

Thalamocortical Resting-State Dynamics in Early Bilinguals

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The medial geniculate body (MGB) projects canonically through primary auditory cortex (HG) and pSTG to reach phonological interfaces such as the angular gyrus (AG). Whether MGB can also engage parietal cortex via an associative thalamocortical route — bypassing this relay chain — and whether such coupling relates to phonological ability, remain open questions. Using resting-state fMRI from early bilinguals who are good and poor perceivers of a Catalan vowel contrast (/e/-/ε/), we quantified directed functional connectivity with lagged FC asymmetry and BOLD temporal irreversibility. Participant-specific functional MGB masks ensured precise subcortical localisation. Good perceivers showed significantly stronger $MGB_L \rightarrow AG_R$ feedforward coupling. Fourteen bootstrap and moderated mediation models ruled out HG, pSTG, and Planum Temporale as relays — the direct effect remained intact and both groups shared the same relay architecture. A whole-brain search across 354 Schaefer–Tian parcels identified right ventral anterior thalamus (THA-VAs) as a suppressive relay, with convergent trends in its supplementary motor cortex targets, consistent with poor perceivers engaging a compensatory articulatory prediction loop. aSMG showed the opposite group pattern (Poor > Good), confirming specificity to AG. These results suggest that $MGB \rightarrow AG$ directed functional coupling is associated with phonological ability in early bilinguals. Whether it reflects a direct anatomical connection or indirect paths cannot be determined from resting-state fMRI alone.

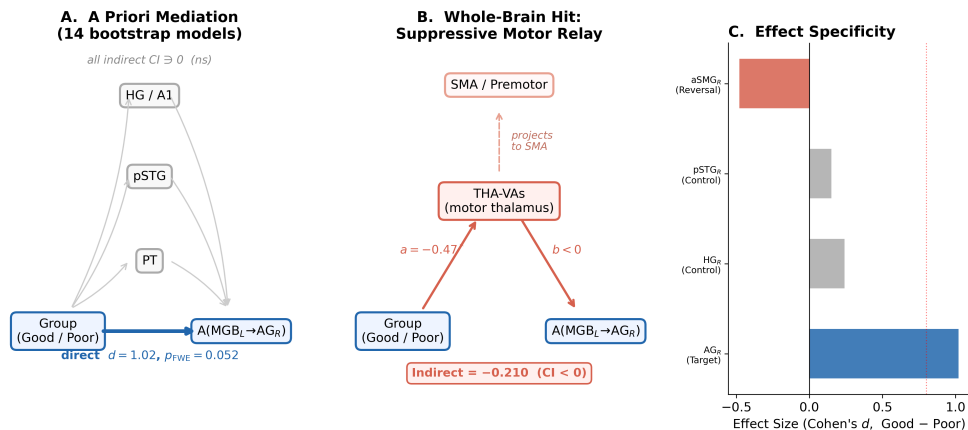


Figure 1: **Mediation and whole-brain relay analysis.** **A.** Fourteen independent bootstrap mediation models (5,000 samples each) tested HG, pSTG, and PT as potential relays of the group difference in directed $MGB_L \rightarrow AG_R$ coupling (first-leg, second-leg, and serial pathways). All indirect effects were non-significant (95% CI $\ni 0$), and the direct effect remained large. **B.** Whole-brain search across 354 Schaefer–Tian parcels identified right ventral anterior thalamus (THA-VAs) as a suppressive relay, consistent with poor perceivers engaging a compensatory articulatory prediction loop via basal ganglia–thalamus–SMA. **C.** Effect specificity: the group difference is large for AG_R (Good > Poor) but negligible for auditory controls (HG, pSTG) and reverses sign for $aSMG_R$ (Poor > Good), confirming the effect is specific to angular gyrus.