The representation of time in modelling of sound change.

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Phonetic variation both within and between speakers is typically time-varying. Compatibly, sound change can be considered to be the result of adjustments in how such time-varying information is processed [1, 2]. Here we seek to understand how these time-varying, synchronic and diachronic aspects of speech are connected by comparing two or more groups of speakers from the same speaking community that are at different stages of a sound change in progress.

The methodology for relating time-varying signals to diachronic change was based on functional principal components analysis (FPCA) which decomposes a data set composed of *n* time-varying signals into *n* vectors (one vector of *K* PC-scores per signal) that modulate a linear combination of *K* principal components. Any one of the original (raw) signals can be approximated by adding this signal-specific modulation of the principal components to the mean calculated across the entire data set [3, 4]. The relevance of FPCA to the present study (and which makes it different from ordinary PCA) is that the input signals, the mean for the data set, as well as the *K* principal components are all functions of time as opposed to vectors of real numbers. A major benefit of this technique for phonetic analysis is that FPCA can be applied to *multidimensional* time-varying signals in order to derive e.g. the time-varying shapes that underlie the first two, or first three formants together.

In the present study, FPCA was used to investigate three different types of sound change. The first was concerned with the increasing tendency for a merger to take place in the New Zealand English NZE falling diphthong exemplified by the lexical set [5] SQUARE in the direction of NEAR (so that e.g. *ear*/*air* are more or less homophonous for younger NZE speakers [6-9]). The focus of the second was on vowel metaphony in southern varieties of Italian in the so-called Lausberg area in which the vowel of the stem is modified by a falling suffix: thus, standard Italian /mɛse, mesi/ (engl: month, months), but metaphonic /mɛs(ə), mis(ə)/ [10-13]. The third was concerned with intervocalic /s/-stop clusters in Andalusian Spanish in words like /pasta/ (engl. pasta) in which for older speakers the /s/ is pre-aspirated but is becoming post-aspirated for younger speakers [14-17].

A comparison of the FPCA-parameterised speech data between two groups (older vs. younger in the case of NZE and Andalusian Spanish; from different regions of the Lausberg area in the case of Southern Italian) provided evidence for all of these very different types of sound change in progress.

We provide finally some suggestions for explaining how sound change emerges from a model of human speech processing in which dynamic information of the type derived from FPCA is stored and updated in memory.

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