Is There a Bilingual Advantage in Executive Functions in Healthy Adults? A Systematic Review

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***Abstract*—Research on the benefits of bilingualism for executive functions has produced conflicting findings. This review systematically summarizes the findings of 27 studies from 23 articles on this topic from the last decade, with participants' ages ranging from 18 to 60. We extracted data on participants' backgrounds and the results of different task paradigms. We found no significant bilingual advantage in executive functions in healthy adults between 18 and 60 years of age, although the conflicting results make it challenging to draw a decisive conclusion.**

***Index Terms*—Bilingualism, bilingual advantage, executive functions, systematic review**

I. Introduction

Bilingualism generally refers to the ability to actively use more than one language or dialect daily [1]. Bilinguals are becoming increasingly common throughout the world [2]. People who can communicate in more than one language have more opportunities to meet people from other countries and cultures, broadening their job and travel opportunities and understanding of other cultures [3]. Bilinguals are often assumed to have superior cognitive abilities since managing two or more language systems requires choosing appropriate expressions in one language while inhibiting others [4].

The impact of bilingualism on cognitive functions, particularly executive functions (EFs), has been a hot topic in recent years. The broad term "EFs" refers to higher-level cognitive functions [5]. Those most discussed in previous literature are *inhibition* (the ability to suppress irrelevant information), *shifting* (the ability to swap between tasks), and *updating* (the ability to control relevant information in working memory) [6].

The findings of bilingual advantage studies have been inconsistent and highly debated. Several studies have found a positive relationship between bilingualism and EFs. One meta-analysis on cognitive abilities and bilingualism [7] found that bilinguals generally outperformed monolinguals in several cognitive domains, including metalinguistic and metacognitive awareness, abstract and symbolic representation, attentional control, and problem-solving.

Previous meta-analyses have yielded mixed results. Hilchey and Klein's [8] investigation of the benefits of bilingualism in three nonverbal inhibitory tasks (Simon, Flanker, and attentional network tasks) found that bilinguals have more cognitive advantage overall. They outperformed monolinguals on reaction times (RT) in all congruent and incongruent trials, but the advantage in inhibitory control was inconsistent. Grundy and Timmer's [9] meta-analysis on the relationship between bilingualism and working memory capacity found that bilingualism had a small to moderate positive effect. In a systematic review of 46 studies [10], Van den Noort *et al.* concluded that 54.3% showed that bilingualism positively affected EFs, 28.3% showed mixed results, and 17.4% showed negative effects. Giovannoli and Martella *et al.*'s [11] systematic review of the relationship between bilingualism and EFs in children and adolescents aged 5 to 17 found a positive bilingual advantage for inhibition and flexibility but not working memory. Similarly, Degirmenci and Grossmann *et al.*'s [12] review found that the data from 24 studies did not support a bilingual advantage in overall EFs, only for inhibition.

Several reviews showed no bilingual advantage for EFs. In contrast to their 2011 review, Hilchey and Saint-Aubin *et al.* [13] found little evidence of a bilingual advantage. Similarly, after reviewing studies published between 2011 and 2015, Paap and Johnson *et al.* [14] concluded that bilingual advantage was unlikely to exist.

De Bruin and Treccani *et al.*'s [15] review of conference papers from 1999 to 2012 found that studies with positive results were more likely to be published than studies with mixed or null results, which influenced the results of related meta-analyses. One meta-analysis [16] revealed a small but significant bilingual advantage for global RT for nonverbal interference-control tasks. However, when publication bias was removed, there was no significant advantage. Similarly, Lehtonen and Soveri *et al.*'s [17] comparison of monolinguals and bilinguals' EFs, including unpublished data, found a slight bilingual advantage initially, but none after publication bias was corrected.

Our systematic review synthesized research on bilingualism and EFs in healthy adults aged 18 to 60. Most previous reviews of studies investigating EFs and age have been about children, adolescents, or older adults. No systematic reviews have focused on adults aged between 18 to 60 years old. The relationship between bilingualism and EFs has been hotly debated, and previous reviews have produced contradictory results because of the influence of different tasks and numerous confounders. Our review compared monolinguals and bilinguals in terms of cognitive abilities—Specifically inhibition, shifting, and updating—and considered the participants' linguistic and social backgrounds. We addressed the following questions:

1) What were the study participants' linguistic characteristics and social backgrounds?
2) What tasks were used in these studies to test the bilingual advantage in EFs, and what were the results?
3) Which EF domain(s) were associated with a bilingual advantage, and did specific cognition tasks show a more significant bilingual advantage?
4) Was there a bilingual advantage in EFs in healthy adults

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between the ages of 18 and 60 years old?

II. Method

A. Search Strategy

This review was conducted according to the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) guidelines. For our systematic review, we searched peer-reviewed original articles and reviews in the PsycINFO, Scopus, and Web of Science databases using these keywords: “bilingual advantage,” “bilingual and monolingual,” “executive function,” “executive control,” “cognitive control,” “inhibition,” “shifting,” “updating,” “switching,” and “working memory.”

B. Selection Criteria

We used the following inclusion criteria. First, all the articles in this systematic review were original research, including journal articles and conference papers; we excluded master’s and doctoral theses. Second, all the studies we included compared bilingual and monolingual adults between aged 18 to 60; we excluded studies on people who are younger than 18 years old and older than 60 years old, and also people with psychiatric or neurological disorders and studies with data on multilinguals. Third, the review covered research on inhibition, switching, and updating domains of EFs.

C. Data Extraction

Data extraction was carried out in July 2022. Information was extracted for authors, country, number of participants, mean age, language of monolinguals, L1 and L2 of bilinguals, L2 proficiency levels, language testing measures, immigration status, age of acquisition (AoA), and SES. The testing domain of EFs, tasks, as well as the outcomes are also extracted. All data was checked for accuracy for a second time.

III. Results

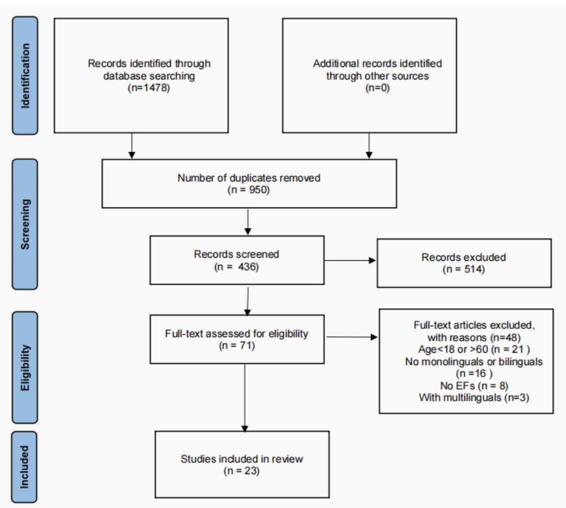

Fig. 1. Flow diagram of study selection.

The flow diagram (Fig. 1) depicts the number of studies found in three databases. A total of 1478 were identified. After duplicates were removed, 950 were remained. By screening through titles, abstracts, and participants, 514 were excluded. There were 71 articles that appeared to meet the potential criteria. Following thorough review of the full text, 27 experiments from 23 articles were found to meet the criteria of this review.

A. What Were the Study Participants’ Linguistic Characteristics and Social Backgrounds?

Appendix 1 presents the main characteristics of the studies. There were 2,704 participants in 27 experiments described in 23 studies. Their mean age ranged from 18.56 to 35.2. The studies were conducted in 11 different countries: the United States, Spain, Canada, the United Kingdom, China, Iran, Colombia, Hungary, Singapore, Belgium, and Korea. The languages of the monolingual and bilingual participants varied according to where the research was conducted. Most of the monolinguals spoke English or Spanish, with six exceptions: Mandarin, Persian, French, Hungarian, Dutch, and Korean. Two studies ([18, 19]) did not report the monolinguals’ languages. In four of 23 studies [20–23], the bilinguals had the same L1 (Spanish) and L2 (English); the L1 and L2 in the other 19 studies were mixed. In nine studies ([20], [24–31]), the monolinguals’ language and the L1 of the bilinguals were the same.

For language proficiency assessment, nine of 23 studies used one or more of these standardized questionnaires: the Language and Social Background Questionnaire (LSBQ) [32]; the Language Experience and Proficiency Questionnaire (LEAP-Q) [21, 23, 29]; the Oral Vocabulary subtest of the Bilingual Verbal Ability Test (BVAT) [33]; the Peabody Picture Vocabulary Test (PPVT) [28, 32]; the Language History Questionnaire (LHQ) [34]; the Language Background Questionnaire (LBQ) [18]; and the Bilingual Language Profile (BLP) [20]. The other 14 studies assessed the participants’ language proficiency through self-ratings or interviews.

The participants’ AoA was reported in all but two studies [18, 19]. Bilinguals who are exposed to an L2 before age seven are considered “early” bilinguals. The participants of 21 studies were early bilinguals. Two studies [20, 31] included late bilinguals, and two studies included both early and late bilinguals [24, 25].

Sixteen of the studies reported the participants’ socioeconomic status (SES); most used parental education level and total or monthly house income as SES indicators. The bilingual families’ incomes or parental education years were higher than the monolingual families’ in four studies [21, 30, 33, 35] except in one study [23], where the opposite was true. The parents’ educational level (PED) or income were matched in nine studies [20, 25, 27, 28], [36–40]. The other nine studies did not mention SES.

Fourteen of the 23 studies reported the participants’ immigration status. The participants in seven studies were born in a region with two co-official languages [21, 23, 24, 28, 34, 35, 37]; the participants in five studies were immigrants [18, 31, 38–41]; and the rest of studies did not report immigration status.

B. What Tasks Were Used in These Studies to Test the Bilingual Advantage in EFs, and What Were the Results?

Table I shows a summary of the studies’ findings regarding the presence (absence) of a bilingual advantage for EFs for three domains (inhibition, shifting, and updating), as exhibited during specific tasks.

TABLE I: RESULTS OF TASKS IN EACH DOMAIN

Domain	Task	Bilingual advantage	Bilingual disadvantage	No significant result
Inhibition	Antisaccade task			1
	Forced-attention dichotic consonant–vowel listening task			2
	Flanker task			2
	Go/No-go task	1		1
	Sustained attention to response task (SART)			1
	Simon task		1	7
	Stroop task	2		4
	Total	3	1	18
Shifting	Color–shape switching task	2		4
	Color–word interference test (CWIT)	1		
	Cued letter–number task-switching paradigm	1		
	Digit–letter tasks			1
	Linguistic switching task			2
	Social category switching task	1		
	Wisconsin Card Sorting Test (WCST)			1
	Total	5	0	8
Updating	Block recall task	1		
	Complex span tasks			2
	Corsi task	1		1
	Digit span	3		9
	Dot matrix task	1		
	Flanker task	1		1
	Go/No-Go task	1		1
	Listening recall task			1
	Nonword recall task	1		
	Operation span tasks			1
	Recent-probe task	1		1
	Running memory task			2
	Spatial recall task	1		
	N-back task	1		1
	Odd one out task	1		
	Symmetry span task			1
	Total	13	0	21

1) Bilingualism and inhibition

Ten studies used 22 different tasks to measure inhibition skills. Three studies showed a bilingual advantage in EFs using the Stroop and Go/No-Go tasks; one study showed a bilingual disadvantage using the Simon task; and the remaining 18 studies yielded indecisive results. The following paragraphs explain the results for each task.

Six experiments in five studies use the Stroop task [20, 24, 32, 35, 42]; two of the six [32, 42] showed a bilingual advantage. Bialystok and Poarch *et al.* [32] used a paper version of the Stroop test to show that bilinguals' mean reaction times were faster than monolinguals' in interference conditions, and they had lower interference costs. Kazemeini and Fadardi [42] used an adopted computerized version of the Stroop test to determine those bilingual adults with mean age of 25 made fewer errors in both congruent and incongruent conditions, and bilinguals had shorter reaction times for incongruent words than their monolingual counterparts. Another four experiments in three studies found no significant difference between monolinguals and bilinguals in verbal [20, 24, 35] and numerical Stroop tasks [35].

Two experiments in one study [33] got mixed results using a Go/No-Go task. The researchers' analysis of the participants' EEG recordings showed that the bilinguals had increased N2 amplitudes during the auditory No-Go task; however, they found no difference between the bilinguals and monolinguals in the visual Go/No-Go task.

Eight studies from six articles conducted nonverbal Simon tasks. Six [21, 23, 30, 35, 38] Simon tasks and one Simon arrow task [24] revealed no significant difference between monolingual and bilingual speakers' performances or response times in either congruent or incongruent conditions. However, Study 3 in Paap and Greenberg's [38] article showed a consistent bilingual disadvantage for inhibitory control.

Two studies using the Flanker task found no significant bilingual advantage in the reaction times or accuracy in all the conditions (congruent, incongruent, and neutral) [35, 38]. Paap and Greenberg [38] also found no evidence for a bilingual advantage in highly proficient and balanced bilinguals.

Two studies using the forced-attention dichotic consonant–vowel listening task to measure the inhibition of irrelevant auditory information found no significant difference between monolinguals and bilinguals in any of the three experimental conditions (forced right, forced left, and unforced) [21, 23].

A study [38] using an antisaccade task found no significant bilingual advantage; monolinguals' mean reaction time was shorter than bilinguals', and the correct rate was almost the same for the two groups.

Kousaie and Matt *et al.* [24] use the Sustained Attention to Response Task (SART), a measure of response inhibition, with monolingual francophones, monolingual anglophones, and bilinguals. They found that the French monolinguals' reaction times were longer than the English monolinguals' and bilinguals' reaction times.

2) Bilingualism and shifting

Ten of the studies (13 experiments total) investigated the relationship between bilingualism and shifting. Five experiments found a bilingual advantage, and eight found none. The details follow.

Five studies used the color–shape switching task to measure bilinguals' shifting ability. Tao and Taft *et al.* [39] concluded that bilinguals had advanced inhibitory control. Bilinguals had lower switching costs but higher mixing costs when they needed to suppress conflicting responses and simultaneously activate another set of conflicting responses. Paap and Greenberg *et al.* [38] analyzed switching costs with a mixed-design ANOVA; they found no bilingual advantage in mixing and switching costs when the groups' PEDs were matched. Stasenko and Matt *et al.* [23] and Paap and Myuz *et al.* [27] found a bilingual advantage in smaller switching costs but no bilingual advantage in mixing costs. In contrast, Wiseheart and Viswanathan *et al.* [18] found that bilinguals and monolinguals performed similarly in switching costs, but bilinguals showed lower mixing costs. Mas-Herrero and

Adrover-Roig *et al.* [34] used a shape-orientation task to determine that bilinguals had lower switching costs than monolinguals under demanding conditions.

In the second experiment of Mas-Herrero and Adrover-Roig *et al.*'s [34] study, a linguistic switching paradigm was used. Concerning accuracy rates or reaction times, no bilingual advantage was present. Similarly, Stasenko and Matt *et al.* [23] also concluded there was no significant bilingual advantage in their language task. The results revealed that bilinguals' accuracy ratings increased with practice, but their reaction times increased correspondingly.

Three studies also found a bilingual advantage in shifting [25, 26, 39]. Lukasik and Lehtonen *et al.* [25] used a cued letter–number task to determine that younger bilinguals had lower switching and mixing costs than monolinguals. Marzecová and Bukowski *et al.* [26] used a social category switching task (SCST) the gender as the stimulus; they found that the bilinguals had reduced switching costs and decreased error rates. Tao and Taft *et al.* [39], using a color–word interference test (CWIT), found that the Spanish–English bilinguals—particularly those with high L1 proficiency—had lower switching costs than the monolinguals. They also found that Mandarin–English bilinguals had reduced switching costs, but the relationship with L1 proficiency was not significant.

Paap and Myuz *et al.* [27] used a letter–digital task to determine that there was no bilingual advantage in switching costs and mixing cost accuracy. Kousaie and Sheppard *et al.*'s [24] study using the Wisconsin Card Sorting Test (WCST) showed mixed results; specifically, the French monolinguals showed a bilingual advantage over English monolinguals and their bilingual counterparts.

3) Bilingualism and updating

Thirty-four experiments from ten articles investigated the relationship between bilingualism and updating, mainly working memory. Thirteen tasks in six studies showed a bilingual advantage in working memory, and 21 experiments in eight articles demonstrated indecisive results.

Eight experiments in six studies used the digit span task to test updating ability. Antón and Carreiras *et al.* [35] found no significant difference between monolinguals and bilinguals with the forward digit span task. However, three others [35, 41, 42] found that bilinguals performed significantly better than monolinguals in the backward digit span task. In contrast, Jiao and Liu *et al.* [37] and Ratiu and Azuma [29] found that their bilingual participants recalled fewer digits than the monolinguals in the backward digit span task. Yang and Fernandez *et al.* [31] tested for a bilingual advantage in intermediate bilinguals, high proficiency bilinguals, and monolinguals using visual and auditory digit span tasks. They found that intermediate bilinguals performed better on the visual/auditory forward digit span task and the auditory backward digit span task. Kousaie and Sheppard *et al.* [24] also used forward and backward digital span tasks but focused more on the differences between young and old adults than between monolinguals and bilinguals.

Antón and Carreiras *et al.* [35] used a Corsi task to measure working memory. They found a significant bilingual advantage in the inverse Corsi task but insignificant differences in the Corsi task.

Jiao and Liu *et al.* [37] use standard and modified Flanker tasks to test accuracy rate and reaction times in interference suppression. Their bilingual participants performed better than the monolinguals in a high-demand working memory task (modified Flanker task). They also conducted Go/No-Go and conditional Go/No-Go tasks to test response inhibition and found a significant bilingual advantage only in high processing-demand conditions.

Bialystok and Poarch *et al.* [32] used a recent-probe task with figures and letters to test proactive interference by measuring the participants' reaction times and accuracy rates. They found a bilingual advantage only in one condition—reaction time in the nonverbal task; it was not salient in the verbal tasks. Warmington and Kandru-Pothineni *et al.* [41] used eight recall tasks (i.e., digital, nonword, dot matrix, block, listening, backward digit, odd one out, and spatial) to test participants' verbal/visuospatial short-term memory and verbal/visuospatial EF abilities. They found that the bilinguals performed significantly better than the monolinguals on seven of the eight tasks (exception: listening recall).

Lukasik and Lehtonen *et al.* [25] used ten tasks measuring working memory (i.e., backward span, forward span, complex span, running memory, and n-back), all in numerical verbal and visuospatial versions. Their Bayesian analyses found significant bilingual advantage only in the visuospatial n-back task. Similarly, Ratiu and Azuma [29] found no bilingual advantage using operation and symmetry span tasks.

C. Which EF Domain(s) Were Associated with a Bilingual Advantage, and Did Specific Cognition Tasks Show a More Significant Bilingual Advantage?

Several studies [25, 35] found that bilinguals generally outperformed monolinguals in updating, especially during backward digit span and nonverbal tasks [41]. However, other studies found a less pronounced bilingual advantage for inhibition [35, 38] and shifting [18, 23]. (See Table I)

D. Was There a Bilingual Advantage in EFs in Healthy Adults within the Ages of 18 and 60?

After reviewing 27 experiments from 23 studies from 2012 to 2022, the current study found no significant bilingual advantage in healthy adults aged between 18 to 60 years old in general.

IV. DISCUSSION

A. Inconclusive Results: Possible Influencing Variables

Despite substantial research, the existence of a bilingual advantage in EFs remains unsubstantiated. Our analysis of 23 studies suggests that various individual and methodological characteristics contributed to the mixed results. The most obvious is the high individual heterogeneity in the participants' linguistic profiles, including differences in the monolinguals' languages, the bilinguals' language pairs, AoAs, L2 proficiencies, language measurements, and backgrounds (e.g., country, SES, and immigration status).

Another factor contributing to the inconclusive results is the wide assortment of tasks used. For example, there were conflicting results from the Stroop task. Two studies [32, 42] confirmed a bilingual effect and three others [20, 24, 35] found no significant differences. We believe that the participants' diverse linguistic backgrounds contributed to these mixed findings. In Bialystok and Poarch *et al.* [32] and Kazemeini and Fadardi [42], the mean AoAs were 5.02 and 4.6, respectively, meaning that all their participants were early bilinguals. However, in Langley and Cardona *et al.*'s [20] participants were all late bilinguals aged 20 to 38 who learned their L2 (English) after age 15. AoA of L2 is a significant confounder in bilingual research. Research suggests that early bilinguals possess better inhibitory abilities than late bilinguals since they have had more time to practice the language [43]. Longer or shorter immersion environments can lead to different levels of language proficiency [44], which influences cognitive development.

Additionally, the influence of social background cannot be excluded. In Antón and Carreiras *et al.* [35] and Kousaie et al. [24], the monolinguals were non-immigrants from Basque, Quebec City. and Ottawa, all of which have dual official languages. Even though the monolinguals in these areas were only proficient in one language, their language environment differed from the monolinguals in other studies [32, 42], who grew up in monolingual societies.

Another task that produced mixed results was the color–shape switching task. The results of Experiment 1 of Mas-Herrero and Adrover-Roig *et al.*'s [34] study showed that bilinguals' switching costs were much lower in for the hard block task than the easy block task. Similarly, the bilingual advantage was more significant in the modified Flanker and the conditional Go/No-Go tasks [37], as well as the backward Corsi and backward digit tasks [35]; these modified tasks were more demanding than the regular versions. Therefore, the results suggested that the bilinguals' switching and updating abilities were superior to the monolinguals' in highly demanding tasks but not necessarily standard tasks, which is in accordance with previous studies [36, 45].

Herrero and Adrover-Roig *et al.*'s [34] found a bilingual advantage using a nonverbal color–shape switching task. However, the differences were insignificant when they used easy and hard block linguistic switching tasks in the same study. Similarly, Lukasik and Lehtonen *et al.* [25] found a more significant bilingual advantage with a visuospatial n-back task than with a verbal version. Research suggests that monolinguals outperform their bilingual counterparts in verbal tasks since the bilinguals' usage frequency is lower for their L1 and L2 because it is split between two languages [46]. Moreover, bilinguals gain language more slowly, which generally means they have smaller vocabularies than their monolingual counterparts [47].

In bilingual studies, the testing language of verbal tasks might be the participants' L1, L2 [34, 41] or randomly selected [28]. Bilinguals perform worse on verbal tests conducted in their L2 than in their L1; this is especially true for imbalanced bilinguals. However, researchers often fail to factor in whether the testing language is the L1 or the L2. Future studies should report the testing language used with bilinguals [9].

B. Limitations and Future Directions

Several limitations in research on bilingual advantage in EFs should be considered. First, many of the previous studies used modified rather than standard versions of the Go/No-Go task [35], the Flanker task [37], and others. This produces different kinds of measurement and reduces comparability. It is next to impossible to compare the results of standard and nonstandard tasks. Future studies should use standardized tasks to avoid "apples and oranges" comparisons and ambiguous interpretations.

Another limitation is the control of confounders. Accounting for the participants' backgrounds is critical in bilingual advantage research. All the studies we reviewed included information about the participants' country, mean age, linguistic background, and language measurements. However, some studies did not mention immigration status [32, 42] or SES [20, 26]. Moreover, future studies should match the language of monolinguals and the L1 of bilinguals and note whether the bilinguals are balanced or not. Consistently including detailed background information for the bilingual participants will improve the reliability of the bilingual study results.

Additionally, there might be a publication bias favoring bilingual advantage in cognitive abilities. We found that studies that fully supported the existence of a bilingual advantage in EFS were more likely to be published than studies with mixed results [15]. Several meta-analyses have produced the same results [17]. However, other studies have found no publication bias [9, 48]. This matter merits further exploration.

Our review intended to include adults aged 18 to 60. However, the maximum age included in this review was 35.2. The main reason was that most participants in bilingual advantage studies were undergraduate or postgraduate university students taking part in the research for credit. Data are lacking for participants in their 40s and 50s. Future studies should endeavor to recruit older and non-student participants.

V. CONCLUSIONS

After reviewing 23 studies of bilingual advantage and EFs, we found no significant bilingual advantage in healthy adults aged within 18 to 60. Among the three most discussed domains, a bilingual advantage was more pronounced in updating than in inhibition or switching. The 23 study results were mixed, mainly due to the participants' diverse linguistic and social backgrounds and the studies' methodological issues. Future studies urgently need task standardization, better matching of participants' background information, and broader participant recruitment.

APPENDIX

TABLE A1: MAIN STUDY CHARACTERISTICS

Article	Country	Number	Mean age	ML language	L1–L2 of BL	L2 level	Language measures	Immigration Status	AoA (Age)	SES
[35]	Spain	M 90	M 21.84	Spanish	Basque–Spanish	Early balanced bilingual	Self-report; interviews;	Non-immigrant	1.13	Monthly income per person

		B 90	B 22.29				LexTale			M lower than B
[32]	United Kingdom	M 27 B 44	M 20.3 B 20.4	English	English–mixed Mixed–English	High proficiency in 2 languages	Shipley Vocabulary Test; LSBQ	/	5.02	/
	United Kingdom	M 36 B 36	M 21.4 B 20.2	English	English–mixed Mixed–English	English 93 Non-English 98	Shipley Vocabulary Test; LSBQ; PPVT; self-rated	/	4.6	/
[21]	United States	M 20 B 19	M 23.8 B 22.1	English	Spanish–English	Early balanced bilinguals	LEAP-Q	Non-immigrant	Before 7	/
[22]	United States	M 15 B 16	M 21.1 B 21.4	English	Spanish–English	Early balanced bilinguals	LEAP-Q	Non-immigrant	By 3	Hollingshed score M lower than B
[33]	United States	M 17 B 18	M 20.41 B 22.06	English	Spanish–English English–Spanish	English 31.28 Spanish 26.39	Oral Vocabulary subtest of the BVAT	Some US-born bilinguals; all lived in the bilingual US households	6.22	House income; M higher than B Parental education (years); M shorter than B
[34]	Spain	M 47 B 49	M 20.6 B 21.3	Spanish	Catalan–Spanish	Early balanced bilinguals	LHQ	Non-immigrant	2.9	/
	Spain	SimB 47 SeqB 48 M Spa 46	SimB 20.6 SeqB 20.6 M Spa 21	Spanish	Catala–Spanish	Highly proficient in both languages	LHQ	Non-immigrant	SimB 2.4 SeqB 3.9	/
[37]	China	M 27 B 31	20.4	Mandarin	Cantonese–Mandarin	High proficient bilinguals	Questionnaire	Non-immigrant	Before 1	Moderate family income
[42]	Iran	M 30 B 30	M 25.93 B 25.90	Persian	Kurdish–Persian	Equally proficient bilingual	Self-rated	/	4.9	/
[24]	Canada	M 70 (30F/40 E) B 51	E 21.48 F 21.8 B 21.49	English French	French–English English–French	Equally proficient in both languages	Self-rated, animacy judgment task	Non-immigrant	Before 13	/
[20]	Colombia	M 20 B 21	M 27.29 B 29.33	Spanish	Spanish–English	Highly proficient in English	BLP	Non-immigrant	After 15	/
[25]	United States	M 220 EarlyB 115 LateB 150	M 35.2 EarlyB 31.9 LateB 33.6	English	English–Mixed	EarlyB 3.84 LateB 2.2	Self-report, questionnaire	/	EarlyB 6 LateB 17.7	/
[26]	Hungary	M 22 B 22	M 27.3 B 27	Hungarian	Hungarian–Polish	Proficient L1 and L2 speakers	Questionnaire	Non-immigrant	1	/
[38]	United States	M 46 B 34	/	English	Mixed–English	Early balanced bilinguals	Self-rated	Moved to the United States as preschoolers	4.3	Matched parents' education level
	United States	M 50 B 36	/	English	Mixed–English	Early balanced bilinguals	Self-rated	Moved to the United States as preschoolers	5.0	Matched parents' education level
	United States	M 55 B 52	/	English/ others	Mixed–English	Early balanced bilinguals	Self-rated	Moved to the United States as preschoolers	2.0	Matched parents' education level
[27]	United States	M 108 B 122	M 22.28 B 21.14	English	English–mixed	Proficient in L1 and L2	Self-rated	/	6.0	Parents educations (years) M longer than B
[28]	Singapore	M 32 B 32	M 20.5 B 20.9	Chinese	Chinese–English	Highly proficient in L1 and L2	PPVT	Non-immigrant	Grew up speaking both languages	Matched family income; middle class family
[29]	United States	M 53 B 52	M 19.4 B 19.5	English	English–Spanish	Proficient in L1 and L2	LEAP-Q, self-rated	/	4	/
[23]	United States	M 79 B 79	M 20.6 B 20.3	English	Spanish–English	E 6.5 S 5.9	Self-rated	/	3.3	Parents educations (years)

										M longer than B
[39]	United States	M 60 E 80 M-E 80	M 20.7 S-E 20.9 M-E 19.8	English	Spanish–English Mandarin–English	Early balanced bilingual	Self-rated, MINT	US-born or immigrated at or before age 1	Before 1	Parent's education; M longer than S–E, and shorter than M–E
[41]	United States	M 23 B 23	M 23.4 mos. B 23.7 mos.	English	Hindi–English	Fluent in both languages	Self-rated; questionnaire	International university students who lived in India for most of their lives and recently moved to the United Kingdom to study	3	/
[18]	Canada	M 37 B 31	M 19.1 B 19.2	/	Mixed–English English–mixed	Fluency L1 19.5 L2 15	LBQ	19 of the bilingual participants were immigrants	/	/
[30]	Belgium	M 16 B 18	M 18.56 B 19.82	Dutch	Dutch–mixed	Proficient in L1 and L2	Self-rated; questionnaire	Non-immigrant	4.72	M equal to B
[31]	Korea	M 20 IB 20 HB 20	M 24.5 IB 24.5 HB 23.5	Korean	Korean－English	Proficient in L1 and L2	Self-rated, TOEFL	Arrived in the United States after age 12	Around 10	M higher than IB and HB
[19]	Canada	M 23 B 20	M 22.83 B 22.7	/	French–English	Highly proficient in L1 and L2	Self-rated	/	/	/

B: Bilingual; BLP: Bilingual Language Profile; BVAT: Bilingual Verbal Ability Test; E: English; EarlyB: Early Bilingual; F: French; HB: High Bilingual; IB: Intermediate Bilingual; LEAP-Q: Language Experience and Proficiency Questionnaire; LateB: Late Bilingual; LHQ: Language History Questionnaire; LBQ: Language Background Questionnaire; LSBQ: Language and Social Background Questionnaire; M: Monolingual; M–E: Mandarin–English; MITN: Multilingual Naming Test; PPVT: Peabody Picture Vocabulary Test; S–E: Spanish–English; SeqB: Sequential Bilingual; SimB: Simultaneous Bilingual

Conflict of Interest

The authors declare no conflict of interest.

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