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A Review of Bilingual Lexical Representation and Cross-language Activation Mechanisms

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Abstract

As a core interdisciplinary topic of psycholinguistics and second language acquisition (SLA), modern bilingual lexical processing explores the inherent rules of cross-language interaction during bilinguals' lexical recognition, storage, and retrieval. Grounded in the core theories from John Field's Psycholinguistics, this paper systematically reviews three dominant models of bilingual lexical storage, analyzes key operational mechanisms including cross-language activation and inhibitory control, and clarifies the action pathways of key core influencing factors such as language proficiency and similarity. It also summarizes ongoing academic debates over the automaticity of cross-language activation and the applicability of representational models, and prospects future research directions combined with global emerging trends. This review aims to provide theoretical support for optimizing L2 vocabulary teaching and enhancing bilingual competence. Current evidence confirms that bilingual lexical representation presents a gradient shared feature, and cross-language activation is regulated by multiple factors, providing new empirical support for the development of psycholinguistic theory.

Keywords

Bilinguals; Lexical Processing; Cross-Language Activation; Inhibitory Control; Lexical Representation Models

1. Introduction

Globalization has significantly boosted bilingual prevalence across academic, professional, and daily contexts, making cross-language interaction in lexical processing a focal topic in psycholinguistics and second language acquisition (SLA). Unlike monolinguals relying on a single lexical system, bilinguals develop a unique mental lexicon architecture, where dynamic cross-talk between two languages shapes lexical recognition, storage, and retrieval—this mechanism encapsulates the complexity of bilingual cognitive flexibility.

1.1 Core Definitions

Bilinguals are categorized by two key dimensions: acquisition timing and proficiency symmetry. Bilingual lexical processing, the review's core, refers to the cognitive process encompassing perceptual identification of lexical forms, mental storage, and dynamic retrieval in specific task contexts.

1.2 Research Significance

Theoretically, monolingual lexical processing has a mature theoretical system, but the interaction logic of dual linguistic systems remains debated. This review integrates classic frameworks with the latest neurocognitive and

behavioral evidence (Zhang et al., 2025; Tarin et al., 2025; Chen et al., 2025) to delineate bilingual-unilingual processing differences and reconcile controversies. Practically, findings provide actionable guidance for L2 vocabulary teaching and cross-cultural communication strategies, optimizing learning efficiency and interaction effectiveness.

2. Theoretical Frameworks

Theoretical inquiry into bilingual lexical processing revolves around two foundational questions: how lexical items of two languages are represented in the brain, and what rules govern their cross-language interaction. Moving beyond early dualistic debates, contemporary theories have evolved into a nuanced, integrative system that balances universality and context sensitivity.

2.1 Core Theoretical Models

Key frameworks offer complementary perspectives on representation and activation dynamics. The Revised Hierarchical Model (RHM; Kroll & Stewart, 1994) remains pivotal for unbalanced bilinguals, positing asymmetric lexical-conceptual links: L1 connects directly to conceptual systems, while L2 initially relies on L1 mediation, with direct L2-concept pathways strengthening as proficiency grows. This asymmetry is corroborated by meta-analytic evidence (Zhang et al., 2025), which confirms non-selective phonological activation (Hedge's $g=0.45$, $p<0.0001$) as a universal feature across proficiency levels.

Dijkstra and colleagues' BIA+ model extends this by emphasizing non-selective lexical recognition—words from both languages activate in parallel, with a task decision system regulating output based on contextual demands (Dijkstra & van Heuven, 2002). Eye-tracking data further enriches this framework: semantic context modulates bilinguals' activation modes, shifting between "monolingual mode" (suppressing non-target language) and "bilingual mode" (co-activating both) based on meaning bias (Tarin et al., 2025).

The Multilink model (Dijkstra et al., 2019) integrates orthographic, phonological, and semantic layers, highlighting parallel activation of lexical neighbors. For cross-script bilinguals like Chinese-English speakers, fMRI evidence suggests this model's core assumptions hold, but requires refinement to account for language-specific semantic tuning shifts (Chen et al., 2025)—shared brain regions (bilateral temporal and parietal cortices) coexist with fine-grained linguistic modulations.

Complementary to these, De Groot's (1992) Distributed Conceptual Representation Theory explains gradient sharing: concrete words and cognates exhibit higher feature overlap across languages, driving stronger cross-language activation than abstract words or non-cognates.

2.2 Key Theoretical Debates

Contemporary disputes have moved beyond "shared vs. independent" dichotomies to focus on the gradient nature of representation overlap. This overlap is shaped by language similarity, word type, and bilingual profile: Uyghur-Chinese bilinguals show "lexical independence with conceptual sharing" (Xu et al., 2022), while Chinese-English bilinguals exhibit partial sharing at both lexical and conceptual levels (Mao, 2023). Neurocognitive evidence further clarifies this—81% of valid voxels in Chinese-English bilinguals show consistent tuning directions, confirming shared core regions with language-specific modulations (Chen et al., 2025).

Another ongoing debate centers on activation pathways: ERP studies (Yang et al., 2024) validate dual routes (conceptual mediation vs. direct lexical access), with selection modulated by task demands. Zhang et al. (2025) add that cross-language phonological activation follows these dual paths, with intensity shaped by task type and script distance.

2.3 Theory Evolution Trajectory

Early theories were marked by static, dualistic debates over representation, lacking systematic empirical support. From the 1980s onward, frameworks like RHM and BIA emerged, grounding theory in dynamic processing of data. Today, three trends define progress: integration of multi-factor regulation (e.g., Tarin et al., 2025), incorporating context, frequency, and individual differences, deepening neurocognitive evidence (Chen et al., 2025's fMRI and voxel encoding models), and emphasis on language specificity (Zhang et al., 2025's focus on script distance effects)—all moving the field beyond the pursuit of a universal model toward context-adaptive explanations.

3. Mechanisms and Modulating Factors

Bilingual lexical processing operates through interconnected core mechanisms, whose efficiency and outcomes are dynamically shaped by a confluence of linguistic, individual, and task-related factors. These elements interact synergistically, yielding the flexible yet predictable patterns that define bilingual cognitive processing.

3.1 Core Processing Mechanisms

Cross-language activation stands as the defining hallmark of bilingual lexical processing, characterized by non-selectivity, dual-pathway transmission, and context-dependent dynamics. Even when focusing on a target language, bilinguals automatically activate non-target lexical representations—an effect robust across script types, with within-script ($g=0.50$, $p=0.002$) and cross-script ($g=0.38$, $p<0.0001$) languages both showing significant activation (Zhang et al., 2025). Activation spreads via two complementary pathways: a conceptual mediation route dominant in semantic tasks, and a direct lexical pathway prominent in form-focused judgments (Chen et al., 2025). This dual-path architecture is corroborated by neural evidence—shared conceptual systems enable cross-language brain activity prediction, while language-specific voxel tuning reflects direct lexical interactions.

Context further modulates this activation: non-target language-biased contexts amplify interlingual homograph interference ($\beta=0.151$, $p<0.001$) in late processing, whereas target language-biased contexts mitigate it (Tarin et al., 2025). Bidirectionality is another key feature—L1→L2 ($g=0.41$, $p<0.0001$) and L2→L1 ($g=0.37$, $p<0.0001$) activation effects are comparably significant (Zhang et al., 2025), with familiarity shaping dependence on L1: low-familiarity L2 words rely more on L1 activation for priming, while high-familiarity items form independent representations (Ang et al., 2016).

Inhibitory control acts as the critical regulatory counterpart, balancing activation competition to ensure target language efficiency. Unlike global suppression of the non-target language, inhibition is targeted—focusing on competing semantic features or lexical nodes that conflict with the target (Tarin et al., 2025). Directional asymmetry marks this mechanism: L1→L2 inhibition is stronger than L2→L1 suppression, likely due to L1's higher resting activation (Zhang et al., 2025). Proficiency and language use flexibility further refine inhibitory efficiency—bilinguals with higher reading entropy (flexible language switching) and advanced proficiency better suppress non-target interference, especially in deep semantic tasks (Tarin et al., 2025).

Frequency effects and proficiency modulation jointly shape processing speed and stability. High-frequency words, with lower activation thresholds, facilitate faster retrieval, but this effect interacts with bilingual proficiency: unbalanced bilinguals show weaker L2 frequency effects due to persistent L1 mediation, while balanced bilinguals exhibit comparable frequency sensitivity across languages (Zhang et al., 2025). Proficiency also strengthens direct L2-concept connections (aligning with the RHM model) and stabilizes semantic representations—native language (Chinese) semantic models show higher prediction accuracy (R^2) than L2 (English) models (Chen et al., 2025), a pattern replicated across language pairs like Tibetan-Chinese (Li et al., 2019).

3.2 Key Modulating Factors

Linguistic factors lay the foundational groundwork, with word type and language similarity driving activation strength. Concrete words, cognates, and content words—rich in shared semantic features—elicit stronger cross-language activation than abstract words, non-cognates, or function words (De Groot, 1992). Language similarity across phonology, orthography, and morphology further amplifies activation: typologically close language pairs benefit from formal overlap, while distant pairs like Chinese-English rely on conceptual sharedness (Bu et al., 2021). Language-specific semantic encoding adds another layer—Chinese emphasizes action-relationship links for location/number terms, while English prioritizes quantity-set associations, a modulation independent of low-level factors like word frequency (Chen et al., 2025).

Individual differences introduce processing heterogeneity, with proficiency, age of acquisition (AoA), and working memory capacity as core modulators. Proficiency remains the most impactful: low L2 proficiency correlates with heavy L1 reliance and heightened interference, while advanced proficiency strengthens direct L2-concept pathways (Kroll & Stewart, 1994). AoA shapes representational integration—early acquirers develop more integrated dual-language systems, leading to stronger interlingual homograph interference ($\beta=0.056$, $p=0.001$), while late acquirers maintain relatively independent representations (Tarin et al., 2025). Working memory capacity further refines inhibitory control: high-capacity bilinguals better suppress non-target interference, particularly in complex semantic tasks

(Xu et al., 2022).

Task-related factors directly steer processing trajectories by regulating depth, activation scope, and resource allocation. Task type dictates processing pathways: shallow form-focused tasks limit activation to formal levels, while deep semantic tasks trigger broader cross-language semantic activation (Zhang et al., 2025). Contextual richness matters too—rich cues reduce irrelevant non-target activation, while isolated word processing expands activation scope and competition (Tarin et al., 2025). Stimulus-onset-asynchrony (SOA) modulates the activation time window: phonological priming peaks at 20–50 ms and grows non-linearly beyond 60 ms (Zhang et al., 2025), while response time demands amplify automatic activation in rapid tasks and enable active regulation in extended-response tasks.

4. Methods and Controversies

Research methods in bilingual lexical processing have evolved in tandem with theoretical advances, while unresolved academic debates continue to shape the field's trajectory—both reflecting the complexity of dual-language cognitive dynamics and pointing to critical gaps in current understanding.

4.1 Research Method Evolution

The methodological landscape has shifted from surface-level behavioral observation to multi-dimensional, technologically enhanced inquiry, following a trajectory of "behavioral foundation → neural breakthrough → multi-method integration." Classic behavioral paradigms—lexical decision, cross-language priming, and translation naming—laid the groundwork by capturing reaction times and accuracy to infer activation patterns (Zhang et al., 2025). The masked priming paradigm, in particular, has proven robust in documenting cross-language phonological activation across script types (Zhang et al., 2025).

Neurolinguistic technologies have since transformed the field, enabling direct observation of neural mechanisms: ERP's millisecond temporal resolution tracks the time course of lexical processing via components like N400 (semantic integration) and P200 (formal analysis), while fMRI's spatial precision localizes shared and language-specific activation in bilateral temporal, parietal, and prefrontal cortices (Chen et al., 2025). Eye-tracking further complements these tools, distinguishing early (gaze duration) and late (total reading time) processing stages to unpack dynamic activation trajectories (Tarin et al., 2025). Contemporary research increasingly adopts multi-method triangulation—combining meta-analysis with behavioral experiments, or fMRI with computational modeling—to enhance generalizability and explanatory power (Zhang et al., 2025; Chen et al., 2025).

Despite these advances, methodological challenges persist: paradigm-specific sensitivity differences complicate cross-study comparisons, variable control complexity risks misinterpretation, and isolated stimuli often lack ecological validity. Future optimization will hinge on standardized procedures, naturalistic experimental designs, and deeper integration of behavioral and neural data.

4.2 Unresolved Academic Controversies

Four core debates remain central to the field, each rooted in competing interpretations of empirical evidence. First, the boundaries of cross-language activation remain ill-defined: while activation extends to semantic categories, consensus is lacking on whether it spreads to indirectly associated non-cognates, or how attenuation varies by word type. Zhang et al. (2025) propose task demands and stimulus quantity as key regulators—complex tasks narrow activation scope, while larger stimulus sets stabilize effects.

Second, the operational level of inhibitory control is contested: does inhibition target semantic network nodes, individual features, or formal levels like phonology? Tarin et al. (2025) argue for semantic-layer dominance, noting that inhibition primarily acts during late integration stages, but early lexical access inhibition effects suggest multi-level regulation.

Third, model unification remains elusive. Existing frameworks (e.g., BIA+, Multilink) excel in specific contexts but fail to account for all bilingual types, word categories, and task scenarios. Chen et al. (2025) demonstrate that shared-representation mechanisms apply to cross-script bilinguals, but language-specific tuning shifts demand model refinement—raising questions about whether a universal framework is feasible or if context-adaptive combinations are more pragmatic.

Fourth, theory adaptability to logographic-alphabetic language pairs (e.g., Chinese-English) remains debated. While core mechanisms like non-selective activation generalize (Chen et al., 2025), logographic languages rely more

on form-meaning pathways, whereas alphabetic languages prioritize phonological links—suggesting theoretical refinement is needed to capture writing-system-specific dynamics (Xu et al., 2022).

5. Conclusion and Future Directions

To summarize, this review systematically unpacks the theoretical frameworks, core mechanisms, and modulating factors of bilingual lexical processing, integrating classic psycholinguistic insights with cutting-edge neurocognitive evidence. At its core, bilingual lexical representation exhibits context-dependent partial sharing—shared neural substrates (bilateral temporal, parietal, and prefrontal cortices) underpin cross-language semantic processing, while fine-grained language-specific tuning shifts shape differential activation patterns (Chen et al., 2025). Cross-language activation operates as a non-selective, bidirectional process with dual pathways (conceptual mediation and direct lexical access), balanced by targeted, directionally asymmetric inhibitory control—all jointly regulated by linguistic, individual, and task-related factors (Zhang et al., 2025; Tarin et al., 2025).

Notably, this review makes three theoretical contributions: it clarifies the gradient nature of representational sharing, reconciling dualistic debates with a "shared core + language-specific modulation" framework; refines the contextual dynamics of activation and inhibition, highlighting multi-factor regulation; and extends classic models' applicability to cross-script pairs like Chinese-English, while emphasizing writing-system-specific adjustments (Xu et al., 2022; Chen et al., 2025).

Practically, these findings offer actionable guidance for L2 vocabulary teaching: leveraging cross-language activation for cognates and concrete words, adopting contextualized input for abstract non-cognates, and designing differentiated strategies based on semantic tuning characteristics (e.g., prioritizing quantity associations for English location terms, action logic for Chinese counterparts; Chen et al., 2025). For cross-cultural communication and translation, understanding bidirectional activation and inhibitory control helps mitigate ambiguity and optimize language switching efficiency (Tarin et al., 2025).

Despite these insights, three limitations persist: overreliance on Chinese-English and similar language pairs, insufficient longitudinal data on proficiency-related developmental trajectories, and a gap between theoretical findings and practical teaching interventions.

Looking ahead, four key directions merit further exploration. First, longitudinal tracking studies should capture how processing mechanisms evolve with L2 proficiency, validating the dynamic adaptability of theoretical models (Chen et al., 2025). Second, multi-modal integration (combining fMRI, ERP, and eye-tracking) will deepen understanding of spatiotemporal dynamics in lexical processing (Zhang et al., 2025). Third, expanded research on minority language pairs and multilingual populations will clarify the balance between universal mechanisms and language-specificity. Finally, more application-oriented studies are needed to translate theoretical insights into targeted teaching interventions, bridging the gap between research and practice (Tarin et al., 2025).

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