

## Speaker epistemic state and ad hoc quantity implicatures in children

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**Background** Gricean and neo-gricean accounts of implicature assume that the listener takes into account the speaker’s epistemic state. For example, the listener infers from the utterance ‘John ate an apple for lunch’ that *John ate only an apple* if he knows or can assume that the speaker is fully informed about John’s lunch – this is known as the epistemic step (Sauerland, 2004) and has been demonstrated in studies with adults (e.g., Breheny, Ferguson & Katsos, 2013; Politzer-Ahles & Fiorentino, 2013). Children succeed with ad hoc implicatures from 3 years, where relevant information is in common ground (e.g., Stiller, Goodman, & Frank, 2015), and are able to match an under-informative utterance to a partially-knowledgeable speaker from 5 years (Hochstein, Bale, Fox & Barner, 2014; Papafragou, Friedman & Cohen, 2016). They also start to reason about others’ epistemic states relatively early, for example predicting another’s actions based on their false belief from age 3 or 4 (Wellman, Cross & Watson, 2001). Here, we present the first study to our knowledge that investigates children’s ability to take into account speaker epistemic state in ad hoc implicature derivation. Our findings support a two-step developmental trajectory: first, children learn pragmatic inferences (assuming full relevant common ground) and reasoning about epistemic states, and then, second, learn to integrate the two processes.

**Experimental study** We tested English-speaking children aged 5;3-6;4 (N=34) and adults (N=36) in a novel experimental design that combined an ad hoc implicature picture-matching task (Horowitz & Frank, 2015), with the director task testing reference and perspective-taking (e.g., Nilsen & Graham, 2009) – Figure 1. Participants collected double-sided picture cards and put them in a ‘card box’, following the puppet’s instructions ‘pick the card with Xs’. There were four conditions (6 trials per condition; 6 lists across participants): unambiguous; common ground ad hoc implicature; privileged ground ad hoc implicature; and privileged ground semantic (checking perspective-taking with no pragmatic inference).

Fig.	Condition + Utterance	Correct
1A	Unambiguous “Pick the card with apples”	Apples
1A	Common ground ad hoc “Pick the card with bananas”	<i>Only</i> bananas
1A	Privileged ground ad hoc “Pick the card with pears”	Pears and bananas
1B	Privileged ground semantic “Pick the card with oranges”	Oranges – in common ground (L)

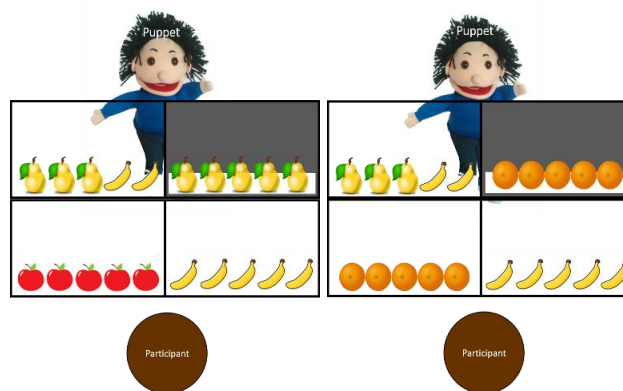


Figure 1A (left) and 1B (right): example experiment displays

In the critical privileged ground ad hoc condition, the card with only Xs was in privileged ground, while the card with Xs and Ys was in common ground. If participants take into account the puppet’s epistemic state (not knowing about the card in privileged ground), they would not derive an ad hoc implicature, and instead choose the card with Xs and Ys – for the puppet, ‘the card with Xs’ is an optimally informative description for the card with Xs and Ys. Participants were asked every 4 trials which cards the puppet could / could not see, and whether he knew what was on them. Adults completed an online version of the task (via Prolific Academic). Children also did a Sally-Anne False Belief task (Wimmer and Perner, 1983).

**Results** All children passed the Sally-Anne task, except for one who is excluded from the analysis. They also invariably answered correctly the questions about which cards the puppet could see and know about. Adults were at ceiling in all conditions except privileged ad hoc; children were at ceiling only in the unambiguous and common ground ad hoc conditions. As the data was largely bimodally distributed, we coded participants as passers (scoring 5/6 or 6/6) or failers (otherwise)<sup>1</sup>. There were significantly more child passers in the privileged ground semantic than privileged ground ad hoc condition (McNemar's  $\chi^2 = 8.5$ ,  $p = .003$ ; Table 2A), and a significant association of age and performance with more adult than child passers in both privileged ground conditions (Fisher's exact test  $p < .001$ ; Tables 2B, 2C).

<b>A. Child:</b>	Ad hoc Passer	Ad hoc Failer
Semantic Passer	4	10
Semantic Failer	0	19
<b>B. Privileged:</b>	Ad hoc Passer	Ad hoc Failer
Adult	27	9
Child	4	29
<b>C. Privileged:</b>	Semantic Passer	Semantic Failer
Adult	36	0
Child	14	19

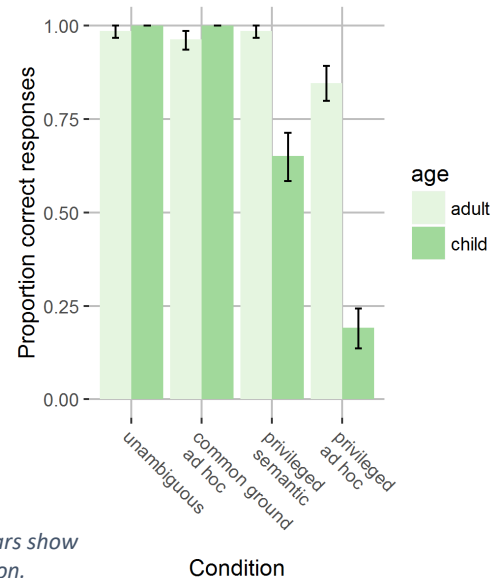


Table 2: Chi-squared contingency tables

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

**Discussion and conclusion** Our results support a two-step development hypothesis. In contrast to adults, children mostly persisted in deriving ad hoc implicatures when the speaker was ignorant of the relevant picture (choosing the one the puppet could not see), despite reasoning correctly about someone's false beliefs or ignorance and exceling in ad hoc implicatures when relevant information is in common ground. Some children also failed to take into account the speaker's perspective when the utterance was semantically ambiguous. Integrating knowledge of the speaker's epistemic state into utterance interpretation therefore seems to be a challenge for children. Our findings support the proposal that children develop the ability to integrate contextual and linguistic information gradually (Papafragou and Skordos, 2016), and raise the question: is integration of full theory of mind always required for some pragmatic competence?

**Select References** Horowitz, A., & Frank, M. (2015). Sources of developmental change in pragmatic inferences about scalar terms. *37th Cog Sci*. Nilsen, E., & Graham, S. (2009). The relations between children's communicative perspective-taking and executive functioning. *Cogn Psychol*, 58(2), 220-249. Papafragou, A., & Skordos, D. (2016). Scalar Implicature. In J. Lidz, W. Snyder, & J. Pater (Eds.), *Oxford Handbook of Developmental Linguistics*. Oxford: OUP. Politzer-Ahles, S., & Fiorentino, R. (2013). The Realization of Scalar Inferences: Context Sensitivity without Processing Cost. *PLOS ONE*, 8(5), e63943. Stiller, A, Goodman, N., & Frank, M. (2015). Ad-hoc Implicature in Preschool Children. *Lang Learn Dev*, 11, 176-190.

<sup>1</sup> The maximal mixed effects logistic regression model (Barr, et al., 2013) failed to converge due to ceiling / floor performances and small random effect sizes (*lme4* in R: R Core Team, 2016; Bates, et al., 2015). A model with condition and age as fixed effects (sum coding), by-item (list) random slope, and by-subject random intercept, indicated a main effect of age ( $\beta = 1.99$ ,  $p < .01$ ) – children performed worse than adults – and condition (common ground ad hoc  $\beta = 1.93$ ,  $p < .001$ ; privileged ad hoc  $\beta = -3.88$ ,  $p < .001$ ; privileged semantic  $\beta = -1.08$ ,  $p < .001$ ).