From Ears to Eyes: Brainstem Encoding of Speech and Lexical Access

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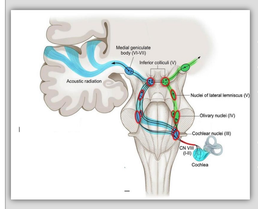
ABRLAB

INTRODUCTION

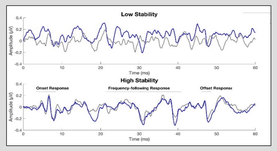
- Successful oral communication depends upon quick and accurate encoding of speech
- Auditory brainstem responses (ABRs)→ relationship between robust neural encoding of speech and language[3,4,5]

Auditory Brainstem Response (ABR[1,2])



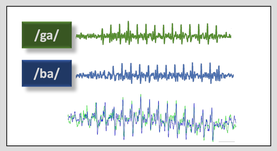
- Auditory evoked potential
- Detected at the scalp
- Generated by auditory nerve & brainstem nuclei
- Onset response: < 12 ms latency
- Obligatory response

Response Consistency



Stability of responses to a repeated stimulus

Response Differentiation



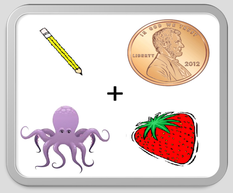
Degree to which responses to different stimuli differ

- ABR relate to children's performance on standardized tests of phonology [6,7,8,9]
- Relationship to online use of phonology in lexical access unknown
- As speech unfolds, candidates compete for recognition based on their shared phonological features [10,11]
- Eye-tracking and the visual world paradigm can be employed to record the process of lexical access[12,13]

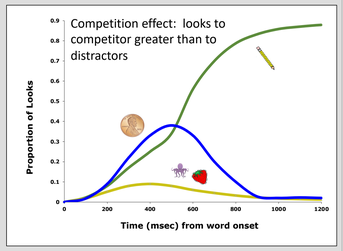
Visual World Paradigm

4 picture array on screen

- Target word (*pencil*)
- Phonological cohort competitor (*penny*)
- 2 phonologically unrelated distractors



Click on the ***pencil***



Here we investigate the role of sensory level auditory processing in online use of phonology by examining the relationship between brainstem encoding of speech and phonological competition during lexical access

METHODS

Participants

39 children 5 to 12 years (M_{age} 8.52(1.8) years)
(20 assigned male at birth)

CTOPP[14] Performance Scaled Scores

Elision	10.27(2.67)
Blending	10.12(2.65)
RAN Letters	8.8(2.4)
RAN Digits	9.02(2.3)

Visual World Paradigm

- 16 trials
- 4 picture display
- Average looks to targets, competitors, and distractors calculated
- Competition effect: average looks to the competitor > average looks to distractors.

Auditory Brainstem Response (ABR)

Stimuli and Recording parameters

- /da/ : 40 ms, 4000 (2x) trials presented at 10.9 Hz
- /ba/ and /ga/: 170 ms, 3000 (2x) trials presented at 3.4 Hz
- 3 Ag-AgCl cup electrodes (Cz, forehead, right earlobe)
- Recording system: SmartEP's cABR module (Intelligent Hearing Systems
- Participants reclined while watching a self-selected movie
- 80 dB SPL through an insert earphone in the right ear

Data Analysis

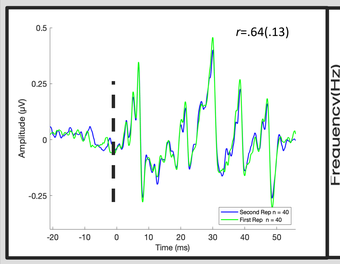
- *Response Consistency*: The two sub-averages compared for linear relationships for formant transition region 20-40 ms [15]
- *Response Differentiation*: A phase-based sliding window technique calculated the average difference between the response to /ba/ vs /ga/ for 20-40 ms (i.e., the consonant to vowel transition period) from 400-720 Hz. [16]

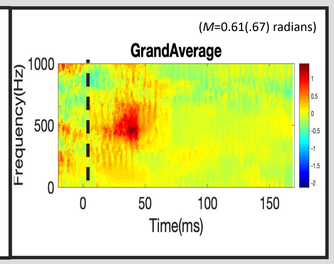
References

(1) Jewett & Williston, 1971; (2) Hood, 1998; (3) Hornickel & Kraus, 2013; (6) White-Schwoch & Kraus, 201); (7) Lam et al., 2017; (8) Bonacina et al., 2019; (9)Neef et al., 2017; (10) Marslen-Wilson & Welsh, 1978; (11) Marslen-Wilson, 1987; (12) Allopenna, Magnuson, & Tanenhaus, 1998; (13) Weighall et al., 2017; (14) Comprehensive Test of Phonological Processing, Wagner et al., 2013; (15) Skoe & Kraus, 2010; (16) Skoe et al., 2011

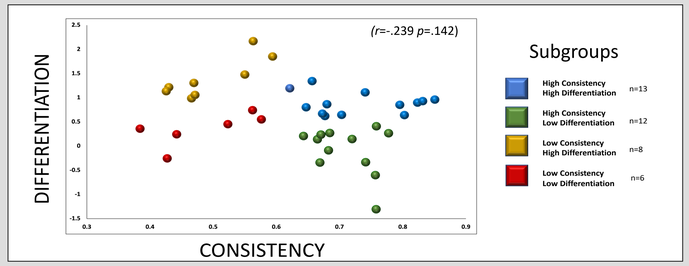
RESULTS

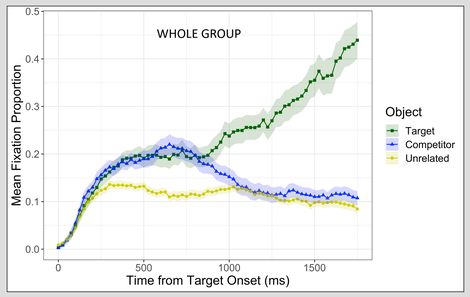
Response consistency and differentiation in typical ranges





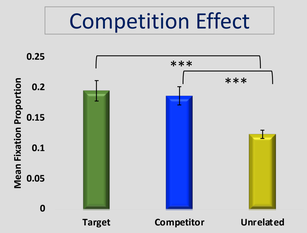
Response consistency and differentiation not correlated





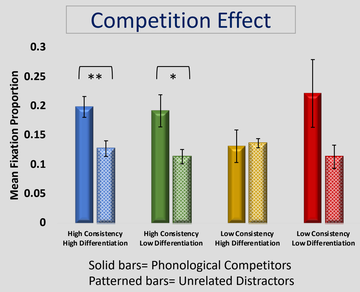
Time course plots show typical competition effect

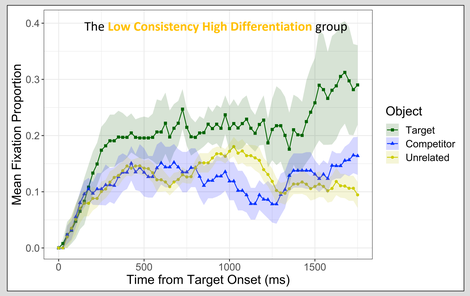
Children as a group looked more to competitors than unrelated objects when the acoustic input overlapped



The children were divided into ABR subgroups

The **Low Consistency High Differentiation** group did not show a competition effect





DISCUSSION

- The strength of the encoding difference between /ba/ and /ga/ was not related to the consistency of their responses to /da/
  - Children with more consistent responses did not always have more differentiated responses
  - ABR dimensions may differentially index language
- Overall children showed a typical phonological completion effect, but some did not
- Children with more differentiated neural encoding, in the absence of stable encoding, looked more to the target but equally to the distractors and phonological competitor
  - The **/pen/** in 'pencil' was not experienced as possibly being the **/pen/** in 'penny'
  - Potentially, the greater ability to differentiate between sounds allow the children to pick up on small coarticulation based differences that are typically ignored
  - Consistent encoding may be the "brake" needed to ignore meaningless differences
  - Without this brake there may be less overlap in lexicon
- Within typically developing children, lexical access may not be uniform, and the role of sensory level hearing deserves more investigation