

Child-Level Factors & Acquisition of the /t/--/k/ Contrast: Production

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1

0.75

0.50

0.75

1.00

0.25

645L31MA1 (57.69%)

Peak ERB numbe



Background

- What do we know about speech development in children who are typically developing? (Smit et al., 1990; Macken &
- What do we know about the /t/--/k/ place contrast and its development in young children? (Stevens, 2000; Hewlett, 1987)
- How is speech characterized in research and in practice? (Munson et al., 2010)
- What are the downsides to transcription? (Munson et al., 2010; Gibbon, 1999; Gibbon, 1990)
- How can acoustic analysis support transcription? (Nicholson et al., 2015; Holliday et al., 2014; Forrest et al.,
- Why are fine-grained measurements clinically relevant? (Tyler, Figurski, & Langsdale, 1993)

Objectives

- Perform spectral analysis of stopconsonant release bursts to describe fine-grained variability in /t/ and /k/ productions in 2-3-year old children
- Use a psychoacoustically 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 spectral analysis of the stop release burst
- % Tokens correctly predicted by mixed effects logistic regression model



Effects of between-category distance and within-category dispersion or discriminability. Top graph shows poor discriminability due to low between-category distance (a) and high within-category dispersion (b). Bottom graph shows good discriminability due to high between-category distance (a) and low within-category dispersion (b).

Data Collection

Visit Tasks

- Demographic Questionnaire (parent task)
- ♦ Language Environment Analysis (LENA[™])
- Hearing Screening
- Expressive Vocabulary Test—2nd edition (EVT-2; Williams, 2007)
- Peabody Picture Vocabulary Test—4th edition (PPVT-4; Dunn & Dunn, 2007)
- Coldman-Fristoe Test of Articulation—2nd edition
- (GFTA-2; Goldman & Fristoe, 2000) Minimal Pair Discrimination Task Real-Word Repetition Task



34 productions of /t/- and /k/-initial words Mean (SD) Range 17 different, familiar words Presented aloud from a computer 111 32.6 (3.5) 28 - 39 Paired with picture on the screen 109 116 (17) 81 - 160 16 /t/ tokens, 8 in back vowel contexts 18 /k/ tokens, 8 in back vowel contexts 109 113 (18) 79 - 153

Adult Norms: Spectral Analysis: To determine how well Peak ERB differentiates [t] and [k]

1 00 -

0.75 -

0.50 -

0.25 -

0.00 -

0.75 -

0.25 -

0.00 -

0.75 -

0.50 -

0.25 -

0.00 -

A52N20E52 (90.32%)

30 35 40 15 20 25 30 35 40

Peak ERB number

- **Analyzable Data:**
- Stop productions
- Transcribed as [t], [k], or intermediate

Participants

Normal hearing

Late Talkers (n = 11)

Females = 51, Males = 60

English speakers (n = 97)

Maternal Education

Child Characteristic

EVT-2 standard score

PPVT-4 standard score

Living near Madison or Minneapolis

African-American English speakers

(n = 14) and Mainstream American

14

26

70

Monolingual, native English speakers

♦ n = 111

Low

High

Middle

Age (months)

Norm: 100 (15)

Norm: 100 (15)

- VOT > 20ms Unobscured by background noise

To Compute Peak ERB:

- From the .WAV recording, extract 5ms preceding burst through
- 20ms following burst with a rectangular analysis window Estimate the spectrum of the window using a Multitaper
- Pass the spectrum through a gammatone filter bank (to better represent the human auditory filter)
- Pass the spectrum through a high-pass filter (to reduce contamination of the signal due to ambient background noise) Output will show a psychoacoustic spectrum relating
- excitation in a gammatone filter to its center frequency along the ERB scale
- The frequency with the greatest amplitude is the Peak ERB our summary acoustic measure

To Calculate Robustness of Contrast:

- model
- Calculate the log-odds for each production: what is the likelihood that the production is a [t] or [k], given its Peak ERB and the vowel context
- Calculate the accuracy of each prediction
- Calculate the % of each child's tokens that were correctly predicted by the model

Coding Praat Tag locations of release burst and VOT Segment word boundaries and code response context

Data Analysis: Coding

Transcription Categories

[\$t]: clear substitution of [t] for /k/

Front vowels

.....

. . . .

- ----

Target /t/

Manner transcription (stop, other) Place [narrow] transcription



Results:

- [t] and [k] were better differentiated in back vowel contexts 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 transcribed as correct

083L30FS1 (100%) 623L31FS1 (96.77%) 014L39MS2 (96.30%) Annie

610L31FS1 (93.33%) -111L31MS1 (92.31%) -

06%)	049L38MS2	(60.00%) -			•
1	629L30MS1	(58.82%) -			
	040L37FS2	(58.06%) -	•	• ••	

051L29ES1 (54.17%) 640L37ES2 (51.85%) 645L31MA1 (57.69%)

051L29FS1 (54.17%) 640L37FS2 (51.85%)

30 20 25 4015 20 25 30 35 Peak ERB numbe

Summary

- Peak ERB differentiates [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 (65% 100%)
- Children show a greater range in Robustness of Contrast, even when analyzing productions that were transcribed as correct (51% - 100%)
- 80% of the adults had at least 90% of their tokens correctly predicted across all vowel contexts
- 29% of the children had at least 90% of their tokens correctly predicted in back vowel contexts only
- None of the child-level variables were significant predictors of Robustness of Contrast

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 $[s] - [\int] or [J] - [w]$
- Look at change in Robustness of Contrast over time
- See if Robustness of Contrast in 2 1/2-3-year-old children predicts any childlevel variables one year later
- See how Robustness of Contrast varies across different populations (e.g., children with cochlear implants)

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Visit learningtotalk.org for more information about our lab and a handout his poster

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productions, we tested the models on 16 adult speakers

- spectrum (K=8, NW = 4)

- Mean-center Peak ERB to improve interpretability of the
- Build a mixed effects logistic regression model to predict Target Consonant (either /t/ or /k/) from Peak ERB values: TargetConsonant ~ PeakERB+ VowelContext + PeakERB*VowelContext + (1 + PeakERB | ID)