3.2.1 Negation tasks

Several past studies have attempted to assess whether children understand that the presupposition associated with *know*, but not *think*, projects out of negation. Harris (1975) tested preschoolers, kindergarteners and older children in first through sixth grade. On one of Harris's tasks, the "truth questioning" task, participants responded to questions of the form "The teacher did not know that Tim was absent. Was Tim absent?" On another, participants made judgments of whether sentences like the following sounded funny "John {knew, didn't know} that {his father was a tree, his sister was not a girl}." Harris concluded that comprehension of factive verbs is a lengthy process that might begin in preschool but definitely extends past sixth grade, although he found the largest improvement in performance was between the ages of four and seven. Harris's measures, while later adopted widely in this literature, might not be appropriate for younger children because they involve activities that are not a common part of everyday life.

Hopmann & Maratsos (1978) tested four-, five- and seven-year-olds on an act-out task with affirmative and negative sentences that contained either factive or non-factive verbs. They found that some children responded as if the complement was true, regardless of the matrix verb, and that this tendency was stronger with the youngest children. Like Harris (1975), these authors concluded that development of an understanding of these verbs as a protracted process (and that acquisition of the factivity of factive verbs was not uniform), but that their seven-year-old participants were sufficiently competent with the verbs. This finding, however, might be due to

the added pressures of an act-out task because the task is such that children can perform an action for any number of reasons (including an attempt to please the experimenter), and not just based on what they understand the sentence to mean

Scoville & Gordon (1980) tested children aged 6, 8, 12 and 14. In their task, participants watched a lottery-style game show where one character would report on another (semi-omniscient) character's understanding of the outcome. Again, like other authors, Scoville & Gordon concluded that acquiring an understanding of factive verbs was an extended process, where each verb is learned to be factive on a case-by-case basis. However, even their were two responses consistent with an adult-like interpretation, instead of allowing participants to choose either of the possible responses or the other, their measure of success require the participants to say they couldn't decide.

Léger (2008) tested children aged 6, 7, 9 and 11. Participants were presented with the following four attitude reports (7-10):

(7) She knows she has a turtle

(8) She knows she doesn't have a turtle

(9) She doesn't know she has a turtle

(10) She doesn't know she doesn't have a turtle

In Léger's task there were four dolls, each of which was uniquely described by one of the sentences in (7-10) and participants were asked to pick the appropriate doll after hearing the attitude reports. She found that even the youngest children tended to pick the right answer but that they had not attained 100% accuracy even by age 11. Yet, Léger's conclusion is based children's performance on sentences like (10), which could be hard to process for reasons outside the domain of understanding factivity.

3.2.2 Metalinguistic tasks

Other studies in this literature require explicit comparison of *know* and *think* statements, which could be too metalinguistically difficult for young children. Macnamara *et al* (1976) told four-year-olds different stories and then probed their participants about the mental states of the characters, including whether the characters *knew* a certain proposition. They found that four-year-olds performed well on this task. Johnson & Maratsos (1977) tested three- and four-year-olds, also on whether characters in a story *knew* or *thought* a certain proposition. Like Macnamara *et al*, these authors concluded that four-year-olds could succeed on such a task, but that three-year-olds could not. Abbeduto & Rosenberg (1985) tested three-, four- and seven-year-olds on three different tasks: (i) a modified Harris (1975) "truth questioning" task, (ii) a verb choice task where participants determined whether *know* or *think* was a more accurate description of a character's mental state, and (iii) a definitional task with questions like "What does it mean to know?" These authors concluded that three-year-olds had not achieved mastery of the verbs but that four- and seven-year-olds had. The results from these studies are unsurprising if we assume that three-year-olds are unable to perform a metalinguistic task like comparing the relative acceptability of two sentences.

3.2.3 Relative strength tasks

Finally, some studies in this literature assessed children's understanding of the relative strengths of these predicates. These studies were concerned with whether *know* indicates more certainty or confidence about the truth of a complement than *think* does. Moore and colleagues (Moore & Davidge 1989; Moore *et al* 1989; a.o.) tested children ages 3, 4, 5, 6 and 8. In their tasks, children were presented with two boxes, only one of which contained a toy. The participants' job was to determine which box contained the toy after hearing two puppets utter sentences like

"I know it's in the red box" and "I think it's in the blue box." The studies by Moore and colleagues all found that three-year-olds were unable to reliably use the *know* statement over the *think* statement, but that children four and over could. Falmagne *et al* (1994) tested third and sixth graders on four different variations of Harris's (1975) "truth questioning" task. These authors also found that development of these verbs was a process that continued through grade school and even after sixth grade. These studies suggest that children have difficulty computing quantity implicatures with these verbs, but this could be due to a variety of reasons that are independent from their understanding of the two verbs' (non-)factivity, for example: difficulties with computing implicatures in general, or with realizing when *know* should be a relevant alternative to *think*.

None of the above tasks was found to be possible for three-year-olds, but their inability to perform well on these tasks may be due not to their lack of understanding of the factivity of the verbs, but to extra-linguistic, task-related difficulties. Most of these tasks require children to make explicit judgments about the truth of a *know* sentence or its complement clause given a context (that is sometimes as impoverished as *Julie knows her horse is ill*). This is arguably difficult for naïve adult participants to do, let alone grade school children or preschoolers. Moreover, some of these tasks required children to answer definitional questions, which equates to giving truth conditions (a task that is most certainly difficult for naïve adults, let alone children). Furthermore, some of these tasks require participants to either explicitly or implicitly compare a *think* sentence with a *know* sentence (*e.g.:* Does John know that Mary's at the office or does John think that Mary's at the office?). This could be independently difficult for preschoolers for many reasons, not the least of which is that adult understanding of *know* logically implies *think* as well, and preschoolers might not have the pragmatic competence to

choose the more informative *know* statement as the "correct" one in cases where both statements are true (Grice 1975).

Furthermore, several of these authors suggest that an understanding of factivity and factive verbs continues to develop well into the grade school years. On a certain level, that seems to be an apt description of the developmental trajectory of these verbs; there are intricacies of their use that surely only adults could grasp. However, we should disentangle assessment of three-year-olds' basic understanding of factivity from a more sophisticated holistic understanding of the verbs. Several of these studies failed to assess that basic understanding for a combination of the following reasons: (i) their age ranges did not go as low as three years (Harris 1975, Macnamara *et al* 1976; Scoville & Gordon 1980; Falmagne *et al* 1994; Léger 2008); (ii) their tasks incorporated extraneous difficulties (Harris 1975; Johnson & Maratsos 1977; Abbeduto & Rosenberg 1985; Moore & Davidge 1989; Moore *et al* 1989); or (iii) their measures of success were too strict (Harris 1975; Scoville & Gordon 1980; Falmagne *et al* 1994).

3.3 Past studies on children's understanding of presuppositions

While the findings in this literature are mixed, there is some indication that children are aware of some presuppositions quite early. Despite this early awareness, children may not deploy their presuppositions in the full range of contexts that adults do. Berger & Höhle (2012) show that German children are aware of the presupposition associated with the focus particles *auch* 'also' and *nur* 'only'. Hamburger & Crain (1982) show that preschoolers' performance on relative clause interpretation is a function of the pragmatic use of relative clauses; children are able to succeed at interpreting object relatives only when relative clauses are used to distinguish two entities that are otherwise similar (e.g., the sheep that the lion bit vs. the sheep that the dog bit).

Syrett *et al* (2010) find that three-year-olds are aware of the uniqueness presupposition associated with *the*, and that they are able to use that information in an online task. Trueswell and colleagues show that children fail to use the discourse context in concert with the uniqueness presupposition of *the* in order to help them resolve a PP attachment ambiguity (Trueswell *et al* 1999), but that they are nonetheless able to use one structure when the discourse demands it (Hurewitz *et al* 2000). Together, these findings suggest an initial understanding of some presuppositional phenomena, but one that is emerging earlier than the literature on children's understanding of factive verbs would suggest.

4. Method

In order to assess three-year-olds' understanding of the factive and non-factive verbs *know* and *think* and the inferences that they license, we designed a simple task that allows them to demonstrate their knowledge without being hindered by difficulties orthogonal to their understanding of the verbs. We ask participants to find a toy hidden in one of two boxes (much like Moore & Davidge 1989 and Moore *et al* 1989) using clues in the form of attitude reports containing *think* and *know* (like Scoville & Gordon 1980). The participant's goal in our task is to uncover the location of the toy.

4.1 Subjects

Child participants were 40 three-year-olds (age range: 3;1 – 3;11 years;months, mean age: 3;6, 19 boys). All children were reported to be monolingual speakers of English by their parents and all were recruited from the University of Maryland Infant Studies Database.

Ten adults also participated. They were recruited from an undergraduate introductory linguistics course at University of Maryland and participated for course credit.

4.2 Design

Participants were seated in front of two boxes (one red and one blue). They were told that the experimenter would hide one toy in either of the boxes and their task was to find the toy, after the experimenter gave them a clue. Participants were also informed that a puppet (Lambchop) would be joining the game as well, but was too shy to do anything but whisper to the experimenter. An occluder kept participants from seeing where the experimenter hid toys and there was always a toy hidden in each box, despite what participants were told. This was done in order to avoid participants learning from negative evidence.

On each trial, the occluder would rise and the puppet would whisper in the experimenter's ear before the experimenter delivered a clue in the form of an attitude report (test sentence). Upon hearing the clue, participants were asked to demonstrate which box they thought the toy was in.

We manipulated two factors within subjects: verb-type (*think*, *know*) and negation-type (none, matrix, embedded). Accordingly children heard *think* and *know* sentences, with or without negation, as in the following table.

Figure 1: Test sentences by factor

Verb-type / Negation-type	Think	Know
None	Lambchop **thinks** that it's in the red/blue box (A)	Lambchop **knows** that it's in the red/blue box (B)
Matrix	Lambchop **doesn't think** that it's in the red/blue box (C)	Lambchop **doesn't know** that it's in the red/blue box (D)
Embedded	Lambchop **thinks** that it's **not** in the red/blue box (E)	Lambchop **knows** that it's **not** in the red/blue box (F)

Participants were given three trials for each of the sentence types in Figure 1, as well as three control trials with the test sentence *It's not in the red/blue box*. Responses were coded as selections of the box mentioned in the test sentence, or as selections of the other box.

Note that this task requires children to accommodate information that is not in the common ground. We decided that this way a necessary trade-off in order to better assess young children's knowledge, using a natural, non-metalinguistic task. However, this task may still underestimate their knowledge of presupposition. Even if children recognize *know*'s factivity, they may still have difficulty accommodating the presupposition that the complement clause is true in order to pick the mentioned box, as we discuss later.

4.3 Predictions

Based on the above discussion, there seem to be only three logical possibilities for children's understanding of these verbs that are consistent with the literature: (i) children understand the (non-)factivity of these verbs in a fully adult manner but previous tasks have obscured their performance; (ii) children lack the understanding that *know* is factive, thereby treating both verbs as non-factive; or (iii) children understand *know* in an adult manner but also treat *think* as a factive, which is why they tend to assume its complement is true.

These possibilities make the following predictions: If children are adult-like, they will only pick the mentioned box when they hear sentences like A, B and D. If children treat *know* as a non-factive, they should only pick the mentioned box when they hear A and B. If children treat *think* as factive, they should pick the mentioned box when they hear A, B, C and D. See Figure 2 for a summary of this discussion.

Figure 2: Summary of predictions

Hypothesis	Trials where mentioned box should be selected					
	No negation		Matrix negation		Embedded negation	
	Think (A)	Know (B)	Think (C)	Know (D)	Think (E)	Know (F)
1) children are adult-like *know* = factive *think* = non-factive	✔	✔	✖	✔	✖	✖
2) children have non-adult-like *know* *know* = non-factive *think* = non-factive	✔	✔	✖	✖	✖	✖
3) children have non-adult like *think* *know* = factive *think* = factive	✔	✔	✔	✔	✖	✖

As shown in Figure 2, the matrix negation trials will be the crucial ones for determining participants' understanding of the factivity of the two verbs.

5. Results

5.1 Control items

Control items were three trials with the following clue:

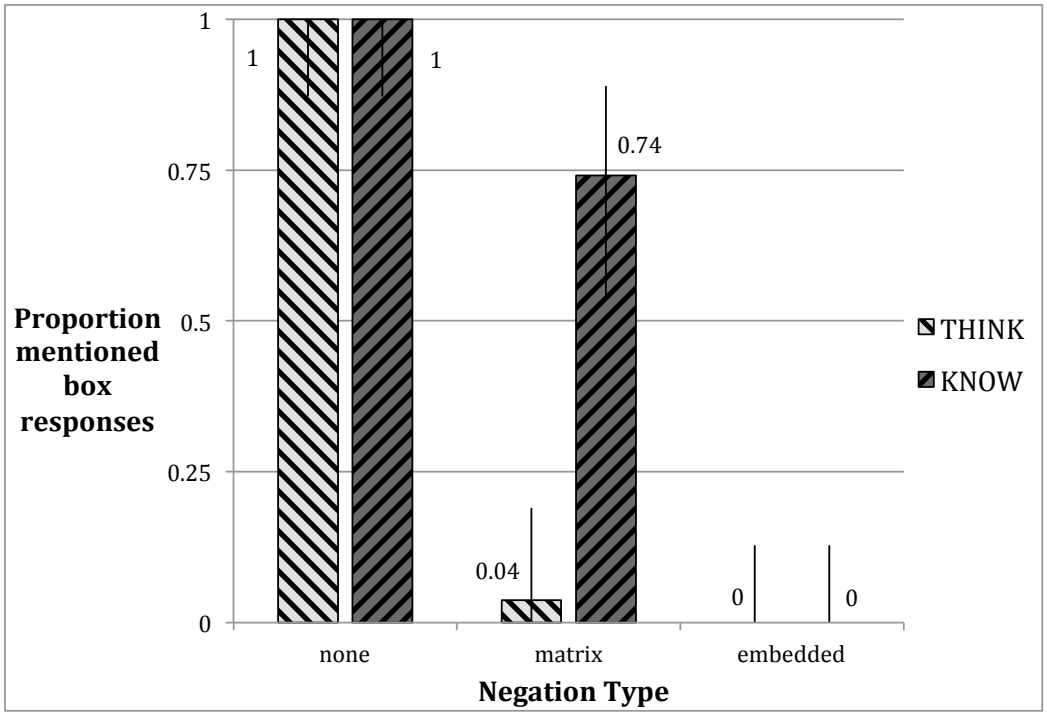
(11) It's not in the red/blue box

For these trials, participants needed to choose the other box (not the mentioned box) at least two out of three times in order to be included in the analyses. Nine out of the ten adult participants chose the other box on every trial. The tenth participant failed to choose the correct box on these trials, and has been excluded from analyses. Out of the 40 three-year-old participants, 9 of them failed the control items (by picking the other box only once or never), and were therefore excluded from analyses. Additionally, three child participants were excluded due to experimenter error, leaving a total of 28 children (age range: 3;1 – 3;11, mean age: 3;6, 12 boys).

5.2 Test items

Adult data (n=9) is given in Figure 3. Adults always chose the mentioned box for affirmative *think* sentences (A) and affirmative *know* sentences (B). They never chose the mentioned box on *think* sentences with embedded negation (E) and *know* sentences with embedded negation (F). Finally, adults chose the mentioned box on 4% of *think* trials with matrix negation (C) and 74% of *know* trials with matrix negation.[2]

Figure 3: Adult performance

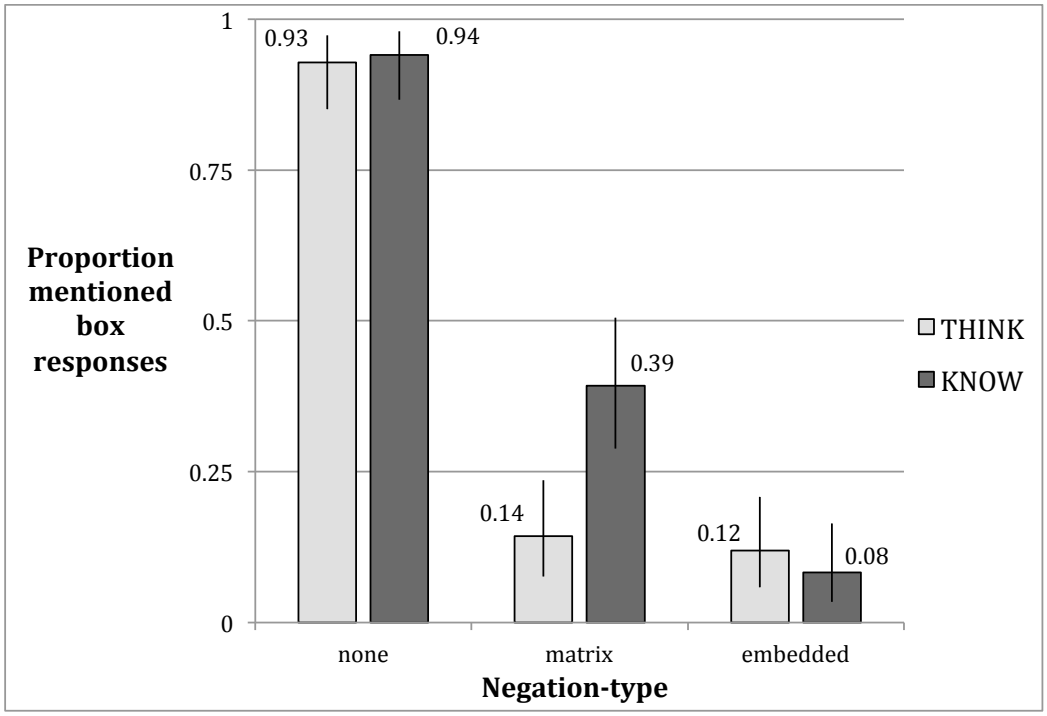


Child participants' performance (n=28) is given in Figure 4. Overall, children picked the mentioned box for affirmative *think* (A) and *know* (B) sentences. They picked the other box for *think* trials with matrix negation (C) and well as for both *think* sentences with embedded

[2] The 74% (instead of the expected 100%) in this condition comes from two participants who reported being unsure about sentences like (D) because they did not know "if the puppet wasn't aware it was in that box, or if it thought something else," otherwise performance was at 95% in this condition. We return to this in section 5.

negation (E) and *know* sentences with embedded negation (F). On *know* sentences with matrix negation (D), they picked the mentioned box about 40% of the time.

Figure 4: Three-year-olds' responses

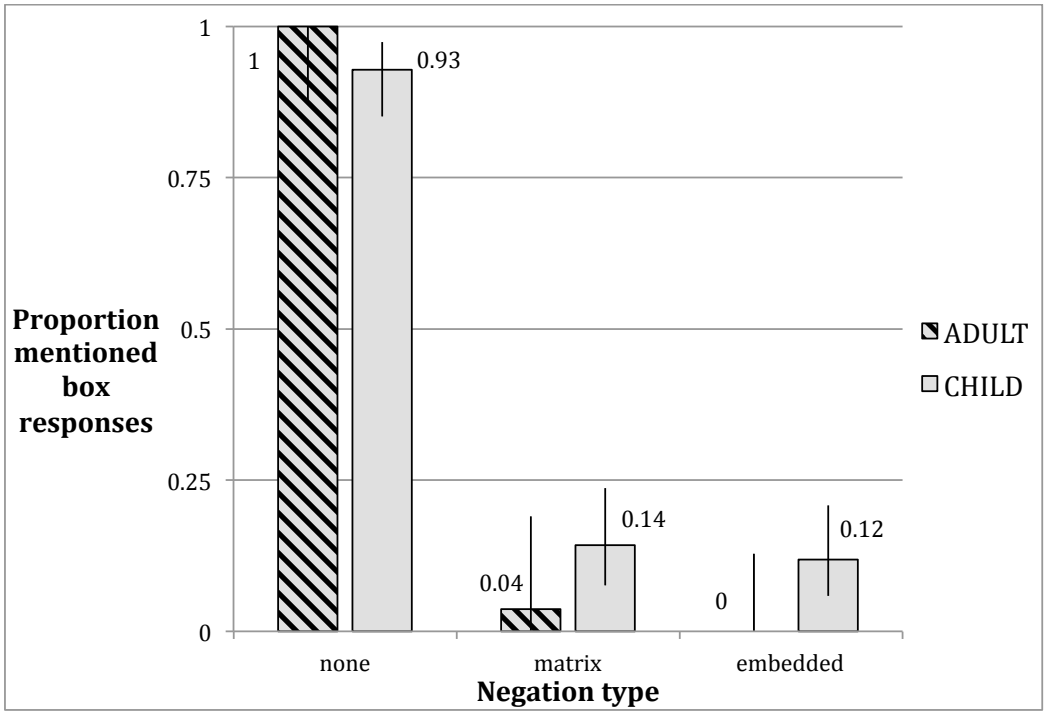


A 2x3 ANOVA revealed a significant main effect of verb-type ($F(1,21)=28, p<0.017$) and negation- type ($p<2.0e-16$) and a significant interaction between verb-type and negation-type ($p<.0072$). Planned comparisons revealed that children treat *think* sentences with matrix negation (C) differently from *know* sentences with matrix negation (D) ($p<.017$) and also that they treated *know* sentences with matrix negation (D) differently from *know* sentences with embedded negation (E) ($p<.0088$).

5.2.1 *Think*

All child participants performed completely adult-like on *think* trials; both child and adult participants picked the mentioned box for affirmative *think* sentences (A) but they pick the other box for both kinds of negative *think* sentences (C, E). See Figure 5 for a comparison of adults' and three-year-olds' performance on *think* trials.

Figure 5: Comparison of performance on *think* for adults and children



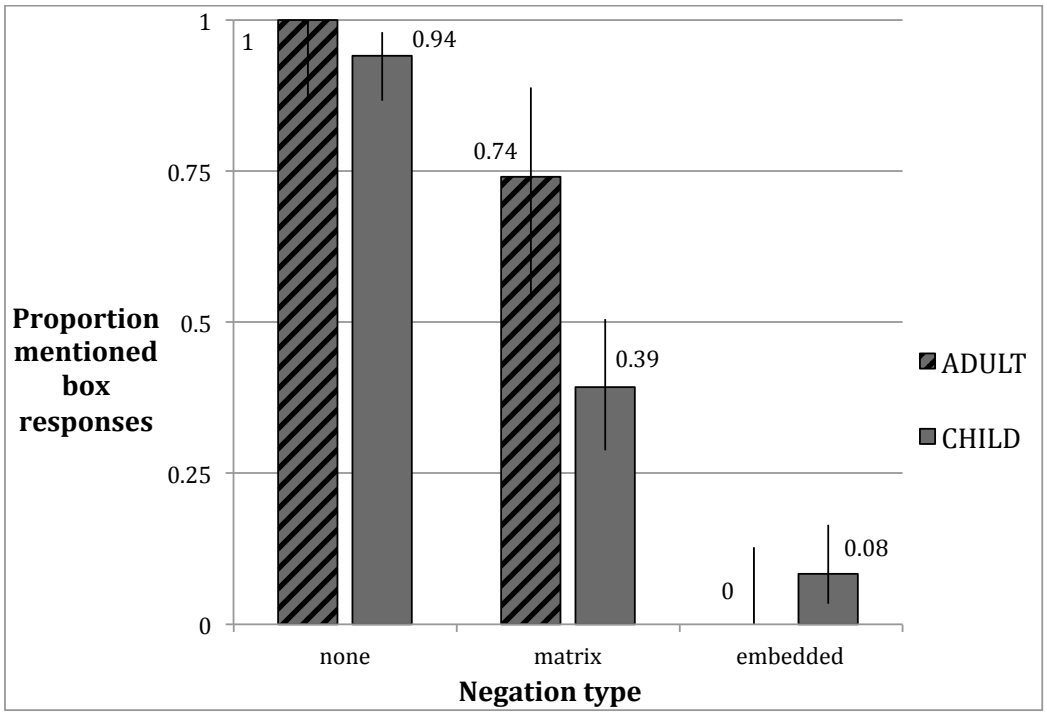
Note that the performance of both adults and children in this task is consistent with the assumption that Lambchop was a reliable source of information, and that neither adults nor children seemed to compute a quantity implicature from the use of "think p" in the context of "know p" and "p": they always picked the mentioned box with affirmative *think* sentences. Given previous results from the literature, we expect that children would do so, but we had no such expectation for adult participants because an adult-like understanding of sentences like

Lambchop thinks that it's in the blue box is consistent with the toy being in either the red or the blue box. We take the apparent lack of implicature computation in this task to be due to the "clue" status of the utterance: participants do not necessarily assume that the speaker is going to make her contribution as informative as possible, but that she will provide just enough information to help them guess the correct location of the toy.

5.2.2 *Know*

Children appear to perform like adults in some *know* conditions, but not others; they pick the same box as adults on *know* trials with no negation (B) or embedded negation (F), but not with matrix negation (D). See Figure 6 for a comparison of adults' and three-year-olds' performance on *know*.

Figure 6: Comparison of performance on *know* for adults and children



On matrix negation (D) trials, which is where their behavior differs, adults tend to pick the mentioned box (consistent with a factive interpretation), but three-year-olds only pick the mentioned box about 40% of the time. An examination of individual performance on this measure suggests that this 40% performance is not due to chance performance (e.g., if children did not know which box to pick, they would alternate between picking the mentioned box and the other box). If all three-year-olds were guessing on sentences like (D), we would expect to see children distributed normally around a mean accuracy of approximately 50%. However, children's performance on *know* sentences with matrix negation is distributed *bimodally*, and not normally around the mean, as it is in other conditions. There is a group that seems to perform below chance (consistent with a non-factive interpretation) and a group that seems to perform above chance (consistent with a factive interpretation). See Figure 7 for an individual measure of performance.

Figure 7: Individual accuracy on *know* with matrix negation for children

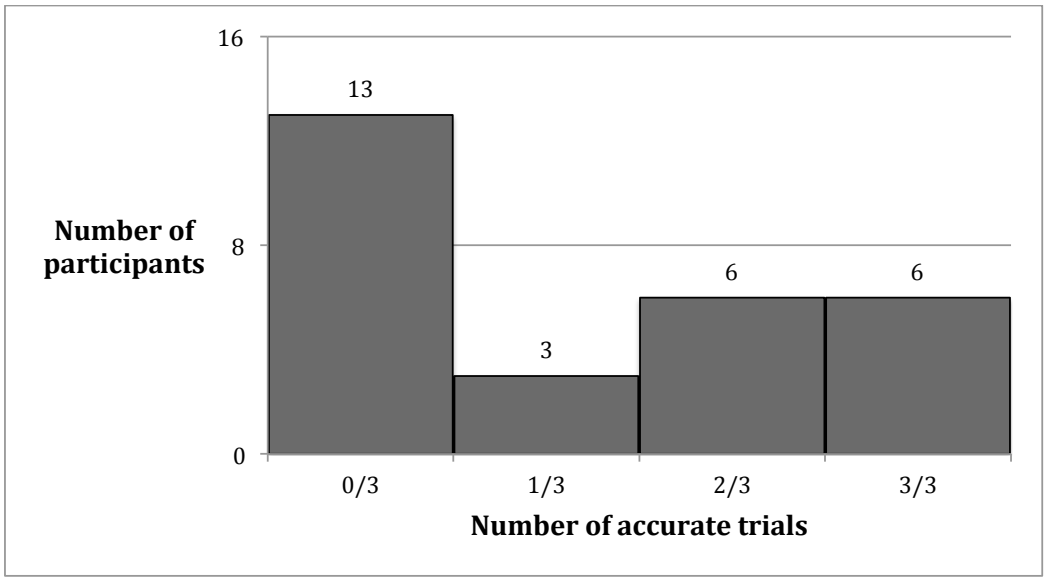


Figure 7 shows that 12 three-year-olds (43% of the group) picked the mentioned box, just like adults did, and 16 three year olds (57%) picked the other box.

6. Discussion

These results demonstrate that three-year-olds, as a group, differentiate the factive verb *know* from the non-factive verb *think*, based on their significantly different responses to *think* and *know* sentences with matrix negation. This finding conflicts with previous findings in the literature where three-year-olds tested on the distinction between these verbs systematically failed (Johnson & Maratsos 1977; Abbeduto & Rosenberg 1985), or were found to be at chance (Moore & Davidge 1989; Moore *et al* 1989). Unlike those studies, this one did not require participants to explicitly compare *think* and *know* sentences to decide which was a better description of the events, or to provide definitions of the verbs. Instead, this task required children to make choices in a game based on some linguistic stimuli. We believe that the metalinguistic nature of the previous tasks masked children's understanding of these verbs, and that our task was better able to assess their understanding.

Three-year-olds' high accuracy in all *think* conditions indicates that they have an adult-like understanding of *think*. Given their performance on the *think* sentences with matrix negation, we can conclude that three-year-olds, just like adults, understand *think* to be non-factive. When they hear sentences like (12), they do not infer that the toy is in the red box (which would be the expected outcome for a factive verb), but rather that the toy is in the blue box.

(12) Lambchop doesn't think [that it's in the red box]

These results would suggest that previous studies in which children failed to differentiate *know*

and *think* could be due to extra pragmatic processing associated with the metalinguistic nature of tasks.

These findings also suggest the need for a more sophisticated analysis of the developmental trajectory of verbs like *know* than was previous thought. Our results show that a factive understanding of *know* may emerge earlier than four years of age. Some three-year-olds (about 43%) consistently behave like they have an adult-like understanding of *know.* However, other three-year-olds (about 57%) reliably treat *know* exactly like they treat *think*, namely as if it were a non-factive verb. The apparent chance performance of three-year-olds in the matrix negation *know* sentences results from averaging the performance of the adult-like and non-adult-like children together. Therefore, past studies which found three-years-olds to be at chance in *know* conditions, like the studies by Moore and colleagues, might have yielded similar results if individual performance were measured.

To the extent that children's performance on our task is a direct reflection of their semantic representations for *know*, our data suggest that some children understand *know* to be factive by age three, but that others do not. It is, however, entirely possible that even this simplified task is still obscuring three-year-olds' performance and that the failure of some to behave as if they understand *know* to be factive derives from an additional factor masking their knowledge. There seem to be three possible explanations of certain children's failure to treat *know* as factive under matrix negation in this task, given below in (13-15).

(13) Semantic failure: These children have the wrong semantics for *know*. They understand *know* to be non-factive.

(14) Accommodation failure: These children have an adult-like semantics for *know.*

Their failure lies in their inability to accommodate the presupposition associated with *know*. Consider the processing demands to succeed on our task. Children hear clues in the absence of context. Upon hearing the sentence "Lambchop doesn't know that it's in the red box", they have to realize that the speaker used a factive verb, which presupposes the truth of its complement. They then have to infer from her use of 'know' that the speaker takes it for granted that the toy is in the red box. If the speaker takes it for granted that it's in the red box (and is in a good position to be justified in doing so, since she hid the toy), it must be that it is in the red box. Children should then choose the red box. It is possible that for some children, this inference process is too demanding. In effect, they would have all the right pieces but they would be unable put them together in this task.

(15) Task failure: Children's performance on this task is obscured by an experimental artifact. They do have the appropriate semantics and they are able to make the right inference. They merely fail to make the inference in this task for the same reason that an adult could fail to make the inference.

To illuminate the last possibility, we have to consider the design of the experiment. Recall that the puppet always whispered something to the experimenter, and after listening to the puppet, the experimenter gave the clue (e.g., Lambchop knows it's in the red box). Participants never heard what the puppet actually said. So, the participant may have made inferences not about the puppet's beliefs about the location of they toy, but instead about what the puppet said. One possibility is that the puppet uttered statements of the form "It's in the red box". The experimenter, who was aware of the actual location of the toy, would then report what the puppet knows or thinks based on what it said. However, it's also possible to imagine that the puppet

instead whispered statements such as "I think it's in the red box" or "I know it's not in the blue box", in which case, the experimenter would merely serve as translator for the shy puppet by reporting "She thinks it's in the red box" or "She knows it's not in the blue box." This conception of the interaction between the puppet and experimenter would lead to the expected "adult-like" behavior in every condition but the matrix negation *know* condition. In that case, the experimenter would be perceived to be relating the puppet's message: "I don't know that it's in the red box." But then the expected inference that the toy is in the red box would not be licensed. The only possible continuations of "I don't know that p" are "I don't know that p because p is not true," "I don't know that p because I know that q" or "I don't know that p because I don't have enough evidence." (An experiment in progress controls for this possibility by ensuring that the participants in the experiment know that the puppets statement was "it's in the …".) While this possible interpretation of the experimental materials may have affected some participants, most adults and at least half of the children however behaved in a way consistent with the experimenter being responsible for giving the clue, and not serving as a mere translator.

To sum up, the variability in children's performance on *know* could either be due to differences (i) in their representations of 'know': as a factive predicate for some, as a non-factive for others; (ii) in the demands of the inference process; or (iii) in their understanding of the experiment.

The first possibility raises interesting questions both about how factivity is encoded in the target (i.e., adult) representation of *know*, and about how children come to acquire it.[3] How do

[3] Note that the question might partly depend on the representational status of this presupposition in the adult grammar. The standard view is that *know p* asserts that the subject believes p, and presupposes that p is true. Alternatively, it could be that *know* is veridical; it entails that p is true and pragmatically (instead of lexically) presupposes p (cf. Stalnaker 1978; Abusch 2002; Simons 2001).

learners determine that that *think* and *know* are different, and specifically that *know* is factive and *think* is not (which half of our three-year-olds seem to have already done)? What gives away the difference between the verbs? What gives away *know*'s factivity?

There are two possible sources of evidence that children might use to infer the meaning of novel words: the conversational context in which these words are used, and the linguistic environment in which they appear. As for the former, perhaps children can glean some meaning differences from the context in which verbs like *think* and *know* are used? Take the sentence '*x thinks that p*'. In contexts in which the speaker could have uttered '*x knows that p*', or simply *p*, but used '*x thinks that p'* instead, we, as Gricean adults, might infer that the speaker does not in fact endorse *p*. Could it be that children pick up on this, and somehow use it figure out the difference between *know* and *think*? They might reason that *think* is used when speakers want to indicate uncertainty, and use *know* when they want to indicate certainty: this, they might reason, must mean that *know* lexically encodes full certainty or 'knowledge'. We believe that this scenario is actually quite unlikely (at least for our successful three-year-olds). The literature on children's understanding of *think* shows that independently of their understanding of *know*, children overwhelmingly tend to assume that *p* is true whenever they hear *'x thinks that p*', even at age four (Lewis *et al*. 2012). If speakers truly and frequently use *think* to distance themselves from the truth of the complement, and use *know* to endorse it, children are not picking up on this, at least not by age 3 or 4. Moreover, this theory would entail that acquisition of both *think* and *know* is dependent on acquisition of the other, and that learners keep track not just of the interpretations that they assign to sentences but also to the pragmatic conditions that led them to make their interpretive decisions.

Perhaps then what gives away the difference in meaning between *think* and *know* is the

syntactic environment in which these verbs appear. Syntactic bootstrapping, or learning about the meaning of a novel verb via its syntactic frames, occurs in conjunction with learning by observation and relies on systematic relationships between syntactic and semantic properties (Landau & Gleitman 1985; Gleitman 1990; Pinker 1989; Lidz 2006; a. o.). Developmental work on verb learning shows that syntactic bootstrapping is a viable option for simple verbs or verbs that span across broad semantic classes (Naigles 1990; Fisher *et al* 2010; a. o.). Using syntactic cues to learn meaning differences between various attitude verbs that are impossibly difficult to figure out from direct observation should be particularly useful, though syntactic bootstrapping studies for attitude verbs are still inconclusive (cf. Asplin 2002).

The theoretical literature on attitude verbs shows that there are systematic relationships between the syntactic properties of biclausal sentences and the semantic classes of attitude verbs generally (Bolinger 1968; Hooper 1975; Stowell 1981; Pesetsky 1992; Grimshaw 1990; a.o.). As for *think* vs. *know* in particular, some authors have shown that there is a correlation between a predicate's factivity and its ability to take both declarative and interrogative complements (cf. Karttunen 1977; Hintikka 1977; Ginzburg 1995; Egre 2007; a.o.). Assuming that the link is principled, and that question-embedding is a reliable cue to factivity, it could be that hearing *know* sentences with interrogative complements provides evidence that it is factive. Under this view we would then want to ask: Why is it that some children have not arrived at the right meaning for *know* when others have? It's possible that the answer to this question boils down to the quantity and quality of input that children hear with respect to *know* and *think*. Some children may not have heard enough sentences of the right type to decide for sure that *know* is factive and *think* isn't. While we do not yet have a good idea of the quality and distribution of *know* and *think* in the input, a principled investigation is now underway.

7. Conclusion

Our data suggest that some children might begin to understand *know* in an adult-like way at an earlier age than the literature has indicated. The behavior of roughly half of our child participants is consistent with an adult-like understanding of *know*. The other half, however, do not distinguish *think* and *know*, even under negation, effectively treating neither one as factive. Thus some children distinguish *think* and *know* before age 4, even when they still assume (by default) that *think* sentences report true beliefs. Moreover, we find no evidence that children build a factive representation for *think*. Still, our results suggest that children's early representations of *know* may be non-factive and raise the question of how children come to recognize that *know* is factive and *think* is not.

These results also have impacts outside of the literature on children's understanding of factivity. Our results, taken in concert with those of Lewis and colleagues, allow us to rule out the possibilities that children's difficulties with *think* are (i) conceptual, (ii) a result of ignoring the matrix verb, or (iii) due to a factive understanding of *think*. Instead, we can conclude that children's difficulties are pragmatic in nature. Additionally, there are implications for work on children's theory of mind. It is a longstanding puzzle that infants seem to track other people's knowledge states but that explicit measures with preschoolers seem to find no evidence of this capacity. The fact that roughly half of our three-year-olds successfully treated *know* as factive suggests that there is more continuity between infants and preschoolers than the explicit measures indicate because it shows preschoolers can be sensitive to their interlocutors' knowledge and belief states in a linguistic task. Finally, these results help to refine the boundary between the pragmatic phenomena that children are good at and those that they are bad at.

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