Instructional and biofeedback training in L2 contrast learning

Susan Lin[1a], Meg Cychosz[1], Alice Shen[1], Emily Cibelli[2]
[1]University of California, Berkeley, [2]Northwestern University
[a]corresponding author: susanlin@berkeley.edu

Berkeley UNIVERSITY OF CALIFORNIA
Northwestern University

- Non-native phoneme acquisition is a challenge in L2 instruction and acquisition (Flege, 1987; Ioup, 2008)
- Targeted phonetic instruction improves learners' ability to produce non-native contrasts (Cibelli, 2015)
- Visual biofeedback such as with EPG and ultrasound has been successfully applied in speech remediation (Bernhardt et al., 2005, McAllister Byun et al., 2014) and L2 pedagogy (Wilson, 2014; King and Ferragne, 2015)

Research Question: Does online visual biofeedback improve learners' ability to produce non-native contrasts more than than targeted phonetic instruction alone?

Methods

Syllable repetition task
- Audio of VCV and CV syllables by a native Marathi speaker
  - Targeted C contrast: dental [t̪,d̪] vs. retroflex [ʈ,ɖ]
  - V: [i, u, ɑ]
- Participants instructed to repeat audio "as best as you can"

14 participants
- Native speakers of English with no experience of languages with dental/retroflex contrast
- Randomized into three experimental conditions: A (control), B (phonetic instruction) and C (visual biofeedback)

Ultrasound
- Ultrasonix SonixTablet with C9-5/10 microconvex transducer
- Transducer secured under participants' chin using a stabilization headset
- Sagittal ultrasound recorded at 107fps with hardware synchronized audio

Procedure

pre-treatment repetition (**pretest**) w/ ultrasound

Trial conditions

A (control; N^*=6)

Experimenters engaged in casual conversation with subject in English for 5 minutes.

B (phonetic instruction; N^*=5)

Experimenters gave subject explicit phonetic instruction on the articulatory distinction between dental [t̪] and retroflex [ʈ], especially with respect to dentition and landmarks along the hard palate.

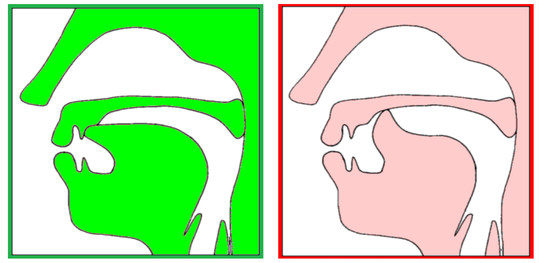
Subjects were encouraged to practice, and were able to ask the experimenter questions throughout the experience.

C (visual feedback; N^*=3)

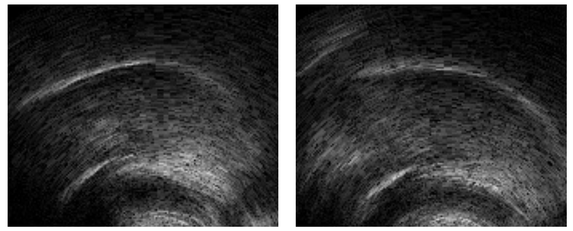
Experimenters turned on live ultrasound video feed from the subject's production, and oriented subjects to the positioning of their tongue within the video feed.

Subjects were given phonetic instruction pertaining to the articulatory distinction between dental [t̪] and retroflex [ʈ], especially with respect to the shape of the tongue contour, but without an external visual reference. Subjects were allowed to practice and ask the experimenter questions.

*Discrepancy in *N* due to problems during experimental procedures; six subjects participated in each condition.



Visual aide for trial condition B

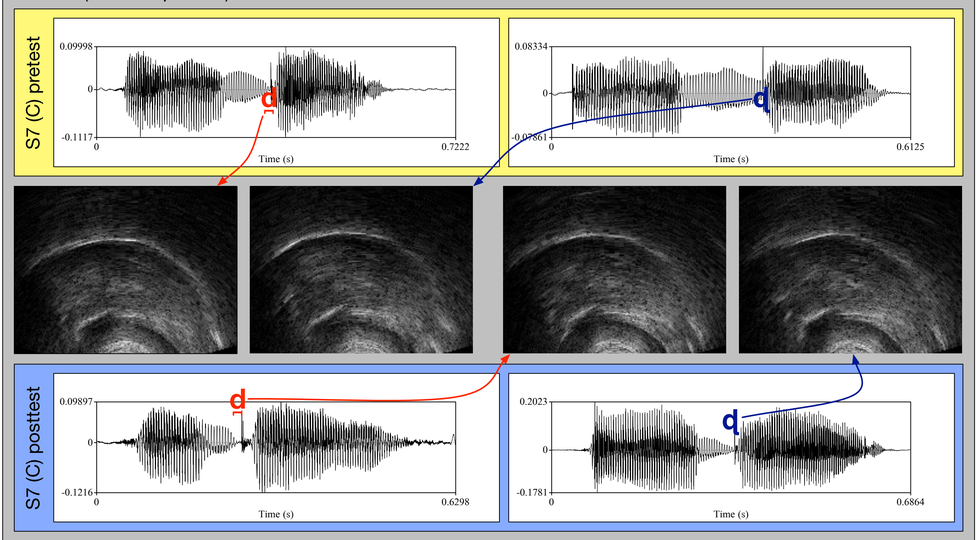


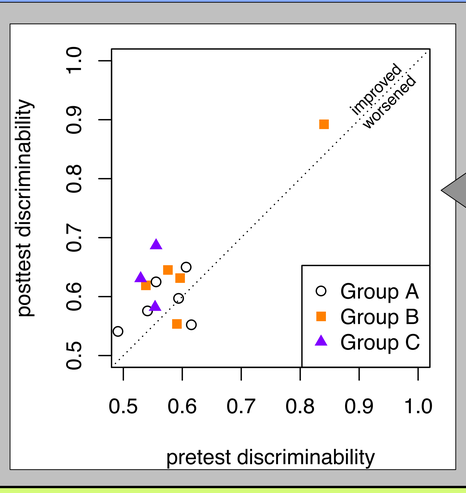
Ultrasound stills from model's dental (left) and retroflex (right) stops

post-treatment repetition (**posttest**) w/ ultrasound

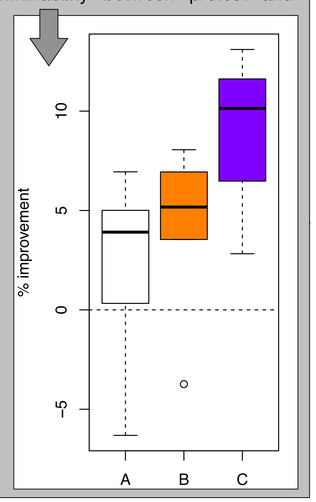
Analysis

Data post-processing
- Syllable productions marked for acoustic stop release in Praat (Boersma and Weenink, 2016)
- Principal Components Analysis run on ultrasound frames from point of stop release, using raw (non-interpolated) ultrasound data





Contrast improvement calculation (within subject)
- A Linear Discriminant Analysis (LDA) was trained on first 4 PC loadings from the PCA, labelled by place of articulation (dental vs. retroflex)
- LDA used to classify articulations as dental or retroflex, and **discriminability** calculated as proportion correct place identification
- Degree of **improvement** calculated as difference in proportion discriminability between pretest and posttest



Results Overview

In keeping with previous literature, while increased phonetic training helps learners improve discrimination ability in non-native contrast production, the addition of visual feedback may provide learners with even greater improvement, at least in the short-term.

- Nearly all participants improved contrast production during the posttest compared to baseline pretest syllable repetition task.
- Improvement in condition B (targeted phonetic instruction) greater than in A (control).
- Improvement in condition C (visual biofeedback) greater than in B.

Future directions

Application to L2 pedagogy
- Are some types of contrasts more easily trained using visual feedback or phonetic instruction than others?

Contrast validity
- Is the articulatory contrast that our participants are learning truly a dental vs. retroflex contrast, or are they simply learning to make *some* contrast?
  - *Acoustic analysis*: in what way are the contrasts acoustically distinct?
  - *Auditory/perceptual analysis*: do speakers of a language with the contrast perceive the contrast?
  - *Long term effects*: do participants retain their ability to produce the contrast?

Depth of learning
- Does a novel learned place distinction in one manner extend to other manners?
- Do participants who improve their production of a novel contrast also improve their perception of the contrast?

References Bernhardt, B. Gick, P. Bacsfalvi and Adler-Bock, M. (2005). Ultrasound in speech therapy with adolescents and adults. *Clinical Linguistics and Phonetics*, 19, 605–617. ▪ Boersma, Paul & Weenink, David (2016). Praat: doing phonetics by computer [Computer program]. Version 6.0.23, retrieved from http://www.praat.org/. ▪ Cibelli, E. S. (2015). Aspects of articulatory and perceptual learning in novel phoneme acquisition. (Unpublished doctoral dissertation). University of California, Berkeley, Berkeley, CA. ▪ Flege, J. E. (1987). A critical period for learning to pronounce foreign languages? *Applied Linguistics*, 8(2), 162-177. ▪ Ioup, G. (2008). Exploring the role of age in the acquisition of a second language phonology. In J. H. Edwards, & M. Zampini (Eds.), *Phonology and Second Language Acquisition* (pp. 41-62). Amsterdam: John Benjamins. ▪ King, H. & Ferragne, E. (2015). The dark side of the tongue: the feasibility of ultrasound imaging in the acquisition of English dark /l/ in French learners. Poster presented at Ultrafest VII. Hong Kong. ▪ McAllister Byun, T., Hitchcock, E. R., & Swartz, M. T. (2014). Retroflex versus bunched in treatment for /r/ misarticulation: Evidence from ultrasound biofeedback intervention. *Journal of Speech, Language, and Hearing Research*, 57(6), 2116-2130. ▪ Wilson, I. (2014). Using ultrasound for teaching and researching articulation. *Acoustical Science and Technology*, 35(6), 271-289.