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A Longitudinal EEG Study of the Impact of Acquisition Age on English Phonological Processing

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ABSTRACT

Age of acquisition (AoA) plays a pivotal role in determining the efficiency and nativelikeness of second language phonological processing. This longitudinal EEG study investigated the impact of English acquisition age on phonological processing abilities in bilingual individuals over a three-year period. Sixty participants comprising three AoA groups—early acquirers (age of acquisition before 6 years), childhood acquirers (ages 7-12), and late acquirers (after 13 years)—were followed with repeated EEG recordings while performing passive and active oddball tasks targeting English-specific phonemic contrasts including /r/-/l/ /θ/-/s/ and vowel length distinctions.

Event-related potential analyses centered on mismatch negativity (MMN), P300, and N400 components. Results revealed that earlier AoA was strongly associated with larger MMN amplitudes and shorter latencies indicating more automatic and efficient phonological discrimination. Early acquirers displayed ERP patterns highly similar to native English speakers from the initial testing phase with minimal changes over time. In contrast late acquirers exhibited reduced MMN responses and greater reliance on later cognitive components reflecting increased effortful processing. Childhood acquirers showed intermediate patterns with significant improvement in ERP indices across the three years correlating with gains in behavioral phoneme discrimination accuracy.

Longitudinal tracking demonstrated clear trajectories of neural maturation modulated by AoA with white matter connectivity measures from supplementary DTI data supporting faster phonological network specialization in early learners. Source reconstruction highlighted greater activation in bilateral superior temporal gyri for early groups whereas late learners engaged additional prefrontal areas for compensation. These neurophysiological differences persisted even after controlling for exposure duration and proficiency level suggesting a sensitive period for phonological tuning in English as a second language.

The findings provide strong empirical support for the critical period hypothesis in the domain of L2 phonology and emphasize the long-term neural consequences of delayed English acquisition. Implications extend to language teaching practices curriculum design and early intervention programs in EFL contexts. Limitations of the study include the relatively small sample size per group and focus on specific phonemic contrasts. Future research should incorporate larger cohorts and multimodal neuroimaging to deepen understanding of AoA effects. This longitudinal investigation advances knowledge of how acquisition timing sculpts the bilingual brain's phonological architecture offering valuable insights for optimizing second language learning outcomes.

Keywords: age of acquisition, EEG, L2 phonology, neuroplasticity