Children's perspective-taking in pragmatic inferences

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Abstract

Deriving pragmatic implicatures involves taking into account what the speaker knows: the inference s*he ate only an apple* from the utterance 'she ate an apple' depends on the assumptions that the speaker is both informative and fully informed. While adults are known to derive implicatures or not depending on speaker knowledge, little is known about how children learn this crucial aspect of pragmatic inferencing. In this study, we tested children and adults' ability to derive or not derive ad hoc quantity implicatures, depending on whether the speaker was knowledgeable or not. We found that both adults and 5-6-year olds excelled in deriving implicatures when the speaker was fully knowledgeable, but only adults reliably did not derive implicatures when the speaker was not knowledgeable, although children passed a Theory of Mind test. Our findings suggest that children learn gradually to integrate relevant information about speaker knowledge into implicature computation.

Keywords: experimental pragmatics; language acquisition; quantity implicature; theory of mind

Introduction

When humans communicate, they typically intend and infer meaning beyond what is literally said – they make pragmatic inferences. To do this they must take into account not only the discourse context but also the epistemic state of the interlocutor, which could be different from their own. One type of pragmatic inference that has received particular attention is quantity implicature (Grice, 1989): the inference that, for example, when a speaker answers the question 'What did she have for lunch?' by saying 'She had an apple', it is meant that *she had an apple and nothing else* (assuming the speaker is both informative and fully informed). While several studies show that adults can and do take into account the speaker's epistemic state when deriving implicatures, little is known about how children learn this skill in their pragmatic development. Here we investigate whether children are able to take into account the speaker's knowledge when they derive ad hoc quantity implicatures, both when the speaker is knowledgeable, and when the speaker is not knowledgeable and the child's and speaker's perspectives differ.

Pragmatic theories following Grice's (1989) conversational principles assume that hearers must take into account the speaker's epistemic state or perspective when deriving an implicature. In particular, to make an ad hoc quantity inference based on the assumption that the speaker is maximally informative, the hearer must also assume that the speaker is fully knowledgeable about the situation. This is known as the epistemic step (Sauerland, 2004) – the step in reasoning, for example, from *the speaker does not know whether she had an apple and sandwich and crisps etc for lunch* to *the speaker knows that she had only an apple for lunch.* Studies using both on-line and off-line methods with adults have shown that when hearers are unable to take the epistemic step because the assumption of speaker knowledge is not met, they tend to suspend (or cancel) the quantity implicature, interpreting our example utterance as *the speaker had at least an apple for lunch* or *the speaker does not know whether she had an apple and other items for lunch* (Bergen & Grodner, 2012; Breheny, Ferguson & Katsos, 2013; Goodman & Stuhlmüller, 2013; Politzer-Ahles & Fiorentina, 2013).

Children are able to make ad hoc quantity implicature inferences at an early age, most likely from 3 years (Stiller, Goodman & Frank, 2015). For example, in a picture-matching task, children are able to choose a picture card with *only* an apple, rather than an apple and a sandwich, to match our example utterance, 'she had an apple' (Horowitz & Frank, 2015; Wilson & Katsos, 2016). However, all studies to date test children's pragmatic skills with ad hoc implicatures in a conversational situation in which the speaker and hearer share relevant knowledge and the same visual perspective – which, of course, is not always the case in real-world conversations.

Taking into account another's perspective in general is actually a skill that children also seem to acquire relatively early. Children demonstrate sensitivity to what has been shared with somebody else or what is new for another person from the second year of life, for example by adapting word learning inferences or pointing gestures appropriately (e.g., Akhtar, Carpenter & Tomasello, 1996; Liebal, Carpenter & Tomasello, 2010). Furthermore, by the age of 4 they are able not only to take another's perspective when it motivates the other's actions, but also confront another's perspective, judging how something is construed by another (Moll, Meltzoff, Merzsch & Tomasello, 2013). The latter is demonstrated by, for example, passing Theory of Mind tests that require representing somebody's false belief about the world and predicting a consequent course of action, such as the change-of-location Sally-Anne task (Wimmer & Perner, 1983). That is, we expect children at the age we test in this study to be able to be able to represent another's perspective and epistemic state that is different from their own, and anticipate what the other person might therefore do.

But when are children able to integrate the two skills of pragmatic inferencing and perspective-taking? In principle,

there are two possibilities for a developmental trajectory. Children may combine the two skills as soon as they have acquired them, and this immediate integration hypothesis would predict that children who are able to derive ad hoc implicatures and reason about another's perspective are also able to adjust their pragmatic inferences based on the speaker's epistemic state. Alternatively, given that children appear to struggle with integrating other aspects of context into pragmatic inferences, such as the Question Under Discussion and associated relevant alternatives (e.g., Skordos & Papafragou, 2016), there could be a two-step developmental process. Children first master quantity implicatures assuming full common ground, and then learn to take the epistemic step or not as appropriate. This hypothesis predicts that children may go through a stage where they can both derive ad hoc implicatures appropriately when the speaker's epistemic state is not relevant, and also reason about other's epistemic states in non-communicative contexts, but not combine the two. Testing these hypotheses has implications for theoretical views of implicature, as neo-Gricean theories typically assume that – at least in adults – these two skills must go hand-in-hand, whereas alternative theories place less emphasis on rich reasoning about others' perspectives (such as grammatical approaches to quantity implicature, e.g., Chierchia, Fox & Spector, 2011).

To date, no studies have looked at this question directly with implicatures. There is some evidence that children can take into account the speaker's perspective in reference resolution tasks from age 5 years (e.g., Nadig & Sedivy, 2002; Nilsen & Graham, 2009). Furthermore, two studies have investigated children's sensitivity to the association between an under-informative utterance and an under-informed speaker. In these studies, children were asked which of two speakers – a fully knowledgeable or partially knowledgeable one – uttered a statement that was under-informative given the actual world (Hochstein, Bale, Fox & Barner, 2014; Papafragou, Cohen & Friedberg, 2016). They found that 5-year-olds (but not 4-year-olds) were able to attribute an under-informative utterance to the partially-knowledgeable speaker. While listeners sometimes do have to engage in reasoning about who said something based on what they know about the world and others' epistemic states, this inference is quite different from taking the epistemic step or not in implicature derivation. In the former, the interpretation of the critical utterance is a given, and is not at stake. What is at stake is which of the two speakers could have said something that was under-informative. Therefore, children have to match under-informative utterances to partially knowledgeable speakers. However, in the latter, the very interpretation of the critical utterance is at stake. Children who take into account that the speaker is only partially knowledgeable will not derive an implicature, while children who do not will, arriving at distinct interpretations.

In the present study, we address the question of whether children are able to integrate speaker epistemic state into reasoning about the speaker's intended meaning, in particular in deriving an ad hoc quantity implicature. We combine two established paradigms in which children at the age we test are known to succeed: deriving ad hoc implicatures in a picture-matching task (Horowitz & Frank, 2015), and resolving reference in the director task (Nadig & Sedivy, 2002). We test 5-6-year-olds and adults, and find that adults but not children tend to suspend an ad hoc implicature when the speaker is not knowledgeable, and some children even struggle with perspective-taking when no pragmatic inference is involved. This supports the two-step developmental hypothesis.

Experiment

Participants 30 children were recruited from two local primary schools in Cambridge, UK, aged 5;3-6;4. A further 4 children were excluded due to experimenter error (N=1), little knowledge of English (N=1) or not completing the task (N=2). Adults (N=36) were recruited via Prolific Academic, an on-line recruitment platform for research.

Stimuli Participants saw a display of four double-sided picture cards, three of which were in common ground with the speaker, and one of which was in privileged ground so that only the participant could see it. Each picture card showed 5 items, either 5 of the same items (e.g., 5 bananas) or 2 of one item and 3 of another (e.g., 2 bananas and 3 pears). In each display, 3 of the cards showed 5 of the same item, and 1 showed two types of item. There were 6 sets of 5 picture cards, each with a theme (e.g., fruit, vegetables, insects). All pictures were easily-recognisable illustrations of objects known to children.

Procedure Participants were told that they were going to play a game with a puppet, called Bob. Bob, whose voice was recorded, was sat on the other side of the display from the child, and gave them instructions.

For the warm-up phase, he explained that he wanted to play a guessing game with the child: he could see three of the items, but not the fourth. Could the child describe it, so that he could guess what it was? In the warm-up phase, each card had only one item on, which were all different from those used in the test phase. After each trial of three warm-up trials the puppet guessed (correctly) what the item was and thanked the child. The aim of the warm-up was to highlight the difference in perspective between the puppet-speaker and participant-hearer.

The puppet then explained that they were going to play a different game: in this game, the child had to collect cards and put them in a 'card box'. He would tell the child which card to pick, each time saying 'Pick the card with Xs'.

Based on the director task, there were four conditions, with 6 trials per condition, so that each child saw 24 trials. In the unambiguous condition, only one card, visible to both the puppet and participant, matched the description. In the common ground ad hoc implicature condition, two cards, both visible to both the puppet and participant, were

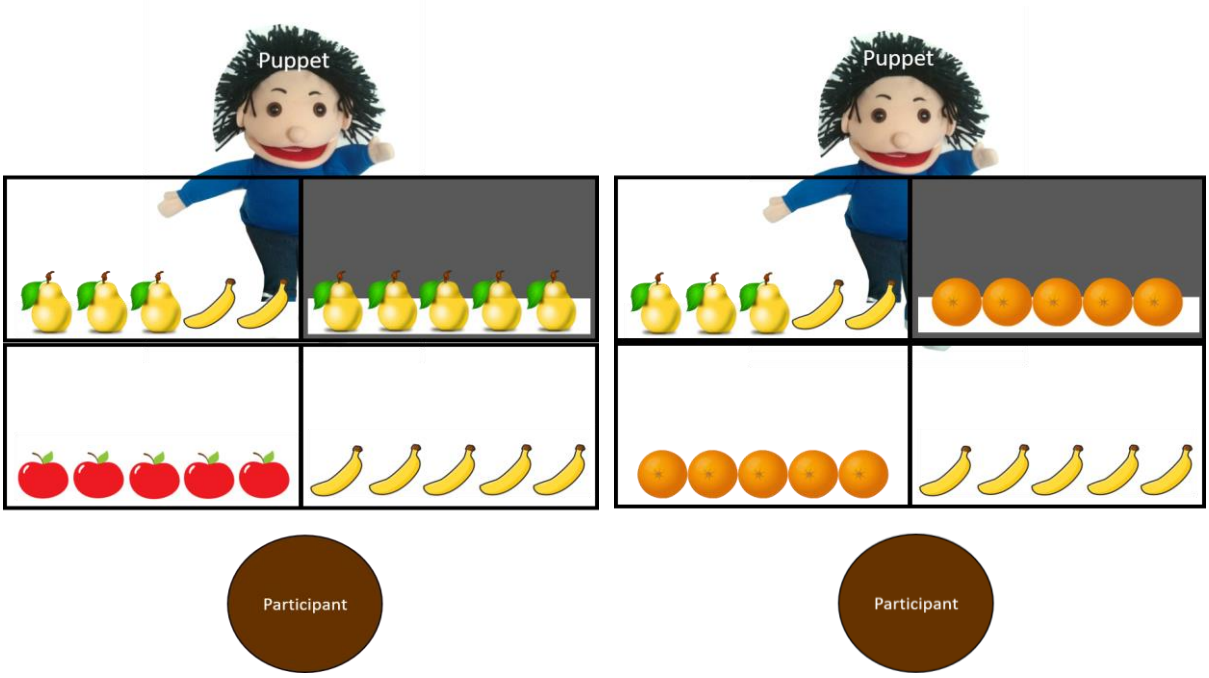

Figure 1: Example display (left) for a) unambiguous condition ("pick the card with apples") – correct selection card with apples, b) common ground ad hoc condition ("pick the card with bananas") – correct selection card with only bananas, or c) privileged ground ad hoc condition ("pick the card with pears") – correct selection card with pears and bananas. Example display (right) for privileged ground semantic condition ("pick the card with oranges") – correct selection mutually visible card with oranges.

semantic matches for the utterance (the card with only Xs, and the cards with Xs and Ys), but only one matched an ad hoc implicature interpretation (the card with only Xs); this condition checked children's ability to make ad hoc inferences with full common ground. In the privileged ground semantic condition, two cards were matches for the utterance (both cards with Xs), but one was in common ground and the other in privileged ground; this condition was designed to check children's perspective taking in this paradigm. Finally, in the critical privileged ground ad hoc implicature condition, one card (the card with Xs and Ys) was in common ground while another (the card with only Xs) was in privileged ground; this tested children's ability to suspend the quantity implicature and pick the card in common ground. From the puppet's point of view 'pick the card with Xs' was the most informative way of describing the card with Xs and Ys given the cards he could see and the fact that he does not know about the card with only Xs. A hearer who takes into account his epistemic state will not derive an ad hoc implicature here, and so select the card with Xs and Ys in common ground; a hearer who ignores the puppet's epistemic state will pick the card with only Xs in privileged ground. In each condition, the remaining two cards in the display were distractors.

For each set of cards, children saw all four conditions, and after collecting four cards they received a sticker for their sticker chart. The experimenter replaced the necessary cards after each trial (with the puppet turning around 'so that he could not see'). In addition, before each set, children were asked which cards the puppet could see and which he could not see, and whether he knew what was on this card. The order of presentation of conditions within each set was counterbalanced across 6 lists (that minimised the number of cards the experimenter had to replace), and the position of the privileged ground card was also rotated around sets. Finally, children did the Sally-Anne task (Wimmer & Perner, 1983) which was acted out with puppets by the experimenter.

Adults did the same task on-line, except that: they heard the audio stimuli but saw an avatar instead of a puppet; they did not do the warm-up production task, but instead completed questions to check they had understood the set-up correctly; and they were asked which cards the speaker could see only twice, at the beginning and half way through the trials.

Results

All children passed the Sally-Anne task, except for one who was still included in the anlsysis. In the main experiment when asked which cards the puppet could or could not see and whether he knew what was on that card, children always answered correctly.

For the main experiment, responses were coded as correct in the common ground ad hoc condition if the card with only Xs was chosen (ad hoc inference); in the privileged ground semantic condition if the card with Xs in common ground was chosen (perspective taking); and in the privileged ground ad hoc condition if the card with Xs and Ys in common ground was chosen (suspended implicature).

Adults were at ceiling in all conditions except privileged ground ad hoc. Children, on the other hand, chose the correct cards in the unambiguous and common ground ad

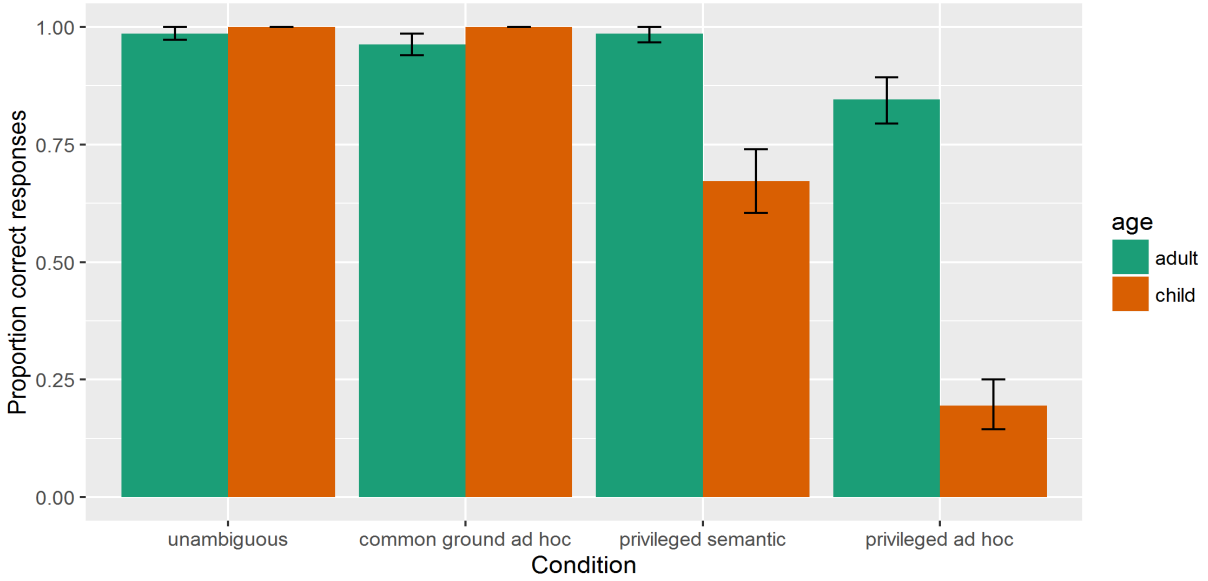

Figure 2: Percentage of correct choice for adults and children. Error bars show bootstrapped 95% confidence intervals for the purpose of between-subject comparison.

hoc inference conditions, but not so much in the privileged ground semantic condition, and hardly at all in the critical privileged ground ad hoc inference condition.

We fit a mixed effects logistic regression model with age and condition as predictors, and participant and item as random effects. We found a main effect of age, such that children performed worse than adults (β= - 3.9, $p < .001$), and a main effect of condition, such that the common ground ad hoc condition was higher than the grand mean ($\beta = 1.9$, $p < .001$), and the privileged ground ad hoc and semantic conditions lower than the grand mean (β = - 3.9, $p < .001$; β = - 0.96, $p = .003$).

As the data was largely bimodally distributed (83% children and 64% adults scored either 6/6 or 0/6 in the critical privileged ground ad hoc condition), we also conducted an alternative analysis that reflected this. We coded participants as passers or failures for each condition: as passers if they were correct on 5/6 or 6/6 trials, and as failures otherwise (cf. Skordos & Papafragou, 2016).

As both adults and children scored at ceiling in the unambiguous and common ground ad hoc conditions, we were interested in comparing their performance in the two privileged ground conditions. Firstly, we looked at children's performance in these two conditions, using McNemar's chi-squared test to examine whether the proportion of passers in both within-subject conditions is the same, and found a significant effect of condition, such that there are significantly more passers in the semantic condition than the ad hoc inference condition (McNemar's $\chi^2 = 6.86$, $p = .008$, with continuity correction).

This indicates that for children there are three strategies in this task that could reflect three stages of development. There are children that cannot consistently take into account the speaker's perspective (in a straightforward semantic condition, let alone in a pragmatic inference), children that can take into account the speaker's perspective in the straightforward semantic condition only, and those that can, in addition, integrate knowledge of the speaker's perspective into ad hoc implicatures.

Table 1: Adult and Child Passers and Failers

Condition	Age	Pass	Fail
Unambiguous	adult	36	0
Common ground ad hoc		35	1
Privileged semantic		36	0
Privileged ground ad hoc		27	9
Unambiguous	child	30	0
Common ground ad hoc		30	0
Privileged semantic		13	17
Privileged ground ad hoc		4	26

Table 2: Contingency tables for A. Child passer-failers in both privileged conditions. B. Adult and Child passer-failers for privileged ad hoc inference condition. C. Adult and Child passer-failers for privileged semantic condition.

A.	Ad hoc Pass	Ad hoc Fail
Semantic Pass	4	9
Semantic Fail	0	17
B.	Ad hoc Pass	Ad hoc Fail
Adult	27	9
Child	4	26
C.	Semantic Pass	Semantic Fail
Adult	36	0
Child	13	17

Secondly, we compared adult and child performance in these two conditions using Fisher's exact test with 2×2

contingency tables, and found a significant association of age and performance: in both privileged ground conditions, there are more adult passers than child passers ($p < .01$). These non-parametric analyses therefore confirm the general findings of the logistic regression, and indicate that 5-6-year-olds are less able than adults to take into account a speaker's perspective and integrate it into utterance interpretation.

Discussion

We conducted a simple, novel task with 5-6-year-old children and adults to investigate whether they take into account the speaker's epistemic state when making pragmatic inferences, in particular ad hoc quantity implicatures. We found that 5-6-year-old children who were easily able to make explicit judgements about others' actions due to their false beliefs (overwhelmingly passing the Sally-Anne test), were less able to take into account a speaker's different perspective – in particular their partial ignorance of relevant facts – in utterance interpretation. While adults derived ad hoc implicatures when this was relevant to the common ground but did not derive it when it was not, children mostly persisted in deriving ad hoc implicatures regardless of the speaker's epistemic state. These findings suggest that the ability to integrate knowledge of a speaker's epistemic state into pragmatic inferences develops gradually.

Our findings about adults' abilities contribute to the existing literature that suggests that adults do indeed take into account a speaker's perspective in their pragmatic inferencing, as Gricean and neo-Gricean theories would predict: when the speaker is ignorant, the hearer cannot take the epistemic step, and so does not derive the implicature (Breheny, Ferguson, Katsos, 2013). As with other off-line behavioural studies (e.g., Goodman & Stuhlmüller, 2013), our results cannot arbitrate on whether this integration is early or late in the processing – an issue more thoroughly investigated with reference resolution, yet still with conflicting findings (e.g., Keysar, Lin & Barr, 2003; Brennan & Hanna, 2009). The adult results also affirm that our novel combination of two experimental paradigms – picture-matching and the director task – is a valid test of implicature comprehension with speaker epistemic state.

Our findings from children support a two-step developmental hypothesis: first, children acquire the ability to reason about others' epistemic states and make pragmatic inferences separately, and then they learn to integrate the two skills. In our study, children demonstrated arguably more complex Theory of Mind skills in a change-of-location false belief task, and, when asked, they were also clear on a difference between their perspective and the puppet's. In addition, they also excelled in ad hoc implicatures where the relevant information is in common ground, again contributing to existing findings (Stiller, Goodman & Frank, 2015; Wilson & Katsos, 2016). However, more than half the children did not consistently choose the mutually visible picture-card in the privileged ground semantic condition, and in the privileged ground ad hoc inference condition, a clear majority consistently chose the picture card that matched the exhaustive meaning, 'only Xs', despite the speaker being ignorant of that card. Some children expressed hesitancy or doubt about their choice in the critical privileged ground ad hoc inference condition, while others made comments such as "Bob has x-ray eyes" – both suggesting that they were sensitive to the conflicting cues but not yet able to resolve them in an adult-like way.

This two-step account is supported by other studies of children's acquisition of implicatures that find that integrating relevant contextual information is challenging. For example, children at this age seem to struggle to track the relevance of the Question Under Discussion and therefore recognise relevant alternatives when deriving scalar implicatures – they perform worse, compared to adults, when the Question Under Discussion alternates between quality and quantity (Skordos & Papafragou, 2016). Similarly, over development from age 5 years to adult, Scrafton & Feeney (2006) observe a rise and then fall in the proportion of scalar inference responses in a judgement task with little supportive context. While the authors suggest an explanation in terms of dual processes, this pattern can also be simply explained in terms of integration of contextual information: the youngest children perform poorly as they are still acquiring scalar implicatures; the older children have acquired the ability to derive implicatures but do so regardless of the context; the oldest children and adults take into account the context (which does not highlight quantity as a Question Under Discussion) and therefore suspend implicatures more often. That is, the ability to integrate linguistic and contextual information to make pragmatic inferences – whether that be Question Under Discussion or the speaker's epistemic state – seems to develop gradually over development, as Papafragou & Skordos (2016) propose. In addition, this finding has implications for theories of pragmatic inferencing, as it suggests that some pragmatic inferencing is possible without taking into account speaker perspective, which is not in accordance with current neo-Gricean theories.

Our results for the privileged ground semantic condition are more puzzling. We designed this condition as a check that children do take the speaker's perspective when there is no intended implicature but simply a semantic match, and expected an adult-like performance. Children's performance for both implicatures and perspective-taking is known to depend to a large extent on the design – and pragmatic context – of the task. There are certain aspects of this task that could have made perspective-taking more challenging for children, for example switching from the 'guessing game' of the warm-up phase to the main experiment, which could have suggested to participants that the goal of the game was to show the puppet what he could not see – and future work can address these issues. Our study therefore reveals not absolute age boundaries at which children start to integrate perspective-taking with pragmatic inferencing,

but rather that it is likely to be a two-step development: in a task of this difficulty, arriving at the correct interpretation can be challenging for children when they have to combine interpretation of the semantic meaning of an utterance with perspective-taking, but even more challenging when they have to combine interpretation of pragmatic implicatures with perspective-taking.

Finally, even adults are not at ceiling in the privileged ground ad hoc condition, which is consistent with the individual variability observed in pragmatic inferencing tasks with adults (e.g., Franke & Degen, 2015). In some cases, as in this study, this could be partly due to pragmatic expectations created by the communicative context that the speaker will be 'over-informative' to guarantee successful reference resolution (Hawkins & Goodman, 2016).

In summary, our work is the first study to our knowledge to investigate children's ability to take into account the speaker's perspective when deriving quantity implicatures. We found that at age 5-6 years, children are able to reason about another's epistemic state in a non-communicative context and easily derive ad hoc implicatures, but that the ability to integrate contextual information about a speaker's epistemic state with this implicature derivation is still fragile.

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