Cognitive Sciences

"We have found the Tobii Eye Tracker to be easy to use with infants and young children and to have sufficient spatial and temporal resolution to provide new insights about spoken word recognition."

Richard Aslin, Professor, Brain & Cognitive Sciences and Center for Visual Science, University of Rochester

Word learning is fundamental to language acquisition, but the successful mapping of a spoken word onto an object in the world is not always transparent. While some labeling contexts are unambiguous, most contexts involve multi-word utterances and multiple objects in the child's visual field. Thus, extra-linguistic cues, such as inferring speaker intention, play a crucial role. The Rochester Baby Lab uses a Tobii Eye Tracker to investigate a previously unexplored cue for inferring speaker intention: speech disfluencies, such as "uh" and "um".

Key questions asked

Adults tend to produce speech disfluencies before words that are infrequent (e.g., "theeee, uh, mangosteen") and words that have not previously been mentioned in the conversation.

Researchers at the Rochester Baby Lab use a Tobii 1750 Eye Tracker to examine whether young word learners (mean age 2;6) are sensitive to this statistical regularity and make use of the disfluency during comprehension. They demonstrate that young children use speech disfluencies to anticipate that an upcoming word is likely to refer to a previously unmentioned or novel object by monitoring their eye-gaze to objects as they hear speech disfluencies embedded in sentences.

The study

To test whether infants could make use of the information contained in speech disfluencies, researchers at the Rochester Baby Lab presented sixteen children (ages 2;4 – 2;8) with pictures of object pairs on their table-mounted Tobii 1750.

A toddler sitting on his mom's lap watches the disfluency study movie on the Tobii screen.

Within each trial, one known object (e.g., shoe) and one novel object (e.g., mog) were presented three times in succession. During the first two presentations, children heard an utterance referring to the known object. During the critical third presentation, the child was told to look at either the known or unknown object. In one condition, the command was fluent; in the other, the command contained a disfluency before the object name. For example, in the fluent condition, the child might hear, "Look! Look at the mog!" In the disfluent condition, "Look! Look at theeeeee… uh…. mog!". Across trials, the critical presentation was fluent or disfluent and referred to the known or the novel object an equal number of times.

Each display contained one familiar object (e.g., a shoe) and one novel object (e.g., a mog).

Researchers predicted that if children have learned that disfluencies occur before discourse-new and unfamiliar referents, then in the 2-second window prior to the onset of the object name (during the speech disfluencey in the disfluent condition), they would look more toward the novel object in the disfluent condition than in the fluent condition. Thus, the researchers compared the total looking time and the proportion of looking time to the novel object in this critical window of interest.

The results

Researchers calculated the proportion of fixations to the novel object at each time point during the critical phase of the fluent and disfluent trials using Matlab.

Timecourse plots (Figures 1 and 2) suggest that children were biased to interpret the disfluency as signaling that the upcoming word would refer to the novel and previously unmentioned object.

To test that hypothesis, researchers compared average total looking time to the novel

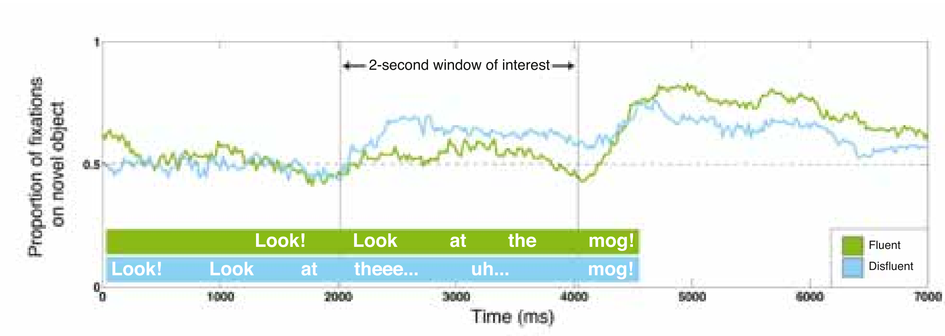

Figure 1: The timecourse plot shows the proportion of looks to the novel object at each time point for trials with novel targets. As predicted, children looked more towards the novel object during the 2-seconds before the onset of the target word in the disfluent trials than in the fluent ones. This suggests that children used the information contained in a disfluency to anticipate an upcoming novel object.

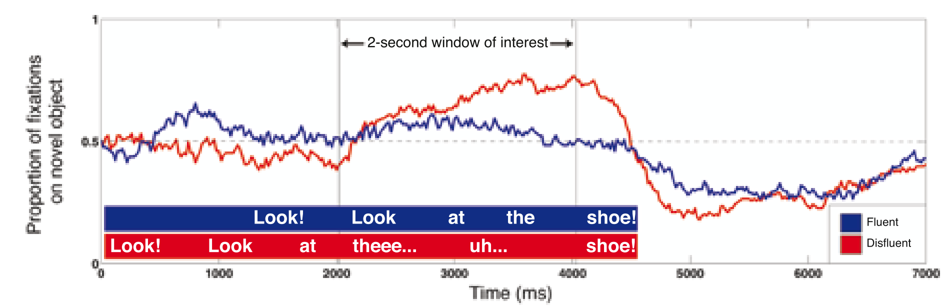

Figure 2: The timecourse plot for trials with familiar targets. Here again, children looked more towards the novel object during the window of interest in the disfluent trials. This suggests that the disfluency set up the expectation of an upcoming novel object.

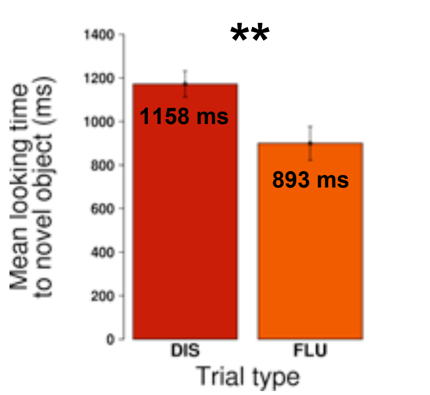

Figure 3: Children's mean total looking time to the novel object during the window of interest was longer in disfluent trials (1158 ms) that in fluent trials (893 ms). A Wilcoxon signed-rank test found this difference to be highly significant (N=16, p < 0.008).

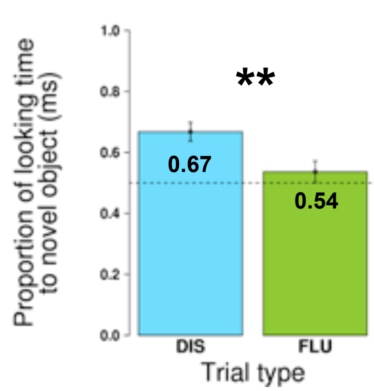

Figure 4: The proportion of children's total looking time to the novel object during the window of interest was greater in disfluent trials (0.67) that in fluent trials (0.54). A Wilcoxon signed-rank test also found this difference to be highly significant (N=16, p < 0.005).

object across fluent and disfluent trials in the 2-second window of interest before the onset of the target word. Children looked longer overall at the novel object in disfluent trials (1158 ms) that in fluent trials (893 ms)—a difference that a Wilcoxon signed-rank test found to be highly significant ($p < 0.008$). This result is illustrated in Figure 3. Children also looked proportionally longer at the novel object during the same temporal window of interest in disfluent trials (0.66) than in fluent trials (0.54). This difference (Figure 4) is also significant ($p < 0.005$). Importantly, the proportion of looking time to the novel object was significantly above chance in the disfluent trials ($p < 0.001$), but not in the fluent trials ($p > 0.37$).

These results indicate that young children (1) have learned that disfluencies contain information, (2) attend to disfluencies in speech, and (3) can make use of the information contained in disfluencies online during comprehension in order to infer speaker intention.

Why eye tracking?

Eye Tracking enabled researchers at the Rochester Baby Lab to demonstrate that children are able to use speech disfluencies to infer a speaker's intended referent. More broadly, Eye Tracking provided researchers with a way of revealing the types of early knowledge children possess and use online during language comprehension.

"Language comprehension is not directly observable, so we use eye movements as an indirect way of inferring the possible referents a child is considering as a sentence is unfolding. Eye Tracking uniquely enables us to investigate children's expectations about upcoming material during comprehension in real time." — Celeste Kidd, Graduate Student Researcher, Brain & Cognitive Sciences, University of Rochester

Eye movements provide language acquisition researchers with a real-time measure of children's understanding as a sentence unfolds over time.

Another example of a display, this one containing a ball (familiar) and a gorp (novel).

In many domains, children may possess knowledge before they have either the linguistic competence or the motor skills required to demonstrate it. Eye Tracking has the potential to reveal that a child possesses competence beyond what she can demonstrate in other performance-oriented experimental tasks.

Since collecting eye movement data using eye-tracking was much faster than other comparable methods (such as hand-coding recorded videos of children's eye movements offline), researchers were able to perform their analyses and ascertain results sooner.

Why Tobii?

Eye Tracking with the Tobii allowed researchers to collect data from children in a very natural way. They sat on their parent's lap and watched a movie, much like they would do at home with a television.

"Our subjects here were toddlers, and toddlers are generally very active. Time is a huge constraint on how much data we can collect from subjects at this age. The Tobii enabled us to get more data from these children by greatly reducing the amount of time needed to calibrate each child."

Celeste Kidd, Graduate Student Researcher, Brain & Cognitive Sciences, University of Rochester

About Rochester Babylab

The Rochester Baby Lab studies how young infants and children perceive visual and auditory stimuli, how they learn about these stimuli, and what brain mechanisms are involved in these abilities. To find out more about the lab, visit: www.babylab.bcs.rochester.edu

To find out how Eye Tracking can improve your research, please visit www.tobii.com or contact one of our offices.

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