Visually-oriented enhancement of vowel contrast in the Northern Cities Shift

Jonathan Havenhill

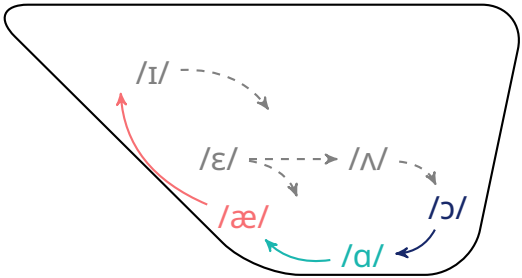
July 7, 2020
LabPhon 17

香 港 大 學
THE UNIVERSITY OF HONG KONG

Introduction

- Vowel systems are organized around principles of acoustic and auditory dispersion (Liljencrants & Lindblom, 1972; de Boer, 2001; Flemming, 2004)
- Are vowel systems also **visually or articulatorily dispersed?**
  - Diehl & Kluender (1989): articulatory dispersion can't predict prevalence of [i u a] over [y ɯ a]. Both systems are equally dispersed in articulatory terms; enhancement is primarily auditory
  - Listeners are also sensitive to non-auditory perceptual cues, including vision (McGurk & MacDonald, 1976; McGuire & Babel, 2012)
  - Can visual perceptibility predict which articulatory configuration is preferred in cases where multiple configurations are possible?

The Northern Cities Shift



- Chain shift characterized by raised TRAP (/æ/), fronted LOT (/ɑ/), and fronted/lowered THOUGHT (/ɔ/) (Labov et al., 2006)
- Fronted THOUGHT fills the vowel space gap left behind by fronted LOT
- Acoustics can't predict how fronted THOUGHT will be articulated: F2 increase can be achieved by tongue fronting and/or lip unrounding

This Study

- **Havenhill & Do (2018)**: Metro Detroit speakers show a range of articulatory strategies for maintaining LOT-THOUGHT contrast, but unround variants of THOUGHT are weaker than round variants in audiovisual perception
- **This study**: Investigation of articulatory patterns for Northern Cities-shifted LOT and THOUGHT among Chicagoans
- **Research questions**:
  - Are round variants of fronted THOUGHT more common than unround variants, given that they avoid the loss of visual contrast?
  - Do speakers actively enhance the LOT-THOUGHT contrast for visual perceptibility in corrective speech?

Methods

- Fifteen (3 men, 12 women, ages 20 to 77) Chicago natives recruited at Northwestern University
- **Normal speech task**: Three repetitions of 123 words containing /æ ɑ ɔ i u o/, in carrier phrase "say ____ again."
- **Corrective focus task**: Subset of words containing LOT and THOUGHT, in carrier phrase 'I said *target*$_x$ and *target*$_y$, not *contrast*$_a$ and *contrast*$_b$."
  - "I said ***nod*** and *sod*, not ***gnawed*** and *sawed*" (words in color were measured)
  - Prompt: "Speak clearly and with as much emphasis as possible, as though you are correcting someone who misheard you."
- Simultaneous high-speed ultrasound (84 fps), lip video (60 fps), and audio recorded in AAA (Articulate Instruments Ltd., 2012)

Acoustic Results

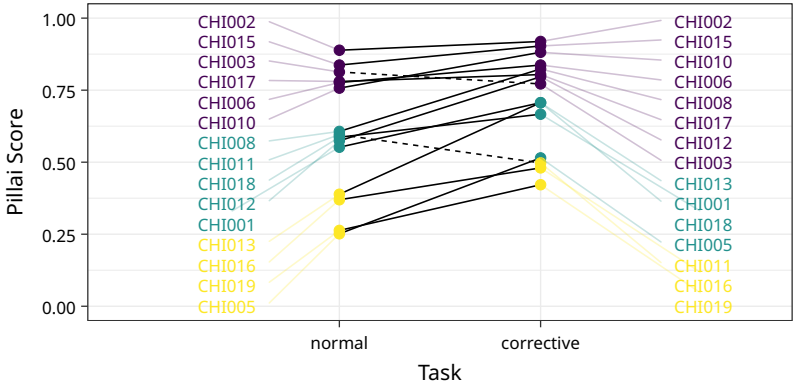


Figure 1: Pillai score (Hay et al., 2006) by task, all participants.

- Speakers vary in the extent to which LOT-THOUGHT contrast is preserved
- 13 of 15 speakers increase acoustic distance in corrective speech

Articulatory Results: Normal Speech

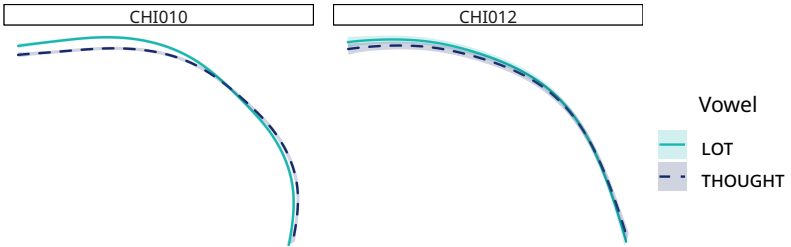


Figure 2: Polar SSANOVA (Mielke, 2015) for LOT and THOUGHT with 95% CI. Tongue front is to the left.

- Seven speakers exhibit significant difference in tongue position (like Speaker 10), while eight do not (Speaker 12)

Articulatory Results: Normal Speech

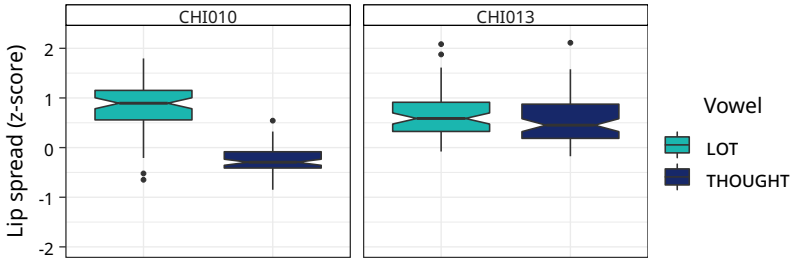


Figure 3: Lip spread measurements for LOT and THOUGHT.

- 14 of 15 speakers (incl. Speaker 10) show significant difference between LOT and THOUGHT in terms of lip spread
- Speaker 13 is the sole exception

Articulatory Results: Corrective Speech

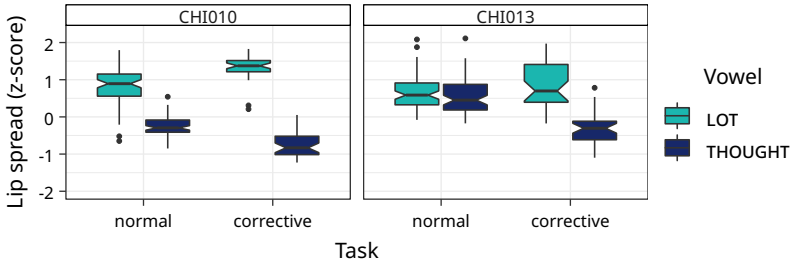


Figure 4: Lip spread measurements for LOT and THOUGHT in normal and corrective speech.

- In corrective speech, 11 of 15 speakers significantly increase lip spread distinction between LOT and THOUGHT
- Speaker 13 produces distinction not observed in normal speech

Articulatory Results: Corrective Speech

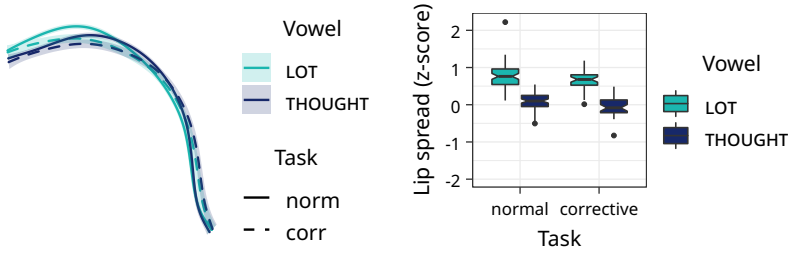


Figure 5: Lip spread measurements for LOT and THOUGHT in normal and corrective speech.

- Three speakers increase lip spread distinction with little or no increase in acoustic distance
- Speaker 18 increases rounding for THOUGHT, while tongue distinction is lost

Conclusions

- Visual perceptibility drives preference for maintaining lip rounding distinction in normal speech (cf. Havenhill, 2018; Havenhill & Do, 2018)
- In corrective speech, speakers show a range of articulatory strategies, but some showed an increase in lip rounding with no accompanying increase in acoustic distance
  - Lip rounding enhancement is not necessarily a byproduct of auditory enhancement
- Articulatory strategies that preserve or enhance both auditory and visual contrast are likely to be favored over strategies that improve contrast in the auditory domain alone

Thank you!

Contact

jhavenhill@hku.hk

https://jhavenhill.com

@jhavenhill

Many thanks to:

Youngah Do, Lisa Zsiga, and Jen Nycz for comments and suggestions; Jennifer Cole, Annette D'Onofrio, and Chun Chan for assistance with lab space and participant recruitment; and research assistant May Chan Pik Yu.

References I

Articulate Instruments Ltd. 2012. **Articulate Assistant Advanced user guide: Version 2.14**. Edinburgh, UK: Articulate Instruments Ltd.

de Boer, Bart. 2001. **The origins of vowel systems**. Oxford: Oxford University Press.

Diehl, Randy L. & Keith R. Kluender. 1989. On the objects of speech perception. **Ecological Psychology** 1(2). 121–144.

Flemming, Edward. 2004. Contrast and perceptual distinctiveness. In Bruce Hayes, Robert Kirchner & Donca Steriade (eds.), **Phonetically-based phonology**, Cambridge: Cambridge University Press.

Havenhill, Jonathan. 2018. **Constraints on articulatory variablity: Audiovisual perception of lip rounding**: Georgetown University Doctoral dissertation.

Havenhill, Jonathan & Youngah Do. 2018. Visual speech perception cues constrain patterns of articulatory variation and sound change. **Frontiers in Psychology** 9. 728. doi: 10.3389/fpsyg.2018.00728.

Hay, Jennifer, Paul Warren & Katie Drager. 2006. Factors influencing speech perception in the context of a merger-in-progress. **Journal of Phonetics** 34(4). 458–484. doi: 10.1016/j.wocn.2005.10.001.

Labov, William, Sharon Ash & Charles Boberg. 2006. **The atlas of North American English**. Berlin: Walter de Gruyter. doi: 10.1515/9783110206838.

Liljencrants, Johan & Björn Lindblom. 1972. Numerical simulation of vowel quality systems: The role of perceptual contrast. **Language** 48(4). 839–862.

References II

McGuire, Grant & Molly Babel. 2012. A cross-modal account for synchronic and diachronic patterns of /f/ and /θ/ in English. **Laboratory Phonology** 3(2). 1–41. doi: 10.1515/lp-2012-0014.

McGurk, Harry & John MacDonald. 1976. Hearing lips and seeing voices. **Nature** 264. 746–748. doi: 10.1038/264746a0.

Mielke, Jeff. 2015. An ultrasound study of Canadian French rhotic vowels with polar smoothing spline comparisons. **The Journal of the Acoustical Society of America** 137(5). 2858–2869. doi: 10.1121/1.4919346.