NEUROLINGUISTICS IN BILINGUALISM: COGNITIVE AND LINGUISTIC MECHANISMS OF DUAL LANGUAGE PROCESSING

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Abstract: *Bilingual neurolinguistics examines how the brain represents and processes two linguistic systems. Research shows that bilinguals do not store or access their languages separately; instead, both languages remain co-activated, requiring continuous control of phonology, lexicon, syntax, and semantics. This article focuses on language-specific neurolinguistic mechanisms and explores how bilinguals access vocabulary, manage competing phonological codes, process syntax, and negotiate semantic representations. Models of bilingual lexical access and language control illustrate that bilingualism creates a unique linguistic architecture shaped by proficiency, dominance, and acquisition age. These findings contribute to theories of language production and comprehension by emphasizing how two systems coexist in a shared neural network.*

Keywords:

INTRODUCTION

Neurolinguistics investigates the relationship between language and the brain. Within this field, bilingualism presents a unique linguistic challenge: two systems coexist and remain active, even in monolingual contexts. Unlike early beliefs that bilingualism caused confusion or slowed language development, neurolinguistic evidence demonstrates that bilingual brains are continuously engaged in regulating linguistic form, meaning, and use. This constant regulation reveals how language is represented neurally and how linguistic processing is shaped by experience.Bilingualism forces the brain to handle two phonological systems, two lexicons, two sets of syntactic rules, and multiple semantic associations. Understanding how these linguistic systems interact allows neurolinguists to refine models of comprehension, production, and acquisition.

RESULTS AND DISCUSSION

Bilingual phonology illustrates how the brain stores and accesses sound systems. Brain imaging shows that bilinguals activate auditory-processing areas in the superior temporal gyrus for both languages, yet phonological processing is influenced by age of acquisition and sound structure similarity.Simultaneous bilinguals build integrated phonological representations and switch between systems more automatically.Sequential bilinguals often recruit additional motor-planning regions in Broca's area when producing non-native phonemes because the articulatory patterns are less automated.

Cross-linguistic phonological influence occurs as both languages remain active. For example, speakers may transfer syllable timing, vowel duration, or stress patterns from one language to another. Neurolinguistic research shows this influence even when no accent is audible, revealing hidden phonological co-activation. The bilingual lexicon is not two separate dictionaries. Both languages compete during lexical retrieval. According to brain-

based lexical models, when a bilingual searches for a word, activation spreads in both languages and inhibition occurs to suppress the non-target word.This explains:

- Slower lexical access in low-proficiency bilinguals.
- Cross-linguistic priming, where activation in one language influences the other (e.g., libro primes library).
- Code-switching, which occurs naturally because both lexicons are active.

Semantic categories may be shared, but concepts can be language-specific. Words do not always encode meaning the same way. For example, emotion words, color terms, or kinship terms may categorize reality differently depending on the language. The brain must therefore negotiate meaning, not only form.

Syntax and Grammatical Processing

Syntactic processing in bilinguals involves neural regions linked to structure building, particularly Broca's area. However, the processing load varies depending on similarity between the grammars. When two languages share structures, bilinguals show overlapping neural activation and while syntactic rules differ greatly, bilinguals activate additional control regions to select appropriate grammatical patterns. Syntactic transfer results from the co-activation of grammar systems. Even highly proficient bilinguals experience structural interference in comprehension, especially when reading sentences that conflict with their dominant language's grammar. Thus, bilingual syntax demonstrates how grammar is a dynamic neural practice, not a static rule system.

Syntactic processing in bilinguals engages neural regions associated with rule construction, hierarchical structure, and morphosyntactic prediction, particularly Broca's area, the left inferior frontal gyrus, and frontal executive regions. While both bilingual languages activate these core areas, the degree and distribution of activation depend on language proficiency, typological similarity, and age of acquisition.

Studies show that when two languages share similar syntactic word order (e.g., Spanish–Italian or English–Dutch), bilinguals exhibit a largely overlapping neural network for both grammars. When languages differ significantly (e.g., English–Arabic or Chinese–French), the brain recruits additional frontal and basal ganglia regions to inhibit rules from the non-target language. This demonstrates that the bilingual brain regulates grammar through linguistic inhibition, not just lexical inhibition. Because both grammatical systems remain active, bilinguals experience syntactic transfer, where structures from one language influence processing in the other. Transfer may be classified into Overt, affecting speech or writing constructions (e.g., word order or verb placement) and Covert, visible only through reaction times or neural activation patterns, showing interference even when output is correct. Neuroimaging indicates that transfer does not disappear with high proficiency; rather, it becomes efficiently controlled, meaning expert bilinguals suppress interference faster, but the competing grammar is still activated.

Morphology interacts strongly with syntax in bilinguals. Late bilinguals tend to rely on lexical-semantic cues (vocabulary meaning) to compute grammar when morphology is difficult (e.g., agreement, gender, and tense marking). This is reflected neurologically as increased recruitment of semantic association regions in the temporal lobe and executive control regions to manage morphosyntactic conflict. By contrast, highly proficient early

bilinguals show more automated morphosyntactic parsing, resembling monolingual patterns, because their grammar is encoded as procedural knowledge — a motor-like linguistic skill.

Current neurolinguistic theory emphasizes predictive processing, meaning the brain anticipates upcoming syntactic structure before hearing or reading it. Bilinguals vary in prediction strength based on experience of their dominant language, bilinguals generate strong syntactic predictions, requiring less neural effort. In their weaker language, predictions are weaker, forcing the brain to rely more on bottom-up cues (actual input rather than expectation). This difference is visible in ERP components which increases when a bilingual encounters unexpected syntax, showing greater syntactic reanalysis and repair cost.

Code-switching is governed by grammatical principles, not random mixing. Bilinguals typically switch languages at syntactically permissible boundaries, suggesting the brain maintains simultaneous rule systems. During a switch the grammar of the current language remains active and the grammar of the incoming language becomes pre-activated. This anticipatory switching reveals that bilingual syntactic processing is proactive rather than reactive, a strategic coordination of grammar rather than accidental mixing.

Language Control and Code-Switching

Code-switching is not a linguistic error but a controlled behavior. Neurolinguistic evidence shows that code-switching requires activation of both linguistic systems and strategic suppression depending on social context. Regions such as the anterior cingulate cortex and dorsolateral prefrontal cortex regulate switching, showing that bilingual language production is fundamentally a language-control process. The Control Process Model proposes that bilingual speech involves: activation of items across languages, competition between phonological, lexical, and syntactic candidates and selection of context-appropriate output. These factors makes bilingual production a constant negotiation between linguistic systems rather than simple alternation between languages.

Bilinguals rarely break grammatical rules when switching; instead, they switch at syntactically predictable locations aligned with the structure of both languages. Examples include phrase boundary switching (switching between noun phrases, prepositional phrases, or clauses) and function word restrictions, where switching is less likely within tightly bound structures, such as between an article and its noun in languages where they must agree morphologically. Neurolinguistic evidence supports this rule because incompatible structures create greater syntactic conflict signals in the brain, reflected in increased activation of the anterior cingulate cortex Brain imaging shows that code-switching is anticipated, not accidental. Before a switch occurs, language-control regions activate to reduce interference from the current language and raise activation for the upcoming one. This refers to the brain pre-activating the grammar of the target language before the speaker switches. The switch is neurologically planned, even milliseconds before articulation. This predictive effect supports the view that bilinguals manage dual syntactic plans simultaneously.

Switching languages does not always increase cognitive effort. Neurolinguistic studies show that frequent code-switchers (e.g., in communities where switching is common)

experience reduced switching costs, meaning they need less activation in inhibitory control regions. In other words, the brain adapts to the linguistic environment: code-switching becomes automatized like any other grammar rule. In some cases certain words can trigger a switch, these are usually: words with no exact equivalent in the other language (often cultural terms), borrowed or frequently mixed lexical items, open-class lexical items (nouns, verbs) that allow full phrase restructuring. When a lexical trigger appears, the brain often activates syntactic frames from the other language, showing that switching is more than vocabulary replacement — it reorganizes grammatical structure. From a neurolinguistic perspective, code-switching is proof that bilingual syntax is integrated, not partitioned

CONCLUSION

Neurolinguistics demonstrates that bilingualism is not a duplication of linguistic knowledge, but a dynamic interplay between two active language systems. Phonology, lexicon, syntax, and semantics interact within shared neural networks, requiring continuous control and selective inhibition.

By studying bilingual processing, neurolinguistics advances theoretical understanding of language representation and language use, shifting from viewing languages as separate mental entities to recognizing them as co-existent systems in one mind.

Bilingualism, therefore, reshapes linguistic theory by revealing how multiple grammars, lexicons, and phonologies coexist, compete, and cooperate in a single brain.

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