

/u/-fronting in RP and the implications of perceptual integration of lip gestures for sound change processes

Felicitas Kleber, Ulrich Reubold, Jonathan Harrington
Institute of Phonetics and Speech Processing, University of Munich

/i/ and /u/ are very common in the world's languages and given that they are perceptually so distinct, they are unlikely to merge in the course of sound change. On the other hand, there is evidence from the sociophonetics literature (Labov, 1994) that back tense vowels are often diachronically fronted which has also recently been found for Standard British English (henceforth RP; Wells 1982, Hawkins & Midgley 2005, Harrington et al 2008). The acoustic correlate of /u/ fronting is F2-raising which may result from two articulatory sources: tongue fronting and/or lip-unrounding (Fant 1970). Although we have so far assumed that diachronic /u/ fronting in RP has been associated articulatorily with tongue fronting (Harrington et al, 2008), we do not know the extent to which lip-unrounding has also contributed to this recent sound change. The purpose of the present study is to establish whether lip-rounding has been maintained in RP speakers' fronted /u/ and to shed some light on whether lip-rounding is necessary for the perceptual contrast to be maintained between /i/ and /u/. Since it has been shown that listeners perceptually integrate visual gestural cues in the decoding of speech (McGurk & MacDonald, 1976; Traunmüller & Öhrström, 2007), we tested the hypothesis by means of an audiovisual experiment.

Whereas English distinguishes only back, rounded /u/ and front, unrounded /i/, German has an additionally closed, front, rounded vowel phoneme /y/. Our hypothesis was that German listeners either perceive an /i/ if English fronted /u/ is produced with unrounded lips or an /y/ if it is produced with lip rounding. We also predict that German listeners identify an English front, closed unrounded [i] as /i/ and an English back, mid-closed, rounded [ɔ] as /o/.

The testing material comprised video-audio recordings of fronted *who'd* as well as acoustically and visually prototypical *heed* and *hoard* tokens (RP is non-rhotic) all produced by a young female speaker of RP-English who had acoustically and perceptually very fronted /u/ variants. Each stimulus was repeated 6 times and presented in randomized order within three blocks that differed with respect to stimulus presentation mode. In the first block, only visual stimuli were presented, in the second block, audiovisual dubbed and cross-dubbed stimuli were presented with pink noise, and in the third block, auditory stimuli were presented also with pink noise. 16 German listeners were asked to identify the vowel in each stimulus either as /i/, /y/, /u/ or /o/ by pressing the corresponding German letter on a keyboard.

In the auditory condition (cf. Fig. 1(a)), German listeners identified English [i] and [ɔ] stimuli almost always as /i/ (92%) and /o/ (100%) respectively, whereas fronted [u] was clearly perceived as /y/ (92%), i.e., the fronted variant of the English /u/ was auditory most similar to German /y/. In the visual condition (cf. Fig. 1(b)), subjects identified English /i/ as /i/ (94%), [ɔ] as /u/ (37%) or as /o/ (55%), and fronted [u] as /y/ (34%) or as /u/ (56%), i.e., English fronted [u] was produced with lip-rounding. In the audiovisual condition, listeners identified dubbed [i] as /i/ (98%) and [ɔ] as /o/ (96%) respectively, and dubbed fronted [u] was clearly perceived as /y/ (91%) (cf. Fig. 1(c)). McGurk effects were found in cross-dubbed stimulus responses (cf. Fig. 1(d)). Most importantly, stimuli consisting of auditory [u] and visual [i] obtained 47% /i/-responses.

Our results for auditory, visual, and audiovisual dubbed stimuli show that English fronted [u] is (1) auditorily unambiguously classified as /y/ by German listeners and (2) that it is produced with lip rounding. The McGurk effect shows that visual cues are perceptually integrated in the perception of close front vowels. This finding supports the idea that the lip-rounding gesture may also be necessary for RP-English listeners to avoid a perceptual confusion with /i/. The closer acoustic approximation of /u/ and /i/ as a result of /u/-fronting is off-

set by the distinct visible lip gestures that prevent a perceptual merger of /i/ and /u/. Thus, we hypothesize that the maintenance of lip rounding is preferred in this sound change in progress.

References

Fant, G. (1970). *Acoustic Theory of Speech Production*. Mouton De Gruyter.
 Harrington, J., Kleber, F., & Reubold, U. (2008). Compensation for coarticulation, /u/-fronting, and sound change in Standard Southern British: an acoustic and perceptual study. *Journal of the Acoustical Society of America*, 123, 2825-2835.
 Hawkins, S., & Midgley, J. (2005). Formant frequencies of RP monophthongs in four age groups of speakers. *Journal of the International Phonetic Association* 35, 183 – 199.
 Labov, W. (1994). *Principals of linguistic change: Internal factors*. Oxford: Blackwell.
 McGurk, H., & MacDonald, J. (1976). Hearing lips and seeing voices. In: *Nature*, 264, 746-748.
 Traunmüller, H., & Öhrström, N. (2007). Audiovisual perception of openness and lip rounding in front vowels. *Journal of Phonetics*, 35: 244 - 258.
 Wells, J.C. (1982). *Accents of English II: The British Isles*. Cambridge: Cambridge University Press.

Figures

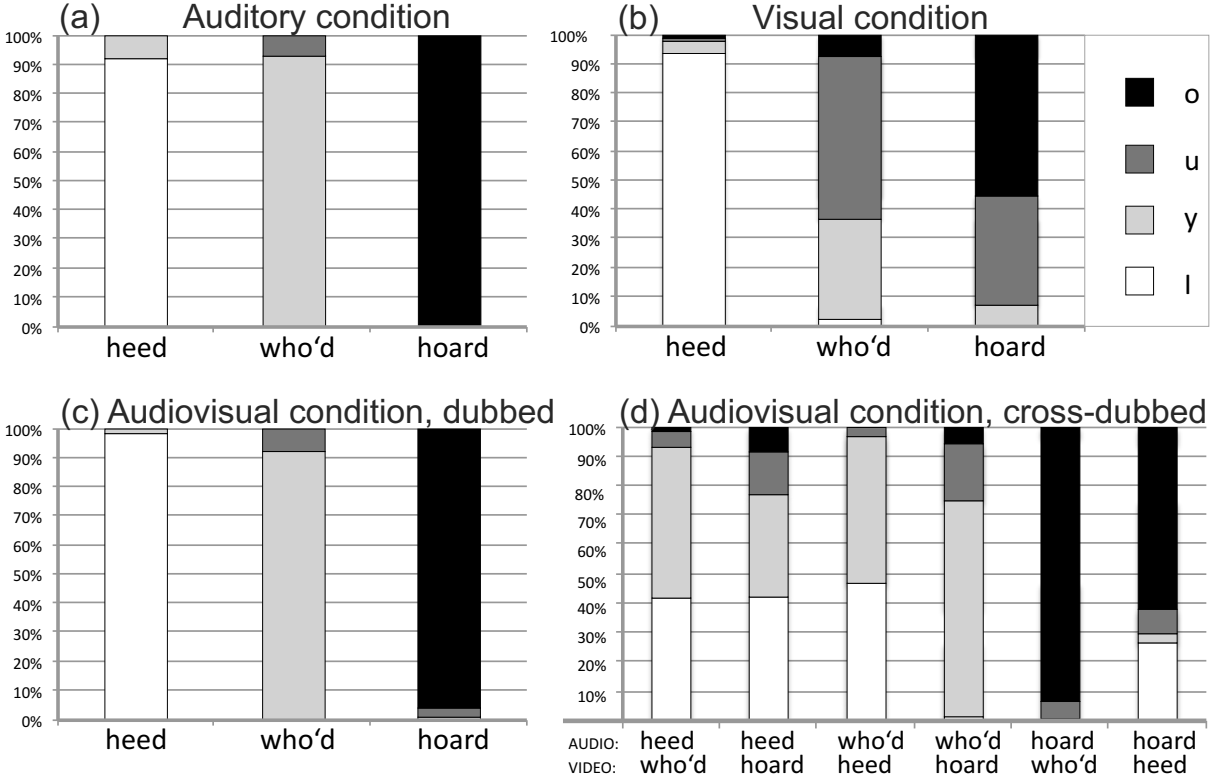


Figure 1: Proportion of /i/, /y/, /u/ or /o/ responses to the *heed*, *who'd*, and *hoard* tokens in the three different presentation conditions.