Changes in Cortical Directional Connectivity during Difficult Listening in Younger and Older Adults

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Fully understanding the neural underpinnings of speech comprehension in difficult listening conditions requires understanding the concurrent cortical connectivity. Granger causality is a useful measure of connectivity, typically employed in functional magnetic resonance imaging (fMRI) studies, but the limited temporal resolution of fMRI restricts the capture of higher frequency neural interactions crucial for complex speech processing. On the other hand, although magnetoencephalography (MEG) can capture neural interactions at the millisecond scale, its limited spatial resolution poses challenges in conventional connectivity analyses. A recently proposed cortical connectivity analysis methodology, network localized Granger causality (NLGC), can extract Granger causal interactions in MEG data without the need for any intermediate source-localization step. This one-shot approach also effectively addresses challenges related to false alarms and localization errors, providing a robust assessment of cortical connectivity. In this study, NLGC is applied to MEG recordings from younger and older adults while performing a speech listening task with varying background noise conditions. The analysis focuses on directional cortical connectivity patterns within and between the frontal, temporal, and parietal lobes, specifically in the delta and theta frequency bands. The results demonstrate significant age- and condition-related connectivity differences, particularly in the theta band. In younger adults, increasing background noise leads to a shift from predominantly temporal-to-frontal (bottom-up) connections for clean speech to dominantly frontal-to-temporal (top-down) connections in noisy conditions. In contrast, older adults exhibit bidirectional information flow between frontal and temporal cortices regardless of the background noise. Furthermore, NLGC allows classification of connections as either excitatory or inhibitory based on their temporal relationships, enabling a more nuanced understanding of the neural mechanisms involved in speech perception. While delta band connection types show no significant age-related changes, theta band connection types exhibit substantial changes in excitation/inhibition balance across age and condition. Supported by the National Institutes of Health (P01-AG055365, R01-DC019394) and the National Science Foundation (SMA 1734892, OISE 2020624, CCF 1552946).