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ARTICLE

Degree of bilingualism and executive function in early childhood

My V. H. Nguyen, Lindsey A. Hutchison, Gabrielle Norvell, Danielle L. Mead and Adam Winsler

Department of Psychology, George Mason University, Fairfax, VA, USA
Corresponding author: My V. H. Nguyen; Email: mvhnguyen@uh.edu

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Abstract
This study explores the relationship between executive functioning (EF) and degree of bilingualism in a sample (N = 79) of 5- to 7-year-old monolingual and bilingual children. The bilingual group included children who are fully fluent in two languages (balanced bilinguals) and children who are still learning their second language (dual-language learners (DLLs). In general, findings revealed mixed associations between bilingualism and EF. There were no language group differences for one type of simple inhibitory control (i.e., go or no-go task). However, a bilingual advantage was demonstrated for another type of simple inhibitory control (the Head–Toes–Knees–Shoulders task), for complex inhibitory control (i.e., the Simon effect), and for cognitive flexibility (Dimensional Change Card Sort). Effects were found when DLLs and balanced bilinguals were analyzed separately, and the latter two effects were found when both types of bilinguals were compared to monolinguals. The findings contribute to the growing literature examining a possible bilingual effect in early childhood.

Keywords: bilingualism; executive function; balance; proficiency

1. Introduction

Executive function (EF) is an important component of school readiness. EF components develop with age, and preschool children acquire many of the higher-order abilities necessary to function attentively and to engage well in kindergarten (Shaul & Schwartz, 2014). EF skills are also at the crux of self-regulation (Blair, 2002; Kaufman, 2010). Therefore, educators and researchers alike should be concerned with specific factors that influence the development of EF, as well as individual children's EF strengths and weaknesses.

In the United States, the number of individuals who speak a home language other than English has increased in the past several decades. In 2017, the U.S. Census Bureau estimated that those with a primary language different from English comprised 21% of the total population, or approximately 47 million people. In U.S. public schools, these individuals are often referred to as dual-language learners (DLLs). The percentage of DLL students has increased at a much faster rate than the general student population (Gandara & Rumberger, 2009).

In general, research has shown that native English-speaking students tend to outperform their DLL peers in U.S. public schools (Halle et al., 2012; Reardon & Galindo, 2007). However, such studies typically include all DLLs in their sample, including DLL students who may have just recently arrived in the school system and have just begun learning English. Importantly, it is English proficiency, not DLL status per se (speaking a non-instructional language at home) that is linked to academic performance. Young DLL students who become proficient in English early in elementary school tend to do better than native English speakers on academic measures (Ardasheva et al., 2012; Halle et al., 2012; Winsler et al., 2014), suggesting potential positive effects of bilingualism on academic performance.

2. Executive function and bilingualism

The term 'executive functioning' (EF) is broad, encompassing several different components or abilities (Anderson et al., 2008; Garon et al., 2008). EF suffers from inconsistent definitions (Diamond, 2013), but most researchers agree that EF involves various processes for planning, initiating, and following through with goal-directed behavior (Anderson et al., 2008; Garon et al., 2008).

A body of research suggests that children who are fully bilingual may perform better in EF tasks compared with monolinguals (Arizmendi et al., 2018; Bialystok, 2007). Although the mechanisms behind such an effect are unclear, the *inhibitory control theory* suggests that since bilinguals continuously engage in suppressing one language over the other, their overall ability to inhibit irrelevant information increases with the bilingual experience (Green, 1998). These abilities expand to other EF skills, creating an overall bilingual effect (Barac et al., 2014). A more recent similar framework is the *adaptive control hypothesis* (ACH; Green & Abutalebi, 2013), positing that, in a broad sense, bilinguals must constantly adapt to their respective linguistic environment. Thus, language context has a role in bilingual language and cognitive control, explaining potential differences in EF between bilinguals and monolinguals. Interestingly, ACH argues that bilinguals who frequently code switch freely (i.e., Spanglish) may not show differences to monolinguals in terms of EF performance as they do not have to actively adapt to the situation to match the language context. However, bilinguals who use two languages in a dual-language context but must match their output to the context (i.e., using each language with a different person) may show positive effects on EF due to the active process of choosing the right language to adapt to the context. Finally, the *neuroemergentism* framework posits that bilingualism and cognitive abilities follow a non-linear developmental trajectory, in which individuals with certain attributes such as greater initial cognitive abilities may be more adept at becoming bilingual, which then shapes their bilingual experience, which further enhances their overall executive function (Claussenius-Kalman et al., 2021; Hernandez et al., 2018).

However, recent findings have often failed to replicate such effects, and a publication bias has been revealed in the bilingualism and EF literature favoring small-sample studies showing large, statistically significant effects (de Bruin et al., 2015;

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Hilchey & Klein, 2011; Lehtonen et al., 2018). For example, when examining 118 young adults, von Bastian et al. (2016) did not find correlations between bilingual language measures such as age of acquisition, proficiency, and usage with inhibitory control, conflict monitoring, shifting, and general cognitive performance. Indeed, the relationship between bilingualism and executive function is complex, as Ware et al. (2020) suggest that differences between monolinguals and bilinguals are dependent on age and task. In particular, bilinguals consistently performed better than monolinguals in their attentional network task, but not in tasks such as card sorting, Simon, Stroop, or Flanker tasks. In addition, the effect is greater in older adults than in young adults, with some differences between language groups found in children (Ware et al., 2020). Finally, a meta-analysis of children under 18 years of age showed little support for a bilingual advantage on overall EF, albeit noting a significant switching effect even after controlling for publication bias (Gunnerud et al., 2020).

It must be noted that studies often compare various groups of bilinguals to monolinguals without considering other factors that contribute to their language experience, such as variation in the EF component being assessed and individual differences between children (i.e., age, home language, and language balance). Additionally, research reveals that when children are both highly proficient and relatively balanced in their first (L1) and second (L2) languages, those who experience more exposure to that second language (e.g., in dual-language programs in school) perform better in EF tasks given in their L2, indicating that language use and exposure affect EF performance above and beyond simply knowing a second language (Kang & Lust, 2019; Thomas-Sunesson et al., 2018). Based on conflicting findings, it is important to examine the relationship between bilingualism and EF further, particularly language use and proficiency in both languages and age of L2 acquisition in early childhood.

2.1. Degree of bilingualism

The degree of bilingualism, which includes individuals' relative level of language usage and proficiency (L1 + L2), is an important dimension that also needs to be considered within bilinguals. Evidence in adults supports the role of degree of bilingualism on EF performance (Rosselli et al., 2016), but if an EF benefit is developing due to the cognitive practice that individuals receive from regularly switching between languages, bilingual children who are not fluent in the second language until a later age may not become proficient in switching and thus may not benefit from an EF advantage (Nicoladis et al., 2018; Yow & Li, 2015). Balanced bilingualism refers to individuals who use both their native (L1) and second language (L2) relatively equally well across multiple contexts (Bialystok, 2001), and balanced bilinguals generally exhibit better performance than unbalanced bilinguals in executive control tasks (Carlson & Meltzoff, 2008).

Additionally, bilingual adults with high L2 proficiency have been found to outperform those with low L2 proficiency on EF tasks involving inhibitory control and cognitive flexibility (Singh & Mishra, 2013; Xie, 2018). When individuals are highly proficient in both languages, other factors contribute to differences in performance. For example, individuals who are exposed to and use a second language more frequently exhibit superior performance in switching and inhibitory control (Leeuw & Bogulski, 2016; Liu et al., 2019). Similarly, Thomas-Sunesson et al. (2018)

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hypothesized that the degree of bilingualism would mediate overall cognitive advantage, even in samples of children from low-income backgrounds. More balanced bilingualism was associated with better performance on working memory tasks, supporting bilingual cognitive advantages in children highly proficient in both languages. It must be noted that null findings have also been found in young adults, showing inconsistent differences between monolinguals and bilinguals when taking into account bilingual experience (Paap et al., 2014). Thus, it is important to further explore effects in early childhood, given conflicting findings in prior research.

2.2. Bilingualism and interference control

Interference control, a form of inhibitory control, is one of two EF components (along with cognitive flexibility) that has been found to show better performance in bilinguals than monolinguals (Garon et al., 2008; Wimmer et al., 2021). Inhibitory control is the ability to control attention, motor behaviors or impulses, thoughts, and emotions and to ignore irrelevant cues to focus on the task at hand (Diamond, 2013). Recent frameworks suggest that, rather than inhibition, attentional control may provide a better explanation for differences between monolinguals and bilinguals (Bialystok & Craik, 2022). Interference control can be conceptualized as a complex inhibitory control process requiring both cognitive control (controlling attention) *and* a choice between competing responses (Martin-Rhee & Bialystok, 2008). Thus, this study focuses on aspects of cognitive control that also require controlling attention rather than only inhibition. Bilingual children do *not* appear to show better performance in inhibitory control when no perceptual (or semantic) conflict is present or when required to simply suppress a response (Carlson & Meltzoff, 2008). Bilingual and monolingual children perform similarly on simple inhibitory tasks that are more response-based in nature and that do not involve much conflict or distraction (e.g., go or no-go and day–night task). However, when perceptual or semantic conflict becomes part of the task and cognitive and attentional controls become necessary for performance, bilingual children seem to have better performance, indicating somewhat better interference control compared with monolinguals (Martin-Rhee & Bialystok, 2008).

2.3. Bilingualism and cognitive flexibility

Cognitive flexibility, or set shifting, is another EF component where bilingual children have been found to outperform monolingual children (Carlson & Meltzoff, 2008; Kalia et al., 2018). Cognitive flexibility or shifting takes place in two phases. First, individuals form an initial rule where a certain stimulus (i.e., the color of a card) requires a certain response (sorting into the appropriate color pile) and selectively attend to this information (Garon et al., 2008). Then, task demands require that a new rule be held in mind (sort by shape instead), and the old rule must now be suppressed (ignore color). Thus, a 'shift' must take place. Most tasks require both a mental shift of attention and inhibition of a no-longer-relevant response for success. Bialystok and Martin (2004) noted better performance compared with monolinguals on a cognitive flexibility task such as the Dimensional Change Card Sort (DCCS) for Chinese–English bilingual children, as well as French–English bilingual children. When Japanese–French bilingual preschoolers were matched on verbal ability, bilinguals

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outperformed monolinguals in the DCCS (Okanda et al., 2010). However, a recent large-scale study (n > 4,500) using a nationally representative sample of 9- to 10-year-old children found little evidence for a bilingual advantage for inhibitory control (Flanker task), attention and task switching (stop-signal task), or cognitive flexibility (DCCS; Dick et al., 2019). While the study had information about English (L2) vocabulary and degree of usage between the two languages, information about children's L1 proficiency was not collected. Thus, it is unclear whether differences in performance within bilinguals may be related to their language background such as degree of bilingualism, an aspect this study attempted to explore.

3. This study

Although there is research examining EF during the preschool period, the focus has often been on the elementary school years. While more is known about how the balance of L1 and L2 affects performance on EF components among older students, less is known about EF patterns for young children still acquiring a second language (not yet fully proficient in both languages). Those who speak another language at home and then get introduced to English in preschool are considered early *sequential bilinguals* (Genesee & Nicoladis, 2007). This study examines whether bilingual effects on EF are present for young children (5–7 years old) who appear to be relatively balanced bilinguals and for those we consider to be DLLs not yet fully proficient in L2. This two-group approach is consistent with other studies that have examined two different bilingual groups, such as a fully proficient, high L2 proficiency group and a not-so-balanced bilingual group (Thomas-Sunesson et al., 2018). Consistent with recent calls in the literature to treat bilingualism as a continuous variable rather than only using group comparisons (de Cat et al., 2018; Leivada et al., 2021), we also created a continuous degree of bilingualism variable to examine how the relative balance between the two languages relates to multiple aspects of EF.

We focused on 5- to 7-year-olds to examine potential bilingualism effects in EF components often studied, including interference control and cognitive flexibility, while including additional tasks not often examined with bilingual children (DCCS, Frye et al., 1995; Head–Toes–Knees–Shoulders task, Ponitz et al., 2008; Simon task and go or no-go). We investigated whether group differences in EF (inhibitory control, cognitive flexibility, and parental report of EF behavior at home) are evident for monolinguals, DLLs, and balanced bilinguals, as well as whether they vary by degree of bilingualism. We expected that the DLL group (with less ability in and use of L2 and those with less balanced proficiency on the continuous measure), compared with the fully bilingual group, would show less differences in EF performance compared with monolinguals. This follows research showing that more balanced bilinguals have better EF performance than unbalanced bilinguals (Nicoladis et al., 2018; Weber et al., 2016).

4. Method

4.1. Participants

Participants originally included 84 five- to seven-year-old children. Five participants were excluded: too much missing data ($n = 1$); language scores so low in both English and Spanish indicating a likely language disorder ($n = 2$); too little Spanish exposure to be considered a DLL (4 months at immersion school) but too much to be classified as monolingual (*n* = 1); and a randomly selected twin sibling who had also participated in data collection, to avoid dependency (n = 1), leaving a final sample of 79 children. Thirty-three participants (41.2%) were monolingual English speakers and the remaining 46 (58.8%) were bilingual Spanish-English speakers, including both balanced bilinguals (*n* = 17) and unbalanced bilinguals or dual-language learners (DLLs; *n* = 29), determined through language assessments discussed as follows. Most children in the DLL group (*n* = 23, 79.3%) were English-dominant, two were Spanish-dominant, and one could not be classified due to inconsistent language data (stronger Spanish receptive skills and stronger English expressive skills). Three children (two in the DLL group and one in the balanced group) had substantial exposure to a third language other than English or Spanish.

Table 1 presents descriptive information for the sample (*n* = 79) broken down by group. Most participants were in kindergarten (41.6%, *N* = 32) or first grade (31.2%, *N* = 24), with an additional ten (12.7%) in preschool and eleven (13.9%) in second grade. Seven (10.3%) children had been diagnosed with a disability, including motor development (*N* = 1; no longer an issue for the child), sensory integration or processing disorder (*N* = 2), speech or fine motor delay (*N* = 1), speech dyspraxia (*N* = 1), and ADHD (*N* = 2). The three children with parent-reported speech delay were retained for analyses, as they were all monolingual and all tested above the 50th percentile on English receptive skills.

4.2. Procedure

Participants were recruited through several means and compensated for their time (see Supplementary Figure S1 for a depiction of all procedures for the parent and child). IRB approval was granted by George Mason University. Supplementary Table S1 describes all measures. Nineteen parents chose to complete surveys in Spanish.

Parents completed three surveys during their laboratory visit on campus. For the children, three language assessments were administered (about 30 minutes total for monolinguals and 45 for bilinguals). Children completed a vocabulary test (English or Spanish) to measure receptive language, a test to measure expressive language skills, and a second vocabulary test for the other language. For monolinguals, the English vocabulary test was always administered first. For bilinguals, 28 received the English assessments first, and the others received Spanish first (children thought to be more comfortable with Spanish). After a 5-minute break, the child completed 45-minute-long EF assessments in their dominant language, determined by 1) answers given by the parent during a screening phone interview before the study, 2) observations of child language use during the rapport-building session and language assessments, and 3) the child's response to questions about language preference (Supplementary Figure S1). All assessments were video–recorded.

4.3. Measures

4.3.1. Language background

4.3.1.1. Receptive language. The third edition of the Peabody Picture Vocabulary Test (PPVT-III; Dunn & Dunn, 1997) was used to assess children's receptive

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Table 1. Descriptive information, overall and by language group

	Overall *N* = 79	Monolingual *n* = 33	Bilingual *n* = 46	Balanced *n* = 17	DLL *n* = 29
Demographic			*N* (%)		
Gender					
Male	39 (49.4%)	16 (48.5%)	23 (50.0%)	4 (23.5%)	19 (65.5%)
Ethnicity*					
White	43 (55.8%)	28 (84.8%)	15 (34.1%)	4 (25.0%)	11 (39.3%)
Hispanic or Other	34 (44.2%)	5 (15.2%)	29 (65.9%)	12 (75.0%)	17 (60.7%)
Immigrant status*					
Native	42 (53.8%)	29 (87.9%)	13 (28.9%)	2 (11.8%)	11 (39.3%)
Immigrant[a]	36 (46.2%)	4 (12.1%)	32 (71.1%)	15 (88.2%)	17 (60.7%)
Family structure					
Two parent	71 (89.9%)	32 (97.0%)	39 (84.8%)	14 (82.4%)	25 (86.2%)
Single parent	8 (10.1%)	1 (3.0%)	7 (15.2%)	3 (17.6%)	4 (13.8%)
			M (*SD*)		
Age (year)	5.77 (.83)	5.67 (.78)	5.85 (.87)	6.18 (.95)	5.66 (.77)
# Children	2.31 (.72)	2.19 (.54)	2.40 (.83)	2.07 (.70)	2.59 (.84)
Annual income[b,*]	6.45 (1.55)	7.00 (1.00)	6.04 (1.76)	5.81 (1.68)	6.17 (1.81)
Mother educ[c]	5.45 (1.13)	5.52 (.97)	5.31 (1.26)	5.44 (.96)	5.24 (1.41)
Father educ[c]	5.65 (1.18)	6.00 (.75)	5.39 (1.40)	5.60 (1.18)	5.28 (1.51)
PPVT percentile	71.78 (24.74)	78.47 (22.54)	69.17 (23.39)	70.17 (20.77)	68.62 (25.06)

*$p < .05$ – significant difference between language groups.
[a]Immigrant = the child and/or at least one parent born in a country other than the United States.
[b]Income: 5 = $60,001–$80,000; 6 = $80,001–$120,000; 7 = $120,001–$175,000; median income = 7.
[c]Mother or father Ed: 5 = bachelor's degree, 6 = master's degree, 7 = doctoral degree.

language skills in English for all children. All participants were also administered the Test de Vocabulario en Imágenes Peabody (TVIP; Dunn et al., 1986). Though monolinguals were expected to have extremely limited or no knowledge of Spanish, they also received the TVIP to ensure that they were monolingual. Percentiles from both the PPVT and TVIP were used to help calculate children's scores for degree of bilingualism (see below).

4.3.1.2. Expressive language. Children's expressive language skills were assessed through an open-ended story-telling task, where children were asked to look at a wordless picture-book and produce an original narrative (see online supplementary materials). For monolingual participants, the task involved one wordless picture-book, with 17 children being given the book *Frog, Where Are You?* (Mayer, 1969) and 16 children being given the book *Frog Goes to Dinner* (Mayer, 1974). For DLL or bilingual participants, the task involved both books, in order, to elicit two different narratives, one in English and one in Spanish, consistent with prior research (Bedore et al., 2010; Simon-Cereijido & Gutiérrez-Clellen, 2009). Twenty-three bilinguals had *Frog Goes to Dinner* first (8 in Spanish), and the other 23 had *Frog Where Are You* first (10 in Spanish). Child narratives were transcribed and coded for two different features: *total number of words uttered by the child* and *number of different words* (NDW; Bedore et al., 2010). Inter-rater reliability was high for both English total word count (r = .997) and unique or different word count (r = .969) and for Spanish total word count (r = 1.00) and unique or different words (r = .984).

4.3.1.3. Language experience and exposure. The Language Background Questionnaire (LBQ; Bialystok, 2010) was administered to parents, with some modifications from the original version, to gather information regarding children's language experience and exposure, as well as child and family demographics. The survey was available in English and Spanish.

Parents' responses to children's understanding and speaking ability in one (monolinguals) or both (bilinguals) languages were converted to numbers, where excellent = 5, good = 4, OK = 3, fair = 2, and poor = 1 (see online supplementary materials). A proficiency score for each language ranging from 1 (poor) to 5 (excellent) was calculated by averaging together the scores from the two statements regarding receptive and expressive ability, resulting in a parent-reported child English proficiency score and a Spanish proficiency score (bilinguals only).

The survey also asked parents about their child's exposure to languages. Each statement required a response ranging from 1 (always English) to 5 (always Spanish), reflecting actual language use by the child in the everyday environment (see online supplementary materials). Because this scale ranged from 1 to 5, a score in the range of 2.5 to 3.5 indicated an almost complete balance in use between the two languages. A score less than 2.5 indicated greater English language use by the child, and a score above 3.5 indicated greater Spanish language use.

4.3.1.4. Determining child language group. Six criteria were used to determine the language group, including parent report and direct assessments (see online supplementary materials). The child had to meet five of six criteria to be considered a balanced bilingual. If they did not meet two or more of the criteria, the child was considered a DLL, provided that they had at least 6 months of substantial exposure to

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the second language (exposed to and/or using L2 several times per week). To be considered monolingual, parents reported that the child did not speak or understand any language other than English (excluding minor exposure, such as a 30-minute class or TV show once per week). The six criteria to be considered a *balanced bilingual* were 1. minimum exposure of three years (or more) to *each* language; 2. average parent-reported proficiency scores of 3 or higher for *each* language; 3. average parent-reported score of 2.5 to 3.5 for language use; 4. PPVT age equivalency score within the confidence interval for the child's age or higher; 5. TVIP age equivalency score within the confidence interval for the child's age or higher; and 6. English and Spanish unique word counts in stories being 50 words or less different.

Scores from the statements about language use (ranging from all English to all Spanish) were averaged to get one score for child language use. We used more lenient cut-offs for what is considered a 'balanced bilingual' (see criterion 3 above). Prior studies (Bialystok, 2010) considered a score of 3 to be fully balanced, and deviations from this indicate a bias for one language or the other. However, language exposure (input) and production (output) are only part of the broader picture of language experience for a bilingual child; the more lenient cut-offs in this study allow a bilingual child with a score slightly above or below a 3 to still be considered balanced, provided that the other criteria were met.

4.3.1.5. Degree of bilingualism. The degree of bilingualism was calculated to provide a continuous measure of how bilingual each bilingual child was. First, three difference scores were calculated: (1) parent report of English and Spanish proficiency, (2) percentile scores from the PPVT and TVIP, and (3) the total word counts from the English and Spanish stories. Absolute value was calculated for each – bigger numbers indicated less balance (a greater difference) in English and Spanish skills. Then, a similar score (from 1 to 3) was created based on the language use variable: middle scores of 2.5 to 3.5 were turned into 1's, more distant scores of 1.5 to 2.4 or 3.6 to 4.5 were turned into 2's, and extreme scores of 1 to 1.4 or 4.6 to 5 were turned into 3's. Thus, a score of 3 indicated less balance in terms of language use and a score of 1 indicated equal use or skill of Spanish and English. These four new variables (parent-reported language proficiency difference score, receptive language difference score, expressive language difference score, and language use scores) were standardized with z-scores for each and then averaged together to create the final 'degree of bilingualism' variable, with a larger score showing *less* balance across the two languages.

4.3.2. Executive function

4.3.2.1. Cognitive flexibility. Children completed the Dimensional Change Card Sort (DCCS; Frye et al., 1995), to assess cognitive flexibility and set shifting. We followed the three-block trial procedures (Zelazo, 2006), with additions from Carlson and Meltzoff (2008) regarding cards in the final block having a star instead of a black border. This task has convergent and predictive validity, as demonstrated by moderate correlations with current ($r = .42$ to $.63$), and later academic skills ($r = .43$ to $.64$), and teacher ratings of child behavior ($r = .56$; Lipsey et al., 2010). The total number of errors made in the final trial block was used (range = 0–6).

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4.3.2.2. Interference control. Children completed the Simon task to assess interference control. Children respond as quickly and accurately as possible by pushing the appropriate sticker color to the square appearing on the screen (Martin-Rhee & Bialystok, 2008). For *congruent trials*, the colored square was presented on the same side of the computer screen as the correct button to push; for *incongruent trials*, the square appeared on the opposite side of the screen from the button. Children first completed eight practice trials containing a mix of congruent and incongruent trials and then moved to 60 experimental trials, with 36 congruent trials and 24 incongruent trials (Borgmann et al., 2007; van Mourik et al., 2009). Scores from this task included *reaction time* and *percent accuracy* for each trial type (congruent and incongruent). Lower scores indicate faster and/or less accurate performance. In addition, a 'Simon effect' score – the differences in reaction time (RT) between incongruent and congruent trials – was calculated (smaller numbers indicate better interference control).

4.3.2.3. Inhibition of a prepotent response. Inhibition of a prepotent response (simple response suppression) was assessed by the go or no-go (GNG) task. Children were instructed to respond as fast as possible when squares with straight or diagonal lines appeared on the screen, but not when a square with an X appeared. There were three 'go' stimuli and one 'no-go' stimulus (Berlin & Bohlin, 2002). Children first completed five practice trials in random order, including one no-go trial (Kuntsi et al., 2005) and then moved on to 60 test trials presented randomly with 70% of 'go' trials, with a trial length of 1,500 ms and an inter-stimulus interval of 1000 ms (Eigsti et al., 2006). The score used for this task was errors of commission (making a response to the no-go stimulus) (Berlin & Bohlin, 2002).

4.3.2.4. Inhibitory control. The Head–Toes–Knees–Shoulders task (HTKS) was used to measure behavioral inhibition (Ponitz et al., 2008). Children played a game where they followed commands from the researcher but had to touch a different body part from what the researcher said (Connor et al., 2010). Children completed two blocks of trials, with six practice trials and 10 test trials for the first block with the two commands ('touch your head' and 'touch your toes') and five practice trials and 10 test trials for all the body parts (head, toes, knees, and shoulders). The researcher alternated between the commands in a predetermined order. Two points were given for a completely correct response; one point for a self-corrected response (the child began movement toward the incorrect body part, but then touched the correct part); and zero points for a completely incorrect response (Ponitz et al., 2008). The total score ranged from 0 to 40.

4.3.2.5. Parent report of executive function. The Behavior Rating Inventory of Executive Function (BRIEF; Gioia et al., 2000) was completed by parents as an assessment of children's general EF at home. The BRIEF is designed for use with children aged 5–18 and rates children's behavior in two domains – behavioral regulation and meta-cognitive skills (Gioia et al., 2000). The BRIEF requires parents to make responses on a three-point scale (never, sometimes, and often) about how often children engage in certain behaviors. In all, 86 items make up eight subscales: inhibit, shift, emotional control, initiate, working memory, plan or organize, organization of materials, and monitor. The first three make up the Behavior Regulation

Index (BRI), and the other five, the Metacognition Index (MI). Together, the BRI and MI represent the Global Executive Composite (GEC). Higher scores indicate greater impairment. The BRIEF has demonstrated high internal consistency reliability (.82–.98; Gioia et al., 2000). The Spanish version of the BRIEF (reliability ranged from .85–.98; Fernández et al., 2014) was available if parents chose to complete the questionnaires in Spanish.

5. Results

5.1. Language group differences in demographic variables

Descriptive information and bivariate analyses are included in the online supplementary materials (Supplementary Table S2). Table 1 presents demographic information for the overall sample and separately by language group. Comparisons were made with the language group as both a two-level (monolingual versus bilingual) and three-level (monolingual versus DLL versus balanced bilingual) variable. Monolingual and bilingual participants did not differ in gender, age, number of children in the family, parent education, family structure, or English language skills. Monolingual families reported higher annual income (M = 6.93, SD = 1.02; about \$120,0001–\$175,000) than bilingual families (M = 6.05, SD = 1.81; about \$80,001–\$120,000), $t(61.94) = 2.53$, $p = .014$. Groups also differed in racial or ethnic composition ($r = .246$, $p < .047$) and immigrant status ($r = .568$, $p < .001$). The majority of bilinguals were Hispanic and White, while the majority of monolinguals were White, with only four classified as Hispanic or Other. The degree of bilingualism was not related to any covariates.

5.2. Language group differences in executive function

The first question examined group differences in EF for the three language groups (monolinguals, DLLs, and balanced bilinguals). For each EF variable, a regression analysis was conducted with the language group as the predictor and relevant demographic variables as covariates. If a covariate were related to the language group (see online supplementary materials), it was included in all analyses; additional covariates in a model for a specific EF variable, however, had to be significantly related to the EF measure to be included. Thus, only child ethnicity[1] and family income were included as covariates for all analyses. The results of the inhibitory control measures (GNG, HTKS, and Simon[2]) are presented first, followed by cognitive flexibility (DCCS), and finally parent report of EF (BRIEF)[3]. Table 2 presents

[1]While immigrant status was also significantly related to the language group, child ethnicity and immigrant status were correlated, with *tetrachoric correlation* = −0.76, $p < .05$. Thus, we did not include immigrant status in the model to avoid multicollinearity, as Hispanic children were also likely to be immigrant children.

[2]Average reaction time (RT) and accuracies are reported for both congruent and incongruent trials of the Simon task (Table 2). Accuracies do differ across groups and approach ceiling ($M \sim .95$; $SD \sim .05$) and thus are not included in our main analyses. Only RT and the Simon effect calculated using RT were analyzed with covariates (Table 3).

[3]While marital status was significantly related to some EF measures, only seven of the 68 children came from a single parent. A large difference in group size may cause a spurious effect, and thus, this variable was not included in analyses.

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Table 2. Unadjusted group means and SDs for EF outcomes by language group

	Monolingual (n = 33)	Bilingual (n = 46)	DLL (n = 29)	Balanced (n = 17)
GNG Comm errors	2.28 (1.94)	2.31 (2.19)	2.39 (2.32)	2.18 (2.04)
HTKS total	34.16 (3.79)	34.93 (3.36)	35.31 (3.72)	34.25 (2.54)
Simon Cong RT	803.97 (143.20)	**899.32*** (176.08)	**891.43*** (176.29)	**912.76*** (180.28)
Simon Cong Acc.	.95 (.06)	.95 (.06)	.95 (.06)	.96 (.05)
Simon Incong RT	886.87 (163.92)	**981.28*** (215.23)	987.07 (228.02)	971.41 (197.82)
Simon Incong Acc.	.86 (.13)	.89 (.09)	.89 (.08)	.89 (.11)
Simon effect	92.89 (87.55)	81.18 (87.55)	94.40 (103.78)	58.65 (81.09)
DCCS errors	1.91 (1.44)	1.48 (1.33)	1.55 (1.33)	1.35 (1.37)
BRIEF BRI	47.21 (8.50)	48.09 (9.02)	47.39 (8.85)	49.24 (9.44)
BRIEF MI	47.97 (8.61)	47.80 (8.93)	46.86 (7.52)	49.35 (10.94)
BRIEF GEC	47.79 (8.03)	47.69 (8.30)	46.54 (7.02)	49.59 (10.01)

*$p < .05$, compared to monolinguals.
Abbreviations: Acc, accuracy; RT, reaction time; Simon Effect, Simon Incong RT – Simon Cong RT.

means and SDs by language group for all EF measures. Table 3 presents regression results.

5.2.1. Inhibitory control

There were no language group differences in commission errors on the GNG (Table 3). In other words, the language groups did not differ on inhibition of a prepotent response (GNG). For the HTKS, DLLs had the higher mean score, followed by bilinguals and then monolinguals (Table 2). The regression analysis supports this finding, showing a significant difference between DLLs and monolinguals' performance on the HTKS, with balanced bilinguals not significantly different from either group (Table 3). This suggests that, in this sample, DLLs are better than monolinguals on a more motor-based inhibitory control task where the individual is required to replace a dominant response with a less dominant one.

Next, we examined interference control via the Simon task. The groups did not differ significantly on the RT on congruent or incongruent trials of the Simon task when controlling for child ethnicity, household income, and number of children in the household (Table 3). For the Simon effect (difference in RT between incongruent and congruent trials), the language group did not appear to be significant. However, the unadjusted group mean for both types of bilinguals combined was different from that for monolinguals (Table 2); the effect size for this comparison (bilinguals versus monolinguals) was $d = .38$. With such an effect size, it is clear that results are in the expected direction, with bilinguals demonstrating a lower Simon effect (and hence better interference control) than monolinguals.

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Table 3. *Regression analyses for EF by language group*

	GNG	HTKS	Simon Cong RT	Simon Incong RT	Simon Effect	DCCS	BRI	MI	GEC
Language group									
Unbalanced vs. monolingual	.036	**.338**	.123	.148	−.063	**−.327**	−.005	−.049	−.065
Balanced vs. monolingual	−.023	.075	.238	.216	−.121	−.244	.093	.018	.070
Unbalanced vs. balanced	.064	.240	−.211	−.122	.086	−.019	−.120	−.072	−.152
Bilingual vs. monolingual[a]	.136	.278	.172	.184	−.093	**−.330**	.029	.047	−.024
Covariates									
Income	−.120	−.140	−.135	−.150	−.028	**−.280**	.032	.009	−.004
Hispanic[b]	−.090	−.134	.045	−.127	−.064	.137	−.167	.043	−.025
Age	**−.323**					−.218	−.253		
N Children[c]					**−.364**	**.273**			
R^2	.040	.051	.042	.065	.089	.165	< .001	< .001	.01

Note: p < .05 significant results are bolded. Covariates are included in the model only if it is related to the outcome and/or differed by language groups. Tabled values are betas.

Abbreviations: BRI, BRIEF behavior regulation index; DCCS, dimensional change card sort; GEC, BRIEF global executive composite; GNG, go or no-go; HTKS, head-to-toes; MI, BRIEF metacognition index.

[a]The bilingual or monolingual contrast was conducted in separate analyses, collapsing the unbalanced and balanced group into a major bilingual group.

[b]Ethnicity: 0 = White, 1 = Hispanic or others.

[c]N Children = number of children in the household.

5.2.2. Cognitive flexibility

We examined group differences in errors of the DCCS. Larger scores indicate more errors and less cognitive flexibility. After controlling for covariates, the language group was a significant predictor. In particular, unbalanced bilinguals performed better than monolinguals, and balanced bilinguals were not significantly different from either group (Table 3). The overall monolingual–bilingual contrast, after controlling for the same covariates, was significant, $b = -.73$, $p = .043$, where monolingual children made more errors on the DCCS than bilingual children. This indicates greater cognitive flexibility for the bilingual group as a whole, compared with monolinguals.

5.2.3. Parent report of EF

Finally, we examined group differences in parent reports of EF on the BRIEF. There were no group differences for parent reports of EF for any of the BRIEF subscales (Table 3).

5.3. Degree of bilingualism and EF

This question examined whether the degree of bilingualism was related to EF, within bilinguals. A series of Pearson's correlations was conducted to address this question. No correlations were significant for the degree of bilingualism and any EF measure ($0.015 < |r| < .176$).

6. Discussion

The purpose of the current study was to examine the relationship between bilingualism and executive functioning (EF) for a sample of bilingual and monolingual 5- to 7-year-old children. The main study goals included are as follows: 1) to add to the current body of literature on relations between bilingualism and EF, 2) to further this literature by examining a bilingual group that is of interest to a growing body of researchers (young Spanish–English bilinguals), and 3) to further explore potential EF advantages for a group of children not fully fluent yet in their second language (Spanish–English dual-language learners (DLLs)).

6.1. Second language fluency and EF

In general, there were mixed findings regarding the difference between bilinguals and monolinguals on various types of EF performance. This is in line with the current literature showing inconsistency in the bilingual effect and how these effects may change depending on the moderators and covariates included in the analyses (Festman et al., 2023). Second language proficiency is one such moderator, with higher proficiency or more balance being associated with better EF, although the importance of this is unclear and might not hold true for all populations (Festman et al., 2023). This is reflected in our findings as discussed as follows. Given the known problem of publication bias toward only statistically significant effects historically in the bilingualism–EF literature (De Bruin et al., 2015), it is important to report and publish null findings and to assist with meta-analyses (Bialystok, 2020; Polanin et al., 2016).

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As expected, there were no language group differences in simple, more response-based forms of inhibitory control, such as inhibition of a prepotent response (GNG). This is consistent with prior research comparing bilingual and monolingual children on inhibitory control tasks that do not require attentional control, such as 'delay' tasks (Carlson & Meltzoff, 2008). The practice bilingual children get at monitoring and controlling two competing languages does not clearly translate to situations that do not require control of attention (Escobar et al., 2018; Martin-Rhee & Bialystok, 2008). Interestingly, however, there was a difference between DLLs and monolinguals in the HTKS, with balanced bilinguals not different from either group, suggesting that unbalanced bilinguals in the current sample were better than monolinguals at inhibition involving a choice between competing responses, with no conflict present (HTKS). This result is different from previous research using tasks such as the day–night Stroop-like task (Martin-Rhee & Bialystok, 2008) that has similar inhibitory demands as the HTKS. It is possible that these mixed results may be related to the students' levels of language proficiency. In the current study, while bilingual children are relatively unbalanced, they still have skills in both languages, and this may be contributing to their scores. It is also possible that the finding is spurious as the study suffers from small cell sizes, which can produce biased estimates (Paap et al., 2014). Notably, the findings that unbalanced bilinguals but not balanced bilinguals outperformed monolinguals may be consistent with the argument presented by Paap et al. (2014), suggesting that bilingual effects might be seen when there is clearly a dominant language as individuals must actively resolve the competition between languages. Similarly, the ACH (Green & Abutalebi, 2013) argues that the language context influences bilingual EF. Perhaps, in this case, balanced bilinguals are sufficiently proficient in both languages and can code switch freely. However, unbalanced bilinguals must actively process and adapt to the language environment around them and thus show more effortful cognitive control, consistent with our results. Further examination is needed to understand whether the level of language proficiency in both languages influences these skills in DLLs and bilinguals and how these results compare with their monolingual counterparts.

The language groups did *not* differ in reaction time (RT) for both congruent and incongruent trials of the Simon task, inconsistent with prior research where balanced bilinguals were faster than other language groups (Martin-Rhee & Bialystok, 2008). The null and inconsistent effect, however, is in line with findings in young adults found in recent meta-analyses (von Bastian et al., 2016; Ware et al., 2020) and children (Gunnerud et al., 2020). This may have to do with bilingual children's cognitive flexibility and inhibition control, as bilinguals seem to have more practice changing the way their attention is directed in their environment, perhaps due to the cognitive control needed for language switching (Bialystok, 2017; D'Souza et al., 2020). Both languages are 'activated' at all times in the bilingual brain, and the mechanisms used to suppress the unneeded language at any point in time are thought to be the same as those used during inhibition that involves control of attention to multiple pieces of information (Green, 1998).

There was a group difference in the Simon effect score (difference in reaction time for incongruent versus congruent trials). Though not statistically significant, bilinguals collectively had a substantially lower score for the Simon effect compared with monolinguals, with a moderate effect size (d = .38 for bilinguals versus monolinguals). The lack of significant findings for the Simon effect, despite large group differences in favor of bilinguals, has also been demonstrated in prior research

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(Donnelly et al., 2019). This could be due to small-sample sizes for both the current and prior studies. Other studies found no differences between bilinguals and trilinguals in the Simon task but differences in other EF tasks such as the Flanker (Poarch, 2018). The resulting effect sizes in the current study indicate a small potential bilingual advantage for both balanced bilinguals *and* DLLs that could be examined further in future research.

These results have a few important implications. First, it seems that balanced bilingual children can still display somewhat better or similar performance in EF, even when residing in a country where there is not much cultural or educational support in place for minority languages. Second, the better performance in interference control for DLLs (who are not yet fully proficient) over monolinguals is an important finding and is consistent with the argument that bilinguals with one dominant language may show better performance due to constantly resolving conflicts between languages (Paap et al., 2014). In their study, Park et al. (2018) included a sample of simultaneous bilingual children and monolingual children to test interference at two separate time points, with one year in between. Their DLL group demonstrated steep improvement in interference from one time-point to another, while the monolingual group displayed stable performance over this period. In the current study, DLL children were exposed to their second language anywhere from a minimum of six months up to their entire lives. Thus, with enough exposure to a second language, positive benefits can be seen for non-linguistic domains of cognitive development, even when the child may not be fully proficient yet in the second language. Additionally, exposure to a home language that is not the societal language does not necessarily be harmful to children when entering the school system, a view that was previously and somewhat persistently held by the school system (Crawford, 2000; Cummins, 2000; Ruiz, 1984). In fact, research suggests the potential benefit of maintaining the home language as it aids in the acquisition of the second and societal language, as well as later language learning (Nguyen et al., 2023; Nguyen & Winsler, 2021).

When the language group was examined as a three-level variable, unbalanced bilinguals had significantly fewer errors on the DCCS compared with monolinguals, and balanced bilinguals did not significantly differ from the other groups in cognitive flexibility (DCCS errors). When bilinguals as a whole were compared to monolinguals, bilinguals had significantly fewer errors on the DCCS compared with monolinguals. This finding implies better cognitive flexibility for both balanced bilinguals and DLLs over monolinguals, consistent with studies using the DCCS (or similar) measures (Okanda et al., 2010; Park et al., 2018). Notably, it seemed that unbalanced but not balanced bilinguals showed an EF effect compared with monolinguals. This is somewhat consistent with ACH (Green & Abutalebi, 2013) as explained above, given the potential differences in the active and effortful adaptation by unbalanced bilinguals relating to enhanced EF.

The current study had several direct assessments of various EF components. However, one-time assessments in a laboratory setting may not accurately reflect children's EF strengths and weaknesses. Some researchers have pointed out the need for parental report of a particular behavior as a complement to direct assessment of that behavior (Isquith et al., 2005). Therefore, we included parent report of children's EF using a measure (BRIEF) that was intended to tap into EF deficits as they would manifest in children's everyday environment (Isquith et al., 2005). The language groups did not differ on this measure. This could be due to the BRIEF being designed to tap into EF *deficits* while theories on bilingualism and EF do not posit any deficits

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for particular groups. In addition, because the BRIEF taps into many components of EF, the components with a demonstrated bilingual advantage are not isolated well enough on this parent report measure to reveal group differences. Finally, there was substantial cultural variability in the current sample. Parents from different language and/or cultural backgrounds may have different expectations and standards for their children's behavior. The BRIEF rating scale is based on frequency (never, sometimes, and often); what a U.S.-born White parent views as 'often' for certain behaviors might be different for parents from different cultural backgrounds. Scores on the BRIEF did not differ by ethnic group or language in which the parent completed the survey (Spanish or English), but there may be some other unmeasured cultural variable, along with social desirability and other more general influences on parent reports that relate to the null findings with the BRIEF.

In addition to being examined categorically, second language fluency of bilinguals and DLLs was also examined as a continuous variable. Surprisingly, our measure of 'degree of bilingualism' (how balanced the two languages were for a child) was not related to any measures of EF. In other words, gradual changes in 'how bilingual' a child was not relate to differences in EF. This was dissimilar to other studies, which also defined bilingualism along a continuum of language dominance, observing that bilinguals who score higher on the bilingual continuum also generally score higher on degrees of EF (Amengual, 2012; Incera & McLennan, 2018). It may be that the effects in the current study are small, and a larger sample size is needed for detection. It may also have to do with the way in which the degree of bilingualism was measured in both the previous studies and this present study. Incera and McLennan (2018), for example, measured the degree of bilingualism as a continuous variable with the Language Experience and Proficiency Questionnaire (LEAP-Q) and used the percentage of time that the participants reported being exposed to their less frequent language(s) as a proxy for language use. Comparatively, the 'degree of bilingualism' variable in this study was an average of four difference scores for children's Spanish and English receptive skills, expressive skills, parent report of proficiency, and language use. However, it may be that the variable we created did not reflect what was intended. Perhaps this variable should have been weighted, with certain aspects of language background receiving more weight than others. For instance, Morton and Harper (2007) said that actual language use by bilingual children should be considered most important. The null findings, however, somewhat align with meta-analyses in young adults finding null effects of bilingual background on EF (Paap et al., 2014; von Bastian et al., 2016). More research is needed to study degree of bilingualism and EF in early childhood.

6.2. Implications, limitations, and future directions

The methodology and findings from the current study contribute to the literature in several important ways. First, the DLL group represents the experience and demographics of many Hispanic children in the United States, who have regular exposure to a non-English language at home (sometimes in addition to English) and exposure to primarily English at school. Second, the current study gathered direct assessments of receptive and expressive language skills in both languages, in addition to parent report of proficiency, frequency, and context and length of exposure for each language. Third, the current study attempted to create a continuum of bilingualism, by calculating a 'degree of bilingualism' variable, based on many quantifiable language background

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information (receptive skills, expressive skills, parent report of proficiency, and parent report of language use or context). This allowed for analyses to be conducted that could examine the linear relation between bilingualism and other variables (EF, behavior problems), as opposed to just mean differences between groups.

There were several limitations, however. First, the sample size was small ($N = 79$), especially when broken down by language group (balanced bilingual: $n = 17$, DLL: $n = 29$, and monolingual: $n = 33$). A post-hoc power analysis with the regression analyses (given $N = 79$, $\alpha = .05$, and expected effect size $\rho \approx .35$) revealed, as expected, that we were under-powered (.68). The small sample and relatively low power (< .80) may raise concerns about our findings, and thus, we interpret our results with some caution. Income was used as a covariate in analyses to help account for the disparity between monolingual and balanced bilingual families. However, there may be other factors related to family SES that relate to child cognitive development that were not controlled in the current study (Festman et al., 2023).

Due to the study location, the majority of the sample not only had very high income (average between $60,000 and $80,000), but several of the parents had higher education as well (most had at least a bachelor's degree). Therefore, the current results may not be generalizable to other samples of Spanish–English bilinguals around the country, as a large percentage of Hispanic or Latino families in the United States are from lower-SES backgrounds (U.S. Census Bureau, 2017). It is important to replicate this kind of study with lower-income samples of Spanish–English bilinguals. In Bialystok and Shorbagi's (2021) study, the sample of bilingual children in the higher SES group outperformed all other children on EF task scores, but a positive relationship between the degree of bilingualism and EF was still significant across the whole sample. This indicates that bilingualism and SES have an influence on EF independent from one another, when other relevant group differences (e.g., verbal ability and age) are taken into account.

Our samples of balanced bilingual and DLL children came from very different cultural backgrounds. Seventy-eight percent of the bilingual group was comprised of either first- or second-generation immigrants, from 24 different countries. Our lack of significant findings for the balanced bilingual group may be partially attributable to this variability, especially for tasks that have historically demonstrated an advantage for balanced children over DLLs and monolinguals (Simon task – interference control; DCCS – cognitive flexibility). Additionally, this variability may be related to some of the EF advantages demonstrated for our DLL group. Finally, most of the children in the DLL group were English-dominant instead of Spanish dominance due to sampling issues (limited recruitment locations or methods for bilingual and DLL children). Regardless, findings for the DLL group are still relevant. Being English-dominant despite having native Spanish-speaking parents is a common situation for many children in Spanish-speaking homes in the United States, especially after progressing a few years through public schooling. Thus, this aspect of the study can also be viewed as a strength, as this is a group of DLLs and balanced bilinguals that exist in large numbers in the United States.

This brings up a different, but related, set of issues these children might face compared with Spanish-dominant children. Anecdotal evidence from the current study suggests that, in homes where one or both parents were native Spanish speakers, parents sometimes focus on English language skills with children at the expense of Spanish skills. Many parents said it was just 'easier' to use English, since the children learned through that language in school. Current study results have implications for supporting Spanish language development. It is indeed important to promote English, but not at the expense of the Spanish language, as knowledge and use of two languages may bring benefit for children, or more importantly does not result in worse cognitive skills. This has implication for parents, educators, and researchers in the maintenance of heritage languages and growing field of research in the United States (Amezcua, 2019; Cummins, 2005; Leeman et al., 2011). Additionally, several Spanish-speaking parents of English-dominant DLLs (and even a few balanced bilinguals) reported that their children seemed to be rejecting the Spanish language and did not really like speaking it at home even though they had the ability to do so. Indeed, during the Spanish story-telling task, a few children refused to produce much (if any) Spanish, though their parents assured the RA that the children spoke it at home (and children's vocabulary scores reflected at least some working knowledge of Spanish for these children). This may be because children in all-English public schools feel peer pressure, even at this young age, to speak English. This suggests that language attitudes and the status of the home language of bilingual children may also serve as moderators of bilingual EF effects (Festman et al., 2023).

In conclusion, the current research examined the relationship between the degree of bilingualism and executive function in early childhood. Findings revealed a complex picture, as some effects appeared stronger for bilinguals who are unbalanced than balanced compared with monolinguals, and there were no differences between groups on some EF tasks. Indeed, there are no clear and consistent bilingual effects in the current findings or in the literature. Regardless, this research contributes to the growing literature on bilingualism in exploring nuances within the bilingual experience and provides additional understanding of factors that contribute to observed differences between different types of bilingual and monolingual groups.

Supplementary Material. The supplementary material for this article can be found at http://doi.org/10.1017/langcog.2023.46.

Data availability statement. Data and syntax are available at https://osf.io/q7rfc/.

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Competing interest. The authors declare none.

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