

Vowel Distribution and the Stability of Long-Term Formants in German

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Introduction

The forensic utility of LTFDs (long-term formant distributions) is based on the fact that formants depend on a speaker's characteristic features, such as the dimensions of the vocal tract or voice quality parameters, such as lip rounding or palatalisation (Nolan & Grigoras, 2005). Previous research shows that LTFDs can indeed reliably distinguish between speakers (Moos, 2010; Gold et al., 2013). In particular, it is the third and fourth formants (LTF3 & LTF4) that tend to show the greatest speaker specificity. F1 and F2 are more closely linked to linguistically driven modifications of the vocal tract, such as those involved in vowel distinction (Clermont & Mokhtari, 1998). Previous studies have produced ambiguous findings regarding the influence of linguistic factors on LTFDs (Tomić & French, 2019; Cho & Munro, 2017; Heeren et al., 2014; Jessen & Becker, 2010). Since phoneme inventories vary across languages, and assuming that the respective languages exhibit at least some divergence in vowel distribution, LTF 1 and 2 are expected to show language-specific differences. This raises the question of the extent to which vowel quality influences LTFDs, compared with the influence of individual characteristics relating to articulation and anatomy.

In this contribution, we test whether manipulating the proportions among the vowels in a given sample affects the LTFs 1-4. We hypothesize that changes in the proportions among the vowels affect the shape of LTFs 1 and 2 in accordance with the vertical and horizontal position of the tongue as well as the degree of lip rounding for the respective vowels. We further expect that the presence of rounded front vowels will lower the values of all LTFs, particularly that of LTF3.

Methodology

In order to study this question, we are conducting an experimental study which manipulates the distribution of the vowel inventory within the sample sets. This is done in such a way that, across five vowel conditions, a disproportionately large number of instances of a particular vowel is produced in each case. We constructed 42 German declarative sentences, each of which was recorded by ten male native speakers of German (mean age = 34.7 years). The study examines the vowels /i:/, /a:/, /u:/, /y:/ and /ø:/, and a neutral control condition approximating the vowel distribution typically found in German (cf. Pätzold & Simpson, 1997). The sentences fulfil the criterion that the target vowel in each condition should account for more than 50% of the stressed vowels in that condition, whilst the phonetic context and sentence structure are kept as constant as possible across conditions. The recordings were made in a professional recording studio and lasted an average of 323 seconds per speaker in their entirety, i.e. before extracting the vocalic stream. For the analysis, the first four formants of all vocalic segments are extracted in Praat using the LPC method at 10ms intervals and corrected manually (cf. Barreda, 2021). The statistical analysis includes linear mixed models to investigate the effects of the conditions, as well as correlation analyses to determine the intra-individual stability of the LTF values.

Expected results

Based on the hypotheses put forward, we expect the results to show an intra-individual effect of vowel condition on the LTFs 1 and 2. In other words, the influence of the rate of occurrence of the different vowels is large enough to make a speaker's LTFs vary with the height and fronting of the respective vowel condition. A disproportionately high degree of, e.g., /i:/ will lead to a lower LTF1 than if there were predominantly /a:/-vowels present. We expect an effect of speaker individuality on LTF 3 and

4 but no effect of vowel condition on these two LTFs except that they may be lowered if there are predominantly rounded front vowels present. This study aims to contribute to our understanding of the validity of long-term formants in forensic speaker comparison and the factors influencing them.

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