Focus on ELT Journal
Vol 7, Issue 2, 2025
ISSN: 2687-5381

Resolving the bilingual advantage paradox: The role of individual differences in executive function

[a]Mehraneh Tahak **[b]Bahram Moghaddas**

[a]Khazar Institute of Higher Education, Iran, mehrnehthk1997@gmail.com
[b]Khazar Institute of Higher Education, Iran, dr.moghaddas@khazar.ac.ir

APA Citation: Tahak, M., & Moghaddas, B. (2025). Resolving the bilingual advantage paradox: The role of individual differences in executive function. *Focus on ELT Journal, 7*(2), 98-113. https://doi.org/10.14744/felt.7.2.6

ABSTRACT

The "bilingual advantage" hypothesis—the claim that lifelong bilingualism enhances executive functions (EF)-has been a subject of intense debate. While numerous studies have reported cognitive benefits, a growing body of research has failed to replicate these findings, creating a significant paradox in the field. This article argues that inconsistent results can be better understood by moving beyond a categorical approach that treats bilingualism as a monolithic experience. Building on existing scholarship that has recognized the heterogeneity of bilingual populations, we propose that the cognitive effects of bilingualism are not a universal property but an emergent outcome of a complex interplay of individual difference factors. This paper reviews the conflicting evidence and advocates for a shift towards a continuous, experience-based model, synthesizing research on linguistic factors, sociodemographic variables, and their neural correlates. By integrating evidence from behavioral measures and neuroimaging techniques, we outline a framework for understanding how specific bilingual experiences shape neural plasticity and modulate EF performance. This individual-differences approach offers a path toward resolving the current paradox and has implications for applied linguistics, educational policy, and our understanding of brain-cognition relationships.

Keywords
bilingualism, executive function, cognitive advantage, neuroimaging, individual differences, applied linguistics, neuroplasticity.

Article History
Received : 07.07.2025
Revised : 19.12.2025
Accepted : 24.12.2025
Published : 30.12.2025

Type
Article

Introduction

For several decades, the notion that bilingualism confers non-linguistic cognitive benefits has captivated researchers, educators, and the public alike. The seminal work of Peal and Lambert (1962) overturned the then-prevailing view of bilingualism as a cognitive handicap, suggesting instead that it could lead to enhanced cognitive flexibility. This line of inquiry was revitalized and formalized in the late 20th and early 21st centuries, primarily through the extensive research program of Bialystok and colleagues, leading to the formulation of the "bilingual advantage hypothesis" (Bialystok, 2001; Bialystok et al., 2012). The core of this hypothesis posits that the constant need to manage and control two or more languages places high demands on the brain's executive function (EF) system, a set of top-down mental processes responsible for planning, focusing attention, inhibiting distractions, and multitasking. This continuous cognitive engagement is believed to result in more efficient and robust EF, with potential benefits

✉**Corresponding Author:** mehrnehthk1997@gmail.com

extending across the lifespan, including a possible delay in the onset of dementia symptoms (Bialystok et al., 2007).

However, the bilingual advantage hypothesis has been significantly challenged. A substantial number of well-controlled studies have failed to find significant differences in EF performance between bilingual and monolingual groups (de Bruin et al., 2015; Paap et al., 2015). This wave of null findings, coupled with meta-analyses revealing potential publication bias (Lehtonen et al., 2018), has created what can be termed the "bilingual advantage paradox." On the one hand, there is a compelling theoretical framework and empirical evidence supporting the advantage; on the other, there is equally compelling evidence against it.

This paradoxical state of affairs suggests that the fundamental research question may have been framed too simplistically. Indeed, researchers within the bilingual advantage tradition have themselves recognized this limitation. As Luk and Bialystok (2013) have argued, the traditional approach, which often compares a broadly defined "bilingual" group with a "monolingual" control group, overlooks the immense heterogeneity that exists within the bilingual population. Bilingualism is not a binary state but a multidimensional continuum of experience. Individuals differ vastly in their age of language acquisition, proficiency levels, the contexts in which their languages are used, the frequency of code-switching, and their cultural and socioeconomic environments.

This article builds upon and extends this existing recognition of bilingual heterogeneity by proposing a comprehensive framework that synthesizes findings across linguistic, social, and neurocognitive domains. We contend that while the importance of individual differences has been acknowledged in the literature, a systematic integration of these factors—particularly through the lens of neuroimaging evidence—can bring new light to the contradictions that have characterized this field. The cognitive effects of bilingualism are not a guaranteed outcome but are contingent upon the specific nature and quality of an individual's multilingual experience.

This paper will first review the foundational literature on the bilingual advantage and the subsequent replication crisis. Second, it will present a detailed framework of critical individual difference factors that modulate the relationship between bilingualism and EF. Third, it will explore how neuroimaging evidence provides a mechanistic link between language experience and cognitive outcomes. Finally, we will discuss the implications for theory, educational practice, and policy in multilingual societies.

The Literature: Unpacking the Bilingual Advantage Paradox

The Genesis and Core Tenets of the Bilingual Advantage Hypothesis

The modern bilingual advantage hypothesis is largely built upon the work of Bialystok (2001, 2017), who proposed a specific mechanism linking language processing to EF. According to this model, because both languages are always active to some degree in the bilingual mind, even in a monolingual context, a constant process of selection and inhibition is required (Green, 1998). To produce a word in Language A, the representation of the equivalent word in Language B must be suppressed. This process of managing inter-language competition is thought to engage and thereby strengthen the domain-general EF system, particularly inhibitory control and cognitive flexibility.

Empirical support for this hypothesis came from studies using classic EF tasks. Bilingual children were found to outperform monolinguals on tasks requiring them to ignore

conflicting perceptual information, such as the Simon task and the Attentional Network Test (ANT) (Bialystok & Martin, 2004; Costa et al., 2008). These advantages were reported across the lifespan, including in older adults, where several studies suggested that lifelong bilingualism could contribute to cognitive reserve, potentially delaying the clinical manifestation of dementia (Alladi et al., 2013; Bialystok et al., 2007).

The Replication Crisis and Critical Perspectives

Despite initial enthusiasm, the empirical foundation of the bilingual advantage began to show cracks. Starting in the early 2010s, a growing number of researchers reported failures to replicate the original findings. Paap et al. (2015) published a series of studies that found no evidence of a bilingual advantage in young adults across a wide range of EF tasks, even after controlling for potential confounding variables like socioeconomic status and immigration status (Paap et al., 2015; Paap & Greenberg, 2013). Similarly, de Bruin et al. (2015) conducted a direct replication of a study by Bialystok et al. (2004) and found no group differences in EF.

The de Bruin et al. (2015) study is particularly instructive in understanding the broader methodological concerns in this field. In addition to their replication attempt, the authors conducted an analysis of conference abstracts submitted to bilingualism conferences over a 15-year period. They found that studies reporting a bilingual advantage were significantly more likely to be subsequently published in peer-reviewed journals than studies reporting null results or a monolingual advantage. This pattern is indicative of what is known as the "file-drawer problem" (Rosenthal, 1979)—a form of publication bias in which studies with statistically significant or theoretically expected results are more likely to be published, while studies with null or unexpected findings remain unpublished. The consequence is that the published literature may present an inflated picture of a phenomenon's true effect size.

This skepticism was amplified by a large-scale meta-analysis conducted by Lehtonen et al. (2018). Analyzing data from 152 studies, they found a very small overall effect size for a bilingual advantage, which disappeared completely when they controlled for publication bias. Their conclusion was stark: the existing evidence did not provide robust support for the bilingual advantage hypothesis. Similarly, Donnelly, Brooks, and Homer (2019) conducted a comprehensive review and concluded that the evidence for bilingual cognitive advantages was "inconsistent at best" attributing positive findings to methodological artifacts and confounding variables.

More recently, several scholars have offered theoretical critiques of the bilingual advantage framework itself. Paap et al. (2021) argued that the original theoretical mechanism—that bilinguals constantly inhibit one language while using another—may be overstated, as research on bilingual language production suggests that inhibition may not be as pervasive or demanding as initially assumed. Antón et al. (2019) further demonstrated that when studies employ more rigorous methodological controls, including larger sample sizes and comprehensive matching procedures, the bilingual advantage often fails to emerge.

Another meta-analysis by van den Noort et al. (2019) reached a more moderate conclusion, suggesting that advantages might exist but are likely moderated by a host of factors. The field thus remains divided, with proponents pointing to methodological flaws in null-finding studies and skeptics highlighting the fragility of the original claims (Bialystok, 2017;

Paap et al., 2021). Crucially, this division suggests not that one side is correct, but that the phenomenon is more complex than a simple categorical comparison can capture.

Moving Beyond Categorical Comparisons

The resolution to this impasse does not lie in declaring the advantage either a "myth" or a "fact" but in recognizing the limitations of the original research paradigm. Treating "bilinguals" as a single, homogenous group is akin to conducting a study on the health benefits of "sports" without differentiating between a professional marathon runner, a weekend golfer, and someone who occasionally walks their dog. The cognitive impact of bilingualism is likely not an all-or-nothing phenomenon but is instead graded and dependent on the specific demands an individual's language experience places on their brain (Luk & Bialystok, 2013). This perspective, increasingly endorsed by researchers on both sides of the debate (Bialystok, 2017; Paap et al., 2021), shifts the research question from "Is there a bilingual advantage?" to "Under what conditions, and for whom, do specific cognitive advantages emerge from bilingual experience?" (Grosjean, 2010).

A Framework of Individual Differences: Operational Definitions and Key Variables

To answer this refined research question, we must systematically investigate the factors that shape a bilingual's linguistic life. This section provides operational definitions for key individual-difference variables, organized into linguistic and sociodemographic categories, to ensure conceptual precision and guide future empirical testing.

Linguistic Factors

Age of Acquisition (AoA)

Definition: AoA refers to the chronological age at which an individual began systematic exposure to and acquisition of each language. This variable is typically operationalized through three categories:

- Simultaneous bilinguals: Individuals exposed to two languages from birth or within the first year of life.
- Early sequential bilinguals: Individuals who acquired their second language (L2) during early childhood, typically before age 6-7, corresponding to the period before formal schooling consolidates literacy in the first language (L1).
- Late bilinguals: Individuals who acquired their L2 after childhood, typically after age 12, when the critical period for language acquisition is generally considered to have closed.

Measurement: AoA is commonly assessed through language background questionnaires (e.g., LEAP-Q; Marian et al., 2007), which ask participants to report the age at which they began learning each language and the contexts of early exposure.

Relevance to EF: It has been hypothesized that early, lifelong immersion provides the most sustained training for the EF system, potentially leading to more robust cognitive effects

than late-learned bilingualism (Luk et al., 2011). However, research also suggests that the process of learning and mastering an L2 later in life can induce significant neurocognitive changes (DeLuca et al., 2019), complicating a simple "earlier is better" narrative.

Language Proficiency and Dominance

Definition: Proficiency refers to an individual's level of competence in each language across multiple domains (speaking, listening, reading, writing). Dominance refers to the relative strength of one language over another, which may vary across contexts and modalities.

Measurement: Proficiency can be assessed through:

- Self-report measures: Likert-scale ratings of ability in each skill area (e.g., LEAP-Q).
- Objective measures: Standardized vocabulary tests (e.g., Peabody Picture Vocabulary Test), grammaticality judgment tasks, verbal fluency tasks (e.g., category and letter fluency), and narrative production measures.
- Dominance indices: Calculated by comparing proficiency scores or usage frequencies across languages.

Relevance to EF: Highly proficient, balanced bilinguals may experience greater cross-language competition and thus receive more EF "training" than unbalanced bilinguals who are heavily dominant in one language (Yow & Li, 2015). The degree of proficiency imbalance may determine the extent of inhibitory demands during language use.

Patterns of Language Use

Definition: This variable captures how, when, and with whom an individual uses each language in daily life. It encompasses frequency of use, contexts of use, and the nature of language mixing.

Measurement: Language use patterns are assessed through:

- Daily usage diaries: Participants log their language use across different contexts over a specified period.
- Questionnaires: Instruments like the Bilingual Switching Questionnaire (BSQ; Rodriguez-Fornells et al., 2012) or the Code-Switching Questionnaire (CSQ; Beatty-Martínez et al., 2020) capture switching frequency and contexts.
- Ecological momentary assessment: Smartphone-based sampling of real-time language use throughout the day.

Relevance to EF: Green and Abutalebi's (2013) Adaptive Control Hypothesis provides a theoretical framework for understanding how different usage patterns engage different control processes:

- Dual-language contexts: Environments requiring frequent switching between languages within conversations (e.g., bilingual workplaces, interpreter settings) place high demands on cognitive flexibility and task-switching mechanisms.
- Single-language contexts: Environments where languages are compartmentalized (e.g., one language at home, another at work) place demands on goal maintenance and interference suppression.
- Dense code-switching: Rapid, within-sentence language mixing requires continuous lexical selection and inhibition, potentially providing intensive EF training (Blanco-Elorrieta & Pylkkänen, 2017).

A bilingual who actively and frequently juggles languages in demanding environments is more likely to show cognitive benefits than a "dormant" bilingual who rarely uses their L2 (Beatty-Martínez et al., 2020).

Language Distance

Definition: Language distance refers to the typological similarity or difference between a bilingual's two languages, encompassing phonological, lexical, syntactic, and orthographic dimensions.

Measurement: Language distance can be quantified using:

- Linguistic databases: Tools like the Automated Similarity Judgment Program (ASJP) or the World Atlas of Language Structures (WALS) provide objective metrics of cross-linguistic similarity.
- Feature-based comparisons: Researchers may calculate distance based on specific features relevant to their hypotheses (e.g., phoneme inventory overlap, word order similarity).

Relevance to EF: Managing two closely related languages (e.g., Spanish and Italian) with significant lexical and phonological overlap may pose different control demands than managing two distant languages (e.g., Mandarin and English) (Vega-Mendoza et al., 2015). Greater overlap may increase interference and thus inhibitory demands, while greater distance may require more extensive representational separation.

Sociodemographic and Experiential Factors

Socioeconomic Status (SES)

Definition: SES is a composite measure of an individual's or family's economic and social position, typically encompassing income, education, and occupational status.

Measurement: SES is operationalized through:

- Income: Household income, often adjusted for family size and regional cost of living.
- Education: Years of formal schooling and/or highest degree obtained, for the individual and/or parents.
- Occupation: Occupational prestige indices (e.g., International Socio-Economic Index of Occupational Status).
- Composite indices: Standardized combinations of the above factors, such as the Hollingshead Index or neighborhood-level measures.

Relevance to EF: SES is a powerful predictor of cognitive development and performance, and it represents a major confounding variable in bilingualism research (Morton & Harper, 2007). In many Western contexts, bilingualism is often associated with immigrant communities that may have, on average, lower SES than the monolingual majority. The cognitive disadvantages associated with low SES (e.g., related to nutrition, chronic stress, reduced educational opportunities) could mask or overwhelm any potential cognitive advantage from bilingualism. Conversely, high-SES "elite" bilinguals may show enhanced EF due to combined benefits of bilingualism and a privileged background. Failure to adequately control for SES represents one of the most significant criticisms of the early bilingual advantage literature (Paap et al., 2015).

Education Level and Quality

Definition: Education encompasses both the quantity (years of schooling) and quality (type of institution, instructional approaches) of formal educational experience.

Measurement:

- Years of education: Total years of formal schooling completed.
- Educational attainment: Highest degree or qualification obtained.
- Quality indicators: School type (public/private), class sizes, teacher qualifications, curriculum characteristics.

Relevance to EF: Education is a strong determinant of cognitive reserve and EF performance across the lifespan (Valian, 2015). Any comparison between bilinguals and monolinguals must meticulously match groups on educational attainment and, where possible, educational quality.

Cultural Context and Literacy

Definition: Cultural context refers to the societal attitudes toward bilingualism and the opportunities for language use that the environment provides. Literacy encompasses reading and writing abilities in each language.

Measurement:

- Cultural context: Assessed through questions about community language demographics, societal status of each language, and availability of bilingual education and media.
- Literacy: Standardized reading comprehension and writing assessments in each language.

Relevance to EF: Being biliterate (literate in two languages) may impose different and potentially greater cognitive demands than being bilingual but monoliterate (García & Li, 2014). The cultural status of a language may also influence how actively and confidently it is used.

Neuroplasticity Markers

Definition: Neuroplasticity markers are structural and functional brain measures that index experience-dependent changes in neural organization. In the context of bilingualism, these markers provide evidence of how language experience shapes the brain.

Measurement:

- Structural markers (grey matter): Voxel-based morphometry (VBM) and surface-based morphometry measure grey matter volume, density, and cortical thickness in regions of interest.
- Structural markers (white matter): Diffusion tensor imaging (DTI) provides measures of white matter integrity, including fractional anisotropy (FA), mean diffusivity (MD), and tract-specific volumes.
- Functional markers: Functional MRI (fMRI) measures blood-oxygen-level-dependent (BOLD) signal changes during task performance, indexing regional activation and inter-regional connectivity.

Relevance to EF: Neuroplasticity markers serve as intermediate phenotypes that can illuminate the mechanisms by which bilingual experience influences cognition. They allow researchers to test whether specific experiential factors (e.g., AoA, usage patterns) predict neural changes that, in turn, predict EF performance.

The Neural Substrates: Linking Experience to the Brain

Neuroimaging provides a powerful lens through which to observe the effects of varied bilingual experiences on brain structure and function. It allows us to move beyond purely behavioral measures and investigate the underlying neural mechanisms that may mediate cognitive outcomes.

Functional Neuroplasticity: Efficiency and Compensation

Functional magnetic resonance imaging (fMRI) studies have been pivotal in identifying the neural networks involved in language control. These studies consistently show that bilinguals, when performing language switching and EF tasks, recruit a network of brain regions including the prefrontal cortex (PFC), anterior cingulate cortex (ACC), and basal ganglia—collectively termed the "bilingual language control network" (Abutalebi & Green, 2016).

Crucially, the pattern of activation within this network appears to be modulated by bilingual experience. Research using specific paradigms illustrates these effects:

Language Switching Paradigms: In cued language-switching tasks, where participants name pictures in one language or another based on a cue, bilinguals show robust activation of the dorsolateral PFC and ACC during switch trials compared to repeat trials (Abutalebi et al., 2012). Importantly, the magnitude of this activation varies with language proficiency: more balanced bilinguals show smaller switch costs and more efficient neural responses, suggesting that extensive practice with switching leads to more streamlined neural processing.

Flanker and Simon Tasks: When bilinguals perform non-linguistic conflict tasks, such as the Flanker task (responding to a central arrow while ignoring flanking arrows) or the Simon task (responding based on color while ignoring spatial location), they engage similar frontal control regions. Studies comparing bilinguals and monolinguals on these tasks have yielded mixed results, but those that find group differences often observe that bilinguals show reduced activation in conflict-monitoring regions while achieving equivalent or superior performance—a pattern consistent with neural efficiency (Abutalebi et al., 2012).

Aging and Neural Compensation: In older adults, a different pattern emerges. Gold et al. (2013) used a perceptual switching task and found that older bilinguals showed greater activation in frontal regions compared to age-matched monolinguals, while maintaining equivalent behavioral performance. This pattern is interpreted not as inefficiency, but as neural compensation—a key component of cognitive reserve—where the bilingual brain recruits additional resources to maintain function in the face of age-related decline.

These seemingly contradictory findings—efficiency in young adults, compensation in older adults—can be reconciled within the individual-differences framework: the nature of bilingual effects on brain function may shift across the lifespan, with intensive bilingual experience first optimizing neural function and later providing reserve capacity.

Structural Neuroplasticity: Grey and White Matter Changes

The effects of bilingualism extend to brain structure, providing evidence of experience-dependent anatomical reorganization.

Grey Matter Changes

Several studies using voxel-based morphometry (VBM) have reported increased grey matter density or volume in bilinguals compared to monolinguals in specific brain areas:

- Left inferior parietal lobule: Mechelli et al. (2004) found increased grey matter density in this region, which is associated with vocabulary knowledge and phonological processing. Crucially, grey matter density correlated positively with L2 proficiency and negatively with AoA, providing direct evidence that the experience of using two languages physically remodels the brain.
- Anterior cingulate cortex: Abutalebi et al. (2012) found increased grey matter volume in the ACC—a key node in the conflict-monitoring network—in bilinguals compared to monolinguals. ACC volume was correlated with performance on conflict tasks, suggesting a functional significance of this structural difference.
- Subcortical structures: Pliatsikas et al. (2017) found that bilingual immersion experience was associated with changes in the shape and volume of subcortical structures, including the caudate nucleus and putamen, which are involved in language control and cognitive flexibility.

White Matter Changes

Diffusion tensor imaging (DTI) allows examination of white matter tract integrity. Key findings include:

- Corpus callosum: Luk et al. (2011) found that lifelong bilinguals showed greater white matter integrity (higher FA values) in the corpus callosum, which connects the two hemispheres, compared to monolinguals. This enhanced connectivity could facilitate more rapid interhemispheric communication during language and cognitive control.
- Superior longitudinal fasciculus: This tract connects frontal and parietal regions involved in attention and cognitive control. Several studies have found enhanced integrity in this tract among bilinguals, with the degree of enhancement correlated with language use variables rather than proficiency alone (Pliatsikas et al., 2017).
- Dynamic changes with immersion: DeLuca et al. (2019) conducted a longitudinal study of L2 learners undergoing immersion and found that white matter changes emerged within months of immersion onset, with the degree of change predicted by intensity of L2 use. This demonstrates that structural neuroplasticity is not limited to early bilinguals but can occur with adult language learning under intensive conditions.

Comprehensive Research Designs

To empirically test the multifactorial framework outlined above, future research must move beyond simple group comparisons. While existing studies have begun to examine some

variables in isolation, fully integrated approaches remain rare. Several recent studies offer promising methodological templates.

DeLuca et al. (2019) examined L2 immersion experience as a continuous variable, finding that duration of immersion predicted grey matter changes independently of proficiency. Beatty-Martínez et al. (2020) developed the Code-Switching Questionnaire (CSQ) to capture fine-grained patterns of language switching behavior, demonstrating that such measures can predict performance on cognitive tasks. Gullifer et al. (2018) used social network analysis to characterize bilinguals' language environments, finding that diversity of language contacts predicted both neural and behavioral measures.

A comprehensive research program in this area would incorporate:

1. Participants: Large, diverse samples of bilinguals varying systematically across AoA, proficiency, and language usage patterns, alongside well-matched monolingual control groups. Power analyses should guide sample size decisions, with the recognition that multivariate designs typically require larger samples than traditional two-group comparisons.

2. Behavioral Measures:

- Detailed language history: Comprehensive questionnaires (e.g., LEAP-Q) capturing AoA, contexts of use, self-rated proficiency, and frequency of code-switching.
- Objective proficiency tests: Standardized tests of vocabulary, grammar, and fluency in each language.
- EF battery: Tasks targeting inhibition (e.g., Flanker, Stroop), switching (e.g., color-shape switching), and working memory updating (e.g., N-back).
- Covariate assessment: Detailed measurement of SES, education, and nonverbal intelligence (e.g., Raven's Progressive Matrices).

3. Neuroimaging Measures:

- sMRI and VBM for grey matter morphometry.
- DTI for white matter tractography and integrity measures.
- Task-based fMRI using established paradigms (e.g., Flanker task, language switching task) to assess functional activation and connectivity.

4. Analytical Approaches: Rather than categorical group comparisons, analyses should employ:

- Multiple regression models testing continuous predictors of EF and neural measures.
- Moderation analyses examining whether factors like code-switching frequency moderate bilingualism-EF relationships.
- Mediation models testing whether neural measures mediate the relationship between experience and behavior.
- Structural equation modeling to test comprehensive models incorporating multiple predictors, mediators, and outcomes.

We acknowledge that such comprehensive designs are resource-intensive. However, large-scale collaborative projects, pre-registered multi-site studies, and secondary analysis of existing datasets offer pragmatic paths forward.

Discussion and Implications

Reconceptualizing the Bilingual Advantage

The individual-differences framework offers a path toward resolving the bilingual advantage paradox by reframing the phenomenon. The "advantage" should not be conceived as a static trait possessed by all bilinguals, but as a form of experience-dependent neuroplasticity. Cognitive benefits are a potential outcome, realized when an individual's bilingual experience provides consistent and demanding engagement of the executive control system. This explains why a highly skilled simultaneous interpreter might show robust EF advantages, while an individual who learned an L2 in school but rarely uses it might show none. Null findings in the literature need not refute the advantage; they may instead reflect the heterogeneous and often sub-optimal bilingual experiences of participants in those samples.

This reconceptualization also accommodates the critical perspectives reviewed earlier. The skeptics are correct that a universal bilingual advantage is not supported by evidence; the proponents are correct that bilingualism can enhance cognition under certain conditions. The individual-differences framework integrates both positions by specifying the boundary conditions under which advantages emerge.

Implications for Applied Linguistics and Language Education

This nuanced understanding has several implications for language education, which we develop here with attention to practical applications.

Promoting Cognitively Demanding Language Use

The framework reinforces the value of pedagogical approaches emphasizing active, cognitively demanding language use. While the general principle that meaningful communicative practice is preferable to rote memorization is well established, the individual-differences perspective provides a neurocognitive rationale for specific activity types:

- Interpretation and translation exercises: Activities requiring real-time conversion between languages engage the language control network intensively and may promote EF development.
- Debate and discussion: Tasks requiring rapid formulation of arguments in the L2 demand simultaneous attention to content and language form.
- Problem-solving in L2: Using the L2 for cognitively challenging tasks (e.g., mathematics, science) provides dual demands on linguistic and executive resources.

Heritage Language Education and Translanguaging

For communities with heritage language speakers, this framework underscores the importance of not just preserving but actively developing both languages. Translanguaging pedagogies (García & Li, 2014), which encourage the fluid and purposeful use of a bilingual's full linguistic repertoire, may be particularly beneficial. By treating code-switching and language mixing as

sophisticated communicative strategies rather than deficits, translanguaging approaches create learning environments that mirror the demanding dual-language contexts associated with enhanced executive control.

Assessment of Bilingual Competence

The findings invite reconsideration of how bilingual competence is conceptualized and assessed. Traditional assessments focused on discrete language skills measured against monolingual norms may miss important aspects of bilingual ability. From a cognitive perspective, a highly competent bilingual is one who can flexibly and efficiently manage linguistic resources to meet varied communicative demands. Assessment approaches that capture dynamic bilingual abilities—such as the capacity to switch languages appropriately, deploy translanguaging strategies effectively, or maintain communication under dual-task conditions—may provide more valid and comprehensive measures of bilingual competence.

Implications for Educational Policy and Curriculum Design

The individual-differences framework has significant implications for educational policy in multilingual societies.

Bilingual Education Program Design

Not all bilingual education programs are equivalent in their potential cognitive benefits. Programs that emphasize (1) active use of both languages for academic content; (b) regular opportunities for language switching in structured contexts; (c) development of biliteracy, not just bilingual oral skills; and (d) high levels of proficiency in both languages are more likely to provide the intensive bilingual experience associated with cognitive benefits. In contrast, transitional bilingual programs that use the L1 only as a bridge to L2 monolingualism, or programs that maintain strict language separation without opportunities for flexible language use, may not maximize cognitive potential.

Policy Recommendations

To empirically test the multifactorial framework outlined above, future research must move beyond simple group comparisons. While existing studies have begun to examine some variables in isolation, fully integrated approaches remain rare. Several recent studies offer promising methodological templates. Based on this framework, we offer the following policy considerations:

- Support for dual-language immersion programs: Programs that develop high proficiency and literacy in two languages, with substantial instructional time in each, create conditions conducive to cognitive benefits.
- Valuing and developing heritage languages: Policies should recognize heritage languages as cognitive resources, not obstacles to majority language acquisition. Support for heritage language maintenance and development—through community

programs, school offerings, and assessment recognition—can help heritage language speakers achieve the balanced bilingualism associated with cognitive advantages.

- Teacher preparation: Educators in multilingual settings should understand the cognitive science of bilingualism, including the potential benefits of code-switching and translanguaging, to create supportive environments for bilingual learners.
- Assessment reform: Standardized assessments should avoid penalizing bilingual students for code-switching or transfer effects, and should consider incorporating measures of bilingual competence that capture flexible language use.
- Research investment: Given the policy implications of this research, public investment in rigorous, longitudinal studies of bilingual cognitive development—particularly in diverse populations and educational contexts—is warranted.

Theoretical Contributions and Future Directions

The primary contribution of this paper lies in synthesizing research across psycholinguistic, sociolinguistic, and neurocognitive domains to provide an integrated framework for understanding the variable cognitive effects of bilingualism. While previous work has identified individual factors that moderate the bilingual advantage, less attention has been paid to how these factors interact and to the neural mechanisms that mediate experience-cognition relationships. By providing operational definitions of key variables and articulating their hypothesized relationships, we hope to enable more systematic and comparable research. Several questions remain for future investigation:

- Longitudinal studies: Cross-sectional designs cannot establish causal relationships between bilingual experience and cognitive outcomes. Longitudinal studies tracking individuals as they acquire languages or undergo immersion experiences are essential.
- Interaction effects: How do linguistic and sociodemographic factors interact? For example, does SES moderate the relationship between language use patterns and EF?
- Developmental trajectories: How do the cognitive effects of bilingualism unfold across the lifespan? Are there sensitive periods for particular types of effects?
- Cross-cultural generalization: Most research has been conducted in Western, educated populations. Studies in diverse cultural and linguistic contexts are needed.
- Cognitive costs: The individual-differences approach should extend to examining potential costs of bilingualism, such as slower lexical retrieval (Bialystok, 2009), and the conditions under which these emerge.
- Intervention studies: Can targeted interventions (e.g., code-switching training, intensive immersion) produce measurable changes in EF? Such studies would provide the strongest evidence for causal effects.

Conclusions

The bilingual advantage paradox arose from an overly simplistic research paradigm that treated bilingualism as a categorical variable. The evidence reviewed here demonstrates that a more productive approach is to investigate how specific types of bilingual experiences shape neural

organization and cognitive function. By adopting a multidimensional, individual-differences framework with clearly operationalized variables, the field can move beyond debates about whether bilingualism is "good" or "bad" for cognition toward a nuanced understanding of when, how, and for whom cognitive benefits emerge.

The cognitive effects of bilingualism are neither myth nor universal truth. They represent real, experience-dependent neuroplasticity that occurs when bilingual experience provides sustained and demanding engagement of cognitive control systems. The bilingual brain is dynamic, continuously shaped by the demands of managing multiple languages.

Understanding this complex interplay between language, cognition, and the brain represents an exciting frontier in applied linguistics and cognitive neuroscience. Beyond its scientific significance, this understanding carries practical implications: it provides a mandate for educators and policymakers to foster not merely bilingualism as a static state, but active, engaged, and cognitively demanding multilingualism as a lifelong practice.

Disclosure Statement

No potential conflict of interest was reported by the authors.

References

Abutalebi, J., & Green, D. W. (2016). Bilingual language production: The neurocognition of language representation and control. *Journal of Neurolinguistics, 40*, 1–18. https://doi.org/10.1016/j.jneuroling.2016.03.001

Abutalebi, J., Della Rosa, P. A., Green, D. W., Hernandez, M., Scifo, P., Keim, R., Cappa, S. F., & Costa, A. (2012). Bilingualism tunes the anterior cingulate cortex for conflict monitoring. *Cerebral Cortex, 22*(9), 2076–2086. https://doi.org/10.1093/cercor/bhr287

Alladi, S., Bak, T. H., Duggirala, V., Surampudi, B., Shailaja, M., Shukla, A. K., ... & Kaul, S. (2013). Bilingualism delays age at onset of dementia, independent of education and immigration status. *Neurology, 81*(22), 1938–1944. https://doi.org/10.1212/01.wnl.0000436620.33155.a8

Antón, E., Duñabeitia, J. A., Estévez, A., Hernández, J. A., Castillo, A., Fuentes, L. J., ... & Carreiras, M. (2019). Is there a bilingual advantage in the ANT task? Evidence from children. *Frontiers in Psychology, 10*, 398. https://doi.org/10.3389/fpsyg.2019.00398

Beatty-Martínez, A. L., Navarro-Torres, C. A., El-Kholy, S., & Dussias, P. E. (2020). A novel measure of everyday code-switching: The Code-Switching Questionnaire (CSQ). *International Journal of Bilingualism, 24*(5-6), 944–966. https://doi.org/10.1177/1367006920914979

Bialystok, E. (2001). *Bilingualism in development: Language, literacy, and cognition.* Cambridge University Press.

Bialystok, E. (2009). Bilingualism: The good, the bad, and the indifferent. *Bilingualism: Language and Cognition, 12*(1), 3–11. https://doi.org/10.1017/S1366728908003477

Bialystok, E. (2017). The bilingual adaptation: How minds accommodate experience. *Psychological Bulletin, 143*(3), 233–262. https://doi.org/10.1037/bul0000099

Bialystok, E., & Martin, M. M. (2004). Attention and inhibition in bilingual children: Evidence from the dimensional change card sort task. *Developmental Science, 7*(3), 325–339. https://doi.org/10.1111/j.1467-7687.2004.00351.x

Bialystok, E., Craik, F. I., & Freedman, M. (2007). Bilingualism as a protection against the onset of symptoms of dementia. *Neuropsychologia, 45*(2), 459–464. https://doi.org/10.1016/j.neuropsychologia.2006.10.009

Bialystok, E., Craik, F. I., Green, D. W., & Gollan, T. H. (2009). Bilingual minds. *Psychological Science in the Public Interest, 10*(3), 89–129. https://doi.org/10.1177/1529100610387084

Bialystok, E., Craik, F. I., & Luk, G. (2012). Bilingualism: Consequences for mind and brain. *Trends in Cognitive Sciences, 16*(4), 240–250. https://doi.org/10.1016/j.tics.2012.03.001

Blanco-Elorrieta, E., & Pylkkänen, L. (2017). Bilingual language switching in the lab vs. in the wild: The spatio-temporal dynamics of adaptive language control. *Journal of Neuroscience, 37*(37), 9022–9036. https://doi.org/10.1523/JNEUROSCI.0583-17.2017

Costa, A., Hernández, M., & Sebastián-Gallés, N. (2008). Bilingualism aids conflict resolution: Evidence from the ANT task. *Cognition, 106*(1), 59–86. https://doi.org/10.1016/j.cognition.2006.12.013

de Bruin, A., Treccani, B., & Della Sala, S. (2015). Cognitive advantage in bilingualism: An example of publication bias? *Psychological Science, 26*(1), 99–107. https://doi.org/10.1177/0956797614557866

DeLuca, V., Rothman, J., Bialystok, E., & Pliatsikas, C. (2019). Redefining bilingualism as a spectrum of experiences that differentially affects brain structure and function. *Proceedings of the National Academy of Sciences, 116*(15), 7565–7574. https://doi.org/10.1073/pnas.1811513116

Donnelly, S., Brooks, P. J., & Homer, B. D. (2019). Is there a bilingual advantage on interference-control tasks? A multiverse meta-analysis of global reaction time and interference cost. *Psychonomic Bulletin & Review, 26*(4), 1122–1147. https://doi.org/10.3758/s13423-019-01567-z

García, O., & Li, W. (2014). *Translanguaging: Language, bilingualism and education.* Palgrave Macmillan.

Gold, B. T., Kim, C., Johnson, N. F., Kryscio, R. J., & Smith, C. D. (2013). Lifelong bilingualism maintains youthful cognitive control processing in older adults. *Journal of Neuroscience, 33*(1), 284–293. https://doi.org/10.1523/JNEUROSCI.3837-12.2013

Green, D. W. (1998). Mental control of the bilingual lexico-semantic system. *Bilingualism: Language and Cognition, 1*(2), 67–81.

Green, D. W., & Abutalebi, J. (2013). Language control in bilinguals: The adaptive control hypothesis. *Journal of Cognitive Psychology, 25*(5), 515–530. https://doi.org/10.1080/20445911.2013.796377

Grosjean, F. (2010). *Bilingual: Life and reality.* Harvard University Press.

Gullifer, J. W., Chai, X. J., Whitford, V., Pivneva, I., Baum, S., Klein, D., & Bhattasali, S. (2018). Bilingual experience and resting-state brain connectivity: Impacts of L2 age of acquisition and social diversity of language use on control networks. *Neuropsychologia, 117*, 123–134. https://doi.org/10.1016/j.neuropsychologia.2018.04.037

Lehtonen, M., Soveri, A., Laine, A., Järvenpää, J., de Bruin, A., & Antfolk, J. (2018). Is bilingualism associated with enhanced executive functioning in adults? A meta-analytic review. *Psychological Bulletin, 144*(4), 394–425. https://doi.org/10.1037/bul0000142

Luk, G., & Bialystok, E. (2013). Bilingualism is not a categorical variable: Interaction between language proficiency and usage. *Journal of Cognitive Psychology, 25*(5), 605–621. https://doi.org/10.1080/20445911.2013.795574

Luk, G., Bialystok, E., Craik, F. I., & Grady, C. L. (2011). Lifelong bilingualism maintains white matter integrity in older adults. *Journal of Neuroscience, 31*(46), 16808–16813. https://doi.org/10.1523/JNEUROSCI.1375-11.2011

Luk, G., De Sa, E., & Bialystok, E. (2011). Is there a relation between onset age of bilingualism and enhancement of cognitive control? *Bilingualism: Language and Cognition, 14*(4), 588-595.

Marian, V., Blumenfeld, H. K., & Kaushanskaya, M. (2007). The Language Experience and Proficiency Questionnaire (LEAP-Q): Assessing language profiles in bilinguals and multilinguals. *Journal of Speech, Language, and Hearing Research, 50*(4), 940–967. https://doi.org/10.1044/1092-4388(2007/067)

Mechelli, A., Crinion, J. T., Noppeney, U., O'Doherty, J., Ashburner, J., Frackowiak, R. S., & Price, C. J. (2004). Neurolinguistics: Structural plasticity in the bilingual brain. *Nature, 431*(7010), 757–757. https://doi.org/10.1038/431757a

Morton, J. B., & Harper, S. N. (2007). What did Simon say? Revisiting the bilingual advantage. *Developmental Science, 10*(6), 759-766. https://doi.org/10.1111/j.1467-7687.2007.00629.x

Paap, K. R., & Greenberg, Z. I. (2013). There is no coherent evidence for a bilingual advantage in executive processing. *Cognitive Psychology, 66*(2), 232–258. https://doi.org/10.1016/j.cogpsych.2012.12.002

Paap, K. R., Johnson, H. A., & Sawi, O. (2015). Bilingual advantages in executive functioning: A reconsideration of the evidence. *Cortex, 69*, 255–270. https://doi.org/10.1016/j.cortex.2015.05.003

Paap, K. R., Sawi, O., & Dalibar, C. (2021). Progress toward resolving the bilingual advantage controversy. *Brain and Language, 221*, 104997. https://doi.org/10.1016/j.bandl.2021.104997

Peal, E., & Lambert, W. E. (1962). The relation of bilingualism to intelligence. *Psychological Monographs: General and Applied, 76*(27), 1–23.

Pliatsikas, C., DeLuca, V., & Saddy, J. D. (2020). Beyond the 'bilingual advantage': the potential effects of bilingualism on the structure of the adult brain. In K. Kroll & A. De Groot (Eds.), *The Cambridge Handbook of Bilingual Processing.* Cambridge University Press.

Pliatsikas, C., Moschopoulou, E., & Saddy, J. D. (2017). The effects of second language immersion on the structure of the adult brain. *Frontiers in Psychology, 8*, 723. https://doi.org/10.3389/fpsyg.2017.00723

Rodriguez-Fornells, A., Krämer, U. M., Lorenzo-Seva, U., Festman, J., & Münte, T. F. (2012). Self-assessment of individual differences in language switching. *Frontiers in Psychology, 2*, 388. https://doi.org/10.3389/fpsyg.2011.00388

Rosenthal, R. (1979). The file drawer problem and tolerance for null results. *Psychological Bulletin, 86*(3), 638–641. https://doi.org/10.1037/0033-2909.86.3.638

Valian, V. (2015). Bilingualism and cognition. *Bilingualism: Language and Cognition, 18*(1), 3–24.

Van den Noort, M., Struys, E., & Bosch, P. (2019). The bilingual brain and cognitive reserve. *Journal of Neurolinguistics, 50*, 191-213. https://doi.org/10.1016/j.jneuroling.2018.11.002

Vega-Mendoza, M., West, G., & Sorace, A. (2015). The impact of bilingualism on executive functions in children and adults: Evidence from the Simon task. *Frontiers in Psychology, 6*, 55. https://doi.org/10.3389/fpsyg.2015.00055

Yow, W. Q., & Li, X. (2015). Balanced bilingualism and early age of second-language acquisition as the underlying mechanisms of a bilingual advantage in executive functions. *International Journal of Bilingualism, 19*(2), 194-210. https://doi.org/10.1177/1367006913508682

Copyrights