Maintenance of the COT-CAUGHT contrast among Detroit speakers: A multimodal articulatory analysis

Jonathan Havenhill (*Georgetown University*)

While the acoustic characteristics of the Northern Cities Vowel Shift (NCVS) are well documented, research on the articulatory components of this shift is comparatively limited. This study employs video analysis and ultrasound tongue imaging to examine the relative contributions of lip configuration and tongue position to maintenance of the contrast between /ɑ/ and /ɔ/. It is found that speakers with acoustically similar vowel spaces differ in articulatory strategy.

Early stage NCVS includes the fronting of /ɑ/ and /ɔ/ (an F2 increase), and the lowering of /ɔ/ (an F1 increase). Despite this shift, /ɑ/ and /ɔ/ remain acoustically distinct. These increased formant values may be associated with tongue-fronting or lip-unrounding, both of which shorten the vocal tract. Majors & Gordon (2008) use video analysis to examine lip rounding among St. Louis speakers with NCVS-like low back vowels. They find that rounding is preserved in /ɔ/, suggesting that /ɔ/-fronting and lowering may be accomplished through tongue position alone. Harrington et al. (2011) demonstrate that /u/-fronting in Southern Standard British is the result of tongue-fronting, and similarly conclude that that /i/ and fronted /u/ are distinguished only through lip rounding.

This study expands on the video analysis methodology of Majors & Gordon (2008) by examining speakers from Detroit, a prototypical NCVS city, and by incorporating ultrasound tongue imaging to simultaneously observe lip and tongue configuration. Two 22–23 year-old female speakers from Metro Detroit produced a list of 100 monosyllabic words embedded in a carrier phrase, with each word containing /i/, /u/, /æ/, /ɑ/, or /ɔ/. Audio, video, and ultrasound data were synchronized and measured at a single point. F1, F2, and F3 were measured and normalized following the technique of Labov et al. (2006). Vertical lip openness and horizontal lip spread were calculated from the number of pixels between the top and bottom lips and between the lip corners. Tongue contours were tracked using EdgeTrak (Li et al., 2005) and modeled with smoothing spline ANOVA (Davidson, 2006; Gu, 2002).

Both speakers' productions are characteristic of the NCVS, exhibiting mean F1 values for /æ/ of less than 700 Hz, and mean F2 values for /ɑ/ between 1350 and 1500 Hz. Acoustically, /ɑ/ and /ɔ/ differ significantly in F1, but not in F2. For Speaker 1, the differences between the smoothing splines for /ɑ/ and /ɔ/ are not significant. However, these vowels differ significantly in lip openness, which may account for the observed difference in F1. For Speaker 2, the opposite is true: /ɑ/ and /ɔ/ do not differ significantly in lip openness or spread. However, the difference between the smoothing splines for these vowels is significant, suggesting that Speaker 2 maintains this contrast through tongue position.

These results demonstrate the value of articulatory analysis in sociophonetics, by revealing interspeaker differences not observable in the acoustic signal. In this study, both speakers maintain a contrast between /ɑ/ and /ɔ/; however, one does so through lip configuration, and the other through tongue position, suggesting that speakers may take differing paths in achieving sound change.

References

Davidson, Lisa. 2006. Comparing tongue shapes from ultrasound imaging using smoothing spline analysis of variance. *The Journal of the Acoustical Society of America* 120(1). 407–415. doi:10.1121/1.2205133.

Gu, Chong. 2002. *Smoothing Spline ANOVA Models*. New York, NY: Springer.

Harrington, Jonathan, Felicitas Kleber & Ulrich Reubold. 2011. The contributions of the lips and the tongue to the diachronic fronting of high back vowels in Standard Southern British English. *Journal of the International Phonetic Association* 41(2). 137–156. doi:10.1017/S0025100310000265.

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

Li, M., C. Kambhamettu & Maureen Stone. 2005. Automatic contour tracking in ultrasound images. *Clinical Linguistics and Phonetics* 19(6-7). 545–554.

Majors, Tivoli & Matthew J Gordon. 2008. The [+spread] of the Northern Cities Shift. *University of Pennsylvania Working Papers in Linguistics* 14(2). 111–120. http://repository.upenn.edu/cgi/viewcontent.cgi?article=1061&context=pwpl.