The role of perspective-taking in children's quantity implicatures

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Young children, aged from 4 years, are known to excel at pragmatic inferences known as ad hoc quantity implicatures: they can infer, for example, that a speaker who said "the card with apples" meant the card with *only* apples. However, it is not known whether children take into account the speaker's perspective in deriving such inferences, as adults are able to do, and as the received theories of pragmatics claim. In two experiments, we tested children (5-7 years, N = 33 and N = 25) and adults using a picture-matching director task, in which participants played a game giving cards to the speaker, with some cards being in common ground and some in privileged ground. We found that adults can both derive implicatures when all information is in common ground and not derive them when relevant information is in privileged ground. Children also derive ad hoc implicatures when relevant information is in common ground but, crucially, fail to not derive them when it is in privileged ground. Children's difficulty to integrate perspective-taking with pragmatic inferencing challenges the received pragmatic theories.

Key Words: Pragmatic development; implicature; perspective-taking; common ground; epistemic state.

Introduction

Learning to communicate involves developing pragmatic skills to make inferences about what others mean, beyond what they say explicitly. One type of communicative inference that children have to learn is known as an 'implicature': for instance, if in answer to the question, 'What is on your card?', the speaker replies, 'there are apples', then the hearer may infer that there are *only* apples on the speaker's card. This case is known as an ad hoc quantity implicature (Grice, 1975).

Widely-accepted though diverse approaches to implicature have in common the notion that such inferences not only involve an assumption that the speaker is being fully informative by giving the maximum quantity of relevant information, but also take into account the speaker's perspective and epistemic state, including what is in common ground with the listener (e.g. Frank and Goodman, 2012; Grice, 1975; Horn, 1984; Sperber and Wilson, 1995). In the example above, the hearer assumes that the speaker knows all the objects on the card (the Competence Assumption, Geurts 2010) and infers that, had there been other objects on the card, the speaker would have said so (the Epistemic Step, Sauerland, 2004). If the hearer knows that the speaker is not fully knowledgeable, then he does not derive this implicature. These are linguistic-theoretical models at the computational level of explanation, but they have implications for behavior and competence in development: pragmatic inferencing and epistemic reasoning have to occur together.

According to alternative proposals, reasoning about the speaker's epistemic state is not always required in pragmatic inferences (e.g. Andrés-Roqueta & Katsos, 2017; Breheny, 2006; Jary, 2013; Kissine, 2016; Moore, 2018; Sperber, 1994). For example, Kissine (2016) suggests that pragmatic processes (like implicature derivation) are distinct from pragmatic strategies, which may be more or less egocentric, taking into account the speaker's epistemic state or not. Children could develop pragmatic strategies consecutively, meaning that some inferences in some contexts may not be available to them at certain points in development, while adults switch between interpretation strategies as required.

For adults there is some evidence that hearers take into account the speaker's perspective in deriving implicatures. For instance, Breheny, Ferguson, & Katsos (2013) used eye-tracking to find that hearers anticipated or did not anticipate a quantity implicature in their on-line sentence processing, depending on whether the speaker had or had not seen some relevant information. Others' findings from reading time (Bergen & Grodner, 2012) or

off-line measures (Goodman & Stühlmuller, 2013) support this conclusion. Children, meanwhile, are able to derive ad hoc quantity implicatures in simple picture-matching tasks when the speaker's epistemic state is not at stake from 3 years (e.g. Horowitz, Schneider & Frank, 2018; Stiller, Goodman, & Frank, 2015). They also learn Level 1 perspective-taking (Flavell, 1977) – assessing what someone can or cannot see – from 2 years (Moll & Meltzoff, 2011; Moll & Tomasello, 2006). The question is whether pragmatic inferencing and perspective-taking occur together throughout their development.

Hochstein, Bale, Fox, & Barner (2016) and Papafragou, Friedberg, & Cohen (2018) found that 5-year-olds (but not 4-year-olds) are able to match an under-informative utterance to an ignorant speaker at above chance rates (see also Barner, Hochsten, Rubenstein &, Bale, 2018). Moreover, Kampa, & Papafragou (2017) presented 4-year-olds with two pictures of a speaker with a box: in one picture the speaker could see only a spoon, for instance, in the box, while the hearer could see a spoon and a bowl, and in the other picture both objects were in common ground. They found that 4-year-olds were mostly able to answer correctly when asked 'which box is she talking about?' regarding the utterance 'I see a spoon'. This suggests that young children can do some sort of epistemic reasoning in pragmatic inferencing. These findings are open to interpretation, though: the correct choice could be arrived at purely based on sensitivity to informativeness (by reasoning that 'I see a spoon' is an under-informative description of a box with a bowl and a spoon, so it must be the other one), or on the ability to match an implicature interpretation to the speaker's perspective (reasoning that 'I see *only* a spoon' is not a true description of a box with a bowl and a spoon, so it must the other one), or by instead answering the question 'which speaker said that'. That is, whether children are taking into account the speaker's perspective in the pragmatic inference is still not entirely certain.

In this study, we investigated children's ability to integrate perspective-taking into the derivation of pragmatic inferences, in particular quantity implicatures, using a paradigm combining the director task, which tests referential communication and perspective-taking, with a simple picture-matching task which tests implicature derivation. We tested two hypotheses: (1) perspective-taking is an integral part of reasoning about informativeness and deriving implicatures throughout development – children are able to take into account the speaker's perspective and derive or not derive an implicature appropriately as soon as they begin to make these inferences. (2) children learn to derive implicatures, assuming common ground with their interlocutor, and, separately, to track someone else's perspective, and then to integrate the two skills – they may be able to derive an implicature when the speaker's perspective is not at stake before they can appropriately not derive an implicature when information is in privileged ground.

Experiment 1

Methods

Participants

33 English-speaking children aged 5;3–6;3 were recruited from primary schools in Cambridge, UK. A further 4 children were excluded due to experimenter error (N = 1), little knowledge of English (N = 1), not completing the task (N = 2) or for failing a Theory of Mind task. Adults (N = 36) were recruited via Prolific Academic, an on-line research recruitment platform. This and the next study were approved by the Humanities and Social Sciences Research Ethics Committee of the University of Cambridge.

Stimuli

Participants saw a display of four double-sided picture-cards (Figure 1). Three cards were in

common ground with the speaker, a puppet, and one was in privileged ground behind a screen, meaning that it could be seen only by the participant. 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 picture-cards, each with a theme such as fruit or animals.

[Figure 1 near here]

Procedure

Participants were introduced to the speaker, a puppet, who was positioned on the opposite side of the picture display from the participant. His voice was pre-recorded.

For the warm-up phase, the puppet (with pre-recorded voice) explained that he wanted to play a guessing game: he could see three of the items, but not the fourth. He asked the child to describe it, so that he could guess what it was. Each card showed only one item, all of which were different from those used in the test phase. For each of the three warm-up trials the puppet correctly guessed the item. The aim was to highlight the difference in perspective between the speaker and hearer.

For the test phase, the puppet explained that they were going to play a different game, in which he would tell the child to pick a card, by saying, for example, “Pick the card with apples”. The child had to select the cards and put them in a “card box”.

There were 4 conditions, with 6 trials per condition, so that each child saw 24 trials. The order of presentation of conditions within each set of 4 trials (containing one of each condition) was counterbalanced across 6 lists and the position of the privileged ground card was rotated across sets. The experimenter replaced the cards as necessary between each trial, turning the puppet around so that he could not see which cards were being changed. Every 4

trials, children were asked which cards the puppet could and could not see, and whether or not he knew what was on the covered card. This reinforced the difference in perspective between the puppet and child. Finally, children were given the Sally-Anne change-of-location task to test their ability to track false belief (Baron-Cohen, Leslie, & Frith, 1985).

In the unambiguous condition, only one card, visible to both the puppet and participant, matched the puppet's utterance (Figure 1).

In the common ground ad hoc implicature condition, two cards visible to both the puppet and participant were semantic matches for the utterance, but only one matched an implicature interpretation. This tested children's ability to make ad hoc inferences with full common ground.

In the privileged ground ambiguous condition, two cards matched the utterance, but one was in common ground and the other in privileged ground. This condition tested children's perspective-taking with semantic ambiguity.

In the critical privileged ground ad hoc implicature condition, two cards were semantic matches for the utterance, but only one of them matched an ad hoc implicature 'only' interpretation. This card was in privileged ground, though, while the other was in common ground. This condition tested the participants' ability to take into account the speaker's epistemic state and *not* derive an implicature, instead selecting the semantically-matched card in common ground. Crucially, from the puppet's point of view, his utterance was the most informative way of describing this card, given the cards he could see. A hearer who is able to take into account the puppet's perspective will suspend the implicature and pick the card with both types of object in common ground; a hearer who is not able to do so will pick the card with only one type of object in privileged ground.

Adults carried out the same task on-line via Qualtrics (Qualtrics, 2016), 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 situation correctly; and they were asked which cards the speaker could see only twice, at the beginning and halfway through.

Results and Analysis

The adult control group was at ceiling in all conditions except the critical one, and the child group was at ceiling for both common ground conditions (Table 1 and Figure 2). All children passed the Sally-Anne Theory of Mind test, except for one who was therefore excluded from the analysis. The responses in the two privileged grounds conditions were bimodally distributed (in ambiguous condition, Hartigan's D = .086, $p < .001$; in ad hoc condition, Hartigan's D = .234, $p < .001$), so participants were coded as passers (scoring 5 or 6/6) or failers (otherwise) for each condition, and chi-squared based analyses were used to compare the two privileged ground conditions across adults and children (McNemar's χ^2 test was used for within group comparison, and Fisher's exact test for between group).

Amongst children, there were more passers in the privileged ground ambiguous condition than in the critical privileged ground ad hoc condition (McNemar's $\chi^2 = 8.1$, $p = .0044$; Table 2). There were significantly more adult passers than child passers in both the privileged ground ambiguous condition (Fisher's exact test $p < .001$) and the privileged ground ad hoc condition (Fisher's exact test $p < .001$)[4].

[4] Due to the floor and ceiling effects, a maximal mixed effects logistic regression models failed to converge, but an intercepts-only model confirmed the results of the chi-squared analyses: a model with condition and age as fixed effects (treatment coding with child age-group and privileged ground ad hoc condition as baselines), and item and subject random intercepts, indicated an effect of age for privileged ground ad hoc condition ($\beta = 3.98$, $p < .001$) – adults performed better than children – and an effect of condition in children, such that they are better in the privileged ground ambiguous condition ($\beta = 2.84$, $p < .001$) and common ground ad hoc condition ($\beta = 5.91$, $p < .001$).

[Table 1 near here]

[Table 2 near here]

[Figure 2 near here]

Discussion

The results indicate that children, like adults, excel in deriving ad hoc quantity implicatures in a picture-matching task when the speaker's perspective does not differ from theirs, in accord with previous findings (e.g. Horowitz, Schneider, & Frank, 2018; Katsos & Bishop, 2011; Stiller, Goodman, & Frank, 2015; Yoon & Frank, 2019). Adults were able to take into account the speaker's perspective to resolve a semantic ambiguity, and largely, to not derive an ad hoc quantity implicature when the speaker did not know the relevant information. In contrast, the majority of children were not able to take into account the speaker's perspective to not derive an ad hoc quantity implicature, and many also struggled to do so to resolve a semantic ambiguity. This lends support to the second hypothesis, that children learn to derive implicatures, and to take another's perspective, and then to integrate the two skills online.

The experiment was designed to follow as closely as possible previous director tasks and implicature picture-matching tasks (Horowitz, Schneider, & Frank, 2018; Nilsen & Graham, 2009). However, some resulting features of the experimental context could have hindered children's performance, masking their actual competence. Firstly, children may have perseverated with the warm-up game of showing the puppet what was on the hidden card, increasing the incorrect responses in the two privileged ground conditions. Secondly, in the privileged ground ad hoc condition, the privileged ground card displayed 5 objects, while the common ground card displayed only 3 of those objects (and 2 others): this could make it harder to ignore the privileged ground card, and, for those children not taking into account

the speaker's perspective at all, could mean that they are choosing this card simply because it has more of the relevant items. Finally, the pseudo-randomized trial order may have increased the difficulty of the task: if children are unable to integrate speaker perspective in implicature derivation, this forces them to choose the privileged card in the privileged ground ad hoc condition, which, in turn, licenses selection of the privileged card for the privileged ground ambiguous condition. We addressed these concerns in Experiment 2.

Experiment 2

Methods

Participants

25 English-speaking children aged 5;11-7;11 were recruited from a primary school in Sussex, UK, and Saturday schools in Cambridge, UK. Five children were excluded, due to not being English-dominant speakers (N = 3), for falling outside this age range (N = 1), and for failing the Theory of Mind task (N = 1). Adults (N = 18) were recruited via Prolific Academic.

Stimuli

The stimuli replicated those used in Experiment 1 (Figure 3), except that cards with just one type of item showed either 3 items or 2 items (e.g. 3 bananas or 2 pears). Also, in the unambiguous condition, for half of the trials the target card had 3 of the requested item and 2 of another, or 2 of the requested item and 3 of another, though in each case the request was unambiguous given the display. For the other half of the trials a card with 3 of the same items was used. This highlighted that the 'correct' choice of card could display two types of item, and ensured this was not only the case in the privileged ground ad hoc condition.

[Figure 3 near here]

Procedure

The procedure replicated that of Experiment 1, except that in the warm-up phase, the experimenter asked the child which cards the puppet could and could not see, and then presented two unambiguous trials. Also, the order of presentation of conditions within each set was again counterbalanced across the 6 sets, but the privileged ground ambiguous condition always appeared before the critical privileged ground ad hoc condition.

Results

The same analysis was followed as for Experiment 1, given that again the data were bimodally distributed (privileged ground ambiguous Hartigan's D = .045, p = .0005; privileged ground ad hoc Hartigan's D = .2, p < .001; Table 3 and Figure 4). Amongst children, there were more passers in the privileged ground semantic condition than in the critical privileged ground implicature condition (McNemar's χ^2 = 10.08, p = .001; Table 4). There were significantly more adult passers than child passers in the privileged ground ad hoc condition (Fisher's exact test p =.005) but not in the privileged ground ambiguous condition (Fisher's exact test p =.37)[5].

[Table 3 near here]

[Table 4 near here]

[Figure 4 near here]

[5] A model with condition and age as fixed effects (treatment coding with child age-group and privileged ground ad hoc condition as baselines), and item and subject random intercepts, indicated an effect of age for privileged ground ad hoc condition (β = 3.85, p < .001) – adults performed better than children – and an effect of condition in children (privileged ground ambiguous β = 3.07, p < .001; common ground ad hoc β = 6.62, p < .001).

Discussion

The results of Experiment 2 corroborate those of Experiment 1: there was still a significant difference between adults and children in the critical privileged ground ad hoc implicature condition, such that children were not able to take into account the speaker's perspective to not derive an implicature. However, in the privileged ground ambiguous condition, there was no longer evidence for a difference in performance between adults and children. This could be due to the methodological improvements to the task, or to the somewhat older age of the sample of children in Experiment 2, though a lack of correlation between age and performance in both privileged ground conditions favors the former explanation.

General discussion

We found that adults are able to take into account the speaker's perspective in implicature processing in order to not derive an implicature when the speaker lacks the relevant knowledge – the first demonstration to our knowledge of this ability with ad hoc quantity implicatures using off-line methods. In contrast, children aged 5-7 years are not able to take into account the speaker's perspective to not derive an implicature when the speaker is ignorant of relevant information. This is despite the fact that they excel at deriving implicatures where the speaker's perspective is not at stake, and are able to track the speaker's perspective in other situations (being able to explicitly say which cards the puppet could not see, and passing the Sally-Anne False Belief task).

This suggests that they have trouble integrating the two skills – implicatures and perspective-taking – and implies a two-stage development, in support of our second hypothesis: first, children learn to derive implicatures, assuming common ground with their interlocutor, and, separately, to track someone else's perspective; then, they learn to integrate the two skills in online interpretation.

This conclusion lends support to the alternative views of pragmatic inferencing, which suggest that, in development at least, and in certain contexts, inferencing may take place independently of integrating information about the speaker's epistemic state (e.g. Andrés-Roqueta & Katsos, 2017; Kissine, 2016), or, at the very least, that common ground with the speaker is always assumed in deriving an inference. As children develop, they acquire more pragmatic strategies which enable them to infer the speaker's meaning when the speaker's perspective differs from theirs. The received views are challenged by a need to explain how some pragmatic inferencing is apparently possible without reasoning about the speaker's epistemic state.

Of course, we need to be careful to restrict this claim to visual perspective-taking as was tested here. It may be for example that children are able to take into account the speaker's perspective when deriving implicatures in *social* perspective-taking, where differences in perspective unfold dynamically through shared interaction, typically with one agent absent when the privileged ground information is revealed (Moll & Kadipasaoglu, 2013). If this were the case, it would allow for the possibility that children do develop pragmatic inferencing from the start in an adult-like way, including social perspective-taking, while particular cognitive skills, like visual perspective-taking, are only developed and integrated later. Moreover, the reasons why children fail to take the speaker's perspective when deriving implicatures remain an open question. At a different level of explanation, a difficulty integrating and inhibiting different sources of information due to developing executive functions is a likely hypothesis. This is a challenge in other domains of language development, too, for instance in syntactic or semantic processing where visual stimuli conflict with common ground more generally (e.g. De Cat, 2015; Pomper & Saffran, 2016; Trueswell, Sekerina, Hill, & Logrip, 1999).

Nevertheless, the main findings reported in this paper remain novel and significant, as the first demonstration that at least in some contexts young children do not integrate perspective-taking into the process of deriving implicatures, which is a central assumption of many pragmatic accounts.

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Declaration of interest

None to declare.

Data availability

Materials and analyses associated with this paper are available at osf.io/syf8w

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	Common ground unambiguous		Common ground ad hoc implicature		Privileged ground ambiguous		Privileged ground ad hoc implicature	
	Fail	Pass	Fail	Pass	Fail	Pass	Fail	Pass
Child	0	33	0	33	19	14	29	4
Adult	0	36	1	35	0	36	9	27

Table 1 Number of child and adult failers and passers in each condition

	Privileged ground ambiguous fail	Privileged ground ambiguous pass
Privileged ground ad hoc implicature fail	19	10
Privileged ground ad hoc implicature pass	0	4

Table 2 Number of child failers and passers for the privileged ground ambiguous and privileged ground ad hoc conditions

	Common ground unambiguous		Common ground ad hoc implicature		Privileged ground ambiguous		Privileged ground ad hoc implicature	
	Fail	Pass	Fail	Pass	Fail	Pass	Fail	Pass
Child	0	25	2	23	5	20	17	8
Adult	0	18	0	18	1	17	4	14

Table 3 Number of child and adult failers and passers in each condition

	Privileged ground ambiguous fail	Privileged ground ambiguous pass
Privileged ground ad hoc implicature fail	5	12
Privileged ground ad hoc implicature pass	0	8

Table 4 Number of child failers and passers for the privileged ground ambiguous and privileged ground ad hoc conditions

Figure 1 Example display in Experiment 1 from the participant's perspective with example utterances and correct card selection for each condition

Figure 2 Proportion of passers by age and condition

Figure 3 Example display in Experiment 2 from the participant's perspective with example utterances and correct card selection for each condition
* Half of the stimuli in the condition displayed two types of object, and half one type.

Figure 4 Proportion of passers by age and condition for Experiment 2