A dynamic analysis of the sound change towards more pre-aspiration in Aberystwyth English

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Aspiration is a form of glottal friction that is often associated with voiceless plosives. According to articulatory phonology, any voiceless plosive is composed of a glottal gesture and a supraglottal closing gesture [1] whose temporal alignment determines whether aspiration occurs before and/or after the closure. Despite their dynamic nature, aspiration phases are almost always quantified in terms of static measures such as duration or frequency of occurrence (e.g. [2]). Here we investigate pre-aspiration in an accent of Welsh English spoken in Aberystwyth, where voiceless plosives are predominantly post-aspirated and frequently pre-aspirated, e.g. *pack* /$p^ha^{(h)}k^h$/ [3]. Using traditional measures, a sound change has been identified: younger speakers pre-aspirate more often and with longer durations than older speakers, and older females more often than older males [4]. The aim of this study is to provide a more fine-grained analysis of this change using the method from [5] where aspiration is quantified by means of two time-varying curves that represent articulatory gestures.

The dataset consisted of 12 speakers from Aberystwyth, equally divided amongst two sexes and two age groups (younger: 21-30, older: 61-89 years of age). The speakers produced up to 92 different $C^hV^{(h)}C^h$ words in isolation or short sentences up to five times, resulting in a total of 2317 tokens. The burst of the second plosive and its post-aspiration were excluded from the analysis. Two continuous acoustic curves were extracted from each token. One was the voicing probability VP [6] as a proxy for the glottal gesture, the other was the (normalised) high-frequency energy HF as a proxy for the supraglottal closing gesture. We expect aspiration to correspond to time intervals where VP is low (= voicelessness) and HF is high (= no closure). To quantify aspiration we computed the area between the time-normalised HF and VP curves: the greater and longer the gap between a high HF and a low VP, the greater the area between the two curves, thus the more aspiration there is. The area before (resp. after) the temporal midpoint is associated with the post-aspiration of C_1 (resp. pre-aspiration of C_2). The post- and pre-aspiration areas depend on the shape of the HF and VP curves. The three main independent variation trends in those curve shapes were determined by applying FPCA [7].

Fig. 1 shows these three main variation trends called PCs. PC1 (top row) mainly captured a variation in the amount of post-aspiration in C_1 (blue area), while PC2 explained a mild trade-off (the more C_1 post-, the less C_2 pre-aspiration) that may hint towards a possible dissimilation process [3]. Importantly, PC3 explained the amount of pre-aspiration in C_2 (yellow) with no change in post-aspiration, so we will focus on PC3 in the remainder of this study. FPCA assigned each input token a score for PC3 (called s3) which determines where the token is situated in the continuum of the shape variation shown from left (negative score) through centre (score = 0) to right (positive score) in the third row of Fig. 1. An LMER with s3 as dependent variable, age and sex of the speakers as fixed factors, and speaker and word as random terms showed a significant effect of age on s3 ($F[1, 10.2] = 5.9$, $p < 0.05$). This can also be observed in Fig. 2 where younger speakers generally have lower values of s3 than older speakers which corresponds to more pre-aspiration in C_2 (see Fig. 1, row 3, left column). This finding supports the evidence for an ongoing sound change towards more pre-aspiration in Welsh English. It was however not confirmed that there was a sex difference in older speakers whereby females would be more advanced in this sound change than males.

This study illustrates the benefits of using a dynamic analysis to quantify (pre-)aspiration: it provides a more natural approach by relying not on a superimposed segmentation [8] but on time-varying curves; and it gives more details than traditional analyses by quantifying the complex relation between temporal extent and amplitude that characterises aspiration phases.

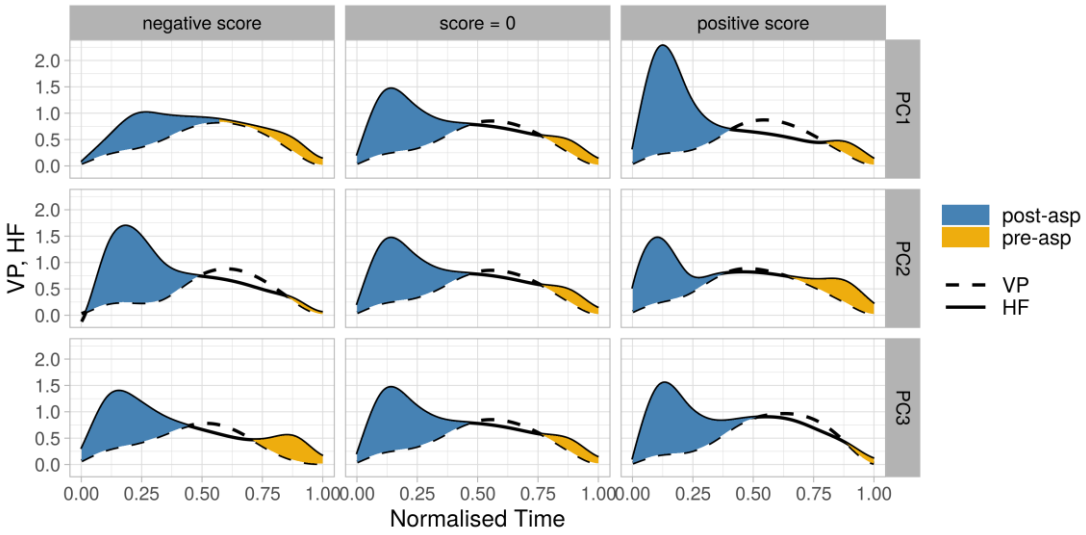

Figure 1. *Three main variation trends (one per row) in the HF and VP curve shapes. Areas that quantify post- and pre-aspiration were coloured. Values near or at 1 in VP (dashed) indicate where the vowel in the CVC sequence is.*

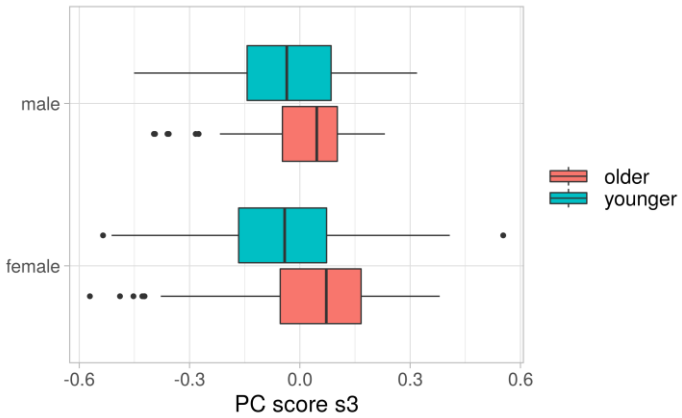

Figure 2. *Distribution of PC score s3 by age group and sex of the speakers.*

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