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**An ERP Study on the Neurofunctional Underpinnings of Code- Switching in
English - Spanish Bilinguals.**

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ABSTRACT

Code-switching the fluid alternation between languages within a single utterance or conversation represents a hallmark of bilingual language use that poses unique challenges and opportunities for understanding the neurofunctional architecture of the bilingual brain. This ERP study investigates the neurofunctional underpinnings of code-switching in 45 highly proficient English-Spanish bilinguals examining how the brain manages linguistic interference lexical access and syntactic integration during real-time language production and comprehension. Participants performed a picture-word matching task and a sentence reading paradigm containing intra-sentential code-switches at predictable and unpredictable points while continuous EEG was recorded from 64 scalp electrodes.

Event-related potential analysis focused on key components including the N400 associated with semantic integration and the P600 linked to syntactic reanalysis and repair. Results revealed a significant N400 amplitude reduction for code-switched words when the switch was pragmatically motivated and contextually supported suggesting facilitated lexical access through cross-language priming. In contrast unexpected code-switches elicited larger N400 and late positivity effects indicating increased cognitive effort for conflict monitoring and resolution. Source localization using sLORETA identified heightened activation in the left inferior frontal gyrus and bilateral superior temporal regions during switch trials reflecting recruitment of domain-general executive control networks alongside language-specific areas. Spanish-to-English switches produced greater neural costs than English-to-Spanish switches consistent with asymmetric language dominance patterns where the dominant language exerts stronger influence on processing.

Behavioral data corroborated ERP findings with longer reaction times and lower accuracy for switched trials particularly in syntactically complex sentences. Individual differences in code-switching frequency and proficiency modulated ERP amplitudes with more habitual code-switchers displaying attenuated neural responses indicative of neural adaptation and enhanced cognitive flexibility. These patterns support models of bilingual language control such as the Inhibitory Control Model and the Adaptive Control Hypothesis by demonstrating dynamic interplay between bottom-up linguistic cues and top-down executive regulation. The study also highlights the role of language mode and contextual predictability in modulating switch costs revealing that the bilingual brain optimizes resource allocation through predictive processing mechanisms.

Findings advance understanding of how code-switching reflects adaptive neuroplasticity rather than linguistic deficiency challenging traditional monolingual-centric views of language processing. In English language and literature contexts these insights inform pedagogical approaches for heritage speakers and second language learners by emphasizing the naturalness and cognitive benefits of



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bilingual practices. Challenges include individual variability in bilingual profiles and the artificiality of laboratory tasks compared to naturalistic discourse. Implications extend to language education neurolinguistic theory and clinical interventions for bilingual aphasia or cognitive decline where preserved code-switching abilities may serve as markers of neural reserve. Future research should integrate multimodal imaging such as fMRI with ERP to achieve higher spatial and temporal resolution while exploring code-switching in trilingual populations and under varying sociocultural contexts. Overall this ERP investigation illuminates the sophisticated neural orchestration required for seamless code-switching underscoring the bilingual brain's remarkable capacity for flexible language management in an increasingly multilingual world.

Keywords: code-switching, ERP bilinguals, neurofunctional underpinnings, English-Spanish bilingualism, N400 P600, language control