Phonetic asymmetry, historical sound change, and agent-based modelling

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Phonetic variation is often asymmetric so that synchronic variation is more likely in one direction than in another. Such asymmetries can sometimes provide the basis for the development of sound change. Thus, synchronically velar stops are more likely to be confused with coronal stops before high vowels than the other way round (Winitz et al, 1972). Compatibly, velars often palatalise to coronals historically in this context (e.g. modern English *cheese* related to German *Käse*) but sound changes in the other direction are much less likely (Chang et al, 2001). The main concern in this talk is with explaining this relationship between phonetic asymmetry and sound change in a model of human speech communication. The general hypothesis is that if there are two phonetic distributions *x* and *y* such that (i) the variation in *x* is greater than that of *y* and/or (2) the direction of the variation in *x* points towards *y* but not the other way round, then *y* can act as an attractor and pull *x* towards it.

The hypothesis was tested using a computational agent-based model in which each agent was equipped with a lexicon, rudimentary phonology, and dynamically changing speech signals (Harrington & Schiel, 2017). Each word of the lexicon was associated probabilistically with the speech signals that belonged to it; phonological classes were in turn defined as probabilistic distributions across the speech signals of the words with which they were associated (Pierrehumbert, 2003). The starting conditions for each agent were speech recordings obtained from real speakers with one agent per speaker. The probabilistic mapping between words, phonological classes, and speech signals could be updated during communication depending on whether the agent listener absorbed an incoming speech signal from an agent talker into memory. Pairs of agents communicated with each other over several thousands of interactions.

The computer simulation was based on two types of sound change in English: /u/-fronting by which backed variants of /u/ have shifted towards the front of the vowel space in the last 60 years in Standard Southern British (Hawkins & Midgley 2005, Harrington et al, 2008; Henton 1983); and an ongoing phonological category change by which /s/ in /r/-clusters (e.g. *street*) has retracted to /ʃ/ in some varieties (Labov, 2001; Rutter, 2011; Stevens & Harrington, 2016). The second of these also required an extension of the model to allow agents to split and merge phonological classes.

In both cases, the computer simulations provided evidence of a gradual shift of *x* towards *y* following the hypotheses outlined above. For /u/-fronting, *x* was the backed /u/-variants of older speakers that were oriented and attracted towards *y*, the fronted and more compact /u/-variants of younger speakers. For /s/-retraction, *x* was the more variable sibilants in *street* words that shifted both phonologically and acoustically towards *y*, the more compact /ʃ/ distribution.

The overall conclusion is that sound change in its initial stages is the outcome of a fortuitous combination of the relative size and orientation of phonetic distributions, their association to phonological classes, and how these types of information vary between speakers that happen to interact with each other.

References

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