Gricean epistemic reasoning in 4-year-olds

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Abstract

Recent experimental evidence suggests that adults incorporate speaker knowledge into the derivation of pragmatic implicatures. Developmental studies report that 5-year-old children also succeed in taking speaker knowledge into account in implicature computation, but 4-year-olds fail. The present study investigated the pragmatic competence of 4-year-olds, specifically the ability to incorporate speaker knowledge into the derivation of ad hoc scalar implicatures. Using a simple paradigm inspired by referential communication, we found that 4- year-olds are able to incorporate speaker knowledge into implicature derivation. These results have implications for our understanding of the linguistic, pragmatic, and epistemic abilities of young children.

Keywords: implicatures; pragmatics; speaker knowledge

Background

As established by Grice (1989), communication involves partners in a conversation working towards the same cooperative goal (cf. also Sperber & Wilson, 1986). To that end, speakers must be as informative as required by the purpose of the exchange. If a speaker is less than fully informative, as in (1), the listener will assume that – as far as the speaker knows - the stronger alternative in (2) is not true.

(1) Some chipmunks collect acorns.
(2) All chipmunks collect acorns.

The inference that the stronger statement in (2) does not hold is known as a *scalar implicature* and requires pragmatic reasoning. Scalar implicatures take their name from the fact that they rely on a comparison to a lexical item on an informativeness scale that the speaker could have used but did not (Grice, 1989). In the case of (1) and (2), the lexical alternatives involved form a scale ordered in terms of logical strength (Horn, 1998). Furthermore, this logically ordered scale is a feature of the language that needs to be accessed in order for the hearer to compute an implicature. Other types of scalar implicatures rely on ad hoc scales that depend upon contextual information. For instance, a speaker can utter (3) to communicate that the stronger statement in (4) does not hold:

(3) Chip and Dale collect acorns.
(4) Chip, Dale and Max collect acorns.

Past findings in the literature have indicated that children struggle with deriving scalar implicatures until late in development: unlike adults, they fail to reject weak (underinformative) statements when a stronger alternative is true (Chierchia et al, 2001; Noveck, 2001). Eye-tracking methods have also revealed weaknesses in early implicature computation (Huang & Snedeker, 2009). However, 5-year-olds have increased success in computing scalar implicatures when task demands set up an expectation of a stronger utterance (Papafragou & Musolino, 2003; Skordos & Papafragou, 2016; Katsos & Bishop 2011; see Papafragou & Skordos, 2016 for a review), and even 3-year-olds succeed in deriving ad hoc scalar implicatures in a simple referent selection task (Stiller, Goodman, & Frank, 2015; cf. also Barner, Brooks, & Bale, 2011). At present, there is much discussion in the field about whether early failures with implicatures were due to children's increased pragmatic tolerance in judgment tasks (Katsos & Bishop, 2011), lack of linguistic processing abilities (Chierchia et al, 2001; Reinhart, 2004), inability to access stronger lexical alternatives (Barner et al., 2011), failures in assessing which alternatives are conversationally relevant (Skordos & Papafragou, 2016), or some combination of these factors.

The present study seeks to incorporate speaker knowledge into the task of implicature derivation (Sauerland, 2004; Fox, 2007; Chierchia, Fox, & Spector, 2009). There is evidence that adults consult the speaker's knowledge state when computing implicatures (Bergen & Grodner, 2012; Breheny, Ferguson & Katsos, 2013). For instance, the hearer upon encountering a statement such as (1) or (3) is justified in concluding that the listener does not know whether the stronger alternative is true (or, in other cases, that the speaker knows that the stronger alternative is false). However, developmental studies have shown that young children have difficulties with such epistemic aspects of implicature computation. Hochstein and colleagues (2016) conducted a study with 4- and 5-year-olds investigating their ability to compute non-scalar "ignorance" implicatures which require the incorporation of the speaker's knowledge state into their derivation. They found that 5-year-olds were able to succeed on this task but 4-year-olds failed.

In a study most closely related to the present experiment, Papafragou, Friedberg and Cohen (in press) found a similar pattern. In that study, 4- and 5-year-old children watched

short videos of two twins. In one video, an observer only saw part of one twin's action, and in the other video, the observer saw the whole action. Children themselves had access to the completed action that was the same in both videos (e.g., a girl colored a star). Children then heard a statement made by one of the observers about the action (e.g. 'The girl colored some/all of the star') and had to decide which observer said it. Five-year-olds were able to successfully incorporate speaker knowledge into their pragmatic reasoning, attributing weak statements to the partly informed observed and strong statements to the fully informed observer, but 4-year-olds struggled. In later manipulations, when the observers' access to the actions was identical to the children's (and hence there was no need to reason about someone else's belief), 4-year-olds' performance improved.

The present paper revisits the issue of whether 4-year-olds can incorporate the speaker's knowledge state into the computation of implicatures, as 5-year-olds and adults have been shown to do. The task designed for this experiment was created with the goal of keeping task demands as simple as possible. The design borrows from the referential communication paradigm (see, e.g., Nadig & Sedivy, 2002). In this paradigm, speaker knowledge is established through the speaker's visual perspective without the need to set up an elaborate background scenario (cf. also Matthews et al., 2006). The task also has a clear goal (referent selection; see Stiller et al., 2014) and targets ad hoc scalar implicatures that rely on contextual knowledge set up within the experimental scene.

Experiment

Participants

Thirty-one 4-year-olds (mean age: 4;6, range: 4:0 to 4:11, 16 female) participated. Children were recruited from Newark (DE) preschools. A control group of 26 adult participants was also tested. Adult participants were recruited with a HIT posted on MTurk.

Method

For the test phase, participants were shown pairs of pictures displayed side by side on a laptop screen (see Figure 1). Within a pair, each picture showed the same person sitting across a table behind a two-compartment box with identical objects (e.g. a spoon and a bowl), facing the camera. In one picture, the girl could see the contents of both compartments in her box (*full access box*), but in the other, she could only see the content of one compartment (e.g. the spoon) because the other compartment was blocked (*limited access box*). The participants could see the full contents of both boxes. Within a pair, the first (leftmost) picture was displayed for 2 seconds, followed by the appearance of the second picture that remained on the screen for 2 seconds. Then an audio recording of a sentence was heard (both pictures remained on the screen). The sentences were either weak (e.g. "I see a spoon") or strong (e.g. "I see a spoon and a bowl").

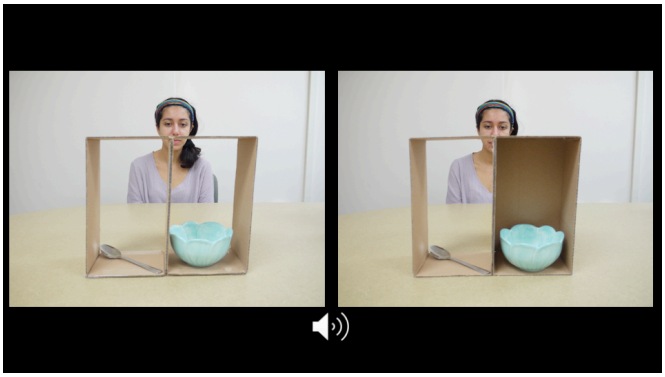

Figure 1. An example stimulus.

Before the test phase, children were introduced to the limited access box and an explanation of how it worked. The explanation involved showing a picture of the girl with the limited access box in front of her and one object in the hidden compartment. The children were asked whether they could look through the open and closed compartments. For the closed compartment, the children were then asked why they could not look through it (answers typically mentioned that it was closed or blocked). They were asked if they thought the girl could look through the blocked compartment. The children were then asked whether the girl knew there was a hidden item in the blocked compartment. To remind children of the properties of the boxes, after the first 4 test trials, children were again asked whether they could look through both compartments of the limited access box and whether they thought the girl could look through both sides and knew there was an object there (for the importance of such reminders of the visual properties of the display, see Nadig & Sedivy, 2002). Children who answered "yes" both times to the question of whether the girl knew there was an object in the hidden compartment were excluded because they did not understand the nature of the limited-access box (N = 6).

The participants were given two pre-test trials. These trials involved a two-picture set-up, as in the test phase. Participants were told that they would see some pictures of the girl looking at a box that was open on both sides, and then looking at a box that was open on one side and closed on the other. The participants were told that the girl was going to talk about only one of the boxes. They were instructed that they would hear a sentence and would have to decide which box she was talking about. For the first pre-test trial, the items in the two boxes were different across boxes rather than identical as in the test trials (a book and a cup in one box; an orange and a spoon in the other). The sentence unambiguously described the full access box ("I see a book and a cup"). For the second pre-test trial, the boxes had different objects again: the full access box had two objects but the limited access box only had an object in

the closed compartment, but no object in the open compartment. The sentence was: "I see nothing." Neither of the pre-tests involved perspective taking. One child failed both pre-tests and was excluded.

The test phase was identical to the pre-test trials, but with identical objects in the two boxes. After hearing either the weak or strong sentence, participants were asked, "Which box is she talking about?", and had to point to the correct picture. The pictures were counterbalanced in terms of whether the limited access box was on the left or the right within the pair. Participants were given 4 strong and 4 weak sentences in a mixed order. Two presentation lists were created; assignment of Type of Sentence (strong, weak) to pairs of pictures was counterbalanced across lists.

In order to succeed on the task, participants had to inhibit their own perspective, since both boxes had identical contents from the children's point of view. If participants successfully incorporated the perspective and knowledge of the speaker, they should say that the strong statement "I see a spoon and bowl" described the full access box, because the spoon was not visible to the speaker in the limited access box. For weak statements, such as "I see a spoon," participants should pick the limited access box because, although the full access box also had a spoon, it would be underinformative to only mention the spoon if the speaker could also see a bowl.

Results

Results are presented in Table 1. In accordance with our predictions and adult judgements, correct answers were defined as choosing the full access box for the strong sentences and the limited access box for the weak sentences. For each of the participants, a mean score across the four trials was calculated for both the strong and weak conditions. Because most of the 4-year-olds received a score of 0 or 1 in the critical weak condition (21 out of 26), participants were divided into passers (score $\geq$ .75) and failers (score $\leq$ .50).

Adults performed at ceiling in both the strong and weak conditions. For the 4-year-olds, Fisher's exact test revealed a marginally significant difference in the number of passers and failers for the strong vs. weak condition (p=.05, 2-tailed). Comparisons across age groups revealed a significant difference between adults and 4-year-olds in the weak condition (p=.01), but no significant difference in the strong condition (p=1). Nevertheless, in the critical 4-year-old weak condition the number of passers was significantly different from the expected ratio due to chance (p=.029).

Table 1: Task performance.

	Classification	Condition	
		Strong	Weak
Adults	Passers	26	26
	Failers	0	0
Children	Passers	25	19
	Failers	1	7

Discussion

This experiment investigated 4-year-olds' ability to incorporate speaker knowledge into the computation of ad hoc scalar implicatures. The results suggest that 4-year-olds display the ability to incorporate speaker knowledge into implicature derivation. These findings lower prior age estimates of children's ability to take the epistemic step during implicature computation – but align with reports in the literature about the epistemic ability of very young children in non-linguistic tasks (Surian, Caldi & Sperber 2007; Baillargeon, Scott & He, 2010). Notice that epistemic stance per se was not as demanding (see strong sentences): when taking someone else's perspective was combined with computing an implicature that this person could have intended, given their knowledge state (weak sentences), performance dropped.

An interesting question is why 4-year-olds were able to succeed at this task when they failed at prior studies targeting sensitivity to the speaker's epistemic stance in implicature-computation (Hochstein et al., 2016; Papafragou et al., in press). In the present experiment, 4-year-olds needed to compute implicatures, but they also needed to reason about what a person had access to, determine how that would affect the speaker's utterances, and inhibit their own perspective. Nevertheless, our paradigm was based on a simple, clear way of establishing that someone's knowledge differs from the child's own; furthermore, the present paradigm included a clear conversational goal (the identification of the box that the speaker is talking about). In both of these respects, the current study is simpler than past attempts to link the informativeness of a sentence to a speaker's mental state.

These findings and the paradigm used in this experiment provide fertile ground for a continued investigation into the pragmatic ability of young preschool children. It is possible that children younger than 4 could be found to demonstrate these abilities with an even simpler task. We are currently pursuing this possibility in ongoing work.

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