**Data Collection**

**Participants**
- N = 111
- Females = 53, Males = 58
- Living near Madison or Minneapolis
- Monolingual, native English speakers

**Visits**
- Demographic: Questionnaire (parent task)
- Language Environment Analysis (LENA®)
- Expressive Vocabulary Test—2nd edition (EVT-2; Williams, 2007)
- Peabody Picture Vocabulary Test—4th edition (PPVT-4; Dunn & Dunn, 2007)
- Goldman-Fristoe Test of Articulation—2nd edition (GFTA-2; Goldman & Fristoe, 2000)
- Minimal Pair Discrimination Task
- Real-World Repetition Task

**Real-Word Repetition Task: Stimuli**
- 34 productions of /t/- and /k/-initial words
  - 9 different, familiar words
  - Presented aloud from a computer

**Spectral Analysis: Analyzable Data**
- Map productions
  - Transcribed as [t] or [k], or intermediate
  - VOT, ERB
- Analyzable by background noise

**To Compute Peak ERB**
- From the (t) or (k) recording, extract the peak ERB from a burst through Praat following burst with a constant envelope in the window
- Estimate the spectrum of the window using a Multitaper filter
- Pass the spectrum through a narrow band filter (let the better represent the final auditory filter (Fl))
- Pass the spectrum through a higher pass filter (To reduce distortion of theipple due to colored band (Fl))
- Pass the spectrum through a narrow band filter (let the better represent the final auditory filter (Fl))

**To Calculate Robustness of Contrast**
- Mean center Peak ERB to improve interpretability of the model
- Build a mixed effects logistic regression model to predict Target Consistent (either [t] or [k]) from Raw ERB

**Results:**
- [t] and [k] were better differentiated in back vowel contexts when compared to front vowel contexts for both children and adults
- Children's productions were highly variable
- Children had a greater range in Robustness of Contrast measures compared to adults, even for productions described as correct

**Future Directions**
- Explore additional measures to help differentiate [t]—[k] in front vowel contexts
- Explore how intermediate productions were classified
- Compare robustness of Contrast for [t]—[k] productions to other speech contrasts, such as [s]—[z] or [θ]—[ð]
- Look at change in Robustness of Contrast over time

**Acknowledgements**

**Background**
- What do we know about speech development in children who are typically developing? (e.g., Egelman, 2014)
- What do we know about the [t]—[k] place contrast and its development in young children? (Leman, 2013)
- How is speech production researched, and in practice? (Blachowicz, 2013)
- What is the role of viscosity in transcription? (Blachowicz, 2013)
- How can acoustic analysis support transcription? (Blachowicz, 2013)
- What are the fine-grained measures clinically relevant? (Peterson, 2013)

**Objectives**
- Perform spectral analysis of stop consonant release bursts to describe fine-grained variability in (t) and (k) productions in a 2½-3-year-old children
- Use a psycholinguistically relevant measure of frequency—Peak ERB—as a summary measure, rather than a physical measure of frequency (i.e., Hz)
- Develop a Robustness of Contrast measure to describe children’s acquisition of the (t)–(k) contrast

**Robustness of Contrast**
- Objective measure based on auditory spectrum analysis of the stop consonant release burst
- Tokens correctly predicted by mixed effects logistic regression model

**Spectral Analysis: Transcription Categories**
- $[t]:$ clear substitution of [t] for [k]
- $[k]:$ clear, correct [k]
- $[t]:$ clear substitution of [k] for [t]
- $[k]:$ clear, correct [t]
- $[t]:$ intermediate, closer to incorrect
- $[k]:$ intermediate, closer to incorrect
- $[k]:$ intermediate, closer to incorrect

**Data Analysis: Coding**
- Brain: Segment word boundaries and coarticulation context
- Tag locations of release burst and VOT

**Summary**
- Peak ERB differences in (t) and (k) better in back vowel contexts than in front vowel contexts
- Adults show a range in Robustness of Contrast across all vowel contexts (55–100)
- Children show a greater range in Robustness of Contrast, even when analyzing productions that were transcribed as correct (18–100)
- 80% of the adults had at least 50% of their tokens correctly predicted across all vowel contexts
- 50% of the children had at least 50% of their tokens correctly predicted in back vowel contexts only
- None of the child-level variables were significant predictors of Robustness of Contrast

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**Special Thanks:**
- ASHA Annual Convention, Nov. 2015
- See if Robustness of Contrast in 2½-year-old children predicts any child-level variables one year later
- See if Robustness of Contrast varies across different populations (e.g., children with cochlear implants)

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**Learning to Talk**
- Learning to talk and understanding language development across age and cultural populations

**References:**