Are infants sensitive to anticipatory coarticulation during word recognition?

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Sept. 12, 2014, 9th Mid-Continental Phonetics & Phonology Conference

Overview
- Developmental Phonetics
- Crash course in eyetracking methods
- Coarticulation: Adult findings
- Current study
  - Can 18-24 month-olds take advantage of coarticulation during word recognition?
- Discussion

Developmental Phonetics
- Language acquisition
  - What do young children know about language?
  - How do they acquire this knowledge?
- Developmental phonetics
  - Acquisition of perceptual, acoustic, articulatory aspects of language
- Lexical processing
  - What do novice word-learners know about their first words?

Production lags behind comprehension
- Toddlers (and late talkers) cannot tell us what they know.
  - Studying language based on spoken language underestimates linguistic knowledge.
- Too young to follow complex or metalinguistic directions.
  - Need to be creative: Habituation studies, head-turn studies, and others.
  - This is how we draw inferences about babies losing nonnative sound contrasts at 8 months, for example.
  - One method: eyetracking

Eyetracking
- "Visual world" or "looking while listening" paradigms
  - Put some images or printed words onscreen.
  - An audio prompt to view one of the images.
  - Eyetracker records where the subject fixates.
  - Measure of real-time language processing.
  - How does the child’s gaze change as the sentence unfolds?
What does an eye-tracking experiment look like?
Video of experiment with eyetracking data overlaid on computer screen.
Yellow dot is current gaze location.
Red trail shows last gazes.

What do eyetracking data look like?
X: Time relative to target onset
Y: Proportion of looking to target (Accuracy)

Coarticulation
Fluent speech is continuous, so that nearby sounds overlap and influence each other.
- Vowel nasalization: ham: [hæ̃m]
- keep vs. coop: [k]eep
- she vs shoe: [ʃ]oe
- Place assimilation:
  - Input: [ŋ]ip
  - in case: [ŋ] case
  - green boat: [ɡreen]boat
  - the[ŋ] dog vs. the[ŋ] ball
- Adults can take advantage of these regularities during lexical processing.
Adults look to gree(m) boat sooner than gree(n) boat 
Gow & McMurray (2007)

Current Study

Current Study

Burning question

- Can toddlers use acoustic information in the word “the” to anticipate the following noun?
- Eight month-old infants use coarticulatory cues in word segmentation (Johnson & Jusczyk, 2001)
- We can learn something about:
  - Processes behind word recognition and context integration
  - Mental representations of speech sounds and early words

Participants

- 30 participants, 16 boys and 14 girls
- Mean age: 21 months, range: 18-24 months

Stimuli

- Word pairs
  - Filler trials to maintain interest (e.g. soup/shoes)
- Manipulated Coarticulation
  - Cross-spliced all stimuli:
    - “the” tokens from “the book”, “the dog”, “the hut”
    - Neutral cues: the[hi] dog/book
    - Facilitating cues: the[di] dog, the[mi] book

Adults look to the[li] ladder sooner than the[lo] ladder 
Salavera, Kleinschmidt, & Tanenhaus (2014)

With these stimuli, effects of speech on eye movement control began about 70 ms earlier than in Experiment 1, suggesting rapid use of anticipatory coarticulation.
Stimuli
F1 and F2 formant transitions

Procedure

- Conditions
  - Facilitating (8 trials)
  - Neutral (8 trials)
  - Fillers (7 trials)
- Two blocks
- Looking-while-listening format
  - Two images presented on screen
  - One image is target, other is distractor.
  - Target words presented in carrier phrases (e.g., find the dog).

Predictions

- Three different possibilities:
  1. Toddlers are not sensitive: Curves don’t differ across conditions.
  2. Sensitive like adults: Head start, but similar shaped curves.
  3. More sensitive than adults: Curves have different slopes (i.e., different processing speeds).

Trial Timeline

Visual presentation

Audio presentation

Find the duck!

Check it out!

(silence)

(silence)

(silence)

(IIH)
Analytic Strategy

- Growth Curve Analysis (Barr, 2008; Mirman, 2014)
  - Restrict analysis to a meaningful window of time
  - Model how fixations to target change as a function of time and condition.
- Empirical Logit Transformation
  - Proportions are bounded between [0,1].
  - Transform to empirical log-odds, so models work \[ \log \left( \frac{p}{1-p} \right) = \beta_0 + \beta_1 t + \beta_2 t^2 + \text{etc} \]
- Mixed Effects Regression
  - Random effects for subjects and subjects x condition

Analysis Window

Transposed Proportions

Results

- Significant effect of condition
- Nonsignificant interaction between condition and slope
- Roughly, 100 ms head-start from coarticulation

Discussion

- Toddlers looked to target approximately 100 ms sooner when they heard facilitating coarticulation cues on “the”.
  - In other words, cues gave them a head-start.
- The non-significant effect of condition on the linear time term means that the average slope of the curves did not differ significantly between conditions.
  - In other words, they did not process the words more rapidly. Just earlier.

Next steps

- How do toddlers do when the target word is not presented at all?
  - Find the ________
- How do younger children perform?
- Is there an effect of age or vocabulary size on access to anticipatory coarticulation?
- Use different sounds
  - Much more coarticulatory information for /d/ rather than /b/
  - /g/ or /m/? (Limited by the words familiar to toddlers)

Rethinking Coarticulation

- We might think of coarticulation as an obstacle to speech perception
  - Fewer perceptual invariants to latch onto.
- But coarticulatory variability adds coherence to speech signal
  - Nearby sounds are more alike.
  - Can support word recognition.
- Much evidence for this view of coarticulation in the adult literature.
- This study is the first evidence that toddlers can use anticipatory coarticulation during word recognition.
  - Process cues as they arrive.
  - Daring interpretation: Show gradient lexical activation from the earliest stages of word learning.
This experiment is part of the Little Listeners project, a study of lexical representations in typically developing toddlers and toddlers with autism. Thanks especially to Susan Ellis Weismer and Courtney Venker from this project.

Thanks to members of the Infant Learning Lab Research team who collected these data, especially Erin Long.

Thanks to the Learning To Talk Research team who helped with stimulus preparation and statistical analyses, especially Matt Winn and Franco Law II.

This research was supported by NICHD grant R01-HD035366 to Jenny Saffran, a grant from the James F. McDonnell Foundation to Jenny Saffran, NIDCD grant 022933 to Susan Ellis Weismer, Jan Edwards, & Jenny Saffran, NIDCD Grant R01-02832 to Jan Edwards, Mary E. Beckman, & Benjamin Munson; NICHD Grant 0-T32-HD007389 to Maryellen MacDonald; and NICHD Grant P30-HD03351 to the Waisman Center.