Neural basis of individual differences in speech monitoring

Müge Özker Sertel[1,2], Laura Giglio[3], Ahmad Beyh[4], Stephanie J. Forkel*[1,2,5,6], Peter Hagoort*[1,2]

1. Donders Institute for Brain, Cognition and Behaviour, Radboud University, Nijmegen, The Netherlands; 2. Max Planck Institute for Psycholinguistics, Nijmegen, The Netherlands; 3. Institute for the Interdisciplinary Study of Language Evolution, University of Zurich, Switzerland; 4. Department of Psychiatry, Brain Health Institute, Rutgers University, Piscataway, NJ, 08854, USA; 5. Brain Connectivity and Behavior Laboratory, Sorbonne Universities, Paris, France; 6. Department of Psychology, School of Human and Community Development, University of the Witwatersrand, Johannesburg, South Africa. * Equal contribution

INTRODUCTION

Fluent speech depends on the brain's ability to monitor self-generated sounds and rapidly adjust motor commands through auditory feedback. **Delayed auditory feedback (DAF)**, which disrupts the timing between speech production and perception, challenges this monitoring system and often disrupts fluency[1,2]. DAF therefore provides a powerful tool for investigating the neural mechanisms underlying temporal coordination during speech.

Current models describe speech monitoring as a continuous interaction between sensory and motor systems[3,4], yet the broader neural network supporting this process, particularly the contribution of white-matter pathways such as the arcuate fasciculus, remains unclear. Moreover, individuals differ substantially in their susceptibility to DAF, and the neural basis of this variability is unknown.

Study aims:

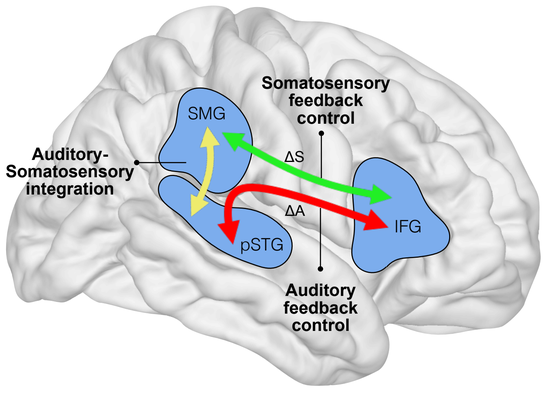
1. Map cortical networks involved in speech monitoring and coordination
2. Characterize the role of the arcuate fasciculus in sensory-motor integration during speech monitoring
3. Identify neural substrates underlying individual susceptibility to DAF

ANALYSIS

We conducted a speech production experiment during **fMRI** in 31 neurotypical native Dutch speakers (18F; 24±6 years), combined with diffusion-weighted imaging (**DWI**) and synchronized in-scanner **voice recordings**. Participants produced three-syllable words under normal (no DAF) and 200-ms delayed auditory feedback (DAF) while sparse-sampling fMRI captured BOLD responses. Articulation durations were extracted from voice recordings to compute a **susceptibility index (SI)**, reflecting individual slowing under DAF.

fMRI data were preprocessed with fMRIPrep and analyzed in SPM12 using **DAF > noDAF contrast**, with SI included as a covariate in group analyses. Diffusion data were reconstructed using spherical deconvolution[5], and deterministic tractography was performed to isolate the anterior, posterior, and long segments of the arcuate fasciculus. **Tract volume** and **HMOA** were extracted as measures of white-matter integrity and correlated with individual DAF susceptibility.

CONCLUSIONS



ΔA: Auditory error

ΔS: Somatosensory error

Arcuate Fasciculus

- Anterior segment
- Posterior segment
- Long segment

- **Susceptibility** to DAF reflects a hyper-reactive feedback loop with an over-reliance on auditory-motor coupling.
- **Resilience** to DAF reflects an efficient right temporo-parietal circuit for auditory-somatosensory integration.

Significance: These findings provide an anatomically grounded account of sensorimotor control during speech production, offering new insight into why some individuals are more susceptible to fluency breakdowns and related disorders (e.g. stuttering).

RESULTS

DAF slows speech but individuals vary in their susceptibility

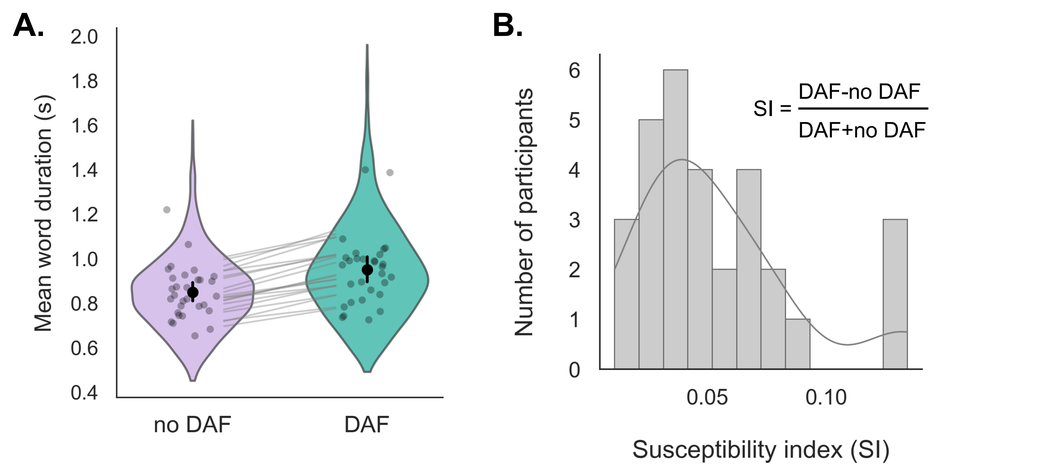


Fig 1. (A) *Word durations were significantly longer during 200-ms DAF compared with normal feedback (paired t-test: t = 7.859, p < 0.001). Violin plots show duration distributions across trials; gray lines indicate mean changes for individual words and gray dots represent participants. Black markers and error bars indicate group mean ± 95% bootstrap CI.* ***(B)*** *Distribution of the Susceptibility Index (SI), where higher values reflect greater speech slowing under DAF.*

DAF activates a right-lateralized sensorimotor network

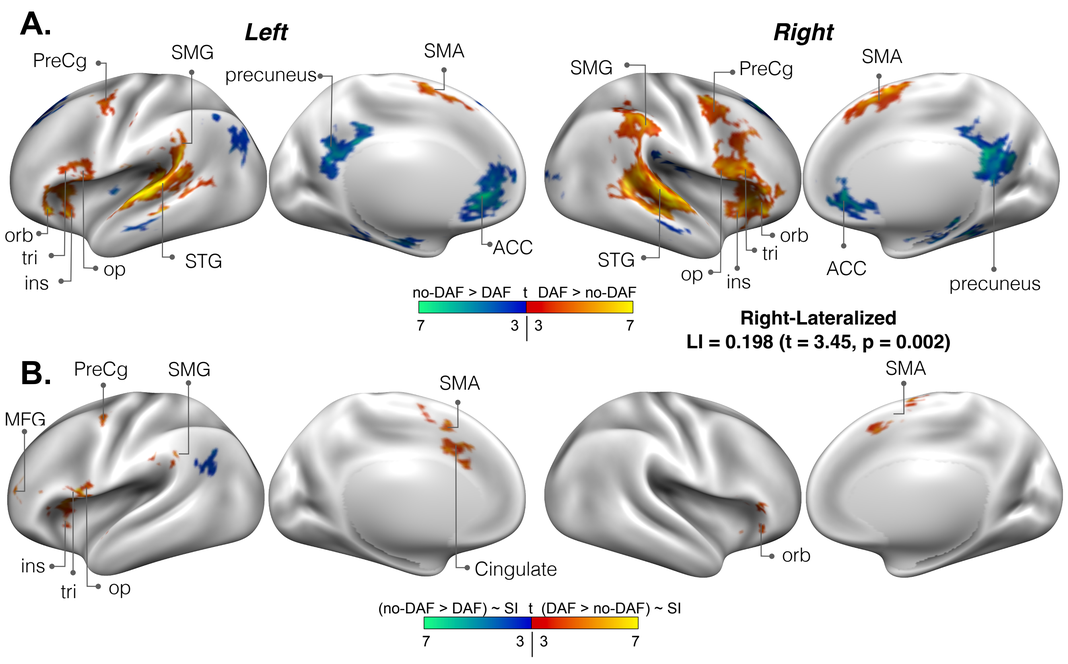


Fig 2. *Cortical surface renderings (MNI152 inflated surface) showing group-level activations for the* ***(A)*** *DAF>no DAF contrast* ***(B)*** *regions where activity significantly covaries with individual susceptibility to DAF (SI). SMA, supplementary motor area; PreCG, precentral gyrus; STG, superior temporal gyrus; SMG, supramarginal gyrus; IFG op/tri/orb, inferior frontal gyrus pars opercularis/triangularis/orbitalis; ACC, anterior cingulate cortex; ins, insula; MFG, middle frontal gyrus.*

Arcuate Fasciculus connectivity is associated with DAF resilience

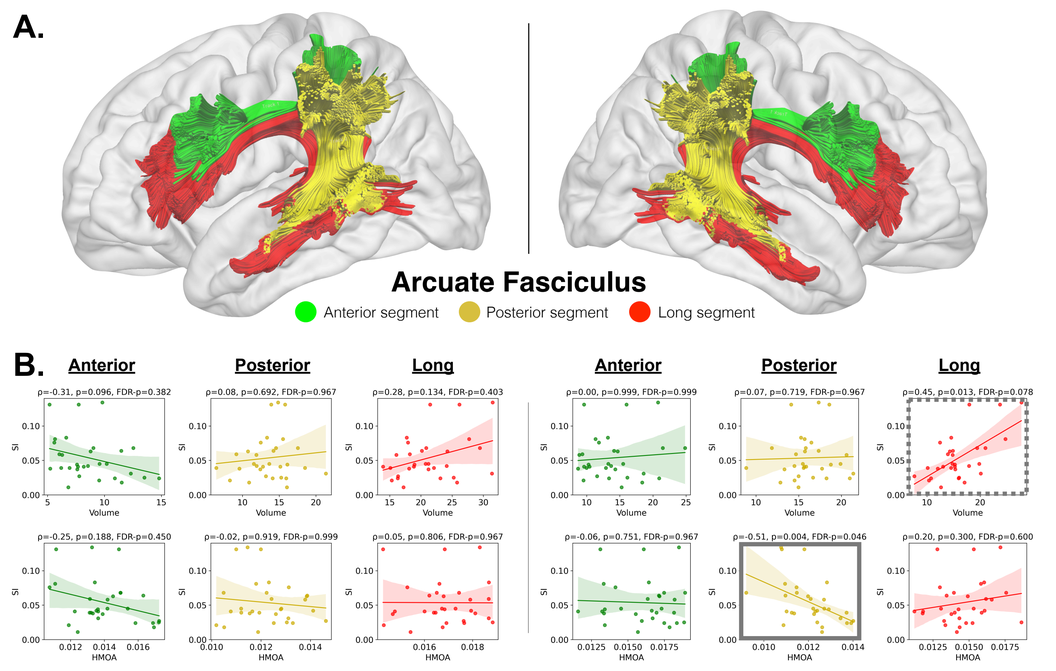


Fig 3. (A) *Tractography-based segmentation of the arcuate fasciculus (AF) into anterior, posterior, and long segments.* ***(B)*** *Spearman correlations between susceptibility index (SI) and AF tract volume and HMOA in the left and right hemispheres . Points represent participants; lines indicate fitted trends with 95% CI.* ***A significant negative correlation was observed for the right posterior AF segment, and a positive correlation was observed for right long segment****. Spearman ρ, p-values, and FDR-corrected p-values are shown above each plot. HMOA, hindrance-modulated orientational anisotropy; SI, susceptibility index.*

REFERENCES

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Email: mozker@gmail.com