Using Functional Data Analysis for investigating multidimensional dynamic phonetic contrasts – Additional material

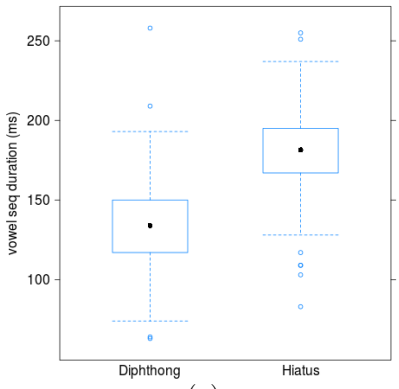
Michele Gubian[a], Francisco Torreira[a,b], Lou Boves[a]

[a] *Centre for Language and Speech Technology, Radboud University Nijmegen, The Netherlands*
[b] *Max Planck Institute for Psycholinguistics, Nijmegen, The Netherlands*

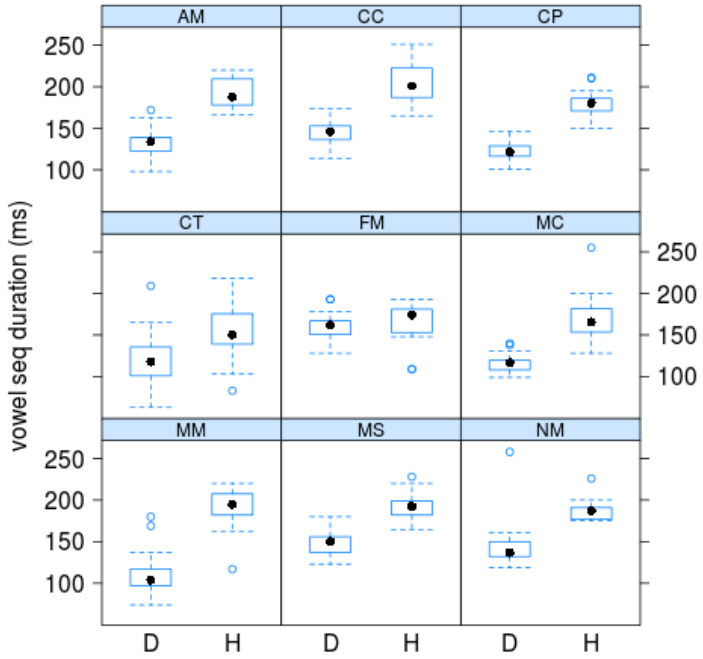
Description

This document is a collection of data plots generated on the basis of the analysis exposed in the main text. Detailed information are provided in the figure captions. The code and the data that have been used to generate the plots are available online for download[1].

[1] `https://github.com/uasolo/FDA-DH/` or direct link to zip bundle: `https://github.com/uasolo/FDA-DH/archive/master.zip`



(a)



(b)

Figure 1: Boxplots showing duration of the vowel sequence /ja/ for D and /i.a/ for H. In (a) the data from all nine speakers are pooled together; in (b) the data from each speaker are shown in a separate panel. See Section 4.1 of the main text.

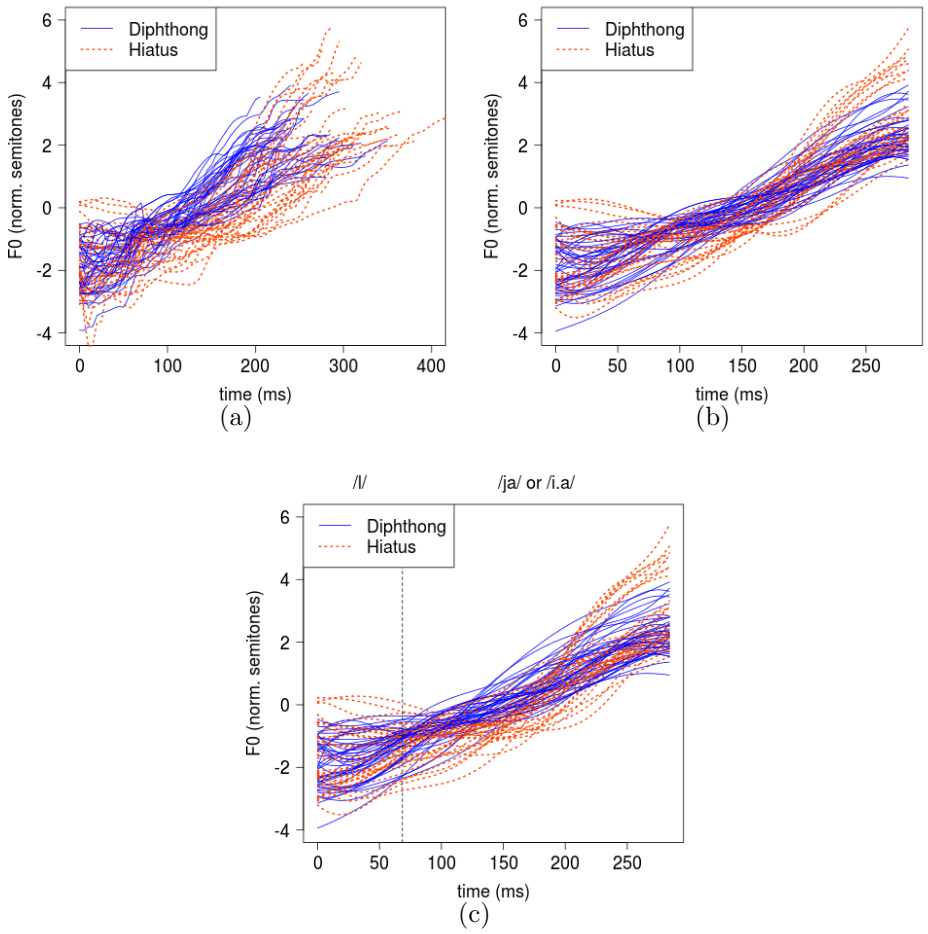
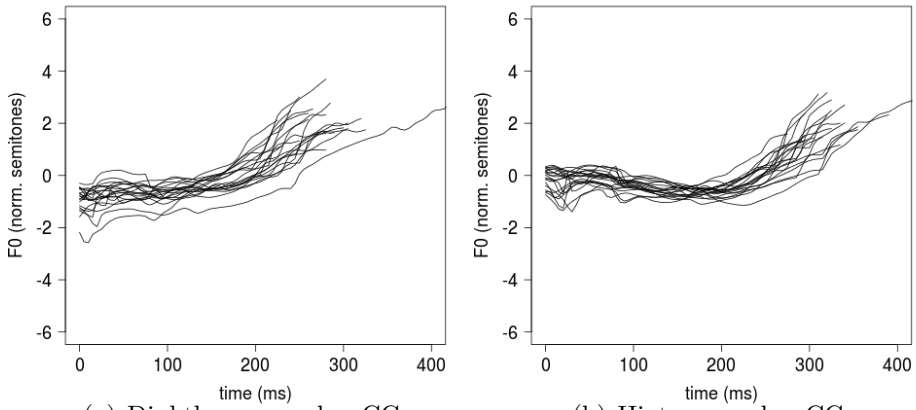


Figure 2: A random subset (20%) of the 365 f_0 contours. In (a) the raw contours; in (b) the smoothed contours, where the effect of linear time normalisation is evident; in (c) the result of landmark registration. See Section 3 of the main text.



(a) Diphthong, speaker CC (b) Hiatus, speaker CC

(c) Diphthong, speaker MM (d) Hiatus, speaker MM

Figure 3: An illustration of the high speaker variability present in the f_0 contour data. Left panels: diphthongs; right panels: hiati. Top panels: speaker 'CC'; bottom panels: speaker 'MM'. Note how the speaker-dependent contour shape variation is more evident than the one induced by the D/H contrast realization. This helps understanding why PC1 for f_0 describes speaker variability rather than the D/H contrast. See Section 3 and 4.2 of the main text.

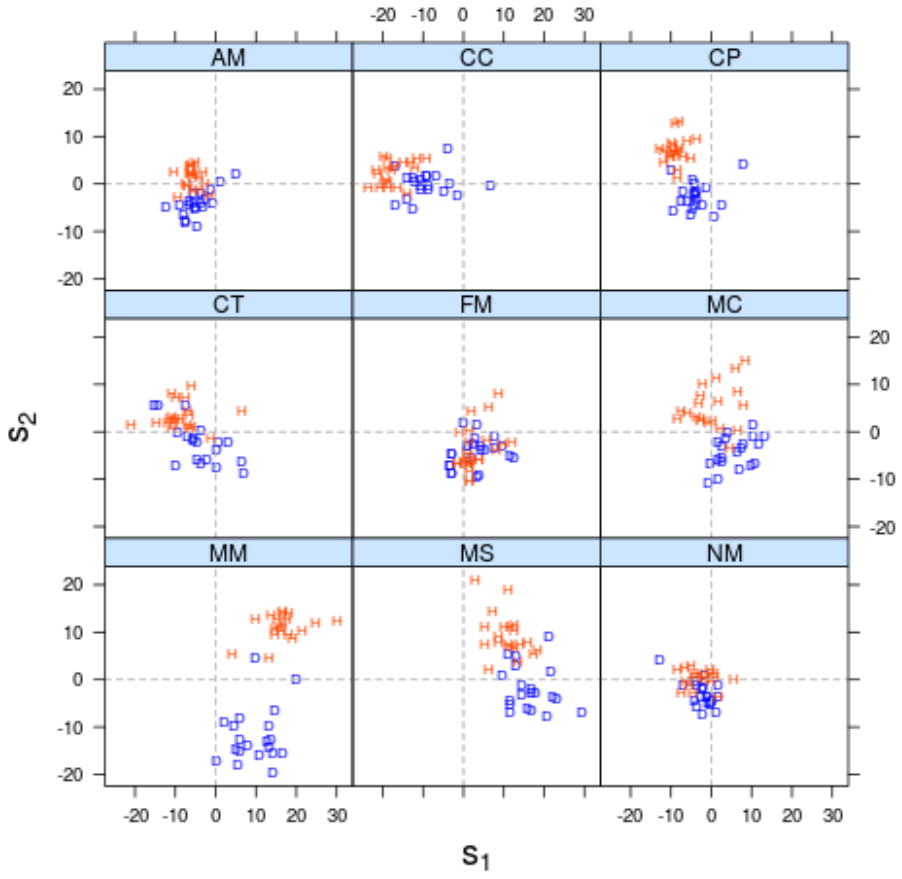


Figure 4: Scatter plots of the first two PC scores $s_1^{f_0}$ and $s_2^{f_0}$ for the f_0 contour data, separated by speaker. Each point, representing the scores of a contour, is labeled with its class (D or H). See Section 4.2 of the main text.

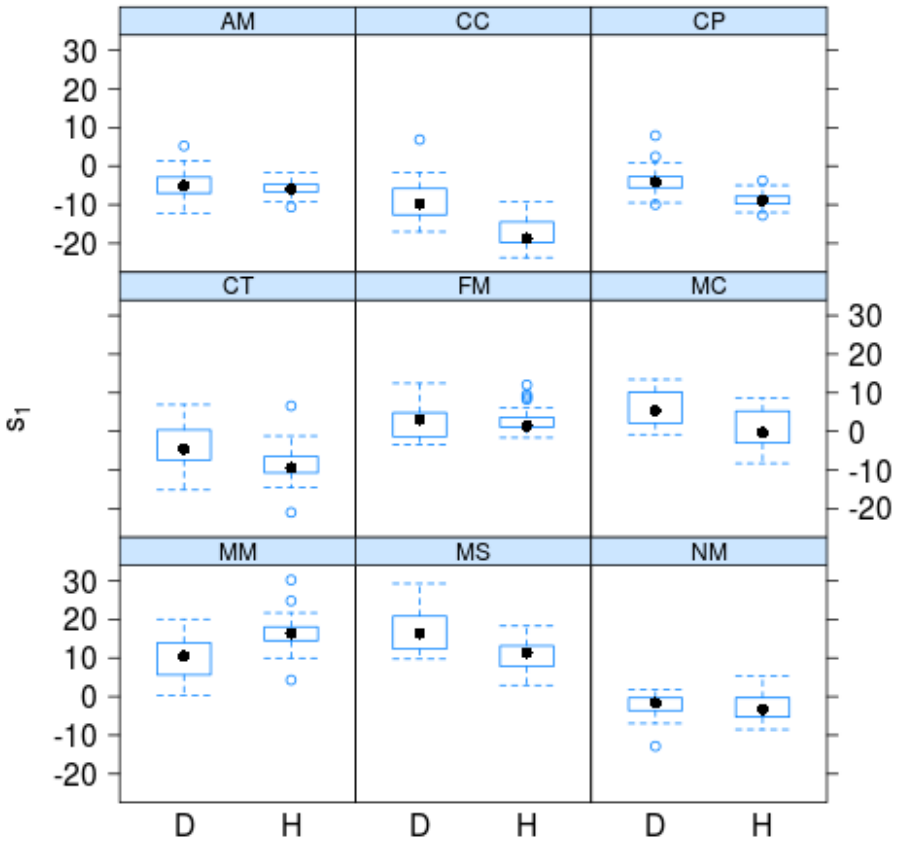


Figure 5: Boxplots of the first PC score $s_1^{f_0}$ for the f_0 contour data, separated by speaker and class (D or H). See Section 4.2 of the main text.

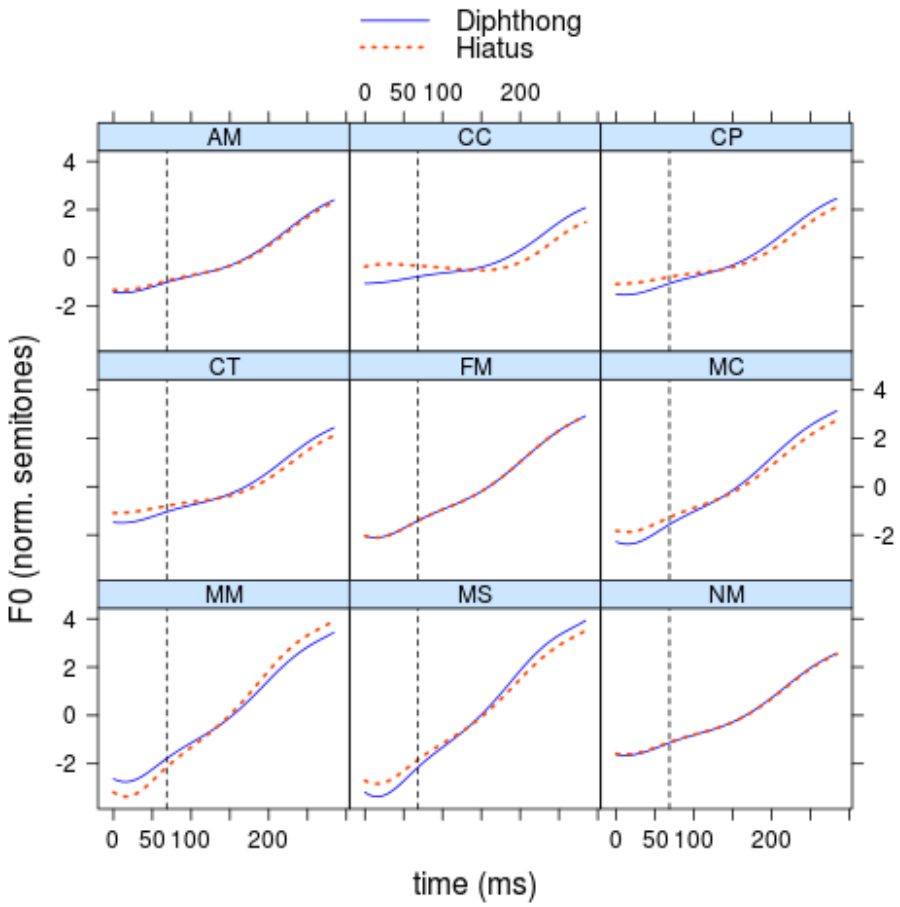


Figure 6: Speaker- and class-specific mean f_0 contours based on the first PC score $s_1^{f_0}$. Each contour is obtained by applying Eq. (1) from Section 3.4 in the main text, where the value used for s_1 is the mean of the scores from the specific speaker and class (i.e. $meanf(t) = \mu(t) + mean(s_1) \cdot PC1(t)$, where $mean(s_1)$ is represented by a black dot in the boxplots of Figure 5 of this document for each speaker and class, respectively). See Section 4.2 of the main text.

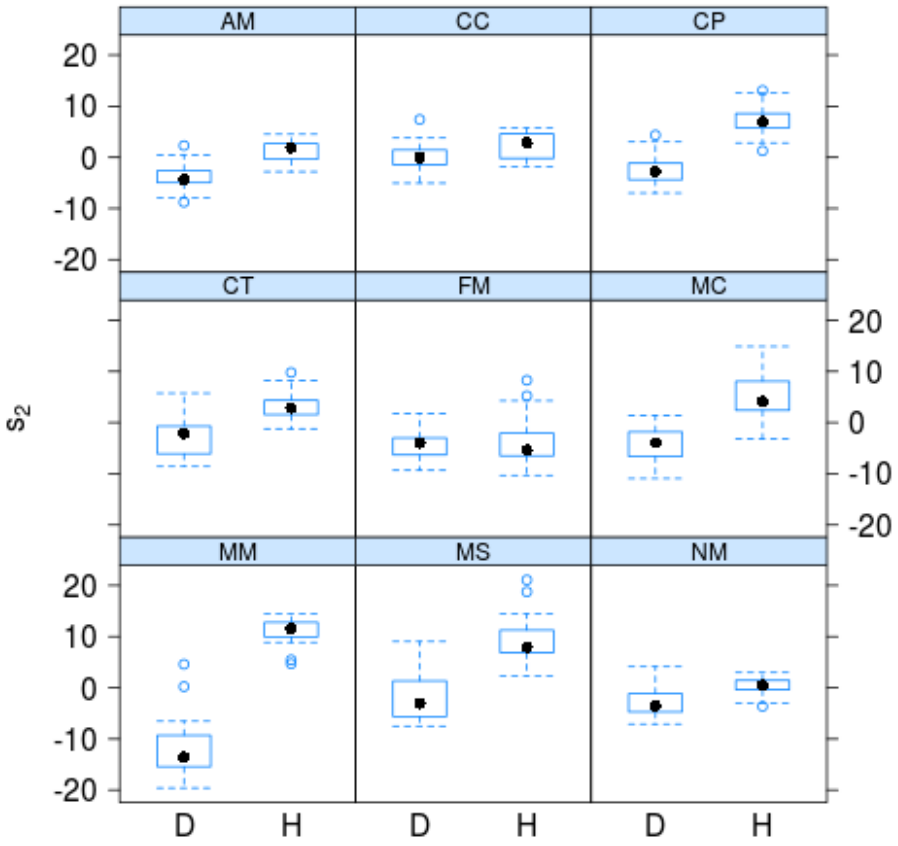


Figure 7: Boxplots of the second PC score $s_2^{f_0}$ for the f_0 contour data, separated by speaker and class (D or H). See Section 4.2 of the main text.

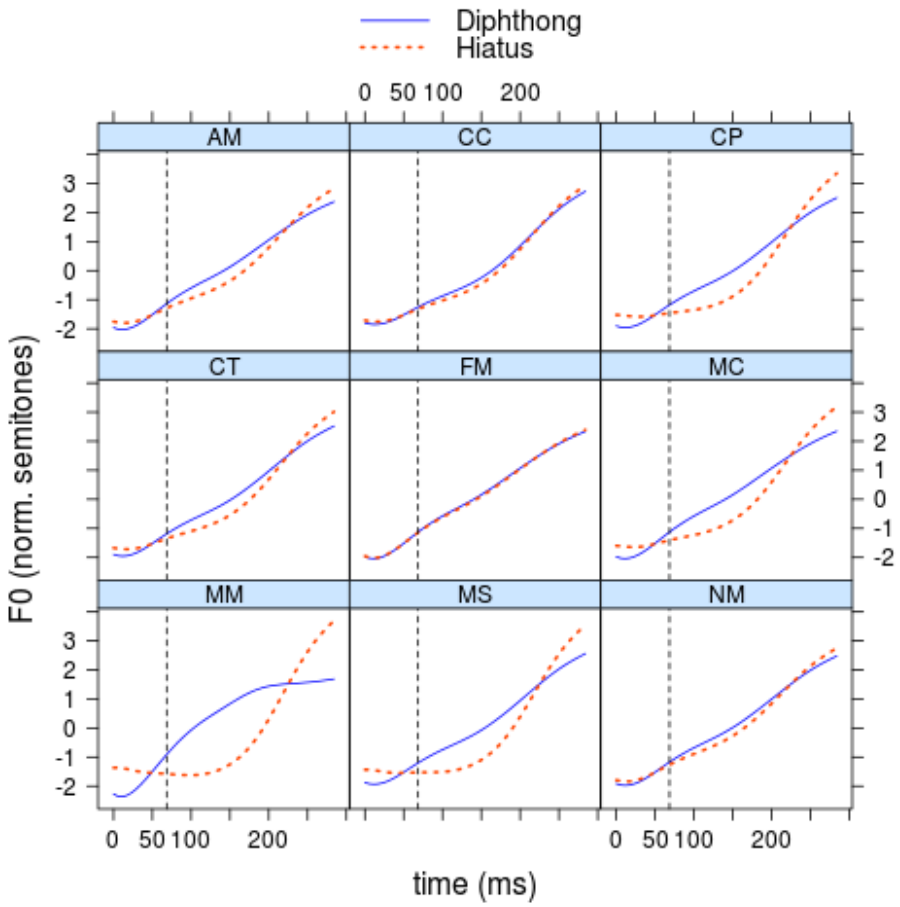


Figure 8: Speaker- and class-specific mean f_0 contours based on the second PC score $s_2^{f_0}$. Each contour is obtained by applying Eq. (1) from Section 3.4 in the main text, where the value used for s_2 is the mean of the scores from the specific speaker and class (i.e. $meanf(t) = \mu(t) + mean(s_2) \cdot PC2(t)$), where $mean(s_2)$ is represented by a black dot in the boxplots of Figure 7 of this document for each speaker and class, respectively). See Section 4.2 of the main text.

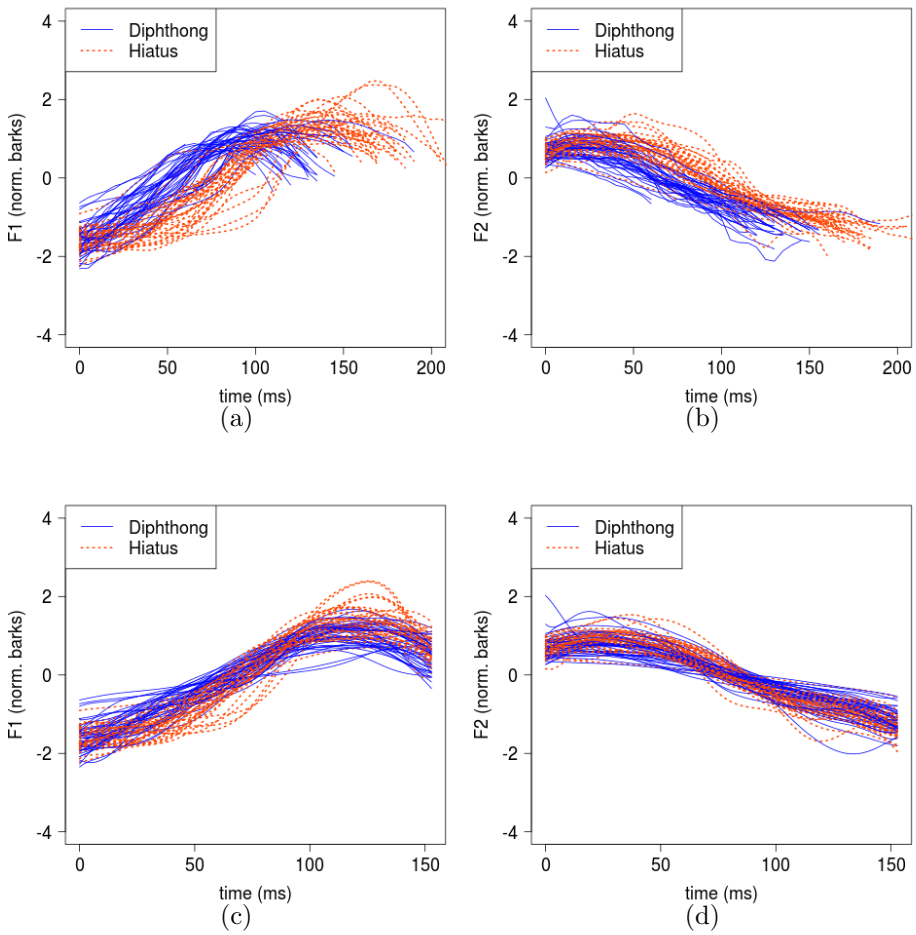


Figure 9: A random subset (20%) of the 365 formant contour pairs. In (a) and (b) the F1 and F2 raw contours, respectively; in (c) and (d) the smoothed F1 and F2 contours, respectively, where the effect of linear time normalisation is evident. See Section 3 of the main text.

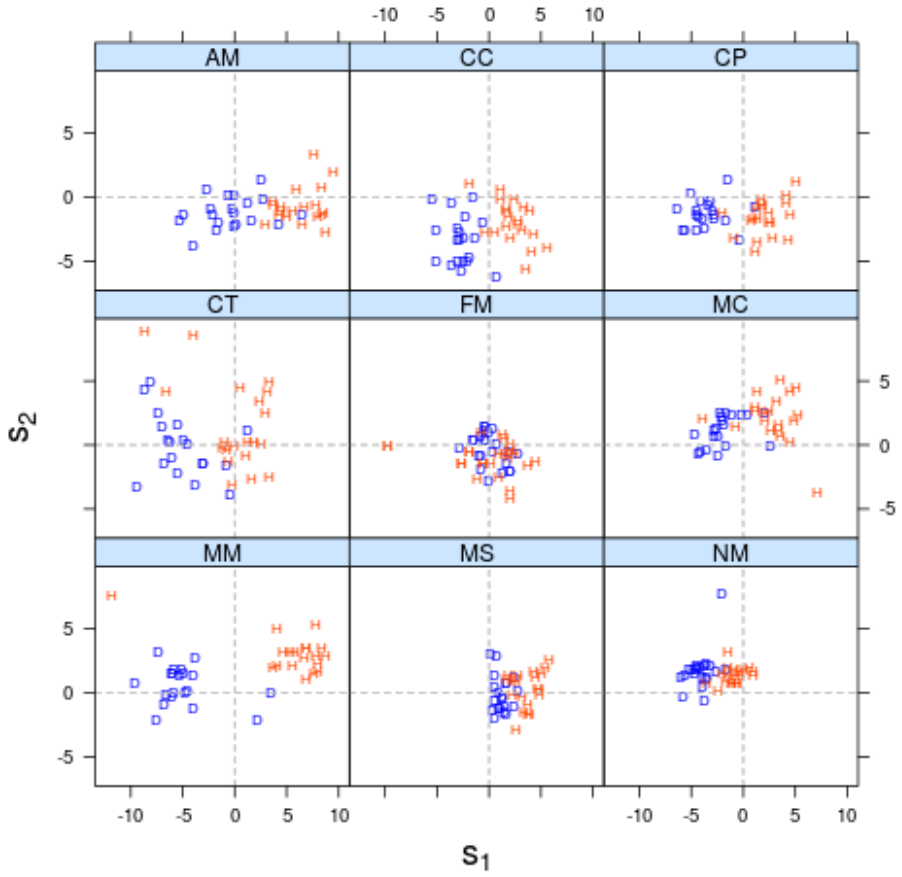


Figure 10: Scatter plots of the first two PC scores $s_1^{F_{1-2}}$ and $s_2^{F_{1-2}}$ for the formant contour data, separated by speaker. Each point, representing the scores of a contour pair (F1, F2), is labeled with its class (D or H). See Section 4.3 of the main text.

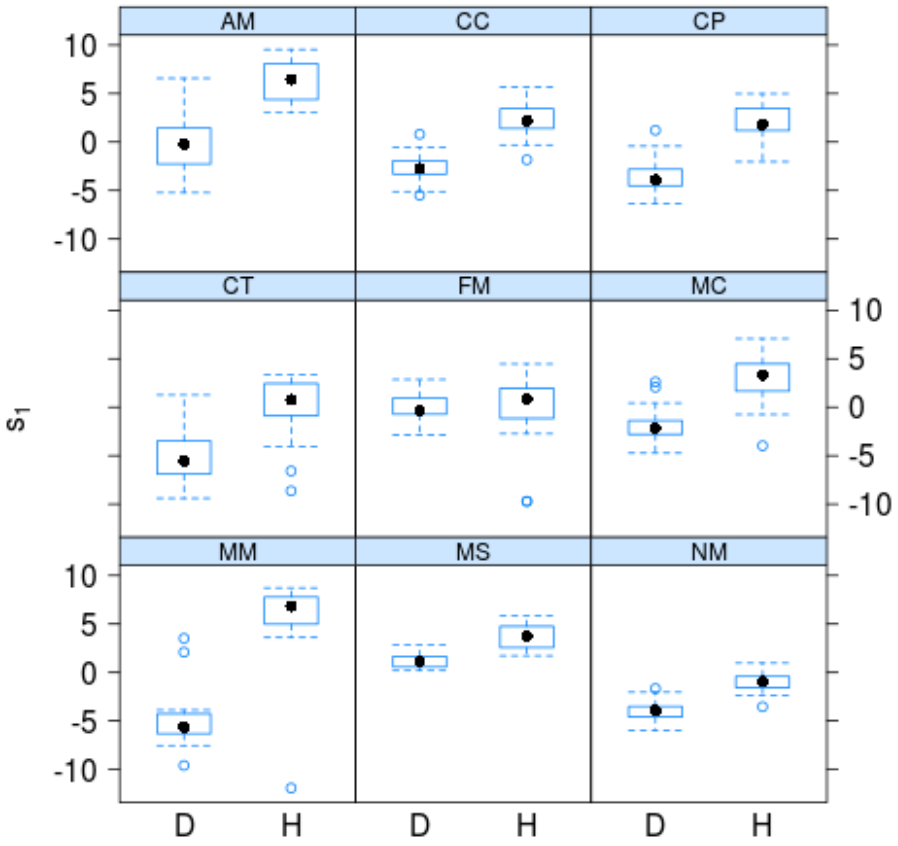


Figure 11: Boxplots of the first PC score $s_1^{F_{1-2}}$ for the formant contour data, separated by speaker and class (D or H). See Section 4.3 of the main text.

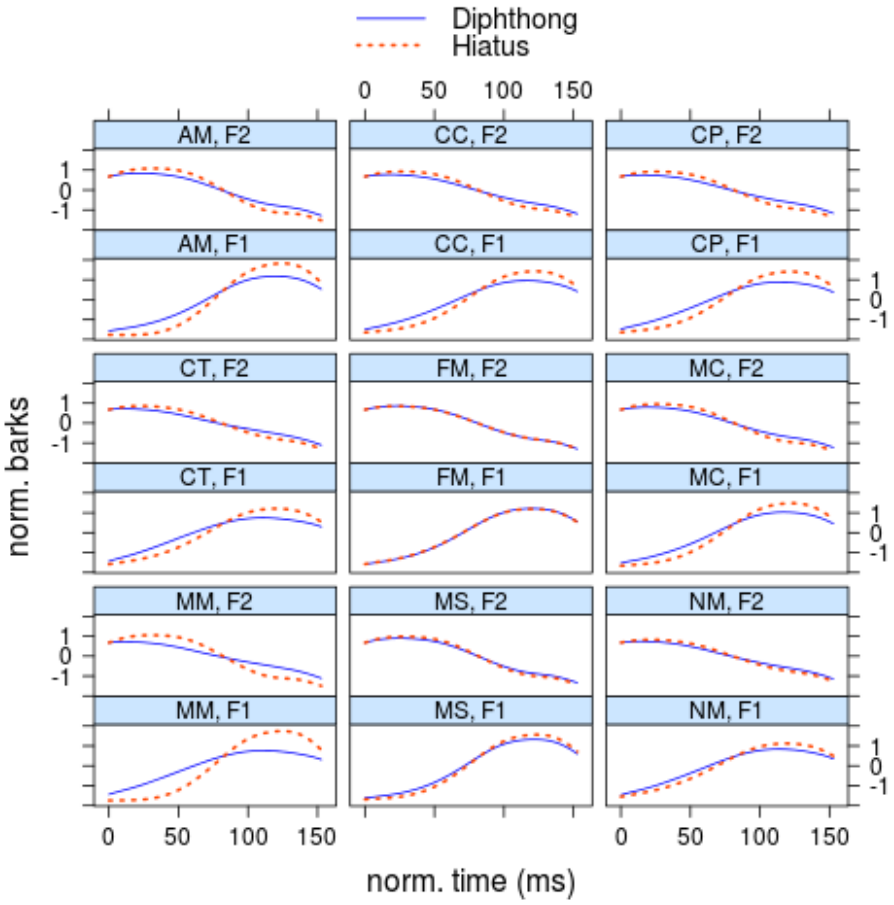


Figure 12: Speaker- and class-specific mean formant contours based on the first PC score $s_1^{F_{1-2}}$. Each contour is obtained by applying Eq. (2) from Section 3.4 in the main text, where the value used for s_1 is the mean of the scores from the specific speaker and class (i.e. $meanF_1(t) = \mu_{F_1}(t) + mean(s_1) \cdot PC1_{F_1}(t)$ and $meanF_2(t) = \mu_{F_2}(t) + mean(s_1) \cdot PC1_{F_2}(t)$), where $mean(s_1)$ is represented by a black dot in the boxplots of Figure 11 of this document for each speaker and class, respectively). See Section 4.3 of the main text.

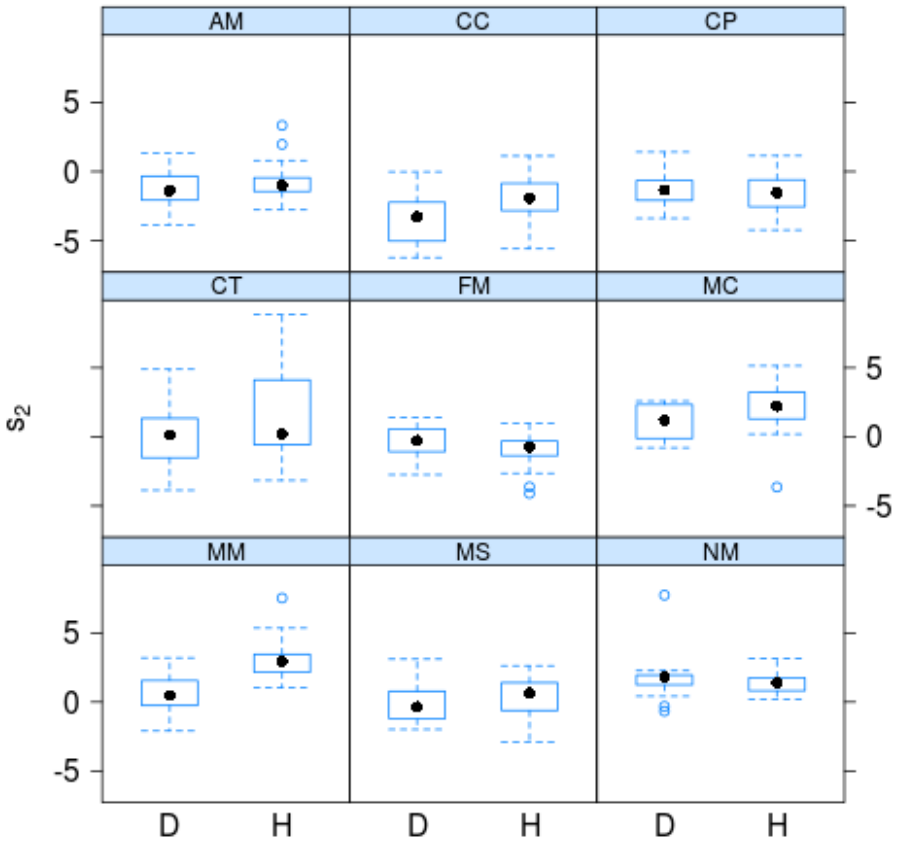


Figure 13: Boxplots of the second PC score $s_2^{F_{1-2}}$ for the formant contour data, separated by speaker and class (D or H). See Section 4.3 of the main text.

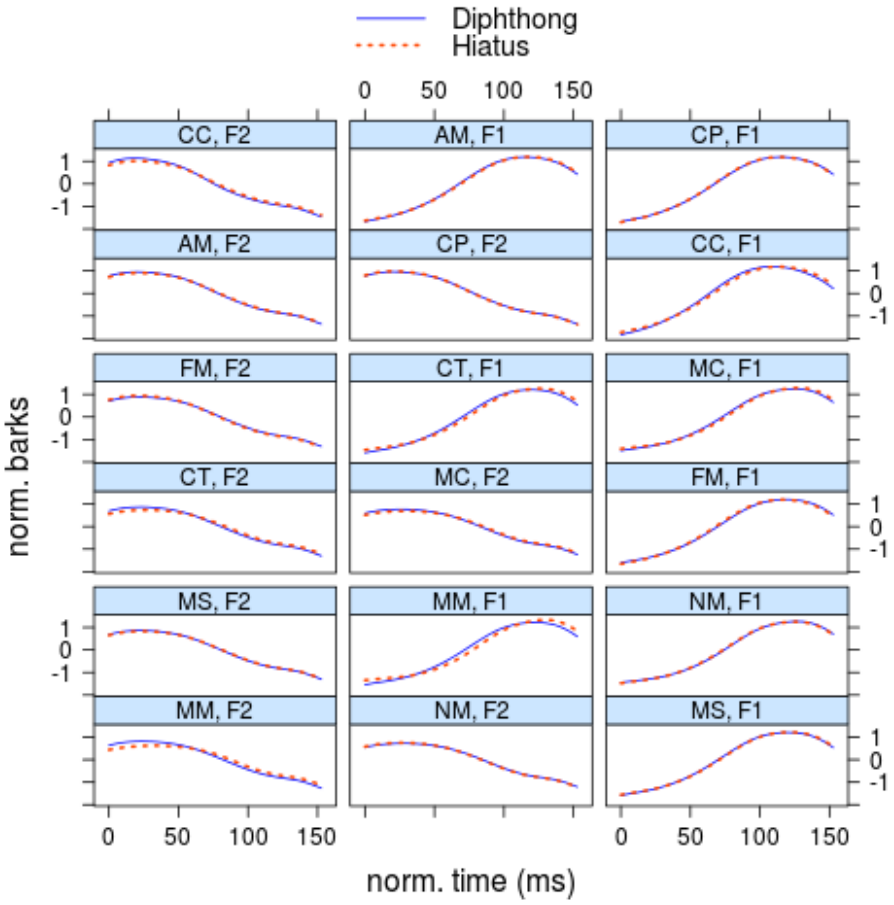


Figure 14: Speaker- and class-specific mean formant contours based on the second PC score $s_2^{F_{1-2}}$. Each contour is obtained by applying Eq. (2) from Section 3.4 in the main text, where the value used for s_2 is the mean of the scores from the specific speaker and class (i.e. $meanF_1(t) = \mu_{F_1}(t) + mean(s_2) \cdot PC2_{F_1}(t)$ and $meanF_2(t) = \mu_{F_2}(t) + mean(s_2) \cdot PC2_{F_2}(t)$), where $mean(s_2)$ is represented by a black dot in the boxplots of Figure 13 of this document for each speaker and class, respectively). See Section 4.3 of the main text.