

The effect of age-related cognitive and motor control changes on acoustic measures of voice

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Introduction: Cognitive and motor systems systematically change as people age [1, 2], which is accompanied by distinct changes in the voice [3, 4]. What is the relationship between general patterns of cognitive/motor ageing and signatures of age-related change in the voice? Acoustic changes in voice quality are a particularly strong marker of vocal ageing [5, 6]. Yet measures such as f_0 , shimmer apq5, jitter ppq5, and HNR show considerable variability within speakers of similar ages, while the sources of this variability remain unclear. In this study, we test the hypothesis that individual differences in cognitive and motor control predict differences in voice quality across the lifespan [7].

Hypothesis: We test two hypotheses. The group-level hypothesis predicts that (1) older speakers will have a higher f_0 in men, and lower f_0 in women [8], and higher values of shimmer, jitter and HNR, due to hormonal changes and increased muscular atrophy with age. The individual-level hypothesis predicts that (2) older adults will have reduced motor and cognitive functionality leading to changes in f_0 and increases in other acoustic measures, due to reduced muscular and nerve functionality within the brain and larynx.

Methods: 145 participants were recruited from the North-West of England across two age-groups: (1) 85 speakers aged 16-37 years ($M=18.51$, $SD=4.44$); (2), 60 speakers aged 65-95 years ($M=74.52$, $SD=7.39$). Participants completed cognitive and motor control tasks including a digit span, diadochokinetic (DDK), and trail making task [9, 10, 11]. Participants also completed an interview, questionnaire, and a reading passage, from which f_0 , shimmer, jitter and HNR were extracted from the vowels. In total 10,536 tokens were used for analysis. Principal component analysis was used to reduce the dimensionality of the cognitive and motor control data and identify latent low-dimensional variables that could predict variation in voice acoustics. Linear-mixed effect models were then fitted to examine interactions between these results and social factors.

Results: As predicted, f_0 significantly decreased in female speakers and increased in male speakers with age [3, 8] (Figure 1), though we observe considerable overlap between speakers. Shimmer, jitter and HNR do not significantly vary by age. Variation in motor control correlated with f_0 in younger/older males and older females, as well as with shimmer for younger males and older females, and for HNR younger males and females. This suggests that the ability to maintain periodic vocal fold vibrations decreases with age, perhaps due to reduced speech-motor control and thinning of the vocal folds [7]. Performance on motor control tasks did not significantly predict variation in jitter. Variation in cognitive control correlated with f_0 for older and younger males, shimmer for younger males and younger and older females, jitter in older females, and HNR for older males and younger and older females.

Discussion: The results of this study demonstrate that cognition and motor control could explain changes in voice quality across the lifespan. Differences in the results of this study compared to previous could be explained by the use of free speech data compared to using sustained vowels, as seen in clinical contexts. While previous research suggests that voice quality measures could act as biomarkers for cognitive impairment [12], the extent of individual variation problematises the use of straightforward diagnostics [13]. In doing so, this study highlights the importance of considering different approaches of ageing in speech research, and motivates further research into which aspects of ageing correspond with specific aspects of voice [4].

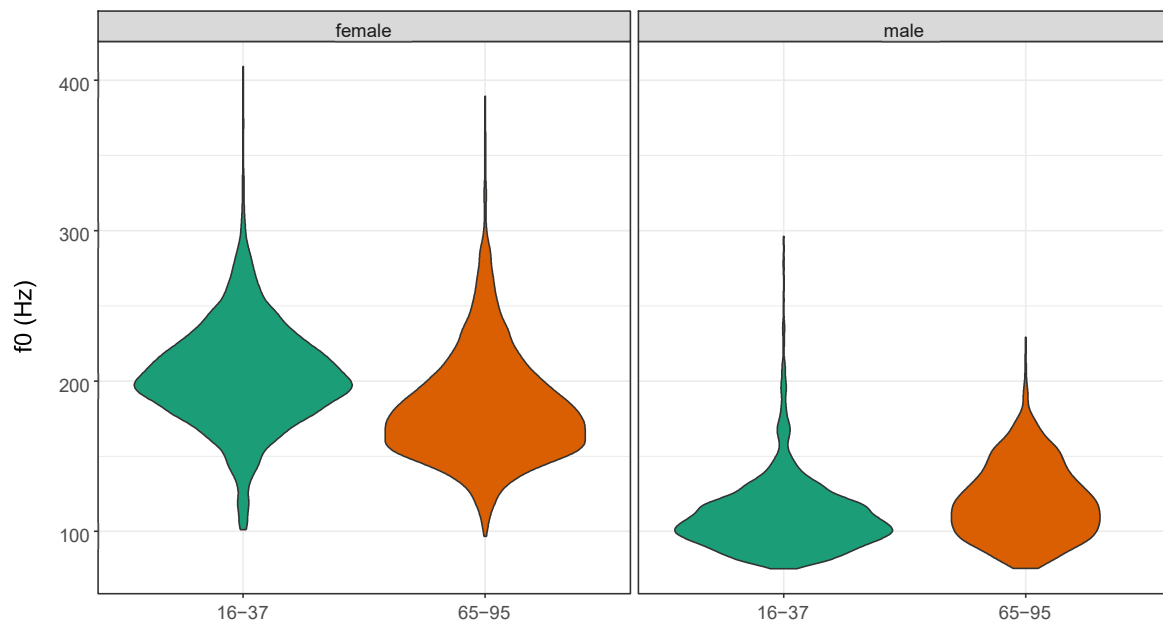


Fig. 1. Results of f_0 plotted by sex

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