

Speech breathing and aging: The impact of prosodic complexity

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Introduction: Respiration is the foundation of successful speech production, yet our understanding of how speech breathing adapts to age-related physiological changes, such as reduced respiratory muscle function [1], remains limited. While prior studies have shown that older speakers produce more and longer pauses during speech [2], suggesting an increased need for additional inhalations, they also initiate speech at significantly higher lung volumes compared to younger speakers [3]. These findings challenge solely deficit-based perspectives by highlighting potential compensatory strategies that older adults employ to maintain effective speech production. The present study investigates how aging and prosodic complexity influence speech breathing and pausing behaviour during habitual speech, with the objective of better understanding the adaptive mechanisms of an aging speech motor control system.

Method: We used electromagnetic articulography (EMA, AG501) to collect acoustic, articulatory and speech breathing data from 52 speakers between 20 and 90 years. In this abstract, we report preliminary results on 12 speakers, including six younger speakers (3M, 3F, aged between 23-25 years) and six older speakers (3M, 3F, aged between 67-90 years). The participants produced two different variants of utterances varying in length (short, long) and prosodic complexity (simple, complex), see Table 1. Speech breathing was tracked using sensors placed below the suprasternal notch and on the first vertebra, as described in [6].

During preprocessing, acoustic data was segmented in Praat, including manual identification of pauses longer than 100 ms, as in [4]. Based on the annotations, kinematic landmarks (Fig. 1) were identified using ADA [7] and manually corrected where necessary. The acoustic analysis included the number and duration of pauses as well as sentence duration. For the statistical analysis, we focus on the kinematic measures, including inhalation amplitude and inhalation and exhalation duration of the first breathing cycle. We built linear mixed-effects models with speech breathing measures as the dependent variable, age group (younger, older), length (short, long) and complexity (simple, complex) as the predictor variables (also tested in interaction), and speaker as a random intercept. A more complex random effects structure was not supported by the model. Pairwise comparisons were conducted using *emmeans*.

Results: On average, older speakers produced longer utterances compared to younger speakers, with mean differences of 783 ms for short simple, 844 ms for short complex, 1332 ms for long simple, and 1422 ms for long complex utterances. Older speakers produced only a few more pauses, but these pauses were longer on average, with mean difference of 46 ms for short simple, 116 ms for short complex, 112 ms for long simple and 127 ms for long complex utterances. Statistical analysis of speech breathing measures revealed a significant effect of age on inhalation amplitude, with higher inhalation amplitudes for older speakers ($\beta = 3.0$ mm, $p = 0.03$; Fig. 2 left) regardless of length and complexity. Both age groups showed lower inhalation amplitudes in short conditions ($\beta = -1.1$ mm, $p = 0.002$). There was a significant effect of age in interaction with length on inhalation duration: older speakers showed significantly longer inhalation durations in long compared to short utterances ($\beta = 259.4$ ms, $p = 0.006$) regardless of complexity (Fig. 2 centre). There was no effect of age on exhalation duration ($\beta = 28.8$ ms, $p = 0.93$; Fig. 2 right).

Discussion: These results demonstrate that aging entails significant, systematic adaptations in speech breathing and pausing behaviour, particularly under increased prosodic complexity. Older speakers' longer utterances, extended pauses and enhanced inhalation effort (as seen in higher inhalation amplitudes) are not simply deficient but also show the adaptive ability of the speech motor control system. Further analysis of more speakers, including those in their 40s and 50s, will help determine how speech breathing changes across the lifespan.

Table 1. Example phrases used in the study.

Condition	Target phrase example
Short simple (18 syllables)	Mélodie Moreau a préparé son repas avec du bon saumon.
Long simple (32 syllables)	Mélodie Moreau a préparé avant huit heures trente-cinq les petits-déjeuners pour toute la famille avec du bon café.
Short complex (18 syllables)	Mélodie Moreau, qui habite à Montreuil, a préparé son repas.
Long complex (32 syllables)	Mélodie Moreau a dit à son papi, qui a téléphoné sur son portable, qu'elle est en train de préparer son repas.

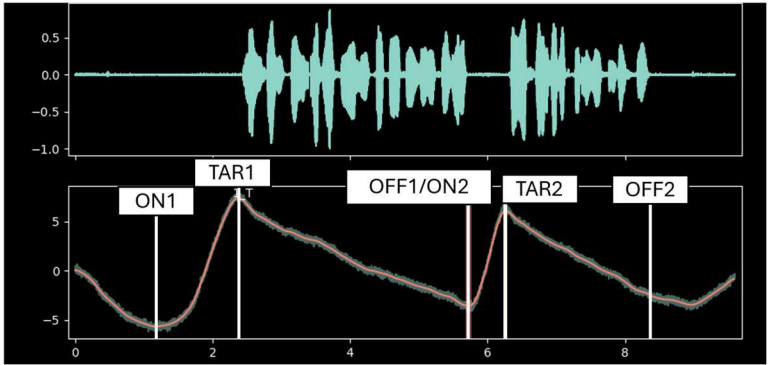


Fig. 1. Example of gestural landmarks in the speech breathing trajectory. The final exhalation offset was set to the acoustic offset of the phrase for consistency across speakers.

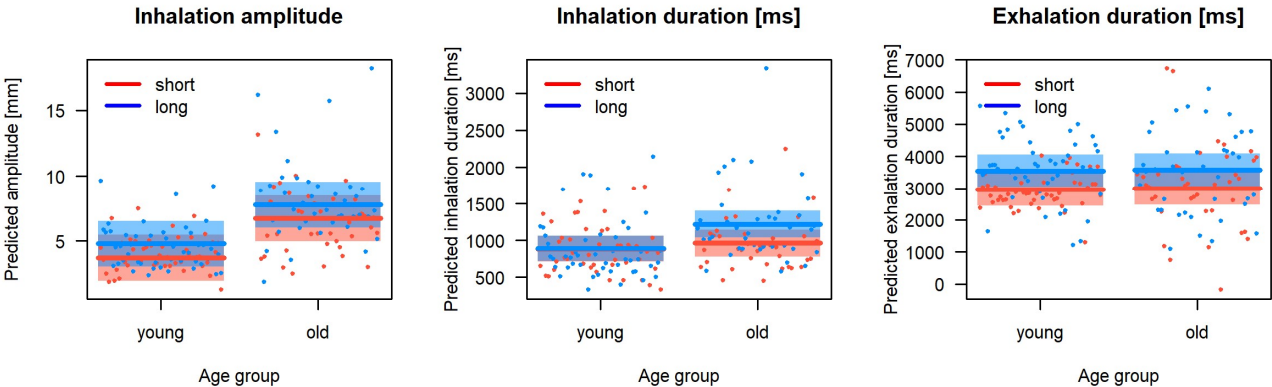


Fig. 2. Model predictions for inhalation amplitude (left), inhalation duration (centre) and exhalation duration (right) per age group as dependent on sentence length.

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