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Supplementary Materials for

Sequence variants affecting voice pitch in humans

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The PDF file includes:

Other Supplementary Material for this manuscript includes the following:

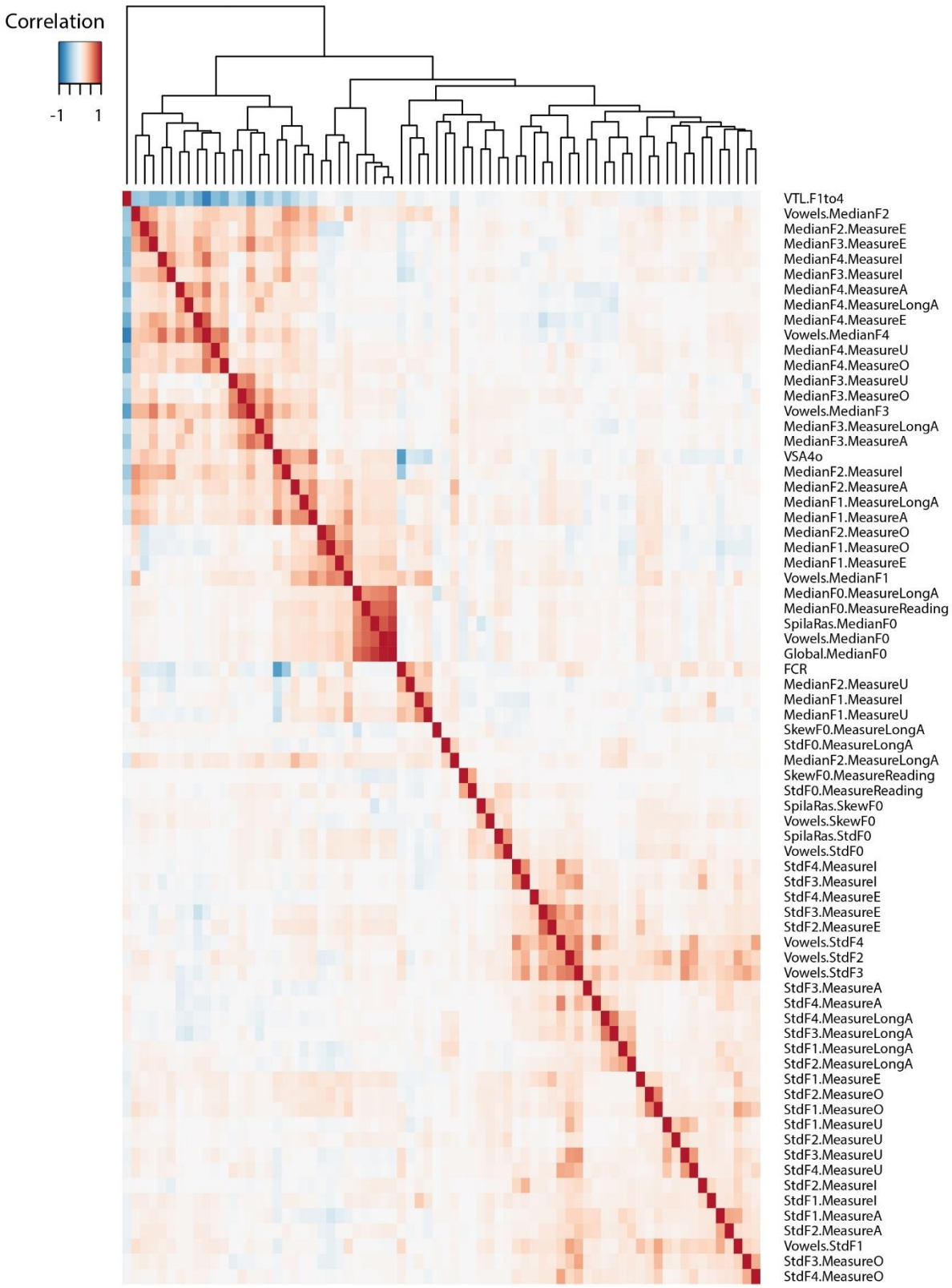

Fig. S1. Correlations between pairs of acoustic measures in females. The measures are ordered by the complete linkage hierarchical cluster method and the top of each panel shows the resulting dendrogram.

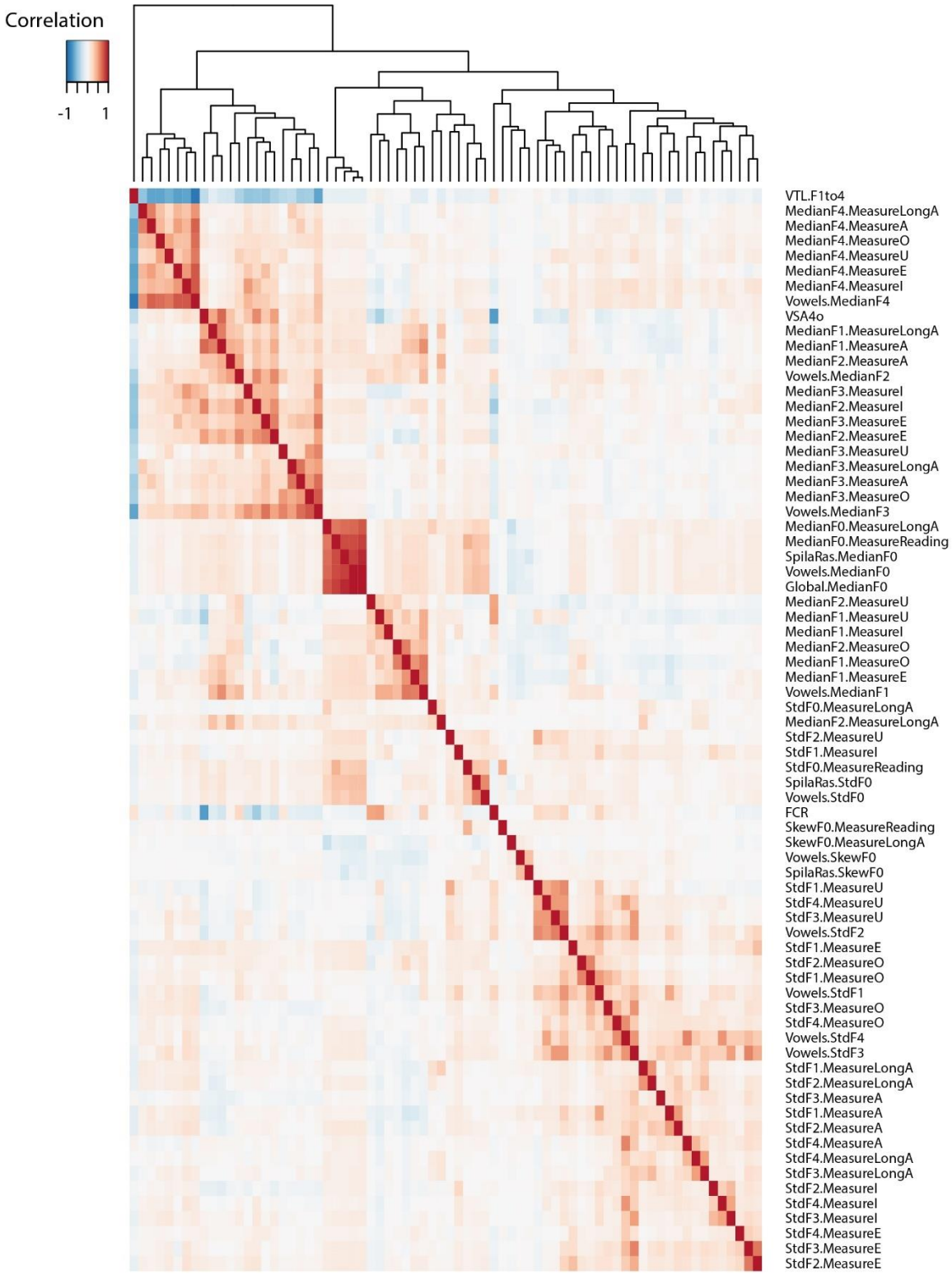

Fig. S2. Correlations between pairs of acoustic measures in males. The measures are ordered by the complete linkage hierarchical cluster method and the top of each panel shows the resulting dendrogram.

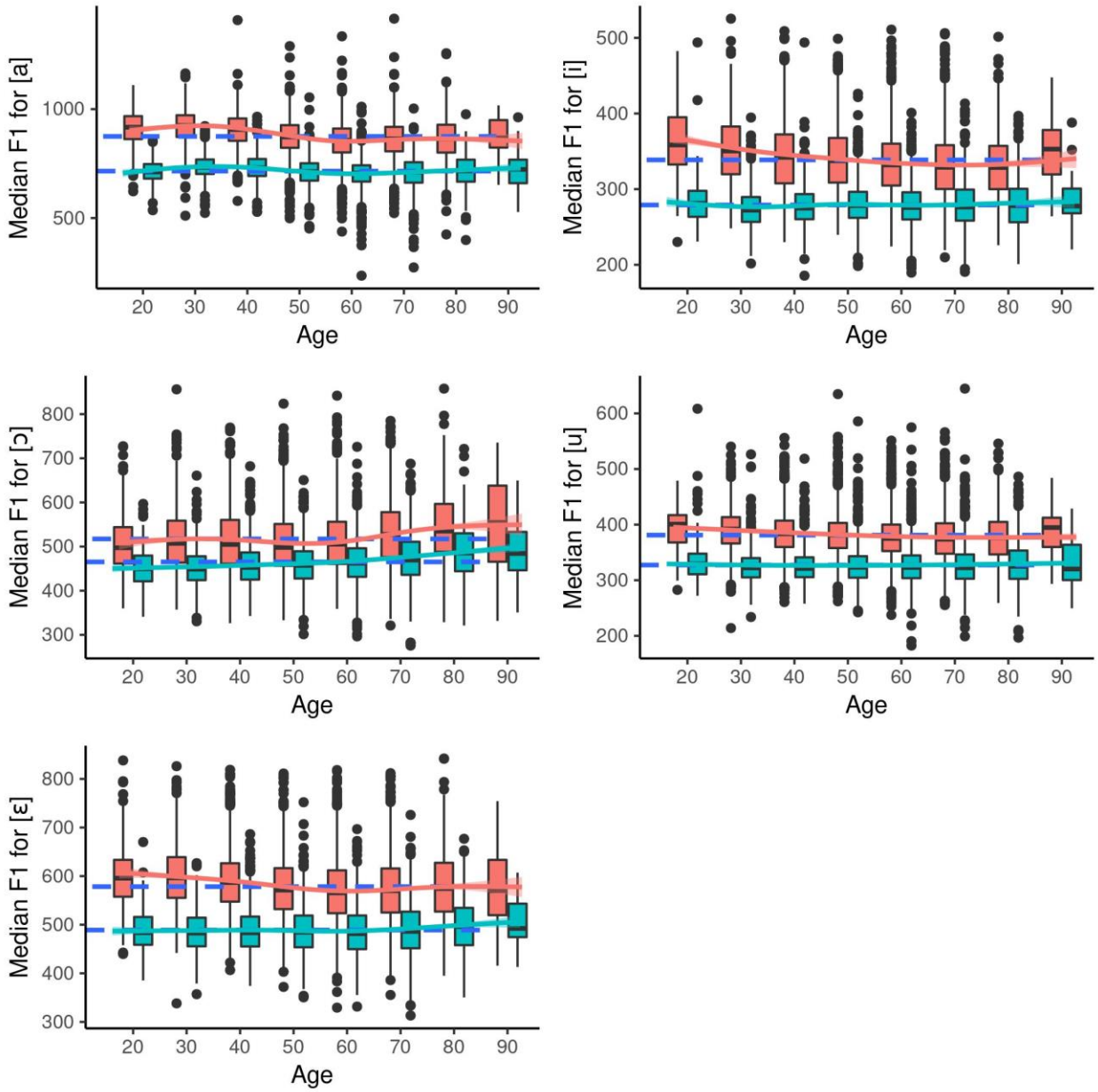

Fig. S3. Vowel formant 1 (F_1) across the lifespan. F_1 (in Hz) is plotted according to age (in years) and sex in the vowels [a], [i], [ɔ], [u] and [ɛ]. Blue boxes indicate values for males, red boxes values for females. For each age group and sex, the bottom and tops of the boxes indicate the bottom and top quartiles, the line inside the box indicates the median, the whiskers indicate the most extreme values inside 1.5 times the interquartile range, and the dots indicate values outside that range.

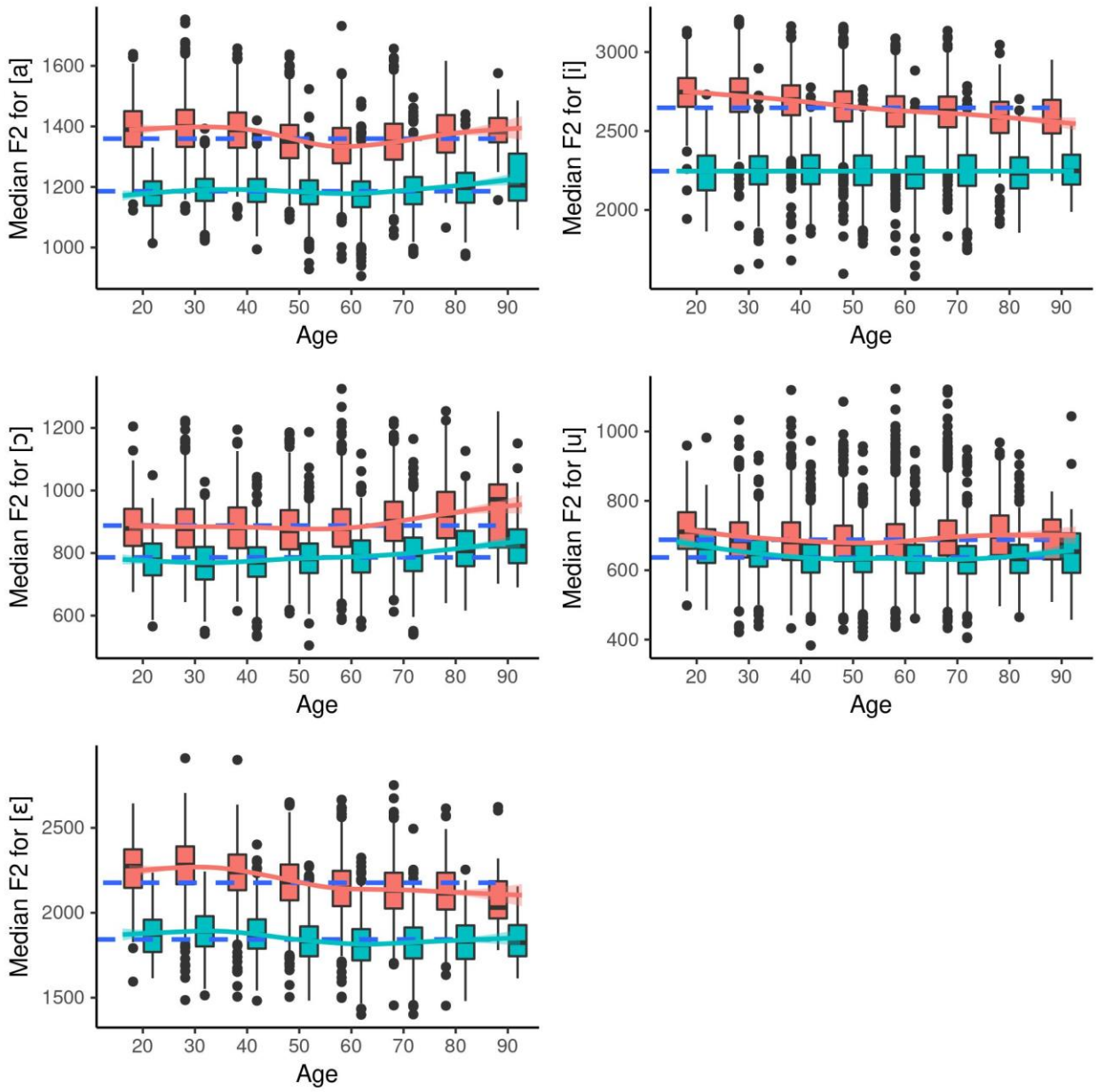

Fig. S4. Vowel formant 2 (F_2) across the lifespan. F_2 (in Hz) is plotted according to age (in years) and sex in the vowels [a], [i], [ɔ], [u] and [ɛ]. Blue boxes indicate values for males, red boxes values for females. For each age group and sex, the bottom and tops of the boxes indicate the bottom and top quartiles, the line inside the box indicates the median, the whiskers indicate the most extreme values inside 1.5 times the interquartile range, and the dots indicate values outside that range.

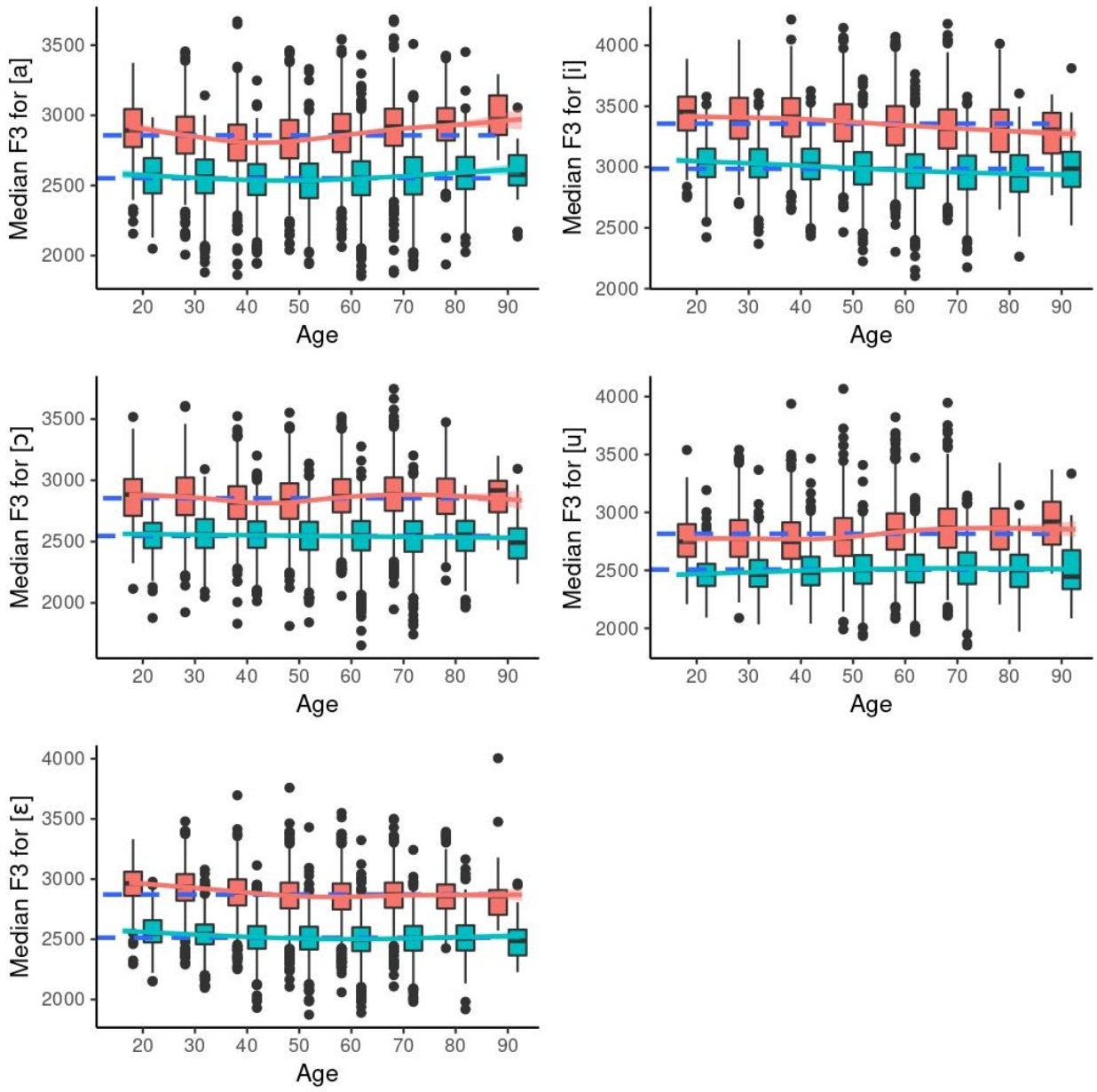

Fig. S5. Vowel formant 3 (F_3) across the lifespan. F_3 (in Hz) is plotted according to age (in years) and sex in the vowels [a], [i], [ɔ], [u] and [ɛ]. Blue boxes indicate values for males, red boxes values for females. For each age group and sex, the bottom and tops of the boxes indicate the bottom and top quartiles, the line inside the box indicates the median, the whiskers indicate the most extreme values inside 1.5 times the interquartile range, and the dots indicate values outside that range.

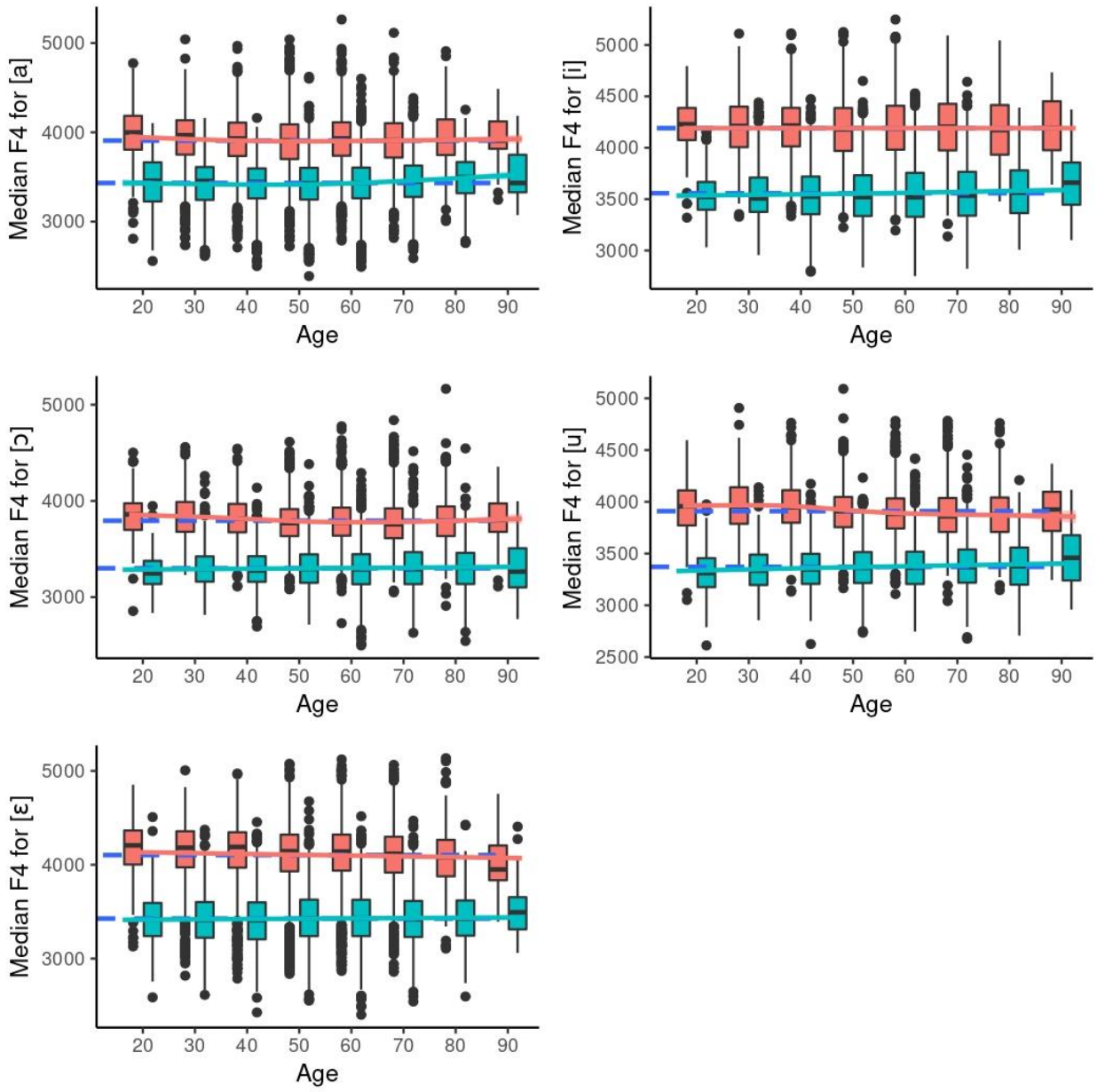

Fig. S6. Vowel formant 4 (F_4) across the lifespan. F_4 (in Hz) is plotted according to age (in years) and sex in the vowels [a], [i], [ɔ], [u] and [ɛ]. Blue boxes indicate values for males, red boxes values for females. For each age group and sex, the bottom and tops of the boxes indicate the bottom and top quartiles, the line inside the box indicates the median, the whiskers indicate the most extreme values inside 1.5 times the interquartile range, and the dots indicate values outside that range.

Supplementary Text

Vowel formant extraction

It is known that automatic vowel formant estimation is error prone and can result in formant numbering errors and contamination from f_o (*1*), the latter, known as *f_o bias*, being particularly difficult to detect and correct. Trained phoneticians show similar patterns of errors as automatic methods (such as the ones used in this study), leading to the conclusion that manual measurement of formant frequencies should not be taken as the gold standard (*81*). f_o bias is known to be a particular concern when voice pitch is high and/or the first formant (F_1) is low (*81*), possibly making formant F_1 in [i] and [u] especially vulnerable since F_1 is lowest in those vowels (figure S3 and table S2). We note that the medians for the vowel formants, including F_1 (figure S3 and table S2), line up closely with expectations based on available data on Icelandic (*96*) and similar vowels in American English (*97*). Nevertheless, given the potential errors in formant estimation, when interpreting results for vowel measures, we recommend considering the range of values and their confidence intervals across a class of measures (e.g., h^2-SNP for F_1 in general), rather than over-interpreting the point estimates for each specific vowel phenotype.

Task demands

Another issue to consider is to what degree the SNP-based heritability estimates and the phenotypic correlations are influenced by details of the experimental design. For instance, reading text requires more cognitive resources than producing isolated vowels. Moreover, the sustained [a] task is more demanding than the isolated (short) vowels both in terms of cognition and respiration. While the short vowel task was preceded by a practice trial, the sustained [a] was elicited without practice and involved a visual prompt (percentage of time completed and a corresponding circle filling up), involving more cognitive load. Sustained vowel phonation – for a duration of 4 seconds in the current study – is also particularly demanding in terms of respiration, and correlates with lung vital capacity in clinical contexts (*98, 99*). Our phenotypic correlations show that voice pitch variability is correlated with forced vital capacity but only in sustained [a] (table S5). Such differences in elicitation tasks should be kept in mind when interpreting the heritability estimates and the phenotypic correlations.

Table S1 to S11 (separate file)

Table S1: Overview of phenotypes
Table S2: Mean values of phenotypes
Table S3: Correlations between voice and vowel acoustics
Table S4: Age effects on vowel formants
Table S5: Correlations with other phenotypes
Table S6: SNP-based heritability estimates
Table S7: Genetic correlations
Table S8: GWAS lead variants
Table S9: *ABCC9* credible set variants
Table S10: Fixed variant in *ABCC9*
Table S11: Text for reading task

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