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Resting-state functional connectivity predicts naturalistic bilingual speaking pattern: Converging evidence from hypothesis-driven tests and connectome-based predictive modeling

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Abstract

Research on bilingualism and resting-state fMRI (rs-fMRI) connectivity has largely emphasized self-reported static L2 proficiency and use, rarely linking rs-fMRI to real-world speaking patterns. In our study, 79 participants finished rs-fMRI scanning, a detailed language background survey, and a 3-min oral narration. We extracted their L2 speaking proficiency, language entropy, and speech patterns based on hesitations. Linking these behavioral measures to rs-fMRI connectivity with hypothesis-driven and data-driven machine learning approaches (connectome-based prediction modeling; CPM), we found the following patterns: Pauses during speaking emerged as the most reliable, showing consistent associations with Language-Somatomotor networks connectivity and the strongest predictability from CPM. Entropy showed weaker, partially replicable effects consistent with reduced Language-Multiple Demand Networks coupling at higher entropy, whereas L2 speaking proficiency showed minimal and non-replicating connectivity links. These findings highlight the importance of combining both self-reported and objectively derived measures during naturalistic tasks to depict non-native speakers' language profile and functioning.