The many meanings of "um": Children draw rich, contextual social inferences after hearing speech disfluencies

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Abstract

Successfully navigating the social world requires figuring out what others know, like, want, and more. Timing and delay in someone's actions hold rich, nuanced information about their underlying mental states. In language, delays are commonly expressed as disfluencies (e.g., the filled pauses "uh" and "um"). Adults use silent pauses to infer speaker desires (Roberts, Margutti, & Takano, 2011) and disfluencies to infer speaker knowledge (Brennan & Williams, 1995). Across three studies, we explore at what point in development children (aged 4- to 9-years-old) use speech disfluences to make rich social inferences about the mental states of others. In Experiments 1a and 1b (n = 44), we present pilot evidence that children infer that a speaker who answers a question accurately, but disfluently is less knowledgable than an accurate and fluent speaker; however, they make no such inference when the speakers express ignorance instead (e.g., I don't know). In Experiment 2 (n = 101), we replicate these results in a larger, pre-registered study, and show that even 4-5 year old children make these inferences. In Experiment 3 (n = 56), we show that these effects generalize to other social inferences– when discussing preferences, children age 6 and older infer a disfluent speaker has a weaker preference than a fluent speaker. Additionally, across Experiments 2 and 3, we see evidence suggesting that children's ability to infer knowlege from disfluencies may emerge earlier than their ability to infer preferences. Overall, this work demonstrates that children can make a range social inferences based on speech disfluencies, flexibly recognizing that disfluencies can mean different things in different contexts.

Keywords: communication, speech disfluency, mental-state inference, hesitation, uncertainty, processing time

Word count: X

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Imagine you ask someone on the street, "Where is the nearest train station?" and they reply "It's um… that way." While plausibly correct, the stranger's reply is slow and marked, indicating uncertainty about accuracy of their statement. Despite getting a relevant answer, you yourself may still feel uncertain, perhaps choosing to confirm the direction by consulting another stranger or checking your smartphone. In this way, adults can use disfluencies to make inferences about the inner workings of a speaker's mind, which is an important social cognitive skill that can shape how they learn from and evaluate others. *How* something is said may be as meaningful as *what* is said. When in development can children use disfluencies to make inferences about others' mental states? In three studies with children 4 to 9 years old, we explore this question.

Producing language in a timely manner may often conflict with demands on processing, memory, and many other factors liable to cause delays. When such delays are unavoidable, speakers may mark them with disfluencies (e.g., filled pauses "uh" and "um"). Conversation is rife with these small disruptions; some data sources estimate that 6 disfluencies occur every 100 words in adult conversations (Fox Tree, 1995; Shriberg, 1996). Disfluencies allow speakers to hold the conversational floor while having planning difficulties or searching for an answer (Clark & Tree, 2002; Smith & Clark, 1993). As a result, disfluencies may signal something to the listener about the cognitive process that generated them.

Children likely have abundant and systematic experience hearing disfluencies in the language around them (Kidd, White, & Aslin, 2011; Shriberg, 1996). Young children also have first-hand experience with disfluencies in their own productions– prevalent from at least age 2 (Casillas, 2014). 22-month-old infants distinguish between fluent and disfluent adult-directed speech, suggesting that children are sensitive to disfluencies in the second year of life (Soderstrom & Morgan, 2007).

Still more impressive, by their second birthday, toddlers are able to monitor these cues online and predict that a disfluent speaker will likely refer to a novel object that is new to the discourse, rather than a familiar one that has already been discussed (Kidd et al., 2011). Later in development this predicition may be tied to a speaker's knonwledge: 3 1/2-year-olds make the same prediction when pre-trained on a reliable speaker, but show no such prediction when pre-trained on a forgetful speaker who fails to remember the names familiar objects during training (Orena & White, 2015). From an early age, children reason about speech disfluencies and use them to guide referential inferences.

While disfluencies are clearly powerful cues for predicting language, disfluencies reflect general processing delays and thus could underwrite broad inferences about the processes going on in other people's minds. Indeed, there is some evidence that adult listeners speech fluency to draw a range of social inferences. When responding to requests (e.g., "Can you give me a ride?"), a speaker who pauses before responding is seen as less willing to accept the request (Roberts, Francis, & Morgan, 2006; Roberts et al., 2011). Similarly, when agreeing with another's past statement (e.g., "The flyers look good."), delays are seen as indicating less agreement (Roberts et al., 2011). These speaker judements are even titrated by the degree of delay– the longer the delay, the less willing a speaker seems (Roberts et al., 2011).

Adults also use disfluencies, including filled pauses (e.g., "um"), to infer a speaker's knowledge. When a speaker answers a trivia question accurately, but disfluently, adult listeners infer that person is less knowledgable about that information, compared with a speaker who gives accurate and speedy answer (Brennan & Williams, 1995). Interestingly, there is even some evidence that when speakers produce non-answers (e.g., "I don't know" or "I can't remember"), disfluency leads adults to infer greater knowledgeability– perhaps assuming the disfluency arose from attempting to retrieve the answer before failing (Brennan & Williams, 1995). These results suggest adults may be reasoning about the underlying mental process that delays speech in powerfully flexible ways. Holding constant what a speaker says, the speed and fluency with which a speaker says it licenses broad, contextual inferences about their mental states.

While no work has directly examined the development of these inferences, a small literature examines children abilities to reason about timing more broadly. In the physical domain, young children believe an agent who succesfully builds a tower faster than another agent building the same tower is better at building– though when the difficulty of the tower is also varied children have more trouble inferring relative competence (Leonard, Bennett-Pierre, & Gweon, 2019). Relatedly, children may use the speed a character solves puzzles in a story to infer competence, at least in some contexts (Heyman & Compton, 2006). By age 7, children seem to use response time on a difficult problem to infer the likely underlying mental process, such that a quick answer is judged as a retrieved memory and a longer response time is judged as a in-the-moment solution (Richardson & Keil, 2020). Timing is an everyday force that even young children are likely very familiar with, and these studies suggest it may be a useful cue in the development of social reasoning.

In the present studies, we test how and when young children use speech disfluencies to draw social inferences about a speaker's knowledge and preferences across a range of conversation contexts. We show that children infer an accurate, but disfluent speaker is less knowledgable (Experiments 1a and 2a), but only in certain conversational contexts (Experiments 1b and 2b). Then in a new conversational context, we demonstrate that children are similarly able to use disfluency to infer a speaker's relative preference (Experiment 3). See Table **??** for an outline of each experiment's design. Ongoing work further examines the richness of children's preference inferences, such as inferring relative dispreference.

Experiment	Population	Method	Condition	Fluent Utterance	Disfluent Utterance
Exp 1a	Children	In-Person	Labelling	"This one is a cat."	"This one is a uh... cat."
Exp 1b	Children	In-Person	Ignorance	"I don't know."	"Uh... I don't know."
Exp 2a	Children	In-Person	Labelling & Ignorance	"This one is a tiger."	"This one is a uh... tiger."
Exp 2b	Adults	Online	Labelling & Ignorance	"This one is a tiger."	"This one is a uh... tiger."
Exp 3	Children	Online	Preference	"The tiger is my favorite."	"Um... the tiger is my favorite."

Experiment 1a

When answering a question (e.g., "What is 5 times 7"), disfluencies indicate a delay in searching for an answer ("Um… 35"), which leads adults to infer a speaker is less knowledgeable even if they offer accurate information (Brennan & Williams, 1995). A large literature demonstrates that children by age 4 use language *accuracy* to judge knowledgeability– for example, children prefer to learn from a previously accurate speaker rather than someone who mislabels or fails to label common objects [e.g., Koenig & Harris (2005); see Sobel & Kushnir (2013) for a review). The present study extends such work to ask how chilidren consider not just what a speaker says, but how they say it. Thus, in all of the present studies, accuracy is held constant.

Relevant prior accuracy information may rarely be available to the developing learner, or they might have limited knowledge on which to judge past accuracy. Moreover, in many situations, a speaker's accuracy alone may convey little about their underlying knowledge of the given domain (e.g., when discussing a relatively simple topic). Here, a better cue might be the speaker's ease and fluency in discussing the topic at hand. Indeed, even children as young as 2 are sensitve to an informant's confidence, preferring not to learn from unconfident speakers who hesitate, appear puzzled, shrug, and emply other uncertainty (Birch, Akmal, & Frampton, 2010). In a small pilot study, we demonstrate that children ages 4-9 use speech disfluencies to infer knowledgeability (Brennan & Williams, 1995).

Methods

Participants. 22 children (ages 4-9, mean age = 7.54, 14 girls) were recruited at a local science museum. Due to timing constraints for collecting data in a museum collection, sample demographics beyond participant gender were not collected.

Procedure. Children were presented with an animated story on an iPad about two speakers and two familiar stuffed animals (a cat and a dog). In the story, each speaker is asked "What is this animal called?" about the animal closest to them, and the experimenter reads their replies. In Experiment 1a, one speaker fluently labels their animal ("This one is a cat") and the other speaker disfluenty labels the other animal ("This one is a… uh… dog"). Across participants, speaker order was counterbalanced, such that half the children heard the disfluency first. Children were then asked a domain-wide knowledge question: "Who do you think knows more about animals– this person or this person?" while the experimenter pointed to each speaker. If children failed to choose one of the speakers (e.g., saying "both") or failed to respond within 5 seconds, the experimenter repeated the question one time. Children completed only a single trial.

Results

Asked which speaker knows more about animals, children were signficantly more likely to select the fluent speaker: 86% of children (19/22) reported that the fluent speaker knows more (binom $p < 0.001$; see Figure 1).

Experiment 1b

Do children think disfluencies always signal a lack of knowledge? Many disfluencies in naturalistic speech are related to discourse history, speech rate, or interlocutor familiarity and may not indicate knowledgeability (Clark & Tree, 2002; Shriberg, 1996). Adults do not always infer that disfluencies indicate incompetence, for example when answering a question

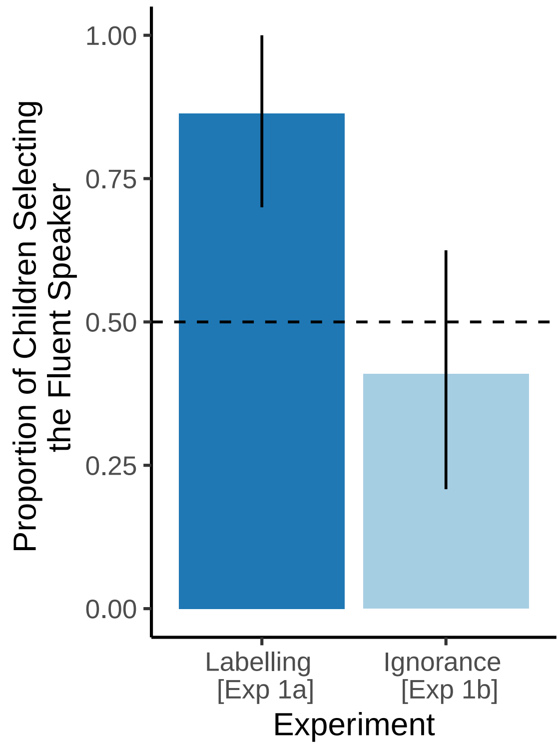

Figure 1. Results from pilot Experiments 1a and 1b, plotting participant repsonses when asked “Who knows more about animals?” with bootstrapped 95% confidence intervals (black lines). The dashed line indicates chance responding.

with a non-answer (e.g., “Uh… I don’t know”). In this context, adults may even treat disfluency as a signal of greater knowledge– the hesitation implied by a disfluency suggests the speaker feels like they might know the answer and attempted to search for it (Brennan & Williams, 1995).

In a pilot study, we demonstrate that children ages 4-9 do not always use speaker disfluencies to assume a lack of knowledge. Specifically, we show that children do not selectively infer knowledge when both speakers produce non-answers.

Methods

Participants. 22 participants (ages 4-9) were recruited at a local science museum. Data from 1 additional participant was excluded due to experiment error.

Procedure. In Experiment 1b, children were presented with an animated story on an iPad about two speakers and two stuffed animals selected to be less familiar to children (an aardvark and an anteater). As in Experiment 1a, each speaker is asked “What is this animal called?” about the animal closest to them, and the experimenter reads their replies. In Experiment 1b, both speakers claim ignorance and produce a non-answer, but one does so fluently (“I don’t know”) and the other does so disflueuntly (“Uh… I don’t know”). Across participants, speaker order was counterbalanced, such that half the children heard the disfluency first. Children were then asked to select the speaker they think “knows more about animals.” If children failed to choose one of the speakers (e.g., by saying “both”) or failed to respond within 5 seconds, the experimenter repeated the question one time. Children completed only a single trial.

Results

Asked which speaker knows more about animals, children were at chance choosing the fluent and disfluent speaker with similar liklihood: 41% of children (9/22) reported that the fluent speaker knows more (binom *ns*; see Figure 1).

Experiment 2a

In two separate pilot studies, we saw preliminary evidence that children ages 4-9 selectively infer competence based on disfluencies, even when both speakers are accurate, but also understand such inferences are not always licensed. Building off these pilot results, Experiment 2a was a pre-registered experiment to replicate our pilot effects in a larger sample and examine potential age-related change. Participants were randomly assinged to

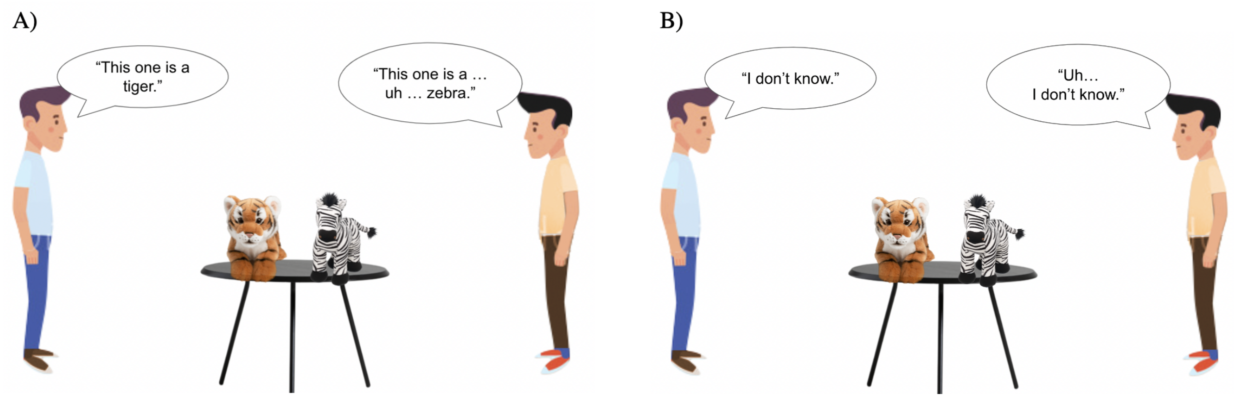

Figure 2. Stimuli used in Experiment 2 for the Labelling condition (A) and the Ignorance condition (B).

either the Labelling or Ignorance condition. We also added an additional trial (with new animals and speakers) to allow us to collect more judgments from each child.

Based on our pilot data and previous adult work (Brennan & Williams, 1995), we expected that even 4-5 year old children would infer an accurate but disfluent speaker would be less knowledgeable (labelling condition). We also predicted that children would make no such inference in the ignorance condition, and that older children may even infer that the disfluent speaker knows more in this condition, as suggested by the adult work (Brennan & Williams, 1995).

Methods

Participants. We pre-registered a planned sample of 120 children, 60 children in each of the two conditions (labelling vs. ignorance). For each condition, we planned to collect data from 20 children in each of 3 pre-deterimend age-groups: 4-5 years-old, 6-7 years-old, and 8-9 years-old. Data were collected at a local science museum. Due to the suspension of human subjects research following the COVID-19 pandemic, we were unable to complete data collection with the 8-9 year-old sample. As of March 2020, we have data from 101 children (40 children ages 4-5, 40 children ages 6-7, and 21 children ages 8-9).

Procedure. The procedure was nearly identical to Experiments 1a and 1b. Two characters in a story are asked to label one of the two familiar stuffed animal on the table in front of them. In the Labelling condition, both speakers correctly label the animal in front of them, but one does so disfluently as in Experiment 1a (see Figure 2). In the Ignorance condition, both speakers produce non-answers, but one does so disfluently– saying, "Uh… I don't know" as in Experiment 1b.

In Experiment 2a, we matched the stuffed animals in the story across conditions, and also added an additional trial with two new animals and two new speakers. For the anmials, we selected familiar animals with no readily available alternative labels (as opposed to "dog", which may acceptably be labeled "puppy"). In trial 1 (for both the Labelling and Ignorance conditions) the speakers were asked about a tiger and a zebra. In trial 2, the speakers were asked about a cow and a pig. Across participants, we counterbalanced the speaker order (whether the first speaker was fluent or disfluent) and the location of the two animals, yielding 4 counterbalanced orders. Note that this also counterbalances which animal the disfluency is paired with across participants. In the second trial, speaker order was always the reverse of the first trial.

Results

Overall, our results are consistent with our initial pilot results from Experiments 1a and 1b (see Figure 3). Children chose the fluent speaker as more knowledgeable in the Labelling condition (mean proportion of trials = 0.83) signficantly more than chance ($t(50) = = 7.29$, $p < .001$). In the ignorance condition, children's responding did not differ from chance (mean proportion of trials = 0.45), suggesting they were not relaibly selecting either speaker ($t(49) = = -0.84$, $p = .403$).

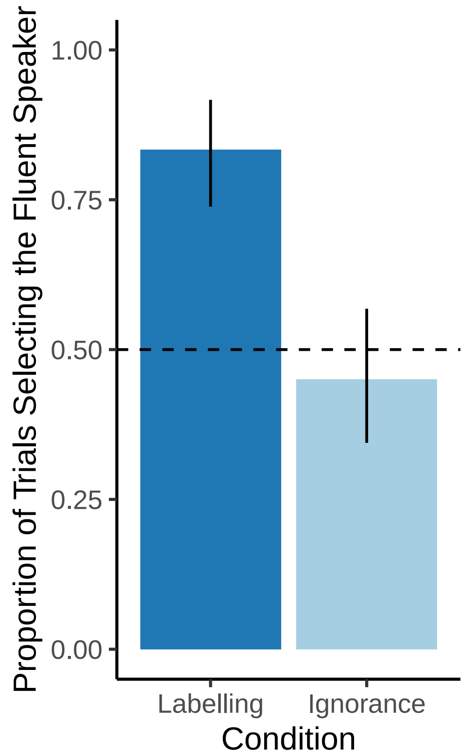

Figure 3. Overall results from Experiment 2a, with bootstrapped 95% confidence intervals (black lines). The dashed line indicates chance responding.

To compare choices across conditions, we used a mixed effects logistic regression prediciting speaker choice by condition and age (continuous), with random effects of subject and trial number. There was a signficant effect of condition, such that children were significantly more likely to choose the fluent speaker as more knowledgeable in the Labelling condition, compared with the Ignorance condition (β = -0.36, $p < .001$). The effect of age was not signficant ($\beta = 0.02$, $p = .308$).

Even the youngest children in our sample show this pattern (see Figure 4). Looking only at the 4-5 year-olds, children selected fluent speaker as more knowledgeable in the Labelling condition (mean proportion of trials = 0.80) signficantly more than chance ($t(19) = 4.49$, $p < .001$). In the ignorance condition, 4-5 year old children's responding did not differ from chance (mean proportion of trials = 0.48), suggesting they were not relaibly selecting either speaker ($t(19)$ = -0.29, $p = .772$).

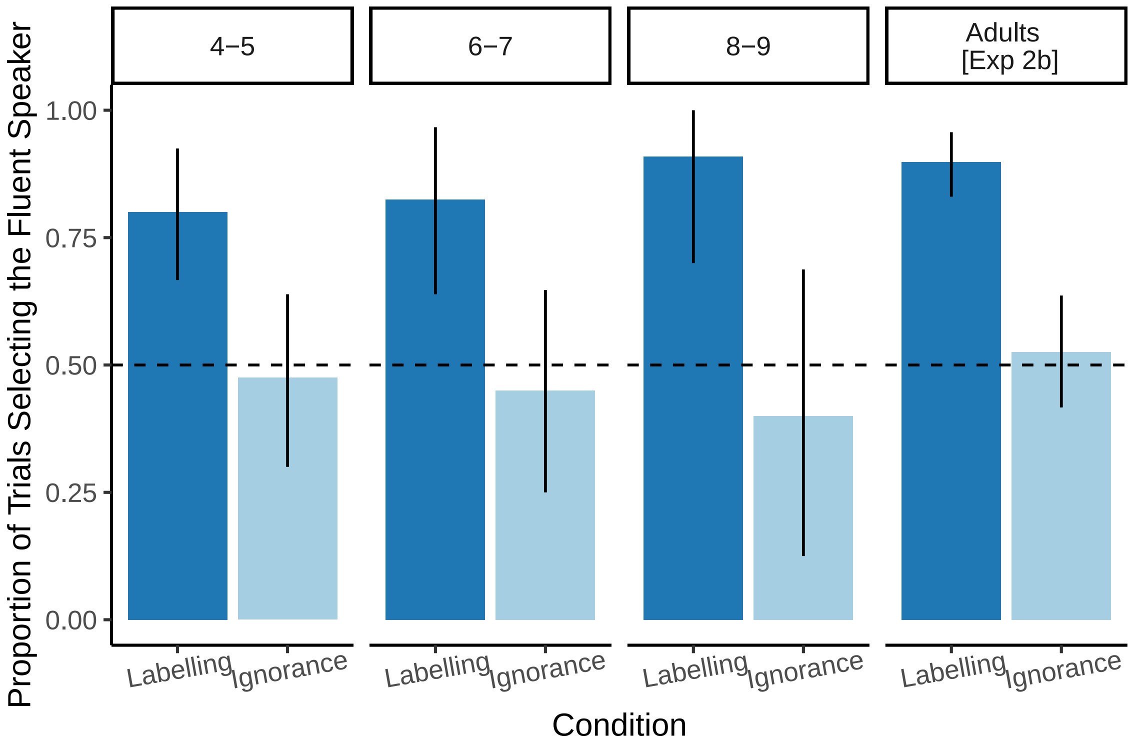

Figure 4. Age-binned results from Experiment 2a, with bootstrapped 95% confidence intervals (black lines). The dashed line indicates chance responding.

Discussion

In Experiment 2a, children made robust, selective knowledge inferences, judging an accurate but disfluent speaker to be less knowledgeable than an accurate and fluent speaker. Supporting our initial pilot results, we also see evidence that even 4-5 year old children are consistently making this inference, with no evidence of developmental change. These results suggest that children are tracking speech disfluencies and using them to make social inferences about another person's knowledge from a young age, as adults do (Brennan & Williams, 1995). This work adds to a small number of demonstrations that young children's knowledge inferences are senstive to not just what you answer (i.e. accuracy), but also how you answer (e.g., Corriveau, Kurkul, & Arunachalam, 2016).

Children showed no reliable speaker preference in the ignorance condition. While a null result, this finding helps rule out the idea that children are heuristically tracking disfluencies and always ascribing incompetence. This finding also suggests that our results cannot be explained by low-level auditory features. There is evidence that preschool age children are sensitive to auditory fluency cues, judging speakers whose utterances were inflected with white noise to be less competent than matched speakers who spoke without such background noise (Bernard, Proust, & Clément, 2014). However, such an effect cannot explain these results as the ignorance condition contains an identical amount of disfluency, yet children make no such knowledge inferences.

Previous work suggests that adults differentiate fluent and disfluent non-answers, judging disfluent non-answers to indicate greater knowledgeability than fluent non-answers (Brennan & Williams, 1995); however, in these data we saw no evidence that kids made such a differentiation. Thus, in our next experiment we collected adult judgements about these very same stimuli.

Experiment 2b

To determine the adult-like pattern of responses in this task, we collected knowledge judgments from a sample of adults online. While past studies have addressed similar questions in adult samples (Brennan & Williams, 1995), our task differs along a number of dimensions and so a separate baseline of adult responses is required. Additionally, while Brennan & Williams (1995) reported that adult listeners inferred that disfluent non-answers indicated more knowledge, we saw no evidence that children were making this inference in Experiment 2a. In Experiment 2b, we can ask whether adults systematically prefer the disfluent speaker in ignorance condition, as the results from Brennan & Williams (1995) might suggest.

Methods

Participants. 120 participants were recruited from Amazon Mechanical Turk, with 60 participants in each of the two conditions (labelling vs. ignorance). Participants were paid a small reward in exchange for completing the study. Two participants had incomplete data and were excluded from the final sample.

Procedure. Experiment 2b was an online adaptation of Experiment 2a. In Experiment 2a, the experimenter read the story and speaker's utterances aloud to children. Adult participants were instead asked to read through survey slide-style qualtrics, and then select which speaker would know more about animals. Otherwise, the stimuli and trial structure were exactly the same. As in Exeriment 2a, particpants completed two trials.

Results

Adult responses closely mirrored children's responses (see Figure 4). Looking at the proportion of trials that adults select the fluent speaker as more knowledgable, we see that adults choose the fluent speaker as more knowledgeable in the Labelling condition signficantly more often than chance. In the ignorance condition, adults did not reliably select either speaker.

Experiment 3

Our account holds that disfluencies can be interpreted by listeners as domain general signs of processing time or conflict. As such, disfluencies should generate inferences in a variety of domains, beyond knowledgeablility. We next ask how children use speech disfluencies to infer an agent's preferences and dispreferences.

In Experiment 3, we changed the question under discussion so that each character is asked which of the two animals they like the best. Disfluency here may indicate a speaker is experiencing conflict between the two options, delaying their response time, while speed may indicate a strong and decisive preference (similar to the degree of agreement inference made by adults in Roberts et al., 2011). When two speakers both state the same preference, but one does so disfluently, we predicted that children would infer they had a relatively weaker preference.

We further expected that this situation might license an additional inference about dispreference. With two options on the table, delay in naming one's favorite may reflect difficulty due to relatively split preferences. Consistent with this reasoning, we asked children to report who likes the unlabelled animal more (i.e. the dispreferred item), and we expected that children would infer the disfluent speaker may have a relatively stronger preference for this item. We hypothesized that this dispreference inference might be difficult for our youngest children, based on some evidence that children as young as infancy seem better able to represent preference than dispreference (Feiman, Carey, & Cushman, 2015).

Data for Experiment 3 were conducted remotely over Zoom, as described more below. To establish that our paradigm sucessfully translated to remote testing, we also included an additonal knowledge trial in Experiment 3, attempting to replicate our findings from Experiment 2a.

Methods

Participants. We pre-registered a planned sample of 60 children to run in Experiment 3. Again, we planned to collect data from 20 children in each of 3 pre-deterimend age-groups: 4-5 years-old, 6-7 years-old, and 8-9 years-old. These data were collected online via Zoom with a live experimentor. Particpanting families were largely recruited via a participant database of Chicagoland families who have previously participated in in-person research studies. These data are still being collected, with a current sample of 56 children (16 children ages 4-5, 20 children ages 6-7, and 20 children ages 8-9).

Procedure. In Experiment 3, the general procedure was largely matched to the previous experiments. We made some changes to facillitate the shift to remote data collection, such as changing the response format (described below). The central change of interest was to shift the question under discussion.

Preference Trial. In Experiment 3, two characters were introduced one at a time, and each character was given an identifiable color by which they are referred (e.g., "the blue person"). This change facillitated children's ability to respond verbally when asked to select a character, rather than pointing to a character which is difficult to capture in remote testing. In Experiment 3, each speaker entered the scene independently, and was alone when asked a question. Viewing the tiger and the zebra, each speaker was asked, "Which of these animals is your favorite? Which one do you like the best?" Both speakers independently stated a preference for the same animal, but one did so disfluently, saying e.g., "Um… the tiger is my favorite." At the end of the trial both speakers were then brought back and children were reminded what each speaker said. This ensured that both speakers were onscreen when the target questions were asked. Across participants, we counterbalanced whether the first or second speaker was the disfluent speaker, and which animal was preferred.

Children were then asked three questions: a preference question: "Who do you think likes the tiger more?", a distractor question: "Who do you think is better at playing basketball?", and a dispreference question: "Who do you think likes the zebra more?" The order of the preference and dispreference questions was counterbalanced across participants. The distractor question was always asked second to ensure children were not merely switching responses across questions. Children completed one preference trial.

Knowledge Trial. After switching to remote testing due to the onset of the Covid-19 pandemic, we wanted to ensure that our paradigm successfully translated to online testing from in-person adminsitration. As an initial check, we included an additional trial always after the key preference trial described above. We made a few additional alterations to our paradigm, thus this additional trial cannot serve as a true replication, but to the extent that we see similar results, it may suggest our online task is an effective replacement of in-person testing.

The Knolwedge trial was structured exactly like the preference trial described above. As in Experiments 1 and 2, the characters in the story were asked, "What is this animal called?" but both were asked about the same animal and respond while alone. Each speaker labelled the animal accurately, but one did so disfluently (e.g., saying "This one is a… um… pig."). Then, both speakers were shown and children were reminded who said what.

Children were then asked three questions: a labelled knowledge question: "Who do you think knows more about [pigs]?", a distractor question: "Who do you think is better at playing soccer?", and an unlabelled knowledge question: "Who do you think knos more about [cows]?" The order of the labelled and unlabelled knowledge questions was counterbalanced across participants. The distractor question was always asked second to ensure children were not merely switching responses across questions. Children completed one knowledge trial.

Results

Note that data colleciton remains ongoing for the youngest age group (4-5 year-olds, current n = 16/20) in Experiment 3, so we will only report overall effects at this time.

Preference. We first analyze children's judgements from trial 1 (the preference trial). When asked which speaker likes the preferred animal more, children were signficantly more likely to select the fluent speaker. When asked which speaker likes the dispreferred animal more, children were signficantly less likely to select the fluent speaker. When asked the distractor question, children showed no robust preference for one speaker over another.

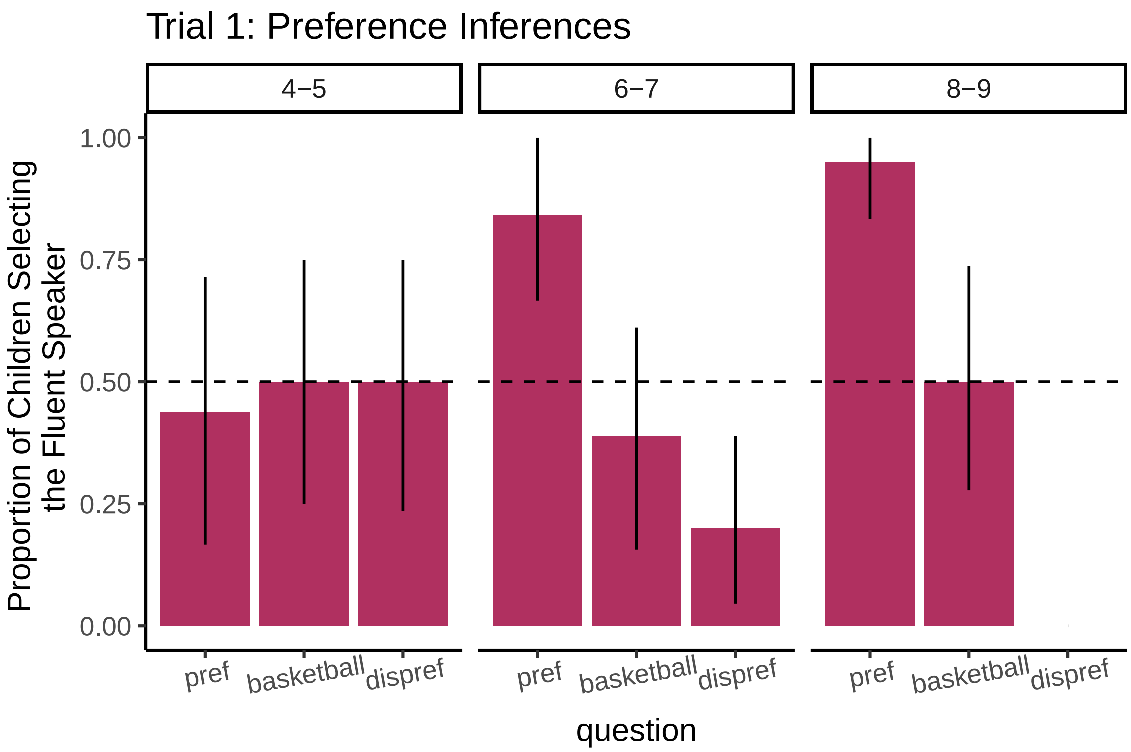

Figure 5. Preference trial results from Experiment 3 with bootstrapped 95% confidence intervals (black lines). The dashed line indicates chance responding.

Knowledge. Next, we analyze children's judgements from trial 2 (the knowledge trial). We see preliminary evidence that the updated paradigm administered over Zoom provides a conceptual replication of our in-person results from Experiment 2. Asked which speaker knows more about the labelled animal species, children were significantly more likely to select the fluent speaker than the disfluent speaker. This suggests that our paradigm successfully adapted to the Zoom administration. Additionally, when asked the distractor question, children showed no robust preference for one speaker over another.

We expected that when asked who knows more about the unlabelled animal, children would be at chance or even favor the fluent speaker. However, children were signficantly more likely to select the disfluent speaker as more knowledgeable about the unlabelled animal. We return to this result below.

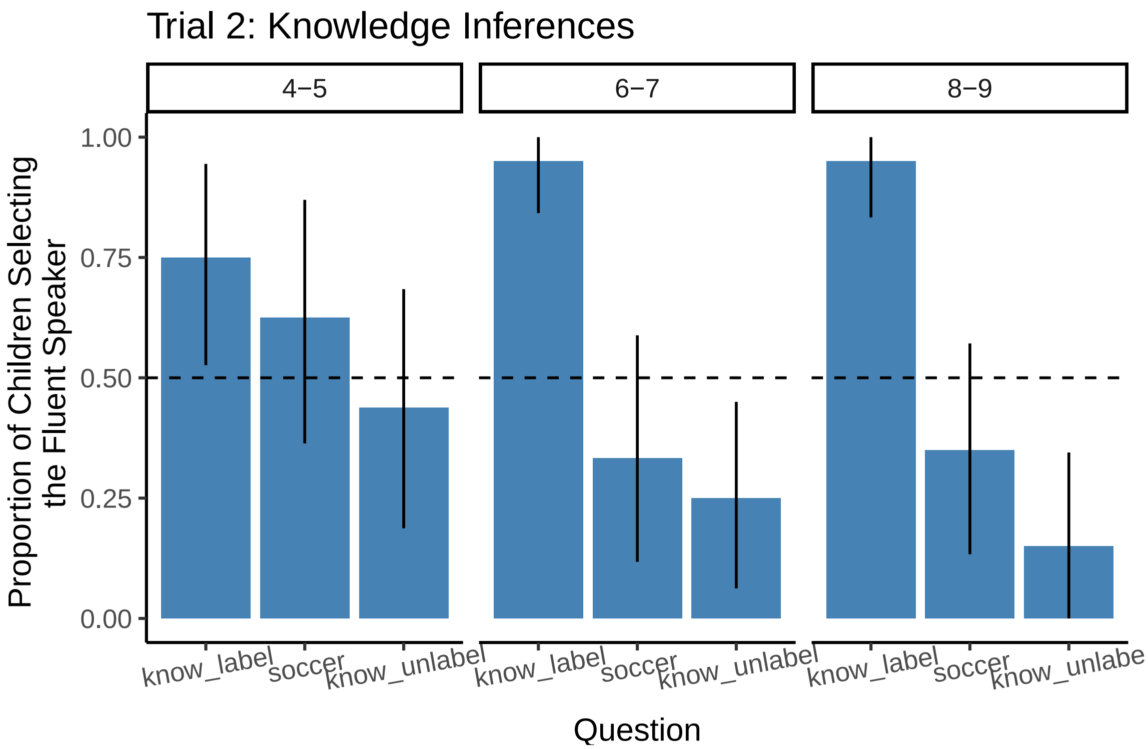

Figure 6. Knowledge trial results from Experiment 3 with bootstrapped 95% confidence intervals (black lines). The dashed line indicates chance responding.

Discussion

Overall, we find support for the idea that children use disfluencies not just to make knowledge inferences, but to make preference inferences as well, consistent with an account where disfluencies serve to signal general delays in processing with contextual intepretation.

While our data collection is still ongoing with the youngest age-group (4-5 year-olds), the current data suggest these youngest children may not be drawing reliable preference inferences. This would be an interesting contrast to our findings from Experiment 2a, which are replicated here, that 4-5 year-olds are able to infer knoweldgeability in a closley matched task. One interesting possiblity is that connection between disfluency and knowledge emerges before it is connected to other domains like preference, at least in this task.

The data on children's inference of dispreference are more difficult to interpret. While children do reliably select the disfluent speaker as having a stronger preference for the unlabelled object as we predicted, we see a similar, unpredicted pattern for children's knowledge inferences about the unlabelled animal. That is, while children made domain-wide competence inferences in Experiment 2a, and reliably report that the fluent speaker knows more about the animal they mentioned, they seem to make the opposite inference when asked about another, unlabelled animal. These data make the dispreference measure difficult to interpret, since this inference may be driven by order effects or task demands. In this experiment, the preference trial was our focus, thus the knowledge trial was always completed subsequently. It is possible that the pattern of responses evident in trial 1 carried over to trial 2 and affected children's knowledge judgements as well. Ongoing work examines the effect of order on this inference.

General Discussion

Across 3 studies, children draw inferences about another agent's mental states based solely on the disfluencies in their speech, and these inferences are flexible and context-sensitive. We see consistent evidence that even young children infer that a disfluent speaker might be less knowledgeable. By age 6, children similarly use disfluencies to infer the relative preferences of a speaker. In sum, these findings suggest that disfluencies may serve as powerful cues to a speaker's mental processes, with broad applications.

These studies add to the rich literature on children's ability to infer knowledgeability and engage in selective social learning (e.g., Koenig & Harris, 2005). In our studies, children make selective competence judgements, even while holding speaker accuracy constant. These results parallel recent demonstrations that young children are able to use accuracy-irrelevant information in selective social learning paradigms (Aboody, Huey, & Jara-Ettinger, 2018; Corriveau et al., 2016). In our study, 4-5 year old children (as young as we tested) made these contextual knowledge inferences at rates similar to adults.

We see preliminary evidence that children's ability to draw inferences about knowledge emerges earlier in development than preference in this task. Across both Experiment 2 and 3, children age 4-5 seem to infer a disfluent speaker might be less knowledgable, but do not extend this inference to the preference domain in Experiment 3 until age 6-7. These results are unlikely to be explained by difficulty following the task, as we see this pattern even looking within-subjects in Experiment 3. That is, the same 4-5 year old children make no systematic preference inference in trial 1, but do infer knowledge on trial 2. These preliminary results present the intriguing possiblity that children may more easily connect fluency and knowledge, compared with fluency and preference. Future work is needed to test the robustness of this developmental change.

While adults derive a range of social inferences based on speech timing and disfluency [Brennan & Williams (1995); roberts2011], these inferences are likely built on underlying general inferences about processing delays and their richness comes from contextualized interpretation. That is, these delays often acquire social meaning only after integrating information from the conversational context– such as inferring that someone who says "sure" slowly is less willing to go along with previous speaker's request. It is possible that the preference inference in our experiments required more contextual information than the knowledge inference and was more difficult for young children as a result.

Children are not merely responding heuristically to the percieved confidence of a speaker, but instead flexibly and contextually employing these inferences. Children as young as 2 are sensitive to an agent's confidence (e.g., facial expression, gesture, etc.) and selectively imitate more confident agents (Birch et al., 2010). Our results cannot be explained by tracking confidence, as a confidence account should predict systematic choices in the ignorance conditions where children and adults show no speaker preference. We also see that children will select the disfluent speaker as having a stronger dispreference, though this effect is difficult to interpret in these data.

Disfluencies are powerful cues for inference– available in-the-moment and informative regardless of whether the child has the relevant knowledge to judge a speaker's statement While these cues are doubtless helpful in language processing, this work extends such findings to suggest that these cues additionally serve a range of social inferences in early childhood. Disfluencies track processing difficulties, and thus can provide a useful window into an agent's mental processes, beyond the content of what is said. As young children learn about the social world, tracking speech disfluencies and processing delays broadly may provide a rich dataset for drawing social inferences.

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