مجلة جامعة جازان للعلوم الإنسانية
Jazan University Journal of Human Sciences (JUJHS)

Age-Related Differences in Semantic Priming Among Bilinguals: A Synthesized Literature Review

Salwa Ibrahim Shabi
Department of Foreign Languages, College of Arts and Humanities, Jazan University, Kingdom of Saudi Arabia

الفروقات المرتبطة بالعمر في التهيئة الدلالية بين ثنائيي اللغة: مراجعة أدبية مُركَّبة

سلوى إبراهيم شعبي
قسم اللغات الأجنبية، كلية الفنون والعلوم الإنسانية، جامعة جازان، المملكة العربية السعودية

DOI	RECEIVED الاستلام	Edit التعديل	ACCEPTED القبول
https://doi.org/10.63908/ttv2h161	2025/04/10	2025/08/08	2025/09/29
NO. OF PAGES عدد الصفحات	YEAR سنة العدد	VOLUME رقم المجلد	ISSUE رقم العدد
9	2025	1	14

Abstract:
This literature review investigates how age influences semantic priming in bilinguals, addressing two research questions: 1. What are the effects of age on the emergence and development of semantic priming in bilingual individuals? 2. How do the characteristics of semantic priming in terms of timing, strength, processing strategies, and language dominance differ across developmental stages? The review aims to identify patterns in semantic priming and analyze age-related changes in cognitive and linguistic characteristics. A qualitative approach was applied using Braun and Clarke's (2006) thematic analysis framework, based on eight empirical studies involving 625 bilingual participants ranging in age from 17 months to 81 years. Relevant studies were selected through a systematic search across four academic databases: Google Scholar, PubMed, ResearchGate, and Semantic Scholar, focusing on literature published between 2008 and 2020. Two central themes emerged from the analysis: first, developmental trajectories in semantic priming; second, developmental differences in priming characteristics. The findings suggest that semantic priming becomes robust between 18–30 months, favoring the dominant language and expanding across both languages. Older children demonstrate deeper semantic associations, and adults rely more on contextual cues despite slower processing. Tools such as CCT, IPL, and MCDI proved essential in tracking priming patterns across developmental stages. Key limitations include the lack of gender-specific data and limited linguistic diversity in the samples. Future studies are recommended to explore underrepresented language pairs, sociocultural and gender factors, and adopt longitudinal methodologies to trace the development of semantic priming over time.

Keywords: Bilinguals, Semantic Priming, Age Differences.

الملخص:
تتناول هذه المراجعة الأدبية أثر العمر في التهيئة الدلالية لدى ثنائيي اللغة، من خلال الإجابة عن سؤالين بحثيَّين: ١. ما هي آثار العمر على نشوء وتطوّر التهيئة الدلالية لدى الأفراد ثنائيي اللغة؟ ٢. ما هي أوجه اختلاف خصائص التهيئة الدلالية من حيث التوقيت، والقوّة، واستراتيجيات المعالجة، وهيمنة اللغة عبر مراحل النمو المختلفة؟ تهدف هذه المراجعة إلى تحديد أنماط النمو في التهيئة الدلالية وتحليل التغيرات المرتبطة بالعمر في خصائصها المعرفية واللغوية. وقد اعتمدت الدراسة منهجًا نوعيًّا، وذلك من خلال تطبيق إطار التحليل الموضوعي الذي وضعه كل من براون وكلارك (٢٠٠٦)، واستندت إلى ثماني دراسات تجريبية شملت ٦٢٥ مشاركًا من ثنائيي اللغة، تراوحت أعمارهم بين ١٧ شهرًا ٨١ عامًا. اختيرت الدراسات ذات الصلة من خلال بحث منهجي في أربع قواعد بيانات أكاديمية Google Scholar وPubMed وResearchGate وSemantic Scholar مع التركيز على الدراسات المنشورة في الفترة ما بين عامي ٢٠٠٨ و٢٠٢٠. وقد أسفر التحليل عن بروز محورين رئيسيين: الأول يتعلّق بالمسارات التطورية للتهيئة الدلالية، والثاني يتناول الفروقات النمائية في خصائص هذه التهيئة. وتُشير النتائج إلى أن التهيئة الدلالية تظهر في سن مبكرة، لكنها تتطور تدريجيًا تحت تأثير عوامل مثل العمر، والتعرض اللغوي، وهيمنة إحدى اللغتين. كما كشفت المراجعة عن عدد من القيود البحثية، من أبرزها غياب البيانات المتعلقة بالفروق بين الجنسين، ومحدودية التنوع اللغوي في العينات المدروسة. وعليه، توصي الدراسة بأن تتوجه الأبحاث المستقبلية نحو استكشاف أزواج لغوية غير ممثلة بشكل كافٍ، مع مراعاة العوامل الاجتماعية والثقافية والنوعية، واعتماد تصاميم بحثية طولية تُمكّن من تتبع مسار تطور التهيئة الدلالية عبر مختلف المراحل العمرية.

الكلمات المفتاحية: ثنائيي اللغة، التهيئة الدلالية، الفروقات العمرية.

Introduction

Semantic priming, the facilitation of word recognition through prior exposure to semantically related stimuli, offers an important lens for understanding bilingual lexical architecture across developmental stages. It reveals how lexical items are semantically connected and how efficiently these connections are accessed during language processing (Neely, 1991).

One of the earliest demonstrations of semantic priming came from Meyer and Schvaneveldt's (1971) lexical decision task, which showed that word recognition is facilitated when the prime and target are semantically related (e.g., "nurse" after "doctor"). This finding laid the foundation for understanding semantic priming as a fast, automatic, and associative process that operates within semantic networks (Ferrand & New, 2004; Harley, 2014; Reisberg, 2007). Such networks allow for rapid spreading activation, enabling more efficient access to related lexical items. Priming effects can be observed both within and across modalities, and may take various forms, semantic, associative, perceptual, or conceptual (Ben-Haim et al., 2015; Weingarten et al., 2016). Understanding bilingual semantic priming is especially important, as bilingual individuals manage two linguistic systems that often share overlapping conceptual representations but differ in lexical access, proficiency, and exposure (Kroll & Tokowicz, 2005). Exploring how these systems develop and interact across different age groups helps us uncover how semantic networks form and reorganize over time (De Anda & Friend, 2020).

This synthesized literature review explores age-related differences in bilingual semantic priming, drawing on findings across infancy, childhood, and adulthood. By analyzing eight key studies (De Anda & Friend, 2020; Farag, 2013; Floccia et al., 2020; Kousaie & Phillips, 2010; Langley et al., 2008; Macdonald, 2013; Sheng et al., 2013; Singh, 2014), the review identifies two recurring themes: (1) shared developmental trajectories in semantic priming, and (2) developmental differences in priming characteristics.

Given the methodological diversity and age-span of existing studies, a synthesized thematic review allows for the integration of complex findings into coherent themes. By focusing on age as a primary variable and analyzing the nuanced characteristics of semantic priming across developmental stages, this review addresses an important gap in the literature. The thematic approach provides a flexible yet rigorous structure to examine both shared and contrasting insights, offering a clearer picture of how bilingual semantic networks evolve over time. Bilingualism offers a competitive advantage in international contexts such as business, diplomacy, and academia. Recent findings suggest that nearly half of the global population now has some degree of bilingual or plurilingual proficiency, indicating that monolingualism is becoming less dominant worldwide (Mendis et al., 2021).

This review aims to explore and provide answers to the following questions:

1. What are the effects of age on the emergence and development of semantic priming in bilingual individuals?
2. How do the characteristics of semantic priming in terms of timing, strength, processing strategies, and language dominance differ across developmental stages?

These questions guide the review by first examining how age influences the onset and progression of semantic priming in bilinguals, and then exploring how the specific features of this phenomenon vary across age groups, ranging from toddlers to adults. This includes analyzing how quickly and strongly individuals respond to semantically related stimuli, the strategies they employ in processing, and how language dominance plays a role throughout development.

Framework and Rationale

This review adopts thematic analysis as its analytical framework, following Braun and Clarke's (2006) model. This method is particularly suited to synthesizing psychological and linguistic research across varied populations and methodologies. Its flexibility allows for capturing patterned meanings within and across studies, while still offering rigorous steps for coding, theme development, and interpretation (Braun & Clarke, 2006). Given that the review spans developmental stages, from early childhood through adulthood, and includes bilingual individuals with diverse languages, thematic analysis provides a way to uncover both shared developmental pathways and experience-dependent divergences in semantic priming. By applying this method, the review moves beyond summarizing findings to identifying nuanced relationships and contradictions across the literature, offering a holistic, developmentally grounded interpretation of bilingual semantic priming.

Literature Review

Overview of Semantic Priming in Bilingualism

Semantic priming refers to the phenomenon where the recognition of a target word (e.g., "dog") is facilitated by the prior presentation of a semantically related prime word (e.g., "cat") (Neely, 1991). In bilinguals, semantic priming is influenced by factors such as language proficiency, exposure, dominance, and cross-language activation (Altarriba & Basnight-Brown, 2007). According to Harley (2014), priming is a widely used experimental strategy in psycholinguistics, involving the idea that related items in the same processing procedure can either help or hinder each other. Research shows that priming effects can occur both within and across languages (Dufour & Kroll, 1995), and that these effects vary across lifespan (Jared & Kroll, 2001) and are shaped by the bilingual individual's linguistic environment (Kroll et al., 2010). According to Weingarten et al. (2016), semantic priming is the process where a stimulus, such as visual or verbal cues, influences a subsequent response without conscious guidance. This effect is typically strongest when both the prime and the target belong to the same modality (e.g., two visual cues or two verbal cues), although semantic priming can also occur across modalities or between semantically related words. For example, studies using event-related potentials (ERPs) have shown that semantic priming effects can be detected within 400 milliseconds, reflecting early lexical-semantic activation (Kutas & Federmeier, 2011). In a perceptual identification test, for instance, individuals are more accurate at detecting words that have been briefly exposed if they have already come across those words during an unrelated study phase (Wagner & Koutstaal, 2002).

Marian and Shook (2012) state that monolingual individuals' semantic networks are primarily built within a single language, leading to robust associations between words. Bilinguals, on the other hand, have the unique advantage of operating in two linguistic systems and often show cross-linguistic priming, where exposure to a word in one language influences processing in the other. Bilingualism enhances cognitive flexibility, attention control, and inhibitory control, often outperforming monolinguals in executive function tasks.

Theoretical Models of the Bilingual Lexicon

Several models provide frameworks for understanding bilingual semantic processing. The Revised Hierarchical Model (RHM) (Kroll & Stewart, 1994) suggests that early second language (L2) learners access meaning through their first language (L1), but with increased proficiency, direct links between L2 words and concepts develop. The Distributed Feature Model of bilingual memory (de Groot, 1992) posits that words across languages share semantic features but differ in their distribution. The PRIMIR framework (Curtin et al., 2011) emphasizes developmental

dynamics, suggesting that early word learning and semantic organization are shaped by perceptual and environmental input, aligning well with findings on age-related changes in semantic priming. Nevertheless, the brain's limitations in articulating multiple languages at once underscore the need for continued exploration of language acquisition and comprehension (Sakai, 2005).

Despite the wealth of studies on bilingual semantic priming, few have examined how these effects differ across age groups. Most research either focuses on toddlers or adults, with limited attention to school-aged children or comparative developmental studies. Furthermore, the role of language dominance also remains debated. Some studies find clear directional priming effects (Singh, 2014), while others report symmetrical priming regardless of language dominance (Floccia et al., 2020). Macdonald (2013), using a semantic neighborhood task, investigated lexical processing in adults and found that semantic interference remains relatively stable across age, though older adults may show slower response times. These gaps suggest the need for a synthesized review that captures both convergence and divergence in findings.

Methodology

Research Design

This study employed a qualitative literature review approach, using a thematic analysis to synthesize findings from empirical research on semantic priming among bilinguals across different age groups. The aim was to identify recurring themes, developmental trends, and age-related patterns in lexical-semantic processing in bilingual individuals.

Search Strategy

To conduct the literature search, four academic databases were used: Google Scholar, PubMed, ResearchGate, and Semantic Scholar. The initial search using the keyword "semantic priming" yielded approximately 347,000 results. To narrow the scope and focus, additional keywords were used, including: "semantic priming AND age", "semantic priming AND toddlers", "semantic priming AND children", "semantic priming AND adults", and "semantic priming AND bilingualism". This refined search yielded approximately 45 to 50 relevant results across the database. These included journal articles, empirical studies, scholarly book chapters, and conference papers.

Inclusion and Exclusion Criteria

Relevant studies were selected through structured screening based on titles, abstracts, and keywords (see Table 1). Duplicates across databases were excluded. Studies were eliminated if they were outdated, did not focus on semantic priming in bilinguals, lacked emphasis on age-related differences, and were not accessible or not available in English.

From the refined collection of studies, fourteen studies were identified as potentially relevant. After applying language and accessibility filters, ten studies were retained. A further two were excluded due to thematic irrelevance, resulting in a final selection of eight studies included in the synthesis. These studies involved 625 bilingual participants, ranging in age from 17 months to 81 years.

Coding and Extraction Process

To facilitate thematic classification, the Avidnote web-based tool was used to annotate and organize the selected studies. Each document was examined line-by-line, with key content coded for its relevance to the research questions. Codes were based on age, priming type and strength, language dominance, experimental tasks, and cross-language interactions. The synthesis was conducted following Braun and Clarke's (2006) six-phase thematic analysis model (see Table 2). This approach was chosen for its flexibility and rigor in organizing patterns across psychologically and linguistically rich studies.

Findings

The findings from the reviewed studies are thematically organized to highlight patterns in developmental trajectories and characteristics of semantic priming across age groups and bilingual contexts. Two major themes emerged from the literature:

Theme 1: Developmental Trajectories in Semantic Priming

Farag (2013) explored the link between semantic priming and vocabulary size in bilingual and monolingual infants using the Intermodal Preferential Looking (IPL) paradigm. Six experiments were conducted, examining the lexical-semantic relationship. The study involved both monolingual and bilingual infants aged 18 and 30 months. In the first, second, and third experiments, the participants were 30 months old, and in the fourth to sixth, they were 18 months old. Monolingual 30-month-olds showed robust semantic priming in word-word conditions, while 18-month-olds did not.

In bilinguals, a significant semantic priming effect was observed in Arabic and English at 30 months, but no effect was found at 18 months. These findings suggest that bilingual infants under 24 months may not consistently show semantic priming, particularly when their vocabulary size is still developing. However, contrasting evidence from De Anda and Friend (2020) offers a more optimistic view of earlier priming emergence in bilingual toddlers. De Anda and Friend (2020) found that lexical-semantic priming effects emerged in Spanish-English bilingual toddlers at 18 and 24 months. They used the Computerized Comprehension Test (CCT), Intermodal Preferential Looking (IPL), and the MacArthur Bates Communicative Development Inventory (MCDI). Their longitudinal study of 32 toddlers showed emergent semantic activation at 18 months and robust priming by 24 months. They concluded that dual and single language exposure can follow similar developmental timetables.

Floccia et al. (2020) observed robust translation equivalent and cross-language semantic priming in 27-month-old bilingual toddlers, independent of language dominance or typological distance. Singh (2014) extends this field of research by examining the role of language dominance at a slightly later developmental stage. Singh (2014) found that 2.5-year-old bilingual toddlers showed stronger priming effects in their dominant language.

Moving into middle childhood, Sheng et al. (2013) explore how increased language experience influences the depth and flexibility of semantic associations. Sheng et al. (2013) reported stronger semantic depth and code-switching in older children (7–9 years), aligning with increased network flexibility.

In adulthood, a growing body of work focuses on how priming is maintained or altered across the lifespan, as demonstrated by Langley et al. (2008) and others. Langley et al. (2008) and Macdonald (2013) showed consistent priming in young and older adults. Kousaie and Phillips (2010) found semantic priming across age groups using ERP, with older adults showing delayed peaks and context reliance.

Theme 2: Developmental Differences in Priming Characteristics

De Anda and Friend (2020) and Singh (2014) noted stronger priming in toddlers' dominant language, driven by translation equivalents and total conceptual vocabulary rather than vocabulary size. De Anda and Friend (2020) found that within-language receptive vocabulary size doesn't reliably predict priming, but total cross-language vocabulary (TCV) does. By 18 months, lexical-semantic priming was marginally correlated with TCV.

Farag (2013) reported weaker effects in bilingual toddlers compared to monolinguals, likely due to

smaller vocabularies. He emphasized that vocabulary size in each language is related to semantic connectivity. Floccia et al. (2020) found that by 27 months, toddlers showed robust priming regardless of dominance or linguistic distance. They also observed that translation equivalents facilitate forward priming more than backward priming.

Sheng et al. (2013) found language experience influenced priming in children. Children with higher English exposure produced more paradigmatic responses, while higher Spanish exposure led to more syntagmatic responses.

In adults, Kousaie and Phillips (2010) showed that younger bilinguals activated both meanings of homographs, while older adults relied on contextual cues. Langley et al. (2008) reported that older adults benefit from semantically supportive contexts. Macdonald (2013) showed semantic neighborhood density affects processing, but no age-related differences in interference.

Discussion

The thematic findings reveal two main aspects of age-related semantic priming among bilinguals: a shared developmental trajectory and diverse characteristics of priming across age groups.

Addressing the primary question, results consistently demonstrate that semantic priming begins to emerge around 24 months and stabilizes by 30 months. This developmental pattern is supported by several studies (De Anda & Friend, 2020; Farag, 2013; Floccia et al., 2020) and is evident in both within- and cross-language priming. Findings from older children and adults (Kousaie & Phillips, 2010; Macdonald, 2013; Sheng et al., 2013) show that while processing strategies may adapt over time, the ability to engage in semantic networks remains stable throughout life.

For the sub-question, studies reveal that the characteristics of semantic priming, timing, strength, language dominance, and processing strategies, are developmentally dynamic. Toddlers rely heavily on dominant-language exposure (Singh, 2014), while by 27 months, priming becomes more symmetrical (Floccia et al., 2020). Older children exhibit more robust and flexible associations influenced by language use patterns (Sheng et al., 2013). In adults, cognitive aging shifts priming from automatic to context-dependent mechanisms (Kousaie & Phillips, 2010; Langley et al., 2008).

Comparing across studies, it shows that early limitations in semantic priming are not lasting difficulties but reflect normal stages of development shaped by vocabulary size, exposure frequency, and conceptual overlap. Over time, these constraints lead to more sophisticated and adaptive processing strategies.

Together, the findings support a model in which bilingual semantic networks are both developmentally consistent and highly adaptable. Early experiences with language input and dominance structure the initial priming responses, while later stages reflect an increased capacity for context-sensitive semantic activation. This underscores the importance of considering both cognitive and linguistic development in understanding bilingual lexical processing at different stages of life.

Summary of Thematic Findings

The eight studies reviewed demonstrate that semantic priming is developmentally sensitive and influenced by exposure, vocabulary, and cognitive maturity. Key tools such as CCT, IPL, and MCDI were essential in early detection of priming. Thematic trends highlight both consistencies and divergences across age groups and languages. The findings from each study contribute to answering the research questions and are summarized below according to the identified themes and developmental stages. A comparative summary of the findings is presented in the appendix tables (see Tables 3 and 4).

Conclusion

This review highlights that semantic priming in bilinguals typically emerges around 24 months and stabilizes by 30 months. Its key characteristics, in terms of timing, strength, processing strategies, and language dominance, continue to evolve across the lifespan. While toddlers often exhibit fragile, dominance-driven effects, older children and adults demonstrate more flexible and context-sensitive priming patterns.

Despite these insights, the current review is constrained by a relatively small and methodologically diverse pool of studies, as well as a lack of research on underrepresented language pairs and gender-related differences. Future research should aim to broaden linguistic diversity, incorporate sociocultural and gender variables, and adopt longitudinal designs to track the development of semantic priming over time.

The findings of this review carry practical implications for educators, speech-language pathologists, and curriculum developers working with bilingual populations. A deeper understanding of how semantic priming changes with age can inform more effective language instruction, early intervention programs, and diagnostic tools tailored to bilingual learners. Furthermore, recognizing age-specific processing strategies can support the creation of language-rich environments that enhance semantic activation and foster long-term lexical development.

References

Altarriba, J., & Basnight-Brown, D. M. (2007). The representation of emotion vs. emotion-laden words in English and Spanish in the bilingual mental lexicon. *Bilingualism: Language and Cognition, 10*(3), 295–309. https://doi.org/10.1017/S1366728907003058

Ben-Haim, M. S., Chajut, E., Hassin, R. R., & Algom, D. (2015). Speeded naming or naming speed? The automatic effect of object speed on performance. *Journal of Experimental Psychology: General*, *144*(2), 326.

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology, 3*(2), 77–101. https://doi.org/10.1191/1478088706qp063oa

Curtin, S., Byers-Heinlein, K., & Werker, J. F. (2011). Bilingual beginnings as a lens for theory development: PRIMIR in focus. *Journal of Phonetics*, *39*(4), 492-504.

De Anda, S., & Friend, M. (2020). Lexical-semantic development in bilingual toddlers at 18 and 24 months. *Frontiers in Psychology*, *11*, 508363.

de Groot, A. M. B. (1992). Determinants of word translation. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 18*(5), 1001–1018. https://doi.org/10.1037/0278-7393.18.5.1001

Dufour, R., & Kroll, J. F. (1995). Matching words to concepts in two languages: A test of the concept mediation model of bilingual representation. *Memory & Cognition, 23*(2), 166–180. https://doi.org/10.3758/BF03197219

Farag, R. (2013) *Lexical/semantic organisation in bilingual and monolingual infants*. Thesis. University of Plymouth. Retrieved from https://pearl.plymouth.ac.uk/fose-theses-other/245

Ferrand, L., & New, B. (2004). Semantic and associative priming in the mental lexicon. In P. Bonin (Ed.), *Mental lexicon: "Some words to talk about words"* (pp. 25–43). Nova Science Publishers.

Floccia, C., Delle Luche, C., Lepadatu, I., Chow, J., Ratnage, P., & Plunkett, K. (2020). Translation equivalent and cross-language semantic priming in bilingual

toddlers. *Journal of Memory and Language*, *112*, 104086.

Harley, T. A. (2014). *The psychology of language: From data to theory* (4th ed.). Psychology Press.

Jared, D., & Kroll, J. F. (2001). Do bilinguals activate phonological representations in one or both of their languages when naming words? *Journal of Memory and Language, 44*(1), 2–31. https://doi.org/10.1006/jmla.2000.2747

Kousaie, S., & Phillips, N. A. (2010). Age-related differences in interlingual priming: A behavioural and electrophysiological investigation. *Aging, Neuropsychology, and Cognition*, *18*(1), 22-55.

Kroll, J. F., & Stewart, E. (1994). Category interference in translation and picture naming: Evidence for asymmetric connections between bilingual memory representations. *Journal of Memory and Language*, *33*(2), 149–174. https://doi.org/10.1006/jmla.1994.1008

Kroll, J. F., & Tokowicz, N. (2005). Models of bilingual representation and processing: Looking back and to the future. In J. F. Kroll & A. M. B. de Groot (Eds.), *Handbook of bilingualism: Psycholinguistic approaches* (pp. 531–553). Oxford University Press.

Kutas, M., & Federmeier, K. D. (2011). Thirty years and counting: finding meaning in the N400 component of the event-related brain potential (ERP). *Annual review of psychology*, *62*(1), 621-647.

Langley, L. K., Saville, A. L., Gayzur, N. D., & Fuentes, L. J. (2008). Adult age differences in attention to semantic context. *Aging, Neuropsychology, and Cognition*, *15*(6), 657-686.

Macdonald, G. (2013). Aging and semantic processing. *Dissertation Abstracts International: Section B: The Sciences and Engineering, 74*(6-B(E)).

Marian, V., & Shook, A. (2012). The Cognitive Benefits of Being Bilingual. *Cerebrum: The Dana Forum on Brain Science*, *2012*, 13. https://pmc.ncbi.nlm.nih.gov/articles/PMC3583091/

Mendis, S. B., Raymont, V., & Tabet, N. (2021). Bilingualism: a global public health strategy for healthy cognitive aging. *Frontiers in Neurology*, *12*. https://doi.org/10.3389/fneur.2021.628368

Meyer, D. E., & Schvaneveldt, R. W. (1971). Facilitation in recognizing pairs of words: Evidence of a dependence between retrieval operations. *Journal of Experimental Psychology, 90*, 227–235

Neely, J. H. (1991). Semantic priming effects in visual word recognition: A selective review of current findings and theories. In D. Besner & G. W. Humphreys (Eds.), *Basic processes in reading: Visual word recognition* (pp. 264–336). Lawrence Erlbaum Associates.

Reisberg, D. (2007). *Cognition: Exploring the science of the mind* (3rd ed.). W. W. Norton.

Sakai, K. L. (2005). Language acquisition and brain development. *Science*, *310*(5749), 815–819. https://doi.org/10.1126/science.1113530

Sheng, L., Bedore, L. M., Peña, E. D., & Fiestas, C. (2013). Semantic development in Spanish–English bilingual children: Effects of age and language experience. *Child development*, *84*(3), 1034-1045.

Singh, L. (2014). One world, two languages: Cross-language semantic priming in bilingual toddlers. *Child development*, *85*(2), 755-766.

Wagner, A. D., & Koutstaal, W. (2002). Priming. In V.S. Ramachandran *(Ed.), Encyclopedia*

of the human brain (pp. 27-46). Academic Press. https://doi.org/10.1016/B0-12-227210-2/00286-7

Weingarten, E., Chen, Q., McAdams, M., Yi, J., Hepler, J., & Albarracín, D. (2016). From primed concepts to action: A meta-analysis of the behavioral effects of incidentally presented words. *Psychological Bulletin, 142*(5), 472–497. https://doi.org/10.1037/bul0000030

Appendices

Table 1

Inclusion and Exclusion Criteria

Parameters	Inclusion Criteria	Exclusion Criteria
Population and Context	• Bilingual individuals of any age group (toddlers, children, adults). • Participants from varied educational and sociolinguistic backgrounds (e.g., students, immigrants, heritage speakers). • Studies situated in bilingual or multilingual contexts that explore language processing or acquisition.	• Studies that included only monolingual participants. • Participants with cognitive, neurological, or language disorders. • Studies lacking a clear bilingual or multilingual focus.
Focus and Outcomes	• Studies investigating semantic priming in bilinguals. • Research examining age-related effects on semantic processing (e.g., timing, strength, language dominance, processing strategies). • Studies exploring cognitive and linguistic development across developmental stages.	• Studies unrelated to semantic priming or bilingual semantic processing. • Research focused solely on syntax, production, or unrelated linguistic domains. • Studies not addressing developmental or age-related differences.
Study Design and Publication Type	• Primary research using experimental, quasi-experimental, longitudinal, cross-sectional, or mixed methods. • Peer-reviewed articles, theses, dissertations, and unpublished manuscripts with accessible full texts.	• Editorials, commentaries, opinion pieces. • Review articles without systematic methods. • Inaccessible or untranslated full-text studies.
Time Frame and Language	• Studies published within the last two decades. • Studies in English or other languages with reliable translations available.	• Older studies published prior to the early 2000s. • Studies in other languages without accessible translations.

Table 2

Braun and Clarke's (2006) Six Phases of Thematic Analysis

Phase	Description Related to the Review
1. Familiarising Yourself with Your Data	Repeated reading and annotation of selected studies to understand the context, findings, and relevance.
2. Generating Initial Codes	Identifying key concepts related to semantic priming, bilingual development, language dominance, and age-related cognitive mechanisms.
3. Searching for Themes	Grouping codes into broader age-related and experiential categories representing emergent patterns.
4. Reviewing Themes	Checking coherence, consistency, and representation of patterns across developmental stages and study contexts.
5. Defining and Naming Themes	Formulating clear thematic labels (e.g., developmental trajectories, priming characteristics) to reflect the central findings.
6. Producing the Report	Synthesizing and interpreting themes to answer the research questions and highlight gaps for future research.

Table 3

Developmental Trajectories in Semantic Priming Across Age Groups

Study	Age Group	Methodological Tools	Key Findings on Emergence and Development
Farag (2013)	18–30 months	IPL	No priming at 18 months; robust within-language priming at 30 months (mono), cross-language at 30 months (bilingual)
De Anda & Friend (2020)	18–24 months	CCT, IPL, MCDI	Emergent priming at 18 months; robust by 24 months; supports similar developmental timing across mono and bilinguals
Floccia et al. (2020)	27 months	Translation Equivalent Priming	Robust cross-language priming; unaffected by dominance or linguistic distance
Singh (2014)	2.5 years	Eye-tracking, Supercoder	Stronger effects in dominant language; cross- and within-language priming present
Sheng et al. (2013)	7–9 years	Repeated Word Association	Older children show stronger semantic depth; more code-switching
Macdonald (2013)	Adults (mean 21 and 67.2 years)	Semantic Neighborhood Task	Consistent priming across ages; similar interference effects
Langley et al. (2008)	18–28 and 61–79 years	Lexical Decision, Contextual Cues	Both age groups benefit from context; older adults slower but accurate
Kousaie & Phillips (2010)	Young & older adults	ERP, Reaction Time	Semantic priming in both groups; older adults rely more on context cues

Table 4

Developmental Differences in Priming Characteristics

Study	Dominance Sensitivity	Processing Strategies	Vocabulary Effects
Singh (2014)	Stronger in dominant language	Language-dependent activation	Not explored deeply
De Anda & Friend (2020)	Moderate dominance effect	Conceptual mapping: early TCV importance	TCV predicts priming; within-language vocab not reliable
Farag (2013)	Mixed; more consistent in monolinguals	Word-word vs. word-image affects outcomes	Vocabulary size affects strength
Floccia et al. (2020)	Minimal dominance effect	Robust priming across types	No dominance or language distance effect
Sheng et al. (2013)	Exposure-dependent asymmetries	Paradigmatic vs. syntagmatic use	Age + exposure shape depth
Macdonald (2013)	None	Consistent lexical decision strategies	Neighborhood size impacts processing
Langley et al. (2008)	Context-based priming	Controlled vs. automatic shift	Context aids older adults
Kousaie & Phillips (2010)	Age-based strategy shift	Homograph disambiguation	ERP shows delayed activation in older group