Children's understanding of others' lexical knowledge

Anonymous CogSci submission

Abstract

Communicating effectively requires keeping track of what others know, and what they do not know. As a result, young children's developing ability to communicate effecitvely also requires they learn to infer and update what others are likely to know. Our study asks children ages 4-8 (n = 62) to make specific predictions about whether a very young child would know 15 familiar animal words. Comparing these judgements with age of acquisition data from adult reports, we see that children as young as 4 years old are able to make item-level predictions, inferring the target child would be more likely to know easy, early-aquired words (e.g., *dog*) and less likely to know harder, later-accquired words (e.g., *lobster*). We also discuss children's explanations for why words might be known or unknown. In sum, this work suggests that even preschool age children are making sophisticated inferences about what words a very young child might know.

Keywords: communication, metalinguistics, knowledge reasoning, cognitive development

Introduction

Imagine being at the zoo with your friend and their young child. As you walk by the peacocks, you hear your friend say, "Do you see those blue birds?" You know immediately that your friend is talking to their child, and not you. While "peacocks" is a fine choice for you, "blue birds" might be a much better description for a child who has never seen a peacock before. Even when talking about the same things, we choose our words carefully to transmit information that we think our partner will understand. To communicate effectively in this way, we must actively consider what our interlocutors know and crucially what they do not know. [Young children sometimes struggle to communicate effectively (e.g., Krauss & Glucksberg, 1977), and partly such struggles could result from difficulty inferring and updating what an interlocutor is likely to know. In this study we ask how children infer another person's lexical knowledge, specifically whether they make item-level predictions about what words a very young child is likely to know.]

Adults track and adapt to an interlocutor's knowledge with relative ease. This is particularly evident in research studying parent-child interactions– where parents are not only sensitive to children's general linguistic abilities, but also keep track of their children's specific lexical knowledge (Wordbank? Fenson et al., 2007?). Furthermore, parents use these models of their children's knowledge in spontaneous communication (Leung, Tunkel, & Yurovsky, in press; Masur, 1992). This line of work reveals that our models of other people's knowledge can be highly specific, and are leveraged for effective communication.

Even in the absence of experience with a specific interlocutor, adults can rely on other metalinguistic knowledge. In a large-scale study, Kuperman, Stadthagen-Gonzalez, and Brysbaert (2012) asked adult participants to report the age at which they understood a given word and obtained judgments for 30,000 English words. These judgments were then directly compared with data on the typical age that a given word is actually learned (also called its age of acquisition, hereafter referred to as AoA). Adults typically overestimate the absolute age at which they learned a given word; however, the estimated order in which words are acquired is intact (Kuperman, et al., 2012). Adults are thus able to make graded and surprisingly accurate relative estimates of when a word was learned.

(if we do it in this order, we need to make a better bridge from AoA to what another agent knows? Like, in order for this skill to be useful in conversation, one must be able to recruit this metalinguistic knowledge to draw on-the-fly inferences about what an interlocutor's likely lexical knowledge…)

While a great deal of work establishes children's ability to use situational knowledge (e.g., knowledge from perceptual access), young children are also able to reason about more general, stable differences in knowledge. Preschool-age children are able to reason about expertise, for example differentiating the knowledge of a doctor and a mechanic (Lutz & Keil, 2002). Preschool-age children also recognize that adults typically have more linguistic knowledge than children (Jaswal & Neely, 2006), but also that children might know more about some things, such as toys (VanderBorght & Jaswal, 2008). Indeed, children are able to reason flexibly about changes in general knowledge across development, ascribing different levels of general knowledge to an infant, preschool child, and an adult (Fitneva, 2010; Taylor, Cartwright, & Bowden, 1991).

Young children show an impressive ability to track other people's knowledge across a wide range of situations, but relatively little work has been done to probe the specificity and granularity of children's inferences about others' knowledge. Reasoning about another person's specific lexical knowledge may prove difficult for young children as they also show consistent errors in reasoning about other's knowledge, commonly over-attributing knowledge (e.g. Gopnik & Astington, 1988; Taylor, Esbensen, & Bennett, 1994). The bias to over-attribute knowledge is particularly pronounced when the child themselves knows the piece of information (Birch & Bloom, 2003). After seeing inside a toy, 3-year-old children often attributed knowledge of what was inside the toy to a puppet that had never played with the toy (Birch & Bloom, 2003). Such curse-of-knowledge biases could severely hinder children's ability to reason about the lexical knowledge of another child.

[better bridge to our study]

In this study, we ask whether children have accurate estimates of other children's knowledge. Specifically, we are interested in whether children are sensitive to the specific vocabulary knowledge of a younger child and are able to make item-wise predictions. Such predictions are crucial to communicate effectively with various interlocutors and account for varying knowledge and perspectives. By age 5, children richly structure their language based on a listener's knowledge, for example offering more general information to ignorant listeners (Baer & Friedman, 2018). However, such studies typically strongly and repeatedly emphasize an interlocutors' knowledge state, to test for children's ability to adapt their communication while controlling for difficulties in knowledge reasoning. Children's performance in other communication tasks (e.g. Krauss & Glucksberg, 1977) might be hindered by difficulty specific knowledge predictions.

To our knowledge, only one study has asked children to give AoA estimates for English words (Walley & Metsala, 1992). In their study, Walley and Metsala (1992) used a broad set of words acquired over a large range of ages (from table to valet) to investigate young children's general metalinguistic knowledge. As young as age 5, children generated AoA estimates that were similar to adults'. Our study builds on Walley and Metsala's (1992) work to collect more sensitive AoA estimates in a single domain (animal words). To probe the specificity and sensitivity of children's AoA estimates, the animal words we use in this study are generally acquired within a narrow age range of 2 to 2.5, based on parent reports of children's vocabulary (Wordbank). Our study also differs from Walley and Metsala's (1992) in a crucial way– rather than asking children when they themselves learned a word, we ask them to estimate the vocabulary knowledge of another fictional child. This framing also allowed us to not ask children the age at which they learned a word, but instead their certainty about the other child's knowledge. Lastly, our study also probes whether children as young as 4 might show this capacity to reason about another child's lexical knowledge.

In the current study, children ages 4-8 were introduced to a younger fictional child, and asked to make judgments about this fictional child's knowledge of various animal words. We expected that overall, children's judgments would recover the ordinal shape of age of acquisition data for these items. That is, children would infer that the child is most likely to know early acquired words, yielding a negative correlation between their judgments of lexical knowledge and adult AoA estimates. We expect developmental change in children's sensitivity to Sam's vocabulary knowledge, with older children's judgments recovering word-level AoA data more closely.

Method

Stimuli Our stimuli consisted of 15 words drawn from a single domain (animal words), along with corresponding images of each animal. We pulled all animal images (n = 45) from a normed image set (Rossion & Pourtois, 2004; recoloring of Snodgrass & Vanderwart, 1980). To ensure our stimuli set spanned a large AoA range, we ranked the animal words from earliest to latest AoA, using data from Kuperman et al. (2012), and split the words into five bins. In order to select animal images that are recognizable and typically identified by a single name, we chose the three animals from each AoA quintile with the highest naming agreement according to a naming task with children (Cycowicz et al., 1997). Our final stimuli consisted of these 15 items, ordered here by estimated AoA: dog, duck, cat, pig, fish, turtle, zebra, elephant, snake, penguin, gorilla, owl, raccoon, leopard, and lobster. While adult AoA estimates for these words range from 2.5 to 7.5 years old, all of these animal words are generally acquired by age 3 according to parent reports of children's vocabulary knowledge (Wordbank?). Because the youngest children in our study are 4 years old, we expect all participants to know these animal words.

Participants We pre-registered a planned sample of 60 children ages 4-8, with 12 children recruited for each year-wise age group. Due to overrecruitment, our final sample included 62 children (12 4-year-olds, 13 5-year-olds, 13 6-year-olds, 12 7-year-olds, 12 8-year-olds). All analyses hold when looking only at the 60 children run first chronologically. Based on our pre-registered exclusion criterion, children who failed to answer all of the questions were excluded and replaced (an additional 7 children). Families were recruited online, primarily through a US University database of families who have expressed interested in doing research or previously participated. Children completed this study over Zoom, interacting with a live experimenter who navigated a slide-style, animated Qualtrics survey.

A separate sample of 30 adults were recruited via Amazon Mecchanical Turk. The adult sample provides a simple test that our task elicits robust inferences about the target child's lexical knowledge, and that these inferences correspond to extant AoA data. The adult participants completed the same task using Qualtrics, with minor modifications detailed below.

Procedure

Introduction. Children were shown a picture of a child named "Sam" (seen in Figure 1). Children were anchored to Sam's knowledge of various familiar skills, specifically some skills

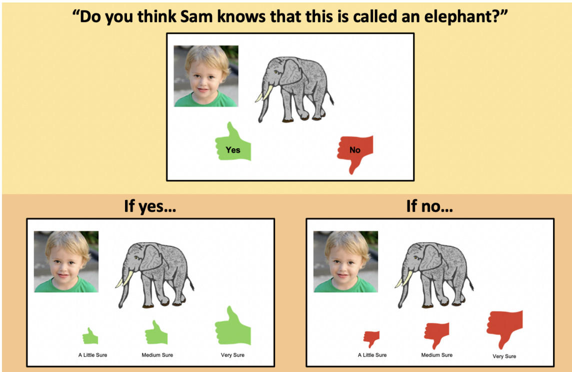

Figure 1: Schematic showing the general structure of an example trial. The experimenter labels the animal, and asks the child "Do you think Sam knows that this is called an elephant?" Based on their response, children are then asked to provide a confidence judgment on a 3-point scale (little sure, medium sure, very sure).

that Sam has acquired (e.g., coloring), and some that Sam has not (e.g., reading). Children are then specifically anchored to Sam's possible word knowledge in an unrelated domain– given an example of one word Sam knows (car), and one word that Sam doesn't know (piano). This introduction is intended to familiarize the children with Sam, roughly anchor them to Sam's knowledge and age, and to ensure that children understand there are things Sam doesn't know yet (even things children themselves likely know, such as how to read).

General trial structure. At each trial, children were shown a drawing of a familiar object or animal (drawings taken from Rossion & Pourtois, 2004, which is a recoloring of Snodgrass & Vanderwart, 1980). The experimenter labelled the object for the child (e.g., "Look, it's a [ball]! Do you think Sam knows that this is called a [ball]? Yes or no?"). Based on their response, children are then asked a follow-up question: "How sure are you that Sam [knows/doesn't know] that this is called a [ball]– a little sure, medium sure, or very sure?" All questions were presented with accompanying pictures of thumbs [up/down] of varying size (see Figure 1). Children as young as 3 are able to engage in uncertainty monitoring and report confidence, although these skills do develop in the preschool years (Lyons & Ghetti, 2011). Children's responses to these two items were recoded onto a 1-6 scale from 1-very sure Sam doesn't know to 6-very sure Sam knows. All trials followed this general structure. The experimenter provided no evaluative feedback on any trials, but did offer consistent neutral feedback (e.g., repeating the child's answer or saying "Okay!"). When a child failed to respond within about 5 seconds or offered a non-canonical response (e.g., saying "Maybe"), the experimenter acknowledged the child's answer and then repeated the question with the possible responses. If a child did not answer after the question was repeated, the experimenter moved on and marked the trial as no response.

Familiarization trials. Children first completed two non-animal familiarization trials, one of an early-acquired word (ball) and one of a late-acquired word (artichoke). These trials followed the trial structure described above and were intended to help familiarize children with the structure of the questions and scales. These trials were always asked first and in a fixed order.

Animal trials. Children were then shown 15 trials of the same form (see example trial in Figure 1). For the 15 animal trials, trial order was randomized across participants to control for any potential order effects in children's responses.

Explanation. After completing the final animal trial, children were asked an open-ended explanation question about their final judgement (e.g., "Why do you think Sam [knows/doesn't know] that this is called [an elephant]?"). Because the trial order was randomized, the explanations concerned different animal words across participants.

Final check questions. Children were asked two questions about Sam's skill knowledge, one early acquired skill (going up and down stairs) and one very late acquired skill (driving a car). These questions again followed the general trial structure described above. The skill knowledge items were included as an additional check that children at all ages were able to use the scale appropriately, in case young children failed to differentiate animal words based on AoA. Lastly, children were asked to report how old they thought Sam was. This question was intended to assess another aspect of children's belief about Sam. Sam's photo and skill knowledge were intended to indicate toddlerhood.

Adult procedure. The adult participants completed a minimally adapted version of the same task online via Qualtrics. Unlike children, adults were simply presented with the full 6-point scale (1 - *very sure Sam doesn't know* to 6 - *very sure Sa does know*). Additionally, the task was administered asychronously, so adult participants did not interact with an experimenter or recieve any feedback during the task. Otherwise, the adult task was identical to the child task descirbed above.

Results

Our primary analyses compare knowledge judgments on our 6-point scale to AoA judgements from adults (taken from Kuperman et al., 2012). Data were analyzed using pre-registered mixed effects model predicting children's judgments from adult AoA estimates (Kuperman et al., 2012), including random effects for participant and word. Using the lme4 package in R (**citation**), our model syntax was `judgment ~ aoa + (1 | participant) + (1|word)`.

First, analyzing adults responses on our task, we the predicted negative effect of AoA on adult's judgements of the target child's knowledge (see (Figure 3), β = -0.63, t = -8.71, p < .01). This provides a simple sanity check that our task is eliciting reliable predictions from adults, that match predictions from AoA estimation tasks (e.g., Kuperman et al., 2012).

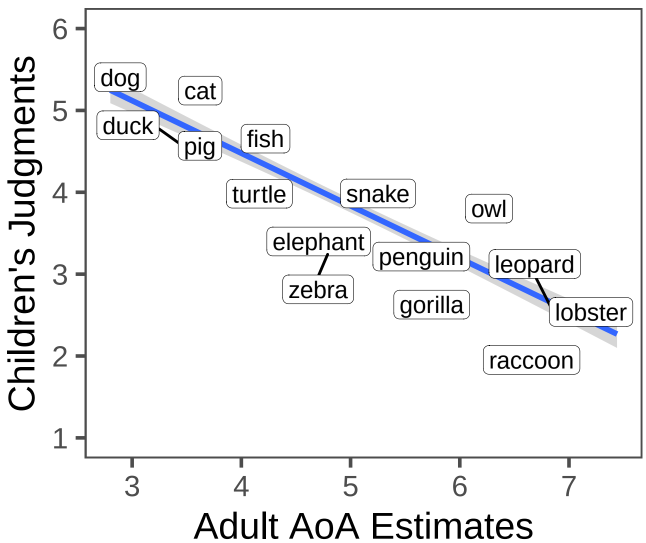

Figure 2: Comparing adult AoA estimates (in years, taken from Kuperman et al., 2012) and children's judgments on our 6-point scale (1 = very sure Sam doesn't know; 6 = very sure Sam knows).

Do children's judgments about a child's vocabulary knowledge also reflect a sensitivity to which words are learned later? To answer this quetion looking at children's responses overall, we ran the model with no age term and see a significant negative effect of AoA on children's judgements (β = -0.65, t = -8.29, $p < .001$). That is, overall, children judged that the target child would be most likely to know an early acquired word (e.g., dog) and least likely to know a late acquired word (e.g., lobster, see (Figure 2)).

To test for developmental changes in children's responses, we used the same mixed effects model but included an effect of age and an interaction between AoA and age. Our model syntax was `judgment ~ aoa * age + (1 | participant) + (1|word)`. We expected that older children's judgments would more closely reflect word-level AoA data, yielding a significant interaction between AoA and child's age. That is, when plotting children's judgments against adult AoA estimates, older children would show steeper negative slopes than younger children. Again, our model shows the same main effect of aoa that we saw in the overall model (β = -0.65, t = -8.29, $p < .001$). We also see a positive main effect of children's age on their ratings (β = 0.55, t = 3.68, $p < .001$). Crucially, we see our expected interaction between child's age and adult's estimated AoA (β = -0.14, t = -5.1, $p < .001$), suggesting that children's judgements are becoming more adult-like in this age range (Figure 3).

To test the robustness of this intuition at each age, we ran the above model separately for each year-wise age group. While we see evidence of developmental change above, this additional analysis helps us understand if even young children are showing this intuition. We found a significant negative effect of AoA on children's judgments at all age groups (with the smallest effect in 4-year-olds: β = -0.33, t = -3.01, p = .01). That is, even 4-year-old children judged that late-acquired animal words were less likely to be known by the target child.

Explanations As a secondary analysis, we were also interested in the reasons young children gave for why the target child would or would not know a given word. While children sometimes offered spontaneous explanations throughout the study, this analysis focuses on the explanation elicited after the final animal trial. Based on preliminary discussions between the authors, the explanations were divided into 5 non-mutually-exclusive categories: *Language*, *Experience*, *Location*, *Age*, *Unsure*, and *Other*.

Language reflects explanations that explicitly appealed to language properties (e.g., "becuase it's a hard word"). *Experience* reflects explanations that appeal to the child's real-world experience with the referent (e.g., "because they might have it for a pet"). *Location* reflects explanations that specifically reference a particular place the animal is associated with (e.g., "because it lives in the water"). *Age* reflects explanations that reference a particular age or general age-group ("lots of babies don't know about them"). Any child that failed to answer the explanation question or expressed ignorance was coded as giving an explanation of *Unsure*. An explanation that didn't fall into any of the above category was coded as *Other*. Note that coding was not mutually-exclusive, so that explanations could be coded as including multiple categories. See Table 1 for examples of each coding category.

Discussion

Our ability to track other people's knowledge is crucial for successful communication. Young children are capable of inferring others' general knowledge states, but do they make accurate judgments about another person's specific knowledge. We asked 4- to 8-year-old children to estimate a fictional child's knowledge of animal words, and found that children as young as 4 are sensitive to a younger child's lexical knowledge. Children across age groups made judgments similar to those of adults, with older children recovering more adult-like patterns.

In line with Walley and Metsala (1992), our findings indicate that even young children have surprising metalinguistic knowledge–they are sensitive to which animal words are acquired earlier versus later, even though the animal words used in our study are generally learned within a 6-month period. Our study also builds upon the extant literature on children's inferences about other people's knowledge to show that children infer others' specific, lexical knowledge. When given fairly minimal information about a fictional child, children readily make estimates about that child's lexical knowledge.

The current work lays the foundation for future research on how children leverage their knowledge of other people to communicate successfully. Young children struggle in a variety of communicative tasks (e.g. Krauss & Glucksberg,

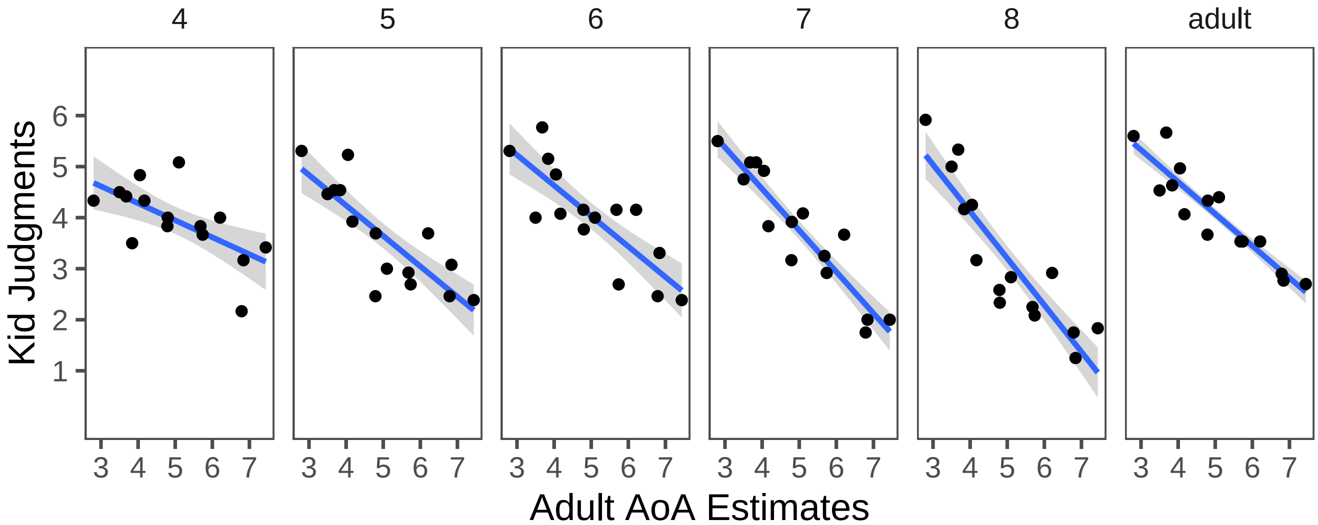

Figure 3: Children's judgements across development. Comparing adult AoA estimates (in years, taken from Kuperman et al., 2012) and children's judgments, split by age in years.

Category	Example Utterance
Language	Because it was a very long word.
Experience	Because maybe he has a dog.
Location	Because penguins live in the artic and it's too cold for little kids so that's why you should have 130 jackets...
Age	Because I think I knew that when I was around 3, I knew what a pig was.
Unsure	I don't know.
Other	Because it had a longer beak than a bird.

Table 1: Example explanations from child participants for each of the five categories used for coding.

1977), and the current work can begin to map out whether such difficulties stem from tracking an interlocutor's knowledge, or may stem from problems using that information to adjust language production. By at least age 5, children selectively talk about general or specific characteristics of an object based on their partners' knowledge state, when the knowledge state is salient and explicit for each item (Baer & Friedman, 2018). Based on our findings that children can reason about others' specific knowledge, we can ask whether children's adaptations extend to the level of lexical knowledge– Do children adjust the way they talk about a referent based on their beliefs about a partners' knowledge of that word?

How are children in our study making estimates about other people's knowledge? One limitation of the current study is that it leaves the mechanisms underlying such estimates unclear. Children's own explanations suggest that they use various cues to make their estimates, mostly appealing to [age/language/experience?]. When making judgments about someone else's vocabulary knowledge, children use information about the person, as well as general knowledge about the word and its referent to inform their estimations. Future should could more directly probe the features underlying this inference– to see if children are relying on their own uncertainty, word length (and other linguistic cues), features of the referent itself, or still other features.

Stimuli, data, and analysis code available after deanonymization.

References