LANGUAGE ACQUISITION
2017, VOL. 24, NO. 4, 343–360
https://doi.org/10.1080/10489223.2017.1366207

Routledge
Taylor & Francis Group

Children's exhaustive readings of questions

Alexandre Cremers, Lyn Tieu, and Emmanuel Chemla

Ecole Normale Supérieure

ABSTRACT

Questions, just like plain declarative sentences, can give rise to multiple interpretations. As discussed by Spector & Egré (2015), among others, questions embedded under *know* are ambiguous between *weakly exhaustive* (WE), *intermediate exhaustive* (IE), and *strongly exhaustive* (SE) interpretations (for experimental evidence of this ambiguity, see Cremers & Chemla 2016). These three interpretations are related in terms of strength. The SE reading entails both the IE and WE readings, and the IE reading entails the WE reading. Certain proposals derive the stronger readings from weaker ones through the same process of enrichment that underlies scalar implicatures, in particular through comparison with alternatives (Klinedinst & Rothschild 2011). Given previous developmental studies of scalar implicatures that suggest children typically perform this enrichment less often than adults do (Noveck 2001; Chierchia et al. 2001; Papafragou & Musolino 2003, among many others), such proposals lead us to expect that children may initially prefer weak readings of embedded questions. The present study revealed that 5-year-olds were sensitive to the multiple readings of questions embedded under *savoir* 'know.' Compared to adults, however, children were more tolerant of weak readings. These findings relate scalar implicatures and exhaustive readings of embedded questions from a developmental perspective and are consistent with a close connection between the two: in both cases, children are sensitive to the various possible interpretations but favor the weaker one more than adults do.

ARTICLE HISTORY
Received 30 April 2015
Accepted 14 January 2016

1. Introduction

1.1. *Strengthened interpretations in child language*

The question of how the child learner arrives at adult-like interpretations for sentences that allow for multiple interpretations in different contexts has been the focus of many developmental studies. Such studies, which document the meanings that children assign to different structures and how these may differ from those of adults, are insightful because they allow us to better understand the developmental path children may take towards the adult linguistic system, and ultimately inform us about the components of this mature system itself (one such example corresponds to the vast literature on scope ambiguity, e.g., Musolino 1998; Musolino, Crain & Thornton 2000; Musolino & Lidz 2003, 2006; Gualmini 2004; Gualmini & Crain 2005; Miller & Schmitt 2004; Gualmini et al. 2008; Conroy, Lidz & Musolino 2009; Zhou & Crain 2009; Notley et al. 2012; Crain et al. 2013).

One highly productive line of research in the developmental literature has highlighted differences between children's and adults' rates of derivation of *scalar implicatures*, such as the one that arises in (1) (Noveck 2001; Chierchia et al. 2001; Gualmini et al. 2001; Papafragou & Musolino 2003; Barner, Brooks & Bale 2011; Katsos & Bishop 2011, among many others).

CONTACT Alexandre Cremers alexandre.cremers@gmail.com Ecole Normale Superieure, Laboratoire de Sciences Cognitives et Psycholinguistique, Paris, France.

Color versions of one or more of the figures in the article can be found online at www.tandfonline.com/hlac.
Cremers and Tieu contributed equally to this work and share joint first-authorship.

(1) Some of the horses jumped over the fence.
  a. Some or all of the horses jumped over the fence.
  b. Some but not all of the horses jumped over the fence.

Scalar implicatures arise as the result of taking into account alternative phrases that could have been uttered but were not. Assuming the speaker is being as informative as she can (Grice 1975), the fact that the speaker uttered the assertion containing *some* (1) and not the stronger alternative containing *all* (i.e., *All of the horses jumped over the fence*), can lead us to conclude that the stronger alternative must be false (for modern versions see, e.g., van Rooij & Schulz 2004; Sauerland 2004; Spector 2007; Franke 2011).

Alternatively, one may capture the strengthened meaning in (1b) through the application of a grammaticalized exhaustification operator EXH, which would be roughly equivalent to a silent *only* (Fox 2007, Chierchia, Fox & Spector 2011), as schematized in (2).

(2) EXH(Some of the horses jumped over the fence) =
  Some of the horses jumped over the fence and NOT(all of the horses jumped over the fence)

Although this is a topic that has generated massive interest, we would like to make it clear from the outset that our study will not address the debate between neo-Gricean and grammatical approaches to scalar implicatures. Instead, we will be interested in whether acquisition studies can help to determine whether scalar implicatures are related to another phenomenon, namely the interpretations of embedded questions. We will therefore abstract as much as possible away from the differences between the alternative perspectives on the two phenomena. For convenience, we may use the more flexible EXH notation from the grammatical approach (which can also be taken as a proxy for a neo-Gricean post-semantic operation, as in original approaches à la Groenendijk & Stokhof 1982 or van Rooij & Schulz 2004).[1] We remain noncommittal, however, and the presentational choices that our notation implies should be translatable from one framework to another without affecting our main conclusions.

With this in mind, let us return to the situation in the context of the *acquisition* of scalar implicatures. Although there is some hetereogeneity across previous studies, a generally robust finding has been that children compute fewer implicatures than adults. While there is an extensive literature characterizing children's performance on different kinds of scalar implicatures (e.g., involving the scalar quantifiers *some/all*, the modals *may/must*, connectives *or/and*, numerals, etc.), there have only been a handful of detailed proposals for why children might differ from adults, and perhaps more importantly, how they might eventually arrive at an adult-like ability to compute enriched meanings.

Katsos & Bishop (2011), for example, propose that children are more pragmatically tolerant than adults. On their proposal, children are sensitive to the difference between weak and strong forms and are competent with informativeness. Where they differ from adults lies in the degree to which they are tolerant of pragmatic infelicity. An alternative proposal attributes children's failures to compute scalar implicatures to a difficulty accessing the required alternatives. For example, to compute the strengthened meaning of (1), i.e. (1b), children must be able to access the lexical item *all* as a stronger alternative to *some* (for relevant discussion, see Gualmini et al. 2001; Chierchia et al. 2001; Reinhart 2006; Barner, Brooks & Bale 2011; Tieu et al. 2016; Singh et al. 2016). This line of proposals derives in part from the observation that children tend to perform more on a par with adults once the relevant scalar alternatives are made explicit.

The issues that arise in the developmental study of scalar implicatures are far from resolved, and much work remains to be done in terms of fully working out the predictions and consequences of

[1]We may also talk about *ambiguity*, which should not be understood as representing any particular bias in favor of a grammatical perspective, despite the term being more commonly used in the context of lexical, syntactic, or semantic ambiguity, than in pragmatic or neo-Gricean terms. We also use the term *reading*, which is the dominant terminology in the literature on embedded questions, but the reader may replace it with *interpretation* if it creates difficulties.

existing proposals. Here we will capitalize on the empirical findings on the topic and use them to conduct a parallel investigation of a phenomenon that has been proposed in the theoretical literature to be related to implicature. The multiple interpretations of embedded questions, to be introduced in the next section, have not been addressed in any previous studies of language acquisition. Given recent theoretical proposals concerning a connection between these questions and scalar implicatures, a developmental study will provide a useful complement to the existing developmental literature on scalar implicatures and may ultimately be informative about how these phenomena should be analyzed in both child and adult language.

1.2. *The different interpretations of embedded questions*

Like the scalar implicature example in the previous section, questions also give rise to multiple readings. And just as in the case of scalar implicature, studying the comprehension of such structures can shed light on key differences between the child learner and the adult. Let us introduce the various possible interpretations on the basis of example (3), which contains a *wh*-question (i.e., *which toys are in the box*) embedded under the attitude predicate *know*. Questions such as (3) have been claimed to potentially have at least three interpretations: a *weakly exhaustive* reading (WE), an *intermediate exhaustive* reading (IE), and a *strongly exhaustive* reading (SE). These readings are logically related: The SE reading entails the IE reading, which in turn entails the WE reading.

(3) Jack knows which toys are in the box.
   a. *Weakly exhaustive (WE) reading*:
   For each toy in the box, Jack knows that it is in the box.
   b. *Intermediate exhaustive* (*IE*) *reading*:
   For each toy in the box, Jack knows that it is in the box,
   and Jack does not have false beliefs about toys that are not in the box.
   c. *Strongly exhaustive* (*SE*) *reading*:
   For each toy in the box, Jack knows that it is in the box,
   and he knows that no other toys are in the box.

Concretely, consider a situation in which there are toy trains and building blocks in the box and toy boats on the floor. For the WE reading in (3a) to be true, all that is required is that Jack have true beliefs about the toys that are in the box, namely the trains and the blocks. It may be the case that Jack mistakenly believes that the boats are also in the box. The WE reading nevertheless comes out true. For the IE reading in (3b) to be true, we require not only that Jack have true beliefs about the toys that are in the box, i.e., the trains and the blocks, but that he furthermore have no false beliefs about toys that are not in the box, i.e., the boats. It may be the case that Jack has no idea where the boats are. The IE reading would nevertheless come out true. Finally, for the SE reading in (3c) to be true, we require that Jack have complete exhaustive knowledge about the toys that are in the box. In other words, Jack must correctly believe that the trains and blocks are the only toys in the box.

1.2.1. *Theoretical background*

The availability and distribution of the WE and SE readings have been the subject of extensive debate in the theoretical linguistics literature. On the one hand, Groenendijk & Stokhof (1984) and George (2011) treat the SE reading as basic and do not derive any weaker readings. On the other hand, Heim (1994), Beck & Rullmann (1999), Sharvit (2002), and Guerzoni (2007) treat the WE reading as basic and derive the SE reading with a strengthening mechanism. Spector (2005) reintroduces the IE reading (which was quickly discussed in Groenendijk & Stokhof 1982 and Preuss 2001), reviving the debate over exhaustive readings. More recently, Cremers & Chemla (2016) provide experimental evidence for the existence of this IE reading. Only recent theories are able to derive the IE reading. These can be split between theories in the tradition of Heim (1994), which treat the WE reading as

(4) a *WE reading*
⟦Jack knows which toys are in the box⟧ =
Jack knows that $x_1, x_2 \ldots$ are in the box (for all x that are actually in the box).

b. *IE reading*
⟦EXH(Jack knows which toys are in the box)⟧ =
Jack knows that $x_1, x_2 \ldots$ are in the box (for all x that are actually in the box),
and NOT(Jack believes that y_1 is in the box),
and NOT(Jack believes that y_2 is in the box)… (for all y that are *not* in the box)

c. *SE reading*
⟦Jack knows EXH(which toys are in the box)⟧ =
Jack knows that…
$x_1, x_2 \ldots$ are in the box (for all x that are actually in the box),
and not(y_1 is in the box),
and not(y_2 is in the box)… (for all y that are *not* in the box)

basic and derive IE and SE readings from it (Klinedinst & Rothschild 2011; Uegaki 2015), and theories that treat IE and SE readings on a par and do not derive the WE reading at all (Roelofsen, Theiler & Aloni 2014; Spector & Egré 2015).

1.2.2. *A concrete implementation*

Most relevant for our purposes is Klinedinst & Rothschild's (2011) proposal (and those that follow it), which treats WE readings as primitive, following Heim (1994). This proposal derives stronger readings through an enrichment process directly imported from theories of scalar implicatures. Let us briefly sketch one such way of deriving the interpretations in (3) (for details, see Klinedinst & Rothschild 2011 and Uegaki 2015).

First, we can take the denotation of a question such as *Which toys are in the box* to correspond to the set of propositions of the form "x is in the box" where x is a toy. Next, we must combine the denotation of our question with the semantics of the verb *know*. We can assume that "knowing Q" is equivalent to knowing the conjunction of all true members of Q (Karttunen 1977; Berman 1991; Heim 1994). Take our example previous, where the set of possible answers to Q (*Which toys are in the box*) corresponds to {The trains are in the box, The blocks are in the box, The boats are in the box}.[2]

Only the first two propositions are true in our toy scenario. Knowing *which toys are in the box* thus amounts to knowing the conjunction of the two propositions *The trains are in the box* and *The blocks are in the box*. In other words, on the WE reading, Jack knows which toys are in the box by knowing that the trains and the blocks are in the box.

Treating the WE reading as basic, we can show that with an appropriate choice of alternatives, the IE and SE readings can be derived just like scalar implicatures. First, we can assume that the alternatives for *know* are obtained from the scale {*know, believe*} (as discussed in the literature on a so-called anti-presupposition of *believe*, e.g., Percus 2006; Sauerland 2008), and second, that the alternatives of *Which toys are in the box* correspond to the set of all propositions "x is in the box," true or false. Simplifying over Klinedinst & Rothschild (2011), we show how the IE and SE readings can be obtained through the application of an exhaustivity operator at different positions in the structure. The WE reading in (3a) is primitive and is derived compositionally through the combination of the semantics of *know* and the denotation for the embedded wh-question (4a). The IE reading is obtained by adding to the WE meaning the negation of all the alternatives of the form "Jack believes that y is in the box", where y is a toy that is *not* in the box (4b). The SE

[2]Strictly speaking, our definition requires that the alternatives be of the form "x is in the box," where x is some individual toy, e.g., the blue toy train on the carpet. For simplicity, however, we lump together toys of the same type, e.g., toy trains. This move does not affect the proposal in any relevant way, as long as the predicate has the same value for all toy trains (e.g., they are all in the box or all out of the box). This will also make it easier to carry over the examples described here to the experimental conditions described in Section 2.1.3.

reading is obtained by enriching the embedded part "x_1, x_2… are in the box" with the negation of the alternatives "y is in the box", and then composing this with the embedding verb, as illustrated in (4c).[3]

1.2.3. *Summary*

What is relevant for our purposes is that stronger interpretations of questions can be seen as the result of applying the strengthening mechanisms involved in classical scalar implicatures (independently of the semantic or pragmatic nature of these mechanisms). Given previous findings that children access strengthened meanings less often than adults do in the case of scalar implicatures, proposals like Klinedinst & Rothschild (2011) and Uegaki (2015) lead us to expect that children may initially display a preference for the WE reading in the case of (3), just as they prefer a weak reading in the case of (1). The predictions of competing theories of questions such as Theiler (2014), Roelofsen, Theiler & Aloni (2014), and Spector & Egré (2015), on the other hand, are very different. First, these theories do not derive the WE reading at all, so children are certainly not expected to access it. Second, these theories treat the availability of different interpretations as a choice between different lexical rules and operators and therefore do not offer predictions as to which readings should be preferred or more difficult for children.

In the next section, we describe an experiment designed to investigate children's comprehension of embedded questions such as (3).

2. Experiment

2.1. *Method*

Our experiment was conducted in French, but the materials will be described here in English. The original French materials can be found in the appendix.

2.1.1. *Participants*

We tested 35 French-speaking children (19 female) between the ages of 4;03 and 6;04 (mean age 5;08) in the ENS-LSCP Babylab and at a local preschool in Paris. All child participants were acquiring French as a first language. We also tested 23 adult native speakers of French using a web-based version of the experiment, which included all the same materials that children saw. Adult participants were recruited through the online platform FouleFactory and were paid € 2.50 for participating.

2.1.2. *Procedure*

We designed a question-answer task involving a puppet named Zap. Participants were introduced to Zap and told that they would play a game with him on the computer. Prerecorded videos of Zap's utterances created the ruse that he was participating live via webcam. Participants saw a series of cartoon images on a laptop computer. Each image contained two sets of objects on the screen: for example, a set of toy trucks and a set of toy boats. Participants were told that Zap too could see the image. Zap was then instructed to put on a blindfold, so that he could no longer see the image (see Figure 1). He was then asked to recall where each of the sets of objects was in the picture, e.g.,

[3]As we mentioned, the presentation is framed using an EXH operator. For questions, it is also the case that dominant theories are phrased in these terms, partly for reasons of notational convenience but also for nontrivial reasons: As the reader may have noted, to derive the SE reading, EXH appears in an embedded position; the possibility of embedding is often seen as the hallmark of the grammatical nature of such a strengthening operation. As in more standard cases of seemingly embedded scalar implicatures, however, alternative ways of deriving this reading have been proposed. For instance, one might posit global exhaustification, complemented by further epistemic reasoning about the resulting interpretation. For details along these lines regarding standard cases of scalar implicatures, we refer the reader to Russell (2006) or Spector (2006). A natural candidate for the implementation of similar ideas in the domain of questions can be found in Uegaki's (2015) theory, which proposes to derive the SE reading from the IE reading through further pragmatic reasoning (but see also difficulties mentioned therein for a plain neo-Gricean interpretation and implementation of this work). Abstracting away from these details, recall that our interest here lies in the comparison between scalar implicatures and exhaustive readings of embedded questions from the perspective of acquisition, and this issue is to a large extent independent of the particular implementation of the proposed underlying strengthening mechanism, as long as the components of this implementation can be translated from one domain to the other.

Figure 1. Zap the puppet.

through the prompts, *Where are the trucks, Zap? Where are the boats, Zap?* Children were asked to repeat each of the puppet's answers, to ensure that they had correctly heard and understood the puppet's utterances and could recall where the puppet thought each of the sets of objects was. At the end of each trial, the participant was asked a question about Zap's knowledge, given what he had reported in the two previous sentences: e.g., *Does Zap know which toys are in the box?* Children received a scorecard booklet, in which they had to place a rubber stamp in colored boxes based on their responses to the final question (Figure 2), i.e., yellow for *yes* and blue for *no*.[4]

All children were tested individually in a quiet room away from their peers. Their responses were videorecorded for later analysis. Adult control participants were tested on the same materials but through a web-based version of the task. Importantly, adults saw the same pictures and videos of the puppet as the children did, in the same order. Instead of providing oral responses and stamping on a scorecard, however, adults provided their responses by clicking on appropriate *yes*/*no* buttons.

2.1.3. *Materials*

There were six conditions in total. Each participant saw three trials per condition, for a total of 18 experimental trials, presented in one of two pseudorandomized orders. These 18 trials were preceded

Figure 2. Children's scorecards.

[4]We chose two neutral colors rather than, for example, a checkmark and an X or a happy face and a sad face. This was to encourage the child to evaluate the puppet's knowledge objectively, without any interfering desires to punish or reward the puppet. For example, we did not want the child to associate a *yes*-response to the critical question with good performance on the part of the puppet or conversely a *no*-response with poor performance on the part of the puppet.

by two training items: On one practice trial, the puppet uttered an obviously true belief, and on the second, the puppet uttered an obviously false belief. The purpose of the practice trials was to show that the puppet was capable of uttering both true and false statements and more generally to familiarize the participants with the task.

WH test conditions. There were four test conditions involving an embedded *wh*-question such as *Does Zap know which toys are in the box?* As described in (5), these conditions varied in which exhaustive readings (WE, IE, SE) were made true. Figure 3 provides an example test image. Table 1 contains the corresponding puppet statements in relation to this test image, as well as the expected responses on each reading, for each condition.

(5) WH test conditions
   a. **Baseline ∅ condition**
   Zap was wrong about the location of both sets of objects. All participants were expected to provide *no*-responses in this condition.
   b. **WE condition**
   Zap knew the location of the first set of objects but was wrong about the location of the second set, compatible with a WE reading only.
   c. **WE+IE condition**
   Zap knew the location of the first set of objects but did not know about the location of the second set. Crucially, he had no false beliefs about the second set of objects. This condition was compatible with the WE and IE readings but not with the SE reading.
   d. **WE+IE+SE condition**
   Zap knew where both sets of objects were; thus all readings were made true. All participants were expected to provide *yes*-responses in this condition.

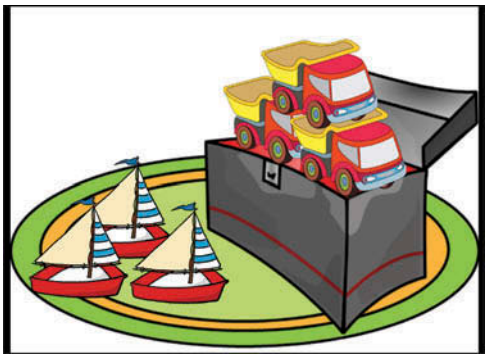


Figure 3. Image accompanying the test question *Does Zap know which toys are in the box?*

Table 1. WH Conditions: Table displays puppet's statements for each Condition (in relation to Figure 3), along with expected responses on each Interpretation.

Condition	Puppet's Statements	WE	IE	SE
∅	The trucks are on the carpet. The boats are in the box.	*no*	*no*	*no*
WE	The trucks are in the box. The boats are also in the box.	*yes*	*no*	*no*
WE+IE	The trucks are in the box. The boats, I don't know.	*yes*	*yes*	*no*
WE+IE+SE	The trucks are in the box. The boats are on the carpet.	*yes*	*yes*	*yes*

In short, participants' responses would indicate the strength of their exhaustive readings of the embedded *wh*-questions: Depending on the readings accessed, a participant would provide *yes*-responses to a different subset of the ordered conditions.[5]

"Know-that" control conditions. Given that there were always two sets of objects in each picture, we wanted to ensure that children were indeed responding to the critical *wh*-questions on the basis of Zap's beliefs about *both* sets of objects. For example, if children rejected WE and WE+IE targets, this might be because they were accessing a stronger reading. However, we wanted to rule out the additional possibility that children might reject as soon as the puppet said something incorrect (as in the WE trials) or explicitly said, "I don't know" (as in the WE+IE) trials. Relatedly, we wanted to rule out the possibility that children might reject based only on Zap's beliefs about the second (most recent) set mentioned e.g., the boats in the previous example.

Conversely, if children accepted WE and WE+IE targets, we wanted to ensure that it was not simply because they were basing their responses only on the puppet's first statement (which always corresponded to a true belief) or were simpy responding "yes" as soon as the puppet uttered at least one correct statement.

To address these concerns, we always had children repeat each of the puppet's statements. Additionally, we included two "*know-that*" control conditions, which were similar to the test conditions except that the final question specifically targeted one of the sets of objects, e.g., *Does Zap know that the trucks are in the box?* or *Does Zap know that the boats are on the carpet?* These were designed to ensure that children were not basing their responses to the embedded *wh*-questions on only one of the sets of objects. The controls were therefore selected on the basis of children's responses to the critical test trials: WE "*know-that*"-controls followed WE test trials, and WE+IE "*know-that*"- controls followed WE+IE test trials.

For example, a child who heard the puppet's statements in (6a) or (6b) and who responded *no* to the question in (6c) would see a corresponding "*know-that*" control trial like (7), targeting the first set of objects mentioned (7c) (*yes*-target). A child who responded *yes* in response to (6c), however, would receive the question in (7d), targeting the second set of objects mentioned (*no*-target).

(6) a. "The trucks are in the box. The boats are also in the box." (*WE*)
b. "The trucks are in the box. The boats, I don't know." (*WE+IE*)
c. EXPERIMENTER: Does Zap know which toys are in the box?

(7) a. "The bumblebees are on the leaf. The ladybugs are also on the leaf." (*WE*)
b. "The bumblebees are on the leaf. The ladybugs, I don't know." (*WE+IE*)
c. EXPERIMENTER: Does Zap know that the bumblebees are on the leaf? (target: *yes*)
d. EXPERIMENTER: Does Zap know that the ladybugs are on the branch? (target: *no*)

Participants saw a total of three WE "*know-that*" control trials (each following one of the three WE test trials) and three WE+IE "*know-that*" control trials (each following one of the three WE+IE test trials). Because the control trials were selected dynamically based on responses to critical trials, they also allowed us to maintain an overall balance of *yes* and *no* responses for each participant.

[5]An anonymous reviewer points out that the elliptical "I don't know" in the WE+IE condition could have given rise to alternative interpretations, such as "I don't know whether the boats are in the box (or not)" or "I don't know whether the boats are in the box or on the carpet," as opposed to "I don't know where the boats are." Note, however, that the "I don't know" was always uttered in response to a specific question, e.g., "Where are the boats?" such that proper ellipsis resolution should force the interpretation, "I don't know where the boats are." Note furthermore that even if a child for some reason accessed one of the alternative interpretations raised by the reviewer, this would not pose a problem in our experiment because of the way we set up the contexts. In all cases, there were only two salient locations available, e.g., in the box or on the carpet, and so the relevant interpretations come out equivalent in response to the general question "Where are the boats?"

2.2. *Results*

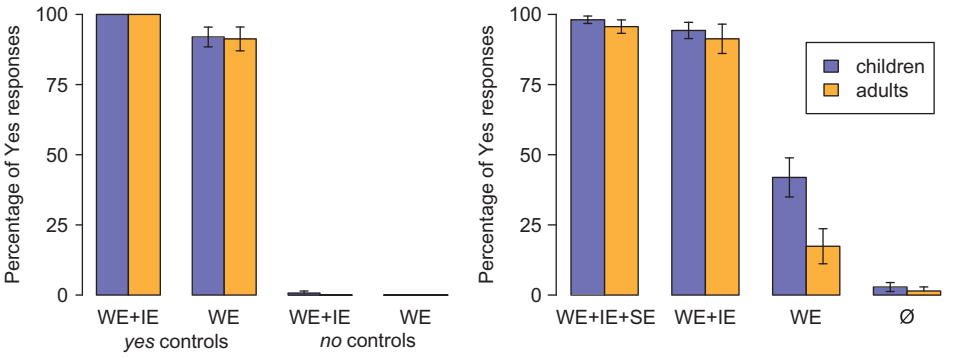
2.2.1. *Control conditions*

Children and adults performed as expected on ∅, WE+IE+SE, and "*know-that*" control trials. Participants had to pass at least five out of the six "*know-that*" control trials in order to be included in the analysis. All participants passed, and consequently no participants were excluded from analysis. The percentage of *yes*-responses on the "*know-that*" control conditions are reported in Figure 4a. Performance on controls was near perfect, though participants provided fewer *yes*-responses to WE controls where the target was *yes* (χ^2-test on the distribution of errors: $\chi^2(3) = 20$, $p < .001$). This may suggest that participants found it more difficult to answer *yes* when one of the puppet's statements was false. Note that this could be expected to have biased these participants towards IE and SE readings on the test trials. Importantly, however, we did not observe any difference between children and adults on the controls.

Children's accuracy on the control conditions indicates not only that they were able to pay attention to, understand, and answer questions targeting Zap's knowledge about specific sets of objects. It also suggests that they were not responding to the critical test questions solely on the basis of one of the sets of objects described by Zap (i.e., the first or the second). In other words, accuracy on these control conditions allows us to rule out a response strategy whereby the participant answered *yes* as soon as Zap uttered a true statement, or *no* as soon as Zap uttered a false statement.[6] Finally, because we dynamically selected the control items to elicit the opposite responses to those provided on the test trials, we can be assured that children did not complete the task with a general *yes* or *no* bias.

2.2.2. *Test conditions*

The results from the four WH conditions are presented in Figure 4b. As expected, all participants accepted WE+IE+SE trials and rejected baseline Ø trials. The difference in the percentage of *yes*-responses between the Ø condition and the WE condition indicates that both groups accessed the



(a) *"know-that"* control conditions, split by target response

(b) WH test conditions

Figure 4. Percentage of *yes*-responses on (a) "*know-that*" control conditions and (b) WH target conditions.

[6]While we do not specifically address the development of Theory of Mind in this article, we note here that children's target-like performance on the "*know-that*" controls provides evidence that 5-year-olds are capable of attribution of both true and false beliefs. While some previous research has suggested children younger than 4 have difficulty differentiating between different mental state verbs such as *think* and *know* (Macnamara, Block & Olson 1976; Johnson & Maratsos 1977; Abbeduto & Rosenberg 1985; Moore & Davidge 1989), recent results by Dudley et al. (2015) reveal that with less metalinguistically demanding tasks, children as young as 3 years of age can be shown to distinguish such mental state verbs. In fact, studies using implicit measures have also demonstrated understanding of false beliefs in infants (Onishi & Baillargeon 2005; Song et al. 2008; Southgate, Senju & Csibra 2007). Crucially, our experiment was conducted with children who were older than the age at which children have previously been shown to have difficulty with mental state verbs. Furthermore, our results from both the test and control conditions suggest that 5-year-olds are also able to distinguish false beliefs from ignorance, and moreover, to make use of this information to provide fine-grained linguistic judgments.

WE reading ($\chi^2(1) = 53$, $p < .001$), and the difference between the WE and the WE+IE conditions likewise indicates that both groups accessed the IE reading ($\chi^2(1) = 180$, $p < .001$).[7]

Children differed from adults, however, in how accepting they were of the WE reading. A logit mixed-model revealed that children gave more true responses than adults in the WE condition ($\chi^2(1) = 7.8$, $p \approx .005$), but did not differ from adults in the WE+IE condition ($\chi^2(1) = 0.02$, $p \approx .9$).

That children tended to respond more "weakly" than adults is also evidenced by the individual results, plotted in Figure 5. Of the 35 children: (i) two were categorized as "SE responders," rejecting both WE and WE+IE items; (ii) 16 "IE responders" rejected when only the WE reading was true but accepted once the IE reading was also made true; (iii) 14 "WE responders" accepted in both WE and WE+IE conditions, suggesting they considered Zap to "know" which toys were in the box as soon as he knew that the trucks were in the box.[8]

Given that the IE reading entails the WE reading, we observe that no participant displayed an inconsistent pattern: *yes*-responses to WE items but *no*-responses to WE+IE items. In sum, children were more or less equally split between WE and IE responders. By contrast, most adults were IE responders, with the exception of two SE and two WE responders.

Fourteen of the 35 children also spontaneously gave some "both yes and no" responses, suggesting that Zap both knew and didn't know (which toys were in the box). Ten of these children did so on WE targets, and four of them did so on WE+IE targets. χ^2-tests revealed that the distribution of "both"-responses across the six conditions is significantly different from chance ($p < .001$) and nearly significant when WE targets are excluded ($p = .05$). This "both"-type behaviour may be taken as further evidence that some children are sensitive to the ambiguity of embedded questions. We suggest that these children responded in this way because they were sensitive to the tension between two possible readings (a weaker and a stronger one) in situations in which one was true and the other was false. An example of the kind of justification that children gave for such a response is provided in (8).

(8) CHI: Oui et non, il a dit que les bananes sont dans le panier et les oranges je ne sais pas.
'Yes and no, he said that the bananas are in the basket and the oranges I don't know.'
(C05-A, age 5;06,01, WE+IE trial)

2.2.3. *Follow-up justifications*

Follow-up justifications were elicited after each trial to ascertain that children were providing the responses they did for the expected reasons. Justifications for *no*-responses to the baseline Ø condition, for example, made reference to Zap's false beliefs about the two sets of objects:

[7] In the WE+IE condition, Zap first correctly stated, for example, that the trucks were in the box and then stated that he did not know where the boats were. An anonymous reviewer points out that out of the blue, such a discourse would strongly suggest that Zap knew that the boats were not in the box but didn't know their exact location. A participant who would interpret Zap's utterance in this way could then consider Zap to know which toys were in the box, even if they accessed an SE reading; this is because they would assume that Zap knew that the boats were not in the box, even if he didn't know they were on the carpet. In our task, however, there were only ever two salient locations, e.g., the box and the carpet, so knowing that the boats were not in the box was contextually equivalent to knowing that they were on the carpet. Zap should therefore not have been able to utter "I don't know" to mean "I don't know where they are, outside of the box". Furthermore, the presence of the WE condition would make it difficult to infer from Zap's true statement about the trucks' location that he necessarily knew what was in the box, given he would sometimes continue by incorrectly stating that the boats were in the box too.

[8] We do not discuss here so-called *mention-some* readings of embedded questions. Under such a reading, the sentence is true as soon as Zap knows of one animal that is on the couch. This reading is even weaker than the WE reading. There are reasons to believe, however, that such readings should not appear in the present cases. For instance, Fox (2013) argues that mention-some readings require the presence of an existential modal. Furthermore, George (2013) and Xiang (2015) show that mention-some readings can also come with a no-false-belief constraint. We will assume, with Roelofsen, Theiler & Aloni (2014), that the distinction between exhaustive and mention-some readings is orthogonal to the distinction between weak, intermediate, and strong readings. In fact, given that mention-some readings, like exhaustive readings, also come in weak, intermediate, and strong flavors, we view our experiment as targeting the distinction between these three flavors, rather than specifically targeting the distinction between mention-some and exhaustive readings. We leave to future research a more targeted investigation of children's knowledge of mention-some readings of questions.

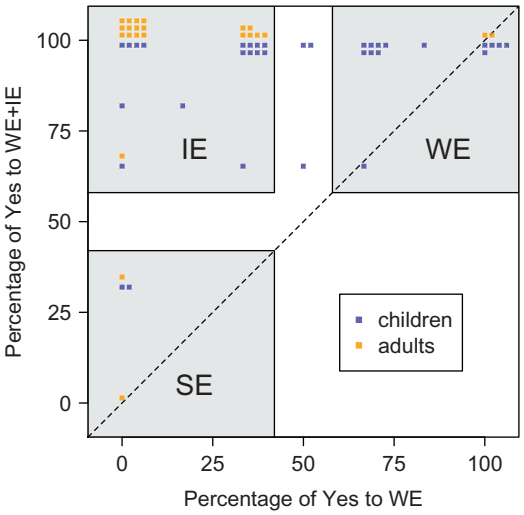


Figure 5. This figure represents each individual as a combination of his/her acceptance rate on WE targets (*X*-axis) and WE+IE targets (y-axis). As indicated in the figure, (i) the top right corner in this space corresponds to participants who accessed the WE reading consistently (i.e., they gave *yes*-responses to both WE and WE+IE targets); (ii) the top left corner corresponds to IE-responders (who rejected the WE targets but accepted the WE+IE targets), and (iii) the bottom left corner corresponds to SE-responders (who rejected both the WE and WE +IE targets) . Given that each participant saw three repetitions of each target condition, we can expect to observe individuals falling into one of 4 × 4 possible positions within the graph (with the additional possibility of "both"-responses for children, which were encoded as 0.5); for better visibility, overlapping individuals are represented within small groups next to their actual position.

(9) Justifications for *no*-responses to baseline Ø condition

a. CHI: Parce qu'il a dit les bananes sont dans le panier et les pommes sont dans la nappe.
'Because he said the bananas are in the basket and the apples are on the cloth.' (C02-B, age 6;04,18)

b. CHI: Il a dit les voitures sont sur le tapis et les balles sur l'étagère.
'He said the cars are on the carpet and the balls on the shelf.' (C05-A, age 5;06,01)

c. CHI: Les pommes il sait pas c'est dans le panier, et il sait pas que les bananes, ils sont dans le panier.
'He doesn't know the apples are in the basket, and he doesn't know about the bananas, they're in the basket.' (C10-B, age 5;09,16)

Justifications for *yes*-responses on the WE+IE+SE control condition made reference to Zap's true beliefs about the two sets of objects:

(10) Justifications for *yes*-responses to WE+IE+SE condition

a. CHI: Beh qu'il vient de le dire parfait, il a dit les bateaux dans la boîte et les avions sur le tapis.
'Well he just said it perfectly, he said the boats in the box and the airplanes on the carpet.' (C07-A, age 5;08,04)

b. CHI: Parce qu'il a dit que les coccinelles étaient sur la feuille et les chenilles étaient sur la branche.
'Because he said that the ladybugs were on the leaf and the caterpillars were on the branch.' (C18-B, age 5;09,22)

c. CHI: Il a dit que les poires sont dans le panier et les fraises sont sur la nappe.
'He said that the pears are in the basket and the strawberries are on the cloth.' (C04-B, age 5;11,04)

Justifications for *yes*- and *no*-responses in the WE condition are provided in (11) and (12). Children who accepted in the WE condition made reference to Zap's true beliefs about the first set of objects (11). In contrast, children who rejected in the WE condition made reference to Zap's false beliefs about the second set of objects (12).

(11) Justifications for *yes*-responses to WE condition
   a. CHI: Il a dit que les avions sont dans la boîte.
      'He said that the airplanes are in the box.' (C13-A, age 5;03,12)
   b. CHI: Parce qu'il a dit les ananas sont dans le panier.
      'Because he said the pineapples are in the basket.' (C06-B, age 5;09,13)

(12) Justifications for *no*-responses to WE condition
   a. CHI: Il y a que des moutons dans la maison et les cochons non.
      'There are only sheep in the house, not pigs.' (C08-B, age 5;08,00)
   b. CHI: Parce qu'il a dit que les cochons ils étaient dans la maison alors qu'ils sont pas dans la maison.
      'Because he said that the pigs were in the house when they aren't in the house.' (C14-B, age 5;07,15)
   c. CHI: Beh parce que les camions sont pas dans la boîte.
      'Because the trucks are not in the box.' (C15-A, age 5;08,21)
   d. CHI: Parce qu'il a mélangé tous les deux ensemble dans le panier, alors que c'était pas ça.
      'Because he mixed up the two together in the basket, but it wasn't like that.' (C26-B, age 6;04,29)

Examples of justifications for *yes*- and *no*-responses in the WE+IE condition are provided in (13) and (14). Children who accepted in the WE+IE condition made reference to Zap's true beliefs about the first set of objects. In contrast, children who rejected in the WE+IE condition made reference to Zap's lack of knowledge about the second set of objects.

(13) Justifications for *yes*-responses to WE+IE condition
   a. CHI: Il a dit que les oranges elles sont dans le panier.
      'He said that the oranges are in the basket.' (C13-A, age 5;03,12)
   b. CHI: Parce qu'il a dit les bananes sont dans le panier, et elles sont dans le panier.
      'Because he said the bananas are in the basket, and they are in the basket.' (C26-B, age 6;04,29)
   c. CHI: Parce qu'il a dit que les oranges étaient dans le panier et que c'est vrai.
      'Because he said that the oranges were in the basket and this is true.' (C26-B, age 6;04,29)

(14) Justifications for *no*-responses to WE+IE condition
   a. CHI: Non, les oranges sont dans le panier et les pommes il sait pas les pommes.
      'No, the oranges are in the basket and the apples he doesn't know about them.' (C08-B, age 5;08,00)
   b. CHI: Parce qu'il a dit les oranges il sait pas.
      'Because he said the oranges he doesn't know.' (C17-A, age 5;09,12)

3. Discussion

Our first main finding is that 5-year-old children are sensitive to the rich range of interpretations that are available for embedded *wh*-questions. Children access WE, IE, and SE readings, as adults do.

In fact, some children explicitly reported their sensitivity to the tension between readings, further suggesting that 5-year-olds are aware of the ambiguity of embedded questions.

Our second main finding is that children are more accepting than adults of weak readings of embedded questions. This is evidenced by two aspects of our results. First, children provided more *yes*-responses in the WE condition than adults. Second, in the context of their individual responses, children were roughly split between WE and IE responders, whereas adults were almost all IE responders.

This main finding that children were more accepting than adults of weak meanings is reminiscent of much of the previous literature on children's development of scalar implicatures. There too, children have been shown to access weaker meanings more than adults. Our results would therefore appear to be consistent with a scalar implicature approach to the strengthened readings of embedded questions.[9]

It may be helpful to consider *why* children appear to access more weak readings of embedded questions than adults do. To do so, we can extend a proposal from the developmental literature on scalar implicatures. According to this line of research (see Gualmini et al. 2001; Chierchia et al. 2001; Reinhart 2006; Barner, Brooks & Bale 2011; Tieu et al. 2016; Singh et al. 2016), children have difficulty computing scalar implicatures such as (2b) because they are less able than adults to access the scalar alternative required to compute the implicature. Consider the ingredients that would be required to compute the implicature in an adult-like way. The child must first acquire (i.e., lexicalize) the coscalar status of the quantifiers *some* and *all*. When presented with the test sentence in (1) containing *some*, the child must then be able to perform lexical retrieval of the stronger alternative *all*. She must then be able to compare the weak and strong forms and exhaustify with respect to the alternatives. Failure or difficulty with any of these steps along the way may cause children difficulty and consequently result in a non-adult-like tendency to accept weaker meanings. Unsurprisingly, when children are provided with the required alternatives explicitly, or when they can easily retrieve these alternatives from the context, they perform more on a par with adults.

How can our data on embedded questions fit within such a story? Recall that on the proposal roughly outlined in Section 1.2.2, the derivation of the IE reading requires two sets of alternatives: those for the *wh*-question, i.e., the set of propositions {*x* is in the box}, and the alternative to *know*, namely *believe*. While it can be argued that children could retrieve the first set of alternatives from the context, e.g., {The trains are in the box, The boats are in the box}, performing lexical retrieval of *believe* as an alternative to *know* is entirely parallel with the case of retrieving *all* as an alternative to *some*. It may therefore not be surprising that children display a similar non-adult-like preference for weak meanings in the two cases. In short, assuming a theory along the lines of Klinedinst & Rothschild (2011) for questions, we can extend the alternatives-based explanation for children's difficulty with scalar implicatures to the present case of questions and explain why children gave the WE response-pattern more than adults. Note that the explanation provided here for children's performance makes the prediction that if we were to make the *believe* alternative more salient to children, more IE responses might be observed. We leave the testing of this prediction to future research.

Finally, we would like to comment on a further consequence of the child data reported here, which we believe can serve to further constrain linguistic theories of questions. Among the theories that are able to derive the IE reading, only the strengthening-based theories additionally derive the WE reading. The fact that we observed many WE-responders among children, and even some among adults, provides evidence in support of theories that can derive the WE reading (although see

[9]It would be interesting to compare the rate of derivation of IE and SE readings with the rate of derivation of global and local scalar implicatures, respectively, since Klinedinst & Rothschild (2011) establish a clear parallel between the two. Preliminary results by Bill et al. (2015) suggest that embedded exhaustification may be accessible to children, possibly even more so than global exhaustification. Although the cases may not be directly comparable (because IE readings here involve multiple replacements and additional alternatives), such results would lead one to expect that children should predominantly access SE readings rather than IE readings. Alternatively, Uegaki (2015) proposes that SE readings are derived from IE readings, through a second step of strengthening that involves agent opinionatedness, via an Excluded Middle presupposition or implicature (following literature on *neg-raising* phenomena) (see footnote 3). Note that on this approach, children's acquisition of neg-raising could be a predictor of their access to SE readings, though only after they have already mastered IE readings. Before further testing the availability of SE readings in children, however, it would be useful to find a task in which the SE reading surfaces more clearly in adults.

Cremers & Chemla 2016 for discussion of some intricacies concerning the availability of WE readings). Moreover, these theories make further predictions for the acquisition of exhaustive readings. They treat the WE reading as basic and derive the IE and SE readings through a process of strengthening that is known to cause difficulties for children. This is very much in line with what we observed in our experiment. In sum, our results can be taken to provide empirical support for strengthening-based theories of questions, which are currently the only ones that can derive both WE and IE readings.

4. Conclusion

Our findings provide novel evidence that 5-year-old children are sensitive to the ambiguity of questions embedded under *savoir* "know." They also show, however, that children answer according to the stronger readings of questions less often than adults. Our results are consistent with the findings from previous studies of children's acquisition of scalar implicatures, which also reveal a preference for weaker meanings in children compared to adults. According to recent proposals in the developmental literature, children's difficulty accessing strengthened meanings may lie in a difficulty with the lexical retrieval of the necessary alternatives. This interpretation of the data allows for a parallel between children's ability to access strengthened readings of embedded questions and their ability to compute classical scalar implicatures and further supports a link that has recently been made explicit in certain theoretical accounts of embedded questions (Klinedinst & Rothschild 2011; Nicolae 2013; Uegaki 2015).

Acknowledgments

For helpful feedback and discussion, we would like to thank Paul Egré, Martin Hackl, Valentine Hacquard, Jeffrey Lidz, Jacopo Romoli, Philippe Schlenker, Benjamin Spector, Wataru Uegaki, Alexander Williams, and audiences at the 6th Generative Approaches to Language Acquisition in North America conference, the XPRAG 2015 conference, the Ecole Normale Supérieure, University of Ulster, and Harvard University. We also received useful comments from two anonymous reviewers and the editors at *Language Acquisition*, which helped to improve the form of the paper. We would also like to thank Anne-Caroline Fievet for coordinating testing at local preschools and Florian Pellet for implementing the adult version of the task. We are grateful to the families of the children who participated in our study, as well as the director and teachers at the École Maternelle Publique Lyonnais, who graciously allowed us to conduct our study in their school.

Funding

The research leading to this work was supported by the European Research Council under the European Union's Seventh Framework Programme (FP/2007-2013) / ERC Grant Agreement n.313610, and by ANR-10-IDEX-0001-02PSL* and ANR-10-LABX-0087 IEC.

ORCID

Alexandre Cremers http://orcid.org/0000-0002-7435-6515

References

Abbeduto, Leonard & Sheldon Rosenberg. 1985. Children's knowledge of the presuppositions of "know" and other cognitive verbs. *Journal of Child Language* 12(3). 621–641.

Barner, David, Neon Brooks & Alan Bale. 2011. Accessing the unsaid: the role of scalar alternatives in children's pragmatic inferences. *Cognition* 188. 87–96.

Beck, Sigrid & Hotze Rullmann. 1999. A flexible approach to exhaustivity in questions. *Natural Language Semantics* 7 (3). 249–298.

Berman, Stephen. 1991. *On the Semantics and Logical Form of Wh-Clauses*. Amherst: University of Massachusetts dissertation.

Bill, Cory, Elena Pagliarini, Jacopo Romoli, Lyn Tieu & Stephen Crain. 2015. Children's interpretation of sentences with multiple scalar terms. Ms. Macquarie University.
Chierchia, Gennaro, Stephen Crain, Maria Teresa Guasti & Rosalind Thornton. 2001. "Some" and "or": A study on the emergence of logical form. In S. Catherine Howell, Sarah A. Fish & Thea Keith-Lucas (eds.), *Proceedings of the 24th annual Boston University Conference on Language Development [BUCLD 24]*, 22–44. Somerville, MA: Cascadilla Press.
Chierchia, Gennaro, Danny Fox & Benjamin Spector. 2011. The grammatical view of scalar implicatures and the relationship between semantics and pragmatics. In Claudia Maienborn, Klaus von Heusinger & Paul Portner (eds.), *An international handbook of natural language meaning vol, 3*, 2297–2332. Berlin: Mouton de Gruyter.
Conroy, Stacey, Jeffrey Lidz & Julien Musolino. 2009. The fleeting isomorphism effect. *Language Acquisition* 16(2). 106–117.
Crain, Stephen, Takuya Goro, Anna Notley & Peng Zhou. 2013. A parametric account of scope in child language. In S. Stavrakaki, M. Lalioti & P. Konstantinopoulou (eds.), *Advances in language acquisition*, 63–71. Cambridge, UK: Cambridge Scholar Publishing.
Cremers, Alexandre & Emmanuel Chemla. 2016. A psycholinguistic study of the exhaustive readings of embedded questions. *Journal of Semantics* 33(1). 49–85.
Dudley, Rachel, Naho Orita, Valentine Hacquard & Jeffrey Lidz. 2015. Three-year-olds' understanding of know and think. In Florian Schwarz (ed.), *Experimental Perspectives on Presuppositions*, vol. 45, 241–262. Springer: Dordrecht, The Netherlands.
Fox, Danny. 2007. Free choice and the theory of scalar implicatures. In Uli Sauerland & Penka Stateva (eds.), *Presupposition and Implicature in Compositional Semantics*, 71–120. New York, Palgrave Macmillan.
Fox, Danny. 2013. Mention-some readings of questions. Class notes (MIT Seminars).
Franke, Michael. 2011. Quantity implicatures, exhaustive interpretation, and rational conversation. *Semantics and Pragmatics* 4(1). 1–82. doi:10.3765/sp.4.1.
George, Benjamin. 2011. *Question embedding and the semantics of answers*. University of California Los Angeles dissertation.
George, Benjamin Ross. 2013. Knowing-"wh", mention-some readings, and non-reducibility. *Thought: A Journal of Philosophy* 2(2). 166–177.
Grice, Paul. 1975. Logic and conversation. In Donald Davidson & Gilbert H. Harman (eds.), *The logic of grammar*, 64–75. Encino, CA: Dickenson.
Groenendijk, Jeroen & Martin Stokhof. 1982. Semantic analysis of wh-complements. *Linguistics and Philosophy* 5. 173–233.
Groenendijk, Jeroen & Martin Stokhof. 1984. *Studies on the semantics of questions and the pragmatics of answers*. amsterdam: University of Amsterdam dissertation.
Gualmini, Andrea. 2004. *Some* knowledge children don't lack. *Linguistics* 42. 957–982.
Gualmini, Andrea & Stephen Crain. 2005. The structure of children's linguistic knowledge. *Linguistic Inquiry* 36(3). 463–474.
Gualmini, Andrea, Stephen Crain, Luisa Meroni, Gennaro Chierchia & Maria Teresa Guasti. 2001. At the semantics/pragmatics interface in child language. In Rachel Hastings, Brendan Jackson & Zsofia Zvolenszky (eds.),Proudings of the 11th Conference on *Semantics and Linguistic Theory [SALT 11]*, 231–247, Ithaca, NY: CLC Publications.
Gualmini, Andrea, Sarah Hulsey, Valentine Hacquard & Danny Fox. 2008. The Question-Answer Requirement for scope assignment. *Natural Language Semantics* 16. 205–237.
Guerzoni, Elena. 2007. Weak exhaustivity and "whether": A pragmatic approach. In Tova Friedman & Masayuki Gibson (eds.), *Proceedings of [SALT 17]*, 112–129. Ithaca, NY: Cornell University.
Heim, Irene. 1994. Interrogative semantics and Karttunen's semantics for *know*. In Rhonna Buchalla & Anita Mittwoch (eds.), *Proceedings of the 9th Annual meeting of the IATL*, 128–144. Jerusalem: Hebrew University of Jerusalem.
Johnson, Carl Nils & Michael P. Maratsos. 1977. Early comprehension of mental verbs: Think and know. *Child Development* 48(14) 1743–1747.
Karttunen, Lauri. 1977. Syntax and semantics of questions. *Linguistics and Philosophy* 1(1). 3–44.
Katsos, Napoleon & Dorothy V.M. Bishop. 2011. Pragmatic tolerance: Implications for the acquisition of informativeness and implicature. *Cognition* 120(1). 67–81.
Klinedinst, Nathan & Daniel Rothschild. 2011. Exhaustivity in questions with non-factives. *Semantics and Pragmatics* 4 (2). 1–23.
Macnamara, John, Erica Baker & Chester L. Olson. 1976. Four-year-olds' understanding of "pretending", "forget", and "know": Evidence for propositional operations. *Child Development* 47(1). 62–70.
Miller, Karen & Cristina Schmitt. 2004. An experimental study on child comprehension of Spanish indefinites and bare singulars. *Language Acquisition* 12(3–4). 247–256.
Moore, Chris & Jane Davidge. 1989. The development of mental terms: Pragmatics or semantics. *Journal of Child Language* 16(3). 633–641.

Musolino, Julien. 1998. *Universal Grammar and the acquisition of semantic knowledge*. University of Maryland dissertation.
Musolino, Julien, Stephen Crain & Rosalind Thornton. 2000. Navigating negative quantificational space. *Linguistics* 38. 1–32.
Musolino, Julien & Jeffrey Lidz. 2003. The scope of isomorphism: Turning adults into children. *Language Acquisition* 11(4). 277–291.
Musolino, Julien & Jeffrey Lidz. 2006. Why children aren't universally succesful with quantification. *Linguistics* 44. 817–852.
Nicolae, Andreea. 2013. *Any questions? Polarity as a window into the structure of question*. Cambridge, MA: Harvard University dissertation.
Notley, Anna, Peng Zhou, Britta Jensen & Stephen Crain. 2012. Children's interpretation of disjunction in the scope of "before": A comparison of English and Mandarin. *Journal of Child Language* 39(3). 482–522.
Noveck, Ira. 2001. When children are more logical than adults: Experimental investigations of scalar implicatures. *Cognition* 78(8). 165–188.
Onishi, Kristine H. & Renée Baillargeon. 2005. Do 15-month-old infants understand false beliefs? *Science* 308(5719). 255–258.
Papafragou, Anna & Julien Musolino. 2003. Scalar implicatures: experiments at the semantics–pragmatics interface. *Cognition* 86. 253–282.
Percus, Orin. 2006. Antipresuppositions. In Ayumi Uyema (ed.), *Theoretical and empirical studies of reference and anaphora: toward the establishment of generative grammar as an empiricial science*, 52–73. Report of the Grant-in-Aid for Scientific Research (B), Project No. 15320052, Japan Society for the Promotion of Science.
Preuss, Susanne Marie-Luise. 2001. *Issues in the Semantics of questions with quantifiers*. New Brunswick Rutgers dissertation.
Reinhart, Tanya. 2006. *Interface Strategies. Optimal and costly Computations MA*. Cambridge, MA: MIT Press.
Roelofsen, Floris, Nadine Theiler & Maria Aloni. 2014. Embedded interrogatives: The role of false answers. 7th questions in Discourse workshop, September 18, Göttingen, Germany.
Roij, Robert man & katrin Schulz 2004. Exhaustive interpretation of complex sentences. *Journal of logic, Language and Information* 13.491.519.
Russell, Benjamin. 2006. Against grammatical computation of scalar implicatures. *Journal of Semantics* 23(4). 361–382.
Sauerland, Uli. 2004. Scalar implicatures in complex sentences. *Linguistics and Philosophy* 27(3). 367–391.
Sauerland, Uli. 2008. Implicated presuppositions. In Anita Steube (ed.), *Sentence and Context: Language, Context and Cognition*, 581–600. Berlin: Mouton de Gruyter.
Sharvit, Yael. 2002. Embedded questions and 'de dicto' readings. *Natural Language Semantics* 10(2). 97–123.
Singh, Raj, Ken Wexler, Andrea Astle-Rahim, Deepthi Kamawar & Danny Fox. 2016. Children interpret disjunction as conjunction: Consequences for theories of implicature and child development. *Natural Language Semantics* 24(4). 305–352.
Song, Hyun-joo, Kristine H. Onishi, Renée Baillargeon & Cynthia Fisher. 2008. Can an agent's false belief be corrected by an appropriate communication? Psychological reasoning in 18-month-old infants. *Cognition* 109. 295–315.
Southgate, Victoria, Atsushi Senju & Gergely Csibra. 2007. Action anticipation through attribution of false belief in two-year-olds. *Psychological Science* 18(7). 587–592.
Spector, Benjamin. 2005. Exhaustive interpretations: What to say and what not to say. Paper, presented at the LSA workshop on Context and Content, Cambridge, MA.
Spector, Benjamin. 2006. *Aspects de la Pragmatique des Opérateurs Logiques*. Paris: Université Paris 7 dissertation.
Spector, Benjamin. 2007. Scalar implicatures: Exhaustivity and gricean reasoning. In Maria Aloni, Alistair Butler & Paul Dekker (eds.), *Questions in dynamic semantics, Current Research in the Semantics/Pragmatics Interface*, vol 17, 229–254. Amsterdam: Elsevier.
Spector, Benjamin & Paul Egré. 2015. Embedded questions revisited: An answer, not necessarily the answer. *Synthese* 192(6). 1729–1784.
Theiler, Nadine. 2014. *A multitude of answers: Embedded questions in typed inquisitive semantics*. Amsterdam ILLC, University of Amsterdam master's thesis.
Tieu, Lyn, Jacopo Romoli, Peng Zhou & Stephen Crain. 2016. Children's knowledge of free choice inferences and scalar implicatures. *Journal of Semantics* 33.269-298 doi:10.1093/jos/ffv001
Uegaki, Wataru. 2015. *Interpreting questions under attitudes.*Cambridge: MA: Massachusetts Institute of Technology dissertation.
Xiang, Yimei. 2015. Complete and true: A uniform analysis for mention-some and mention-all questions. In Nadine Bade, Polina Berezovskaya & Anthea Schöller (eds.), *Proceedings of Sinn und Bedeutung*, the 20th annual confernece of the Geseusachaft for semantik, 815–832.Tübingen.
Zhou, Peng & Stephen Crain. 2009. Scope assignment in child language: Evidence from the acquisition of Chinese. *Lingua* 119. 973–988.

Appendix

(15) Puppet's statements, followed by experimenter's question, for WE and WE+IE test conditions
a. WE condition (target: *yes* on WE reading, *no* on IE and SE readings)
(i) Les avions sont dans la boîte. Les camions aussi sont dans la boîte.
Est-ce que Zap sait quels jouets sont dans la boîte ?
(ii) Les moutons sont dans la maison. Les cochons aussi sont dans la maison.
Est-ce que Zap sait quels animaux sont dans la maison ?
(iii) Les ananas sont dans le panier. Les poires aussi sont dans le panier.
Est-ce que Zap sait quels fruits sont dans le panier ?

b. WE+IE condition (target: *yes* on WE and IE readings, *no* on SE reading)
(i) Les oranges sont dans le panier. Les pommes, je ne sais pas.
Est-ce que Zap sait quels fruits sont dans le panier ?
(ii) Les chevaux sont dans la mare. Les vaches, je ne sais pas.
Est-ce que Zap sait quels animaux sont dans la mare ?
(iii) Les bananes sont dans le panier. Les oranges, je ne sais pas.
Est-ce que Zap sait quels fruits sont dans le panier ?

(16) Puppet's statements, followed by experimenter's question, for Ø and WE+IE+SE control conditions.
a. Ø control condition (target: *no*)
(i) Les moutons sont dans la maison. Les poules sont sur l'herbe.
Est-ce que Zap sait quels animaux sont dans la maison ?
(ii) Les bananes sont dans le panier. Les pommes sont sur la nappe.
Est-ce que Zap sait quels fruits sont dans le panier ?
(iii) Les balles sont sur l'étagère. Les voitures sont sur le tapis.
Est-ce que Zap sait quels jouets sont sur l'étagère ?

b. WE+IE+SE control condition (target: *yes*)
(i) Les coccinelles sont sur la feuille. Les chenilles sont sur la branche.
Est-ce que Zap sait quels animaux sont sur la feuille ?
(ii) Les bateaux sont dans la boîte. Les avions sont sur le tapis.
Est-ce que Zap sait quels jouets sont dans la boîte ?
(iii) Les poires sont dans le panier. Les fraises sont sur la nappe.
Est-ce que Zap sait quels fruits sont dans le panier ?

(17) Puppet's statements, followed by experimenter's question, for NP control conditions
a. WE NP-control condition
(i) Les lapins sont sur le fauteuil. Les singes aussi sont sur le fauteuil.
Est-ce que Zap sait que:
i. les lapins sont sur le fauteuil ? (target: *yes*)
ii. les singes sont par terre ? (target: *no*)
(ii) Les cubes sont sur l'étagère. Les voitures aussi sont sur l'étagère.
Est-ce que Zap sait que:
i. les cubes sont sur l'étagère ? (target: *yes*)
ii. les voitures sont sur le tapis ? (target: *no*)
(iii) Les abeilles sont sur la feuille. Les coccinelles aussi sont sur la feuille.
Est-ce que Zap sait que:
i. les abeilles sont sur la feuille ? (target: *yes*)
ii. les coccinelles sont sur la branche ? (target: *no*)
b. IE NP-control condition
(i) Les singes sont sur le fauteuil. Les souris, je ne sais pas.
Est-ce que Zap sait que:
i. les singes sont sur le fauteuil ? (target: *yes*)
ii. les souris sont par terre ? (target: *no*)
(ii) Les camions sont dans la boîte. Les bateaux, je ne sais pas.
Est-ce que Zap sait que:

i. les camions sont dans la boîte ? (target: *yes*)
ii. les bateaux sont sur le tapis ? (target: *no*)

(iii) Les vaches sont dans la mare. Les canards, je ne sais pas. Est-ce que Zap sait que:
i. les vaches sont dans la mare ? (target: *yes*)
ii. les canards sont sur l'herbe ? (target: *no*)