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Bilingual advantages in executive functioning: Evidence from a low-income sample

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Abstract

Recent research suggests that bilinguals might exhibit advantages in several areas of executive function, including working memory, inhibitory control, and attentional control. However, few studies have examined potential bilingual advantages within lower socioeconomic status (SES) populations. Here we addressed this gap in the literature by investigating whether low-SES Spanish-English bilingual preschoolers exhibited advantages in executive function relative to two monolingual control groups (English, Spanish). Across three experiments, bilingual children exhibited superior performance on two different measures of visual-spatial memory, as well as measures of inhibitory and attentional control. These results suggest that bilinguals exhibit broad advantages in executive function during the preschool years, and these advantages are evident within a disadvantaged, low-SES population.

Keywords: Bilingualism; bilingual advantage; executive function; working memory; socioeconomic status

Over the last several decades, considerable research has focused on the consequences of learning multiple languages. While some research has examined the language acquisition process itself (e.g., Hoff et al., 2011; Kroll et al., 2015), other studies have explored whether bilingualism impacts other areas of cognition (e.g., Bialystok et al., 2008; Bialystok et al., 2006; Carlson & Meltzoff, 2008). Specifically, do individuals who learn multiple languages experience cognitive benefits, or a 'bilingual advantage'? Considerable debate surrounds this question (Costa et al., 2009; Duñabeitia, et al., 2014; Paap & Greenberg, 2013). Here we sought to shed new light on this debate by investigating potential advantages in several facets of executive function in low-income preschoolers, while also addressing several methodological issues in the literature.

Bilingualism and Executive Function

Bilingual advantage refers to the possibility that learning and regularly using multiple languages enhances learners' cognitive abilities. Research on potential bilingual advantages has focused largely on components of executive function (Barac et al., 2014; Hilchey & Klein, 2011; Luk et al., 2010). Executive function (EF), also sometimes called executive control or cognitive control, refers to a set of general-purpose control mechanisms, linked to the prefrontal lobe of the brain, that regulate one's thoughts and behaviors (Diamond, 2013; Miyake & Friedman, 2012). Historically, there has been some disagreement about whether EF is a single unitary construct or a collection of separable mechanisms (Miyake et al., 2000). Miyake et al. (2000) used a latent variable approach to examine whether three facets of EF were distinct or reflected a single underlying ability: working memory (updating), inhibition (suppressing irrelevant information and prepotent responses), and attention (shifting). Results indicated that these three EF components are distinguishable but not completely independent (Miyake et al., 2000). These findings and theoretical model are commonly utilized by bilingual cognition researchers (including the present study) to describe the relationship of EF mechanisms and language use among bilinguals (Engel de Abreu et al., 2012).

The real-life practice of managing and switching between two or more languages on a regular basis might train and enhance bilinguals' EF (Adesope et al., 2010; Bialystok, 1999; Bialystok et al., 2009). Researchers have suggested that bilinguals might exhibit better inhibitory control because whenever they speak, they must simultaneously attend to the language they are currently using while inhibiting their other language (Green, 1998). This practice has also been suggested to improve bilinguals' attentional control or selective attention (Bialystok et al., 2005) and their task-switching abilities (Weissberger et al., 2015; Wiseheart et al., 2016). Researchers also suggest that bilingualism might lead to better working memory because the "juggling" of the simultaneous activation of both languages in the mind requires constant maintenance of representations related to language comprehension, reasoning, planning, and discourse, while also holding incoming information in the mind (Daubert & Ramani, 2019; Kroll et al., 2012; Yang, 2017). Consistent with this view, there is evidence that bilinguals recruit prefrontal brain regions associated with executive function during tasks that require monitoring attention to a target language and language switching (Coderre et al., 2016; Kroll et al., 2012; Luk et al., 2012; Van Heuven et al., 2008).

Some studies have supported claims of bilingual advantages in EF (Adesope et al., 2010; Grundy & Timmer, 2017; Mezzacappa, 2004; Yang et al., 2011; Yoshida et al., 2011). Researchers have found that bilinguals exhibit better inhibitory control in both a Stroop Task (interference suppression) and a Simon Task (stimulus-response conflict) (Bialystok et al., 2004; Martin-Rhee & Bialystok, 2008; Nayak et al., 2020). In a meta-analysis of 63 studies, Adesope et al. (2010) concluded there was consistent evidence that bilinguals outperformed monolinguals in several areas of EF, including working memory and attentional control. The presence of a bilingual advantage for working memory was again found in a recent meta-analysis by Grundy & Timmer (2017), which expanded on Adesope et al. (2010) by including grouped age comparisons (e.g., children vs. young adults) and studies of both bilingual and monolingual populations. Grundy and Timmer (2017) found that the largest effect sizes were observed in children compared to older age groups.

However, more recent studies on potential bilingual advantages in EF have found mixed results (Ansaldo et al., 2015; Blanco-Elorrieta & Pylkkänen, 2017; Goral et al., 2015), while still others suggest no difference between bilinguals and monolinguals (Costa et al., 2009; Desjardins & Fernandez, 2018; Duñabeitia et al., 2014; Lehtonen et al., 2018; Naeem et al., 2018; Paap & Greenberg, 2013; Paap et al. 2015). Hilchey and Klein (2011) reviewed 31 experiments using non-verbal interference tasks (e.g., Simon or flanker tasks) and concluded bilingual advantages in these tasks were rare and inconsistent in both children and adults. These negative findings have led some researchers to question the overall theoretical framework of the 'bilingual advantage,' suggesting instead that the differences shown in previous studies might be related to other factors (e.g., demographic differences, publication bias, etc.). For instance, Paap and Sawi (2014) recently revisited EF advantages and suggested that the psychometric properties of the measures used often do not support a generalization of a performance advantage, and studies may be subject to small samples with low effect sizes and publication bias.

One possibility is that these mixed results stem in part from methodological inconsistencies in the literature (Calvo & Bialystok, 2014; Grundy & Timmer, 2017; Paap & Greenberg, 2013). Here we focus on three such issues: socioeconomic status, age, and language group comparisons.

Socioeconomic Status

A long-standing issue in bilingualism research is socioeconomic status (SES). Bilingual and monolingual children often differ in both language experience and SES. Yet the way that SES is measured and the extent to which it is controlled for remains inconsistent across studies on potential bilingual advantages in EF (for reviews see Lehtonen et al., 2018; Paap et al., 2015). This is problematic given the well-documented negative effects of SES on several aspects of development (Gathercole et al., 2016; Hart & Risley, 1995; McLoyd, 1998; Morton & Harper, 2007). For instance, a recent study by Gathercole and colleagues (2016) found significant effects of SES on several measures of language and cognitive abilities in a large sample of monolingual and bilingual participants ranging in age from 3 to over 60 years of age. Moreover, children from high-SES families outperform those from low-SES families on measures of EF (Noble et al., 2005). Failure to adequately consider SES could thus contribute to the mixed pattern of findings in the literature, as negative effects of SES could potentially offset, or even exceed, any potential positive impact of bilingualism on EF.

Calvo and Bialystok (2014) recently addressed this issue by examining EF in monolingual and bilingual 6-year-olds from both working-class and middle-class families. Children completed three tasks that assessed inhibition, selective attention, and working memory. Monolinguals performed better than bilinguals on the selective attention task, which had greater verbal demands than the other two tasks (see also Meir & Armon-Lotem, 2017). After controlling for children's English vocabulary scores, the two language groups did not differ on this task. However, in the other two tasks, results revealed independent effects of SES and language experience on children's performance: middle-class children performed better than working-class children, and bilinguals performed better than monolinguals; the same pattern was found for a composite of the two EF tasks. These findings point to the importance of examining the impact of both SES and language experience on EF and suggest that bilingual advantages emerge once SES is adequately taken into account.

Similarly, several other studies have found that bilingual advantages in EF were only apparent after SES differences were controlled for (Bialystok & Martin, 2004; Blom et al., 2014; Carlson & Meltzoff, 2008; Engel de Abreu et al., 2012). For instance, Carlson and Meltzoff (2008) found that low-SES bilingual 6-year-olds' raw scores on an EF battery did not differ from those of higher-SES monolingual children. However, after controlling for SES, the bilingual children significantly outperformed monolingual children. Blom et al. (2014) likewise found that after controlling for SES, low-SES bilingual 6-year-olds outperformed monolingual 6-year-olds on measures of verbal and visual-spatial working memory. These findings suggest that the benefit of learning multiple languages might offset the negative impact of SES on EF (see also Santillán & Khurana, 2018).

There is also some evidence that the effect of bilingualism on EF might be greater in lower-SES groups. Morton and Harper (2007) tested a group of middle- to high-SES 6-year-olds using a Simon task and found no effect of language experience on children's accuracy or response times. In a study by Naeem et al. (2018), bilingual adults responded marginally faster on a Simon task than monolingual adults. However, this effect interacted with SES: low-SES bilinguals had significantly shorter reaction times than low-SES monolinguals, but there was no effect of language experience in high-SES participants. Finally, although Calvo and Bialystok (2014) did not report comparisons of bilinguals and monolinguals separately for their two SES groups, examination of the EF composite scores suggests a larger difference between bilinguals and monolinguals in the working-class group compared to the middle-class group. Together these findings suggest that effects of bilingualism are smaller in higher-SES samples than in lower-SES samples. One possible explanation for these findings is that higher-SES individuals already tend to have better EF skills, and thus there is less room for bilingualism to further enhance these skills. This would be consistent with work by Turkheimer and colleagues suggesting that environment has a greater impact on cognitive abilities in low-SES children (Turkheimer et al., 2003).

To summarize, the mixed findings regarding bilingual advantages in EF might stem in part from inconsistent consideration of SES in prior studies. Moreover, despite evidence suggesting that effects of bilingualism on EF might be most evident within low-SES populations, few studies have directly compared monolingual and bilingual children from low-SES backgrounds. Thus, further work examining the effects of language experience on EF within low-SES children is needed.

Age

Whether a given study finds evidence for a bilingual advantage in EF might also depend on the age of the participants tested. As mentioned above, a recent meta-analysis by Grundy and Timmer (2017) on 27 studies found evidence for a small to medium effect size for greater working memory capacity in bilinguals compared to monolinguals. However, this effect was larger in studies that tested children than in those that tested adults. Similarly, Bialystok et al. (2005) found that when tested with a Simon task, bilingual children responded more quickly than monolingual children. However, no effect of language experience was found in college-aged adults. The explanation that Bialystok et al. (2005) offered for these findings is similar to the argument we made above regarding SES: because EF performance peaks in young adulthood, there is little room for bilingualism to boost performance in this age range. A second possibility, suggested by Grundy and Timmer (2017), is that cognitive advantages might be most evident in children both because of greater neural plasticity, and because they are regularly experiencing the cognitive demands of learning their two languages. This early experience continuously navigating between two languages might influence the cognitive system, leading to greater EF advantages (Bialystok, 2015; Bialystok et al., 2006; Carlson & Meltzoff, 2008; Costa et al., 2008).

These findings suggest that there might be larger effects of bilingualism at younger ages. Indeed, a number of studies have found evidence of EF advantages in younger bilingual populations (Bialystok, 1999; Bialystok et al., 2005; Kapa & Colombo, 2013; Martin-Rhee & Bialystok, 2008; Yang & Lust, 2004; Zelazo, 2006). In particular, preschool-aged children make dramatic gains in EF skills due to the rapid cognitive, social, and emotional changes that occur during this time (Carlson, 2005). Bilingual advantages in EF might be particularly evident during this period of EF development. However, few studies have examined whether bilingual advantages emerge in preschoolers from a low-SES background.

Language comparison groups

Most prior studies on bilingual advantages in EF have compared bilingual participants to a single monolingual control group (Adesope et al., 2010; Lesniak et al., 2014). For instance, researchers might compare a group of Spanish-English bilinguals to a group of monolingual English speakers. Prior studies have also varied in whether the bilingual participants all spoke the same two languages (i.e. all French-English bilinguals) or not (i.e. all speak English but speak a variety of second languages). In their meta-analysis, Adesope et al. (2010) found that the size of bilingual advantage effects varied across distinct geographical and language groups. This could be because advantage effects depend on the particular pair of languages learned, or because particular languages lend themselves to particular tasks (e.g., phonological awareness; Yang et al., 2011). The tendency to pool participants from a variety of linguistic backgrounds would obscure such differences and could contribute to inconsistency across studies. Therefore, there is a need for studies that control for both of the bilinguals' languages using two monolingual groups, thereby addressing any potential influence of the individual languages on EF.

The Present Research

The present study investigated whether low-income bilingual preschoolers show advantages in the three components of EF identified by Miyake et al. (2000): working memory, inhibition, and attentional control. To do so, we tested three groups of preschoolers: monolingual English speakers, monolingual Spanish speakers, and English-Spanish bilingual speakers. All three groups of children were from low-SES backgrounds, allowing us to examine whether bilingual advantages in EF emerge within this population. Although some studies of bilingual advantages have examined preschoolers and have included lower-SES populations, to our knowledge no prior study has examined bilingual advantages in these three components of EF within a low-SES population with two monolingual control groups. Based on the findings discussed above suggesting that bilingual advantages might be most evident at lower levels of SES and younger ages, we predicted that the bilingual children would exhibit superior performance on all three components of EF. On the assumption that these advantages result from the experience of learning two languages, rather than learning English or Spanish specifically, we further predicted that bilingual children would outperform both monolingual groups.

Experiment 1

In Experiment 1, we examined whether low-SES bilingual preschoolers exhibit advantages in working memory. In particular, we focused on visual-spatial memory, which is the ability to hold in mind and manipulate information about the visual properties (i.e. color, shape) and the spatial arrangement of objects (Hornung et al., 2011; Kerrigan et al., 2017; McAfoose & Baune, 2009). We chose to use visual-spatial memory as our measure of working memory because it can easily be studied with tasks that involve minimal verbal demands and hence can readily be investigated in preschoolers, who may not yet be literate and are limited in their verbal abilities. Previous work by Morales et al. (2013) found that bilingual 5- and 7-year-olds exhibited advantages in visual-spatial working memory. The current study sought to extend this work by examining whether a bilingual advantage in visual-spatial working memory is also present in 4-year-olds within a low-income population.

Method

Participants. Participants were recruited from a local Head Start and two city preschools. Recruitment and testing were completed in the first two months of the school year to facilitate recruitment of a monolingual Spanish sample. Parents provided written informed consent for their children's participation in the study. The university's Institutional Review Board approved all procedures.

Parents of potential participants first completed a demographics questionnaire that included a question about the family's total household income. In order for children to be eligible, their parent had to report a total household income of less than $40,000 (this was based on the state cutoff for eligibility for free and reduced lunch; California Department of Education, 2014).

Children who met the income requirements were screened for receptive vocabulary in both English and Spanish using the Peabody Picture Vocabulary Test, fourth edition (PPVT), a widely used standardized measure of receptive vocabulary (Dunn & Dunn, 2007). How best to categorize children as monolingual or bilingual remains a pervasive issue in the bilingual advantage literature (we return to this issue in the General Discussion). We chose this form of language assessment primarily because it is well-suited for use with preschool aged children. Moreover, there is robust evidence that bilingual children exhibit a gap between their expressive and receptive vocabulary for both of their languages (see Gibson et al., 2018 for a review of the receptive-expressive gap and discussion of possible causes). We therefore reasoned that receptive vocabulary would provide a better indicator of bilingual children's language experience/skill than expressive language assessments such as the Preschool Language Scales (Zimmerman et al., 2011) or the Woodcock-Muñoz (Woodcock et al., 2005).

At the time of testing, no up-to-date Spanish version of the PPVT was publicly available. The *Test de Vocabulario en Imágenes Peabody* (TVIP; Dunn et al., 1986), while standardized, was based on the original version of the PPVT created in 1981 (PPVT-R, Dunn & Dunn, 1981). Although the PPVT has been updated several times to address issues related to efficiency, design, and cultural bias, the TVIP has not been changed since 1986 and remains outdated (Kester & Peña, 2002). The TVIP was also developed in Mexico City and Puerto Rico and not normed in the United States. Spanish terms and usage vary greatly across Spanish-speaking regions, and researchers have suggested that depending on where the test is administered, the terms in the TVIP might actually not be used by local Spanish speakers (Gibson et al., 2018). For these reasons, we chose not to use the TVIP in the current study.

Instead, we created a Spanish assessment by adapting the current PPVT-4. Two local native-Spanish speaking research assistants independently provided Spanish terms for each of the images in the PPVT easel. Disagreements on the appropriate term for a given image (3 out of 912 images) were resolved via discussion. After translation was completed, a target stimulus image was randomly selected for each page. To reduce possible practice effects across administrations of the PPVT, the target stimulus image from the English test was never selected; instead, the Spanish target stimulus item was randomly chosen from one of the other three images on each page.

All children completed both the English and Spanish versions of the PPVT (order counterbalanced). This was done to ensure that (a) monolinguals were not sufficiently proficient in the other language to be considered bilingual and (b) bilinguals were proficient in both languages.

Children were labeled English monolinguals if they received a raw score of 20 or less on the Spanish PPVT and 40 or higher on the English PPVT (these cutoffs were selected because they correspond to standard scores 3 SD and 2 SD below the mean, respectively, for the oldest children tested). Spanish monolinguals were those who scored a raw score of 40 or higher on the Spanish PPVT and less than 28[1] on the English PPVT. Children who received a 40 or more on both PPVTs were considered bilinguals. Children whose scores did not fall into one of these three classifications were excluded.

[1] A slightly higher cutoff was used for Spanish monolinguals because passive exposure to English in the United States could result in higher English raw vocabulary scores even if the child was not proficient in English. Note that if the same lower cutoff is used for both monolingual groups (i.e. Spanish-speaking children who received English-vocabulary scores over 20 are excluded), the patterns of significance reported in the Results' section do not change for any of the three Experiments.

The final sample consisted of 20 4-year-olds (10 male, 10 female) in each language group. An additional 4 participants were excluded because they did not meet the vocabulary cutoffs (2) or did not complete at least one of the two experimental tasks (2). Demographic characteristics appear in Table 1. Comparison of the bilingual group to each of the monolingual groups revealed no significant differences in age (monolingual English, $t(38) = .24$, $p = .81$; monolingual Spanish group, $t(38) = 1.44$, $p = .16$) or income (monolingual English, $\chi^2(1, N = 40) = .10$, $p = .75$; monolingual Spanish, $\chi^2(1, N = 40) = 1.91$, $p = .17$). The bilingual children's Spanish vocabulary scores did not differ from those of the monolingual Spanish group, $t(38) = 1.22$, $p = .23$. However, the bilingual children's English vocabulary scores were marginally lower than those of the children in monolingual English group, $t(38) = 1.87$, $p = .07$.

Table 1

Mean (SD) Age, Vocabulary, and Income for Participants in Experiment 1, Separately by Language Group.

	Monolingual English	Monolingual Spanish	Bilingual
Age in months	53.8 (3.1)	52.2 (2.8)	53.6 (3.3)
PPVT Raw Scores			
English	63.5 (15.6)	18.9 (6.6)	55.1 (12.5)
Spanish	10.7 (5.1)	47.0 (8.4)	51.0 (12.0)
Income	55% < $20,000, 45% $20,000-$39,999	80% < $20,000, 20% $20,000-$39,999	60% < $20,000, 40% $20,000-$39,999

Measures. Children completed two measures of visual-spatial memory: Concentration and Colorforms. Each task required children to remember the visual (i.e. color, shape) and spatial (i.e. relative location) features of items.

Concentration. Concentration is a memory game that has been used to assess visual-spatial memory in children and adults (e.g., Baker-Ward & Ornstein, 1988; Chagnon & McKelvie, 1992; Eskritt, Lee & Donald, 2001; Gellatly, Jones & Best, 1988) and has been used to examine differences in visual-spatial memory between people who use sign language (deaf and hearing signers) and non-signers (Arnold & Mills, 2001; Arnold & Murray, 1998).

Stimuli consisted of 8 pairs of cards; one side of each card was blue and the other side showed a red shape on a white background. Cards were placed on a table in a 4x4 grid. Children were told that their goal was to find matching pairs of cards by turning over two cards at a time. If the cards matched, they were removed. If the cards did not match, they were turned back over picture-side-down to the original positions. This procedure continued until all matches were found. All children played one practice game, followed by six scored games.

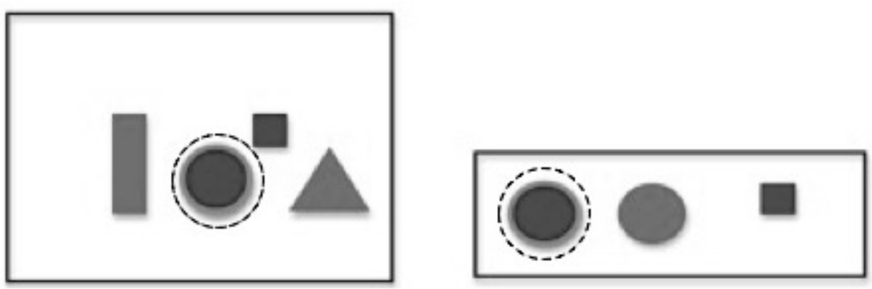

Figure 1. Example picture design (left) and forced-choice options (right) from the Colorforms task in Experiment 1. Dotted outline indicates the shape that was removed after initial presentation (left) and correct response (right).

Colorforms. The Colorforms task was a novel task developed to assess children's memory for the visual properties and spatial arrangement of objects. Stimuli were individual sheets containing paper-thin, vinyl shapes that could be applied and removed via static cling to create different picture designs. On each trial, children were shown a picture design that contained four shapes of different sizes and of two different colors (Figure 1). Children were asked to look at the picture, the different colors and shapes, and their locations. After 10 seconds, the experimenter moved the picture out of the child's sight and removed one of the four pieces. The experimenter then showed the child the picture again and asked if this picture was the same picture the child had seen before or if it was different. If the child said the picture was not different, the experimenter proceeded to the next trial. If the child indicated that the picture was different, the child was asked if some pieces were missing. If the child said yes, the experimenter presented the child with three choices: the correct missing piece, a piece of the same color but a different shape, and a piece that was the correct shape but different color. The child was asked to place the piece of their choice in the location of the missing piece. Thus, to answer all questions correctly, children had to remember the color and shape of the missing piece and its location relative to the remaining items. Children received one practice trial and six scored trials. A different picture was used for each trial.

Procedure. Children were tested in three different sessions at least five days apart. Children completed the English and Spanish PPVT in the first and second session (one session for each language, order counterbalanced). The two sessions were administered by different experimenters. In the final session, children participated in the Concentration and Colorforms tasks (order counterbalanced). In this and the following experiments, monolingual English and bilingual participants were tested by the experimenter who administered the English PPVT, and monolingual Spanish speakers were tested by the experimenter who administered the Spanish PPVT. Monolingual children were tested in their native language. Bilingual children were asked which language they preferred; with the exception of one child in Experiment 3, all bilingual children in this report selected English.

Coding. Both visual-spatial memory tasks were video-recorded and coded offline by two trained coders who were blind to the child's language group (i.e. bilingual vs. monolingual) and the hypotheses. For the Concentration task, each game was coded for the total number of card-flip errors (i.e. turning over two cards that did not match = 1 card-flip error). This measure excluded the first pair of cards flipped (because success on this flip was chance) and the last pair of cards flipped (because it necessarily resulted in a match). Inter-rater agreement was 95%.

For the Colorforms task, each trial was coded on a scale of 0 to 3. Children received a 0 if they indicated that the picture had not changed. If they indicated the picture had changed, their subsequent choice to replace the missing shape was coded for color, shape, and location. Children received one point for each element that correctly matched the missing shape (every child that said the picture had changed correctly identified at least one of these elements). Scores were summed across trials. Inter-rater agreement was 98%.

Results

Data analysis. For the Concentration task, we predicted that bilingual children would be better able to remember the features and location of previously-turned over cards, leading to fewer card-flip errors for bilingual children than for monolingual children. Similarly, for the Colorforms task, we predicted that bilingual children would remember more features of the removed shape, resulting in higher Colorforms scores for bilingual children than monolingual children.

To test these predictions, a generalized linear model with a poisson distribution and a log link function was performed for each visual-spatial memory score with language group as a between-subjects factor and the child's age in months as a covariate. This model was used because it is appropriate for count data. Wald chi-square values are reported for significant effects. Bonferroni corrected p-values are reported for all post hoc comparisons.

Preliminary analyses indicated no significant effects of child sex or income group on performance in either task, all *p*s > .23. Due to the marginal vocabulary difference between the monolingual English and bilingual participants, we also conducted preliminary analyses to determine whether these participants' performance on the visual-spatial memory tasks was correlated with their English vocabulary scores. Partial correlations controlling for child age revealed that English vocabulary was not correlated with either the number of card-flip errors children made on the concentration task, $r(37) = .05$, $p = .76$, or children's Colorforms score, $r(37) = -.07$, $p = .65$. These factors were therefore not examined further.

Concentration. The generalized linear model on children's total card-flip errors (Table 2) revealed a significant effect of language group, $\chi^2(2, N = 60) = 89.46$, $p < .001$. Post hoc pairwise comparisons indicated that as predicted, bilinguals made fewer card-flip errors than both monolingual English ($p < .001$) and monolingual Spanish ($p < .001$) children. Monolingual Spanish children also made significantly fewer errors than monolingual English children ($p < .001$).

Table 2

Mean (SD) Scores and Score Ranges for Experiment 1, Separately by Language Group.

	Concentration Card Flip Errors		Colorforms Score	
	Mean (SD)	Range	Mean (SD)	Range
Monolingual English	72.6 (19.3)	31 – 112	7.7 (2.6)	4 – 13
Monolingual Spanish	62.0 (11.3)	43 – 84	7.4 (2.5)	4 – 12
Bilingual	49.5 (10.0)	32 – 74	11.6 (3.3)	6 – 17

Colorforms. The generalized linear model on children's Colorforms score (Table 2) revealed a significant effect of language group, $\chi^2(2, N = 60) = 22.29$, $p < .001$. Pairwise post hoc comparisons indicated that bilingual children received significantly higher scores than monolingual English and monolingual Spanish children, both *p*s < .001. Scores for monolingual English and monolingual Spanish children did not differ ($p = .99$).

Relationship between tasks. Controlling for child age, the number of errors children made on the Concentration task was significantly negatively correlated with their score on the Colorforms task, $r(57) = -.38$, $p = .003$ (see Figure 2). Children who made fewer mistakes on the Concentration task were also better at remembering the color, shape, and location of the missing piece in the Colorforms tasks. This suggests that our novel Colorforms task taps into a similar underlying visual-spatial memory ability as the Concentration task.

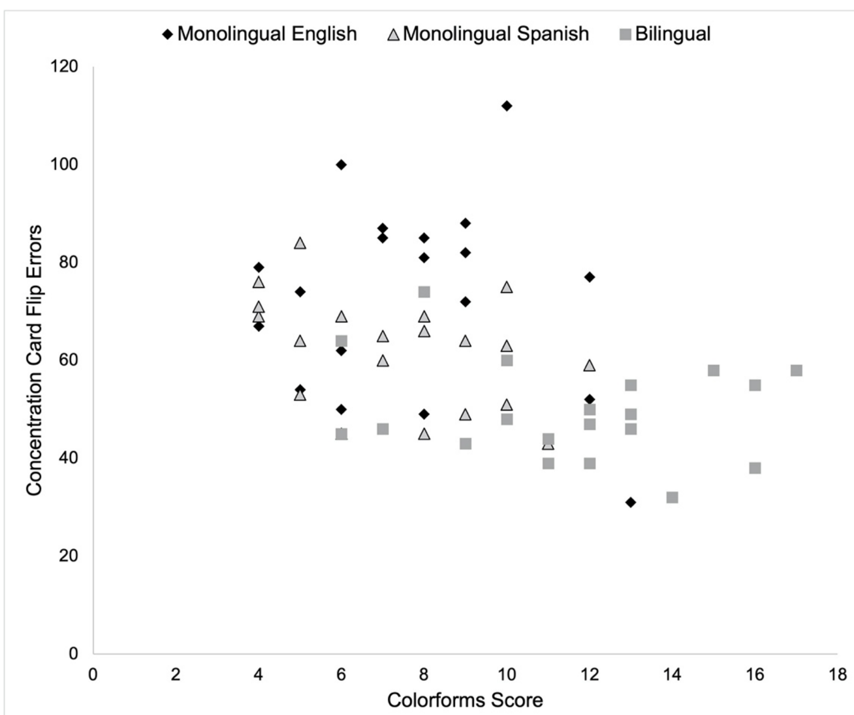

Figure 2. Relation between scores on the Colorforms task and the number of card flip errors in the Concentration task.

Discussion

In Experiment 1, bilinguals outperformed monolinguals on two measures of visual-spatial memory: they produced fewer card-flip errors in games of Concentration, and they were more accurate at recalling correct shapes, colors, and locations in the Colorforms task. Bilingual children outperformed both monolingual groups, suggesting that the advantage the bilinguals displayed was not due to the particular languages they spoke. Unexpectedly, the monolingual Spanish speakers made fewer card-flip errors than the monolingual English speakers in the Concentration task. The reason for this difference is unclear. However, given that the two monolingual groups did not differ on the Colorforms task, and that bilinguals outperformed both monolingual groups in both tasks, we think it unlikely that the superior performance of the Spanish speakers in the Concentration task stems from learning Spanish per se (i.e. Spanish speakers have better visual-spatial memory). Instead, the overall pattern of findings in this experiment suggests that bilinguals exhibit advantages in visual-spatial memory during the preschool years due to their experience learning two languages, and these advantages are evident within a low-income population.

Experiment 2

Experiment 1 showed that low-SES bilingual preschoolers exhibit advantages in visual-spatial memory. In Experiment 2, we asked whether bilingual advantages in inhibition are also evident in this population. Research suggests that bilinguals demonstrate advantages in different facets of inhibitory control, such as response inhibition and interference suppression, as a result of their experience managing two languages (see Bialystok et al., 2009 for review). In the present study, we measured children's response inhibition using the Day/Night task (Gerstadt et al., 1994), which was created specifically for preschool-aged populations.

Method

Participants. Participants were recruited from a local Head Start and two city preschools and screened in the same manner as in Experiment 1. Parents provided written informed consent for their children's participation in the study. The university's Institutional Review Board approved all procedures.

Table 3

Mean (SD) Age, Vocabulary, and Income for Participants in Experiment 2, Separately by Language Group.

	Monolingual English	Monolingual Spanish	Bilingual
Age in months	54.1 (3.3)	54.8 (3.4)	55.7 (3.0)
PPVT Raw Scores			
English	54.5 (10.6)	21.7 (6.9)	56.8 (23.3)
Spanish	9.8 (3.9)	60.6 (16.5)	57.5 (16.1)
Income	65% < \$20,000, 35% \$20,000-\$39,999	75% < \$20,000, 25% \$20,000-\$39,999	70% < \$20,000, 30% \$20,000-\$39,999

The final sample consisted of 20 4-year-olds (10 male, 10 female) in each language group. None of the children participated in Experiment 1. An additional 5 participants were excluded because they did not meet the vocabulary cutoffs (4) or did not complete the experimental task (1). Demographic characteristics appear in Table 3. Comparison of the bilingual group to each of the monolingual groups revealed no significant differences in age (monolingual English, $t(38) = 1.63$, $p = .11$; monolingual Spanish group, $t(38) = .85$, $p = .40$) or income (monolingual English, $\chi^2(1, N = 40) = .11$, $p = .74$; monolingual Spanish, $\chi^2(1, N = 40) = .13$, $p = .72$). The bilingual children's Spanish vocabulary scores did not differ from those of the monolingual Spanish group, $t(38) = .60$, $p = .55$, and their English vocabulary scores did not differ from those in the monolingual English group, $t(38) = .40$, $p = .69$.

Measures and procedure. The procedure was identical to Experiment 1, except that in the third session children completed the Day/Night task, as well as a second task not reported here (order counterbalanced). Day/Night is a Stroop-like task in which children are required to inhibit salient visual stimuli and answer with an opposing label (Gerstadt et al., 1994). Stimuli were two types of cards, one depicting a day scene with a yellow sun (day card) and one with a night scene with a moon and stars (night card). Children were instructed to say “day” when shown a night card, and to say “night” when shown a day card. Children were given four practice trials; if a child answered incorrectly, the experimenter repeated both rules and repeated the practice trial again. Children then completed 16 trials in a fixed random order.

Coding. The task was video-recorded and coded offline by two trained coders who were blind to the child’s language group (i.e. bilingual vs. monolingual) and the hypotheses. For each of the 16 trials in the Day/Night task, children’s response was coded as either correct or incorrect. Interrater reliability was 96%.

Results

We predicted that bilingual children would be better able to inhibit the prepotent incorrect label, resulting in more correct responses for bilingual than monolingual children. Because performance was coded as a series of dichotomous outcomes (correct or incorrect response), data were analyzed with a generalized linear model with a binomial distribution and a logit link function with language group and child sex as between-subjects factors and the child’s age in months as a covariate. Wald chi-square values are reported for significant effects. Bonferroni corrected p-values are reported for all post hoc comparisons. Preliminary analyses indicated no significant effects of income group, all *p*s > .62, and thus this factor was not examined further.

Table 4

Mean (SD) and Range of the Percent Correct Responses in the Day/Night Task, Separately by Language Group

	Percent Correct Responses	
	Mean (SD)	Range
Monolingual English	46 (29)	13 – 100
Monolingual Spanish	43 (24)	13 – 88
Bilingual	70 (15)	50 – 94

The generalized linear model revealed a significant effect of language group, $\chi^2(2, N = 60) = 51.33$, $p < .001$ (see Table 4). Post hoc pairwise comparisons indicated that bilingual children performed significantly better than monolingual English and monolingual Spanish children, both *p*s < .001. The monolingual English and monolingual Spanish children did not differ ($p = .99$). There was also a significant main effect of child sex, $\chi^2(1, N = 60) = 13.35$, $p < .001$, reflecting the fact that girls ($M = .60$) performed significantly better than boys ($M = .47$). However, there was no interaction between child sex and language group, $\chi^2(2, N = 60) = 2.41$, $p = .30$.

Discussion

In Experiment 2, bilingual children exhibited better response inhibition than both monolingual English and monolingual Spanish children. In contrast, the two monolingual groups did not differ from one another in their Day/Night scores. Together these findings suggest that low-SES bilingual children exhibit an advantage in response inhibition, and this advantage stems from experience with two languages rather than learning English or Spanish.

Experiment 3

Experiments 1 and 2 together show bilingual advantages in visual-spatial memory and response inhibition in a low-income population. In Experiment 3, we explored a third component of EF: attentional control. Research suggests that bilinguals display an advantage for attentional control (Bialystok, 2001; Bialystok & Shapero, 2004; Emmorey et al., 2008). A meta-analysis by Adesope et al. (2010) revealed that the largest effect size across a series of cognitive correlates of bilingualism was for attentional control, with a weighted mean effect size of .96 across 14 studies. Bialystok (1999) identifies analysis (representation) and control (attention control) as components of language processing and has shown that control develops earlier in bilingual children compared to monolinguals. Bilinguals between the ages of 4 and 8 display an advantage when solving experimental problems where high levels of control are required (Bialystok, 1999; Bialystok & Majumder, 1998; Bialystok et al., 2005). In the present study, we extended these findings by examining whether low-SES bilingual children exhibit advantages on an embedded figures task.

Method

Participants. Participants were recruited from a local Head Start and two city preschools and screened in the same manner as in Experiments 1 and 2. Parents provided written informed consent for their children's participation in the study. The university's Institutional Review Board approved all procedures.

The final sample consisted of 20 4-year-olds (10 male, 10 female) in each language group. None of the children participated in Experiments 1 or 2. An additional 4 participants were excluded because they did not meet the vocabulary cutoffs (2) or did not complete the experimental task (2). Demographic characteristics appear in Table 6. Comparison of the bilingual group to each of the monolingual groups revealed no significant differences in age (monolingual English, $t(38) = .65$, $p = .52$; monolingual Spanish group, $t(38) = .23$, $p = .82$). The bilingual group did not differ in household income from the monolingual Spanish group, $\chi^2(1, N = 40) = 1.11$, $p = .29$. However, the household income in the bilingual group was marginally lower than in the monolingual English group, $\chi^2(1, N = 40) = 3.14$, $p = .08$. The bilingual children's Spanish vocabulary scores did not differ from those of the monolingual Spanish group, $t(38) = .02$, $p = .98$, and their English vocabulary scores did not differ from those in the monolingual English group, $t(38) = .40$, $p = .69$.

Table 6

Mean (SD) Age, Vocabulary, and Income for Participants in Experiment 3, Separately by Language Group.

	Monolingual English	Monolingual Spanish	Bilingual
Age in months	53.3 (3.7)	53.9 (3.4)	54.1 (4.1)
PPVT Raw Scores			
English	57.1 (12.1)	17.1 (6.6)	55.0 (23.7)
Spanish	8.9 (4.1)	55.6 (12.2)	55.7 (15.5)
Income	75% < \$20,000, 25% \$20,000-\$39,999	85% < \$20,000, 15% \$20,000-\$39,999	95% < \$20,000, 5% \$20,000-\$39,999

Procedure. The procedure was identical to Experiment 1, except that in the third session children complete the Embedded figures task, as well as another task not reported here (order counterbalanced). In this task (Figure 3), children had to identify more than one of a particular embedded shape (e.g., triangle) within a picture of overlapping distracting shapes (e.g., squares, rectangles). These trials tested the child's ability to control attention and focus on the embedded target shapes rather than the non-target shapes. In other words, children needed to select relevant from irrelevant stimuli by focusing and refocusing their attention.

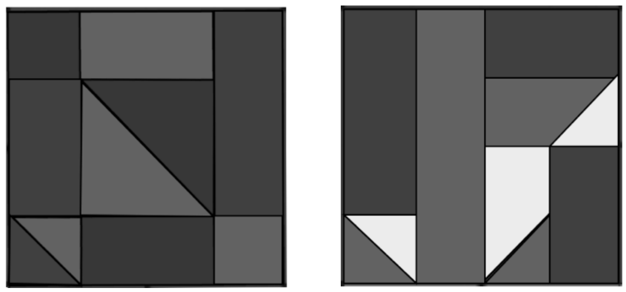

Figure 3. Sample stimuli from the embedded figures task in Experiment 3. The target shapes were triangles (left) and rectangles (right).

Children were first shown the shapes (two at a time) to ensure that they knew the name of each shape. For example, children were presented with a rectangle and a square and asked to point to the rectangle. Children then completed a practice trial and six scored trials. On each trial, children were first told which target shape they needed to identify. A picture was then placed in front of the child; each picture had four embedded target-shapes out of nine shapes total (the number of target shapes was not disclosed to participants). Children were instructed to touch all the target-shapes they could find as fast as they could. The picture was removed after the child indicated their response through pointing to or touching their answers.

Coding. The task was video-recorded and coded offline by two trained coders who were blind to the child's language group (i.e. bilingual vs. monolingual) and the hypotheses. The task was coded for the number of correctly identified target shapes out of 4 on each trial. Scores were summed across the six trials. Interrater reliability was 97%.

Results

Data analysis. We predicted that bilinguals would identify more of the target shapes than children in either monolingual group. To test this prediction, the total number of shapes that children correctly identified was analyzed with a generalized linear model with a poisson distribution and a log link function with language group as a between-subjects factor and children's age in months as a covariate, as in Experiment 1. Wald chi-square values are reported for significant effects. Bonferroni corrected p-values are reported for all post hoc comparisons. Preliminary analyses indicated no significant effects of child sex or income group on performance in either task, all *p*s > .31. These factors were not examined further.

Table 6

Mean (SD) Scores and Range of Total Correctly Identified Shapes in the Embedded Figures Task, Separately by Language Group

	Mean (SD)	Range
Monolingual English	14.7 (6.4)	2 – 22
Monolingual Spanish	12.7 (4.6)	5 – 19
Bilingual	19.3 (3.5)	10 – 23

The generalized linear model revealed a significant effect of language group, $\chi^2(2, N = 60) = 29.17$, $p < .001$ (see Table 6). Post hoc pairwise comparisons revealed that bilingual children identified significantly more shapes than the monolingual English children, $p < .001$, and the monolingual Spanish children, $p = .001$. The two monolingual groups did not differ, $p = .27$.

Discussion

The results of Experiment 3 paralleled those of Experiment 2: bilingual children outperformed both monolingual groups on a measure of attentional control, and the two monolingual groups did not differ from one another. Together, these three experiments show that bilingual children exhibit broad advantages in EF and these advantages are evident in a low-income population.

General Discussion

Evidence in favor of a bilingual cognitive advantage in EF is mixed. This inconsistency within the literature could be due to methodological concerns across the field. The current paper sought to address these issues by examining several components of EF in a rarely studied population of low-SES Spanish-English bilingual preschoolers and comparing their performance to that of two low-SES monolingual control groups (English, Spanish). Across three experiments, we found that low-SES bilingual children exhibited advantages in three components of EF: visual-spatial working memory, inhibition, and attention. Bilinguals outperformed both monolingual groups on every task, which suggests their superior performance was due to bilingual experience, rather than experience with either language.

In the Introduction, we speculated that bilingual advantages might be more evident in low-SES populations. Our finding that low-SES bilingual children exhibited robust advantages in three different facets of EF is consistent with this possibility. Additionally, previous research that has investigated low-SES populations has found that although bilinguals maintain lower-vocabulary scores compared to monolinguals, their performance on cognitive tasks remains high (Meir & Armon-Lotem, 2017). However, our study cannot explain why other studies with similar populations find no bilingual advantage (Timmermeister et al., 2020). We suggest that perhaps one way forward in the literature is to test for significant predictors, including SES, to identify what additional factors could be contributing to these differences in the literature. Like age and language, examining SES may reveal differences within subsets of populations that could speak to differences across studies.

More generally, our findings speak to the potential cognitive advantages of bilingualism, despite low-SES backgrounds (see also Santillán & Khurana, 2018). With an increase in English language learners in the United States, the majority of whom come from low-SES backgrounds, there is a need to understand the role of language experience in the cognitive development of such populations early in development (Park et al., 2017). Additionally, research has demonstrated that SES is a significant predictor of cognitive performance particularly for bilingual populations (Blom et al., 2014). The present findings reinforce previous work and suggest that bilingualism can confer cognitive benefits even in a disadvantaged population, which could in turn suggest that bilingualism could serve as a buffer for some of the negative effects on cognitive development that are sometimes observed in low-SES populations (Hart & Risley, 1995). These conclusions are particularly important for younger bilingual populations, as there are substantial improvements in EF growth in early childhood (Crivello et al., 2016; Carlson, 2005) when larger effect sizes for bilingual advantages are observed (Grundy & Timmer, 2017). We hope that future studies will consider the significance of examining low-SES populations specifically and incorporate SES as a standard baseline measure for their studies of bilingual and monolingual populations.

The present work also included two monolingual control groups, which is uncommon in bilingual advantage research. The bilinguals differed from both monolingual groups on all measures and, with one exception, the two monolingual groups did not differ from one another. The one exception occurred in Experiment 1, where the monolingual Spanish speakers produced fewer card-flip errors than the monolingual English speakers on the Concentration task. Note it was the monolingual Spanish speakers who performed better than might be expected. One possibility is that our monolingual Spanish speakers were less monolingual than the children in the monolingual English group. A recent study by Santillán and Khurana (2018) found that after monolingual Spanish speakers entered Head Start and began receiving instruction in English, they exhibited greater gains in inhibitory control than their monolingual English peers and began to converge on their bilingual peers. We attempted to circumvent the impact of Head Start instruction on the monolingual Spanish group by recruiting participants early in the school year. Nevertheless, it is possible that our monolingual Spanish speakers, although by no means proficient in English, had already begun to transition to English Language Learners due to their preschool experience and thus exhibited slightly better visual-spatial memory performance. This underscores the importance of having multiple monolingual control groups, as this effect would not have been evident if only a monolingual English control group were included.

This also points to a broader issue within the literature surrounding how bilingual proficiency is measured and operationalized. One issue concerns whether children should be categorized into discrete groups as we have done here (i.e. bilingual or monolingual) or whether research should instead focus on degrees of bilingualism. Several studies suggest cognitive advantages are present in bilinguals with balanced proficiency in their first and second language (see Bialystok, 2001 for review), but less is known about the impact of various degrees of proficiency. Our results, along with those of Santillán and Khurana (2018), suggest that young children might exhibit benefits of bilingualism as they are beginning to acquire their second language, before they achieve a balanced level of bilingualism. Additional studies that assess children at varying levels of proficiency are needed to address this issue.

A second, related question is how bilingual experience and proficiency should be measured. There is considerable inconsistency in the literature on this issue. The methods used to assess bilingualism range from objective measures of receptive or expressive language skills

(Gibson et al., 2018; Kester & Peña, 2002) to self-report (Kester & Peña, 2002) and parent- and teacher-report (Barac et al., 2014). In the present study, we used a measure of receptive vocabulary to categorize participants as monolingual or bilingual because of its ease of use with our preschool population. Receptive vocabulary, although one dimension of language skill, is arguably not the same as proficiency. However, other ways of assessing bilingualism also have their drawbacks. Measures of expressive language might underestimate bilingual children's knowledge in both of their languages (Gibson et al., 2018), and self-report measures are subjective and therefore vulnerable to bias.

This inconsistency in how bilingualism is measured and operationalized could contribute to the mixed pattern of findings in the literature. There is thus a need for an agreed upon way of identifying language groups. One promising avenue, which has been advocated for by a number of researchers, is to move away from isolated measures of proficiency and instead incorporate multiple measures that assess multiple dimensions of language ability and experience (e.g., Abu-Rabia & Sigel, 2002; Gathercole et al., 2008; Meir & Armon-Lotem, 2017). This approach would not only provide a more comprehensive picture of children's language exposure and skill, but it might also provide new insights into which measures are most strongly correlated with bilingual advantages.

Finally, we note two potential limitations of the present study. First, our studies examined children's accuracy in our tasks, but not their processing speed. With the exception of the embedded figures task in Experiment 3, children were not instructed to answer quickly, and therefore our tasks did not lend themselves to examining potential differences between bilinguals' and monolinguals' response times. Identifying potential differences in processing times could offer additional information regarding overall EF functioning and efficiency in bilinguals and monolinguals. For instance, a recent study found that low-SES bilingual adults responded more quickly, but not more accurately, than low-SES monolingual adults in a Simon task (Naeem et al., 2018). Thus, examining both accuracy and processing speed could clarify mixed results for bilingual advantages and, more generally, provide a more complete picture of these complex processes.

An additional limitation is that we did not measure children's general cognitive abilities and therefore we cannot rule out the possibility that the results of our tasks stem from differences in IQ. In a recent study, researchers presented results to suggest that in addition to SES, IQ also significantly contributed to cognitive control in a series of conflict monitoring tasks (Xie & Pisano, 2018). Thus, it is possible that the EF differences we observed stemmed from differences in IQ across our language groups. However, if this were the case, this would mean that bilinguals had a higher IQ than the other two language groups which would in turn, suggest a potential different kind of cognitive advantage altogether. While we cannot rule out this possibility, we do not think it contradicts our broader claim that robust cognitive advantages emerged in a low-SES bilingual population.

In summary, across three experiments we found bilingual cognitive advantages in EF in a low-income sample. These results suggest that bilingual experience might offset the negative effects of SES on children's developing EF skills. More generally, our findings speak to several methodological issues within bilingual advantage research, and add to a growing body of literature that suggests a need for greater examination of these methodological issues within the field.

References

Abu-Rabia, S., & Siegel, L. S. (2002). Reading, syntactic, orthographic, and working memory skills of bilingual Arabic-English speaking Canadian children. *Journal of Psycholinguistic Research*, *31*(6), 661-678.

Adesope, O.O., Lavin, T., Thompson, T., & Ungerleider, C. (2010). A systematic review and meta-analysis of the cognitive correlates of bilingualism. *A Review of Educational Research, 80*, 207-245.

Ansaldo, A., Ghazi-Saidi, L., & Adrover-Roig, D. (2015). Interference control in elderly bilinguals: Appearances can be misleading. *Journal of Clinical and Experimental Neuropsychology, 37*, 455-470.

Arnold, P., & Mills, M. (2001). Memory for faces, shoes, and objects by deaf and hearing signers and hearing nonsigners. *Journal of Psycholinguistic Research*, *30*(2), 185-195.

Arnold, P., & Murray, C. (1998). Memory for faces and objects by deaf and hearing signers and hearing nonsigners. *Journal of Psycholinguistic Research*, *27*(4), 481-497.

Baker-Ward, L., & Ornstein, P. A. (1988). Age differences in visual-spatial memory performance: Do children really out-perform adults when playing Concentration? *Bulletin of the Psychonomic Society*, *26*(4), 331-332.

Barac, R., Bialystok, E., Castro, D. C., & Sanchez, M. (2014). The cognitive development of young dual language learners: A critical review. *Early Childhood Research Quarterly, 29*, 699-714.

Bialystok, E. (1999). Cognitive complexity and attentional control in the bilingual mind. *Child Development*, *70*(3), 636-644.

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

Bialystok, E. (2015). Bilingualism and the development of executive function: The role of attention. *Child Development Perspectives, 9*(2), 117–121.

Bialystok, E., Craik, F. I., Green, D. W., & Gollan, T. H. (2009). Bilingual minds. *Psychological Science in the Public Interest*, *10*(3), 89-129.

Bialystok, E., Craik, F. I., Klein, R., & Viswanathan, M. (2004). Bilingualism, aging, and cognitive control: evidence from the Simon task. *Psychology and Aging*, *19*, 290-303.

Bialystok, E., Craik, F.I.M., & Luk, G. (2008). Cognitive control and lexical access in younger and older bilinguals. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 34*, 859-873.

Bialystok, E., Craik, F.I.M., & Ryan, J. (2006). Executive control in a modified anti-saccade task: Effects of aging and bilingualism. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 32,* 1341–1354.

Bialystok, E., & Shapero, D. (2004). Ambiguous benefits: the effects of bilingualism on reversing ambiguous figures. *Developmental Science, 8*, 595-604.

Bialystok, E., & Martin, M.M. (2004). Attention and inhibition in bilingual children: evidence from the dimensional change card sort task. *Developmental Science, 7,* 325-339.

Bialystok, E., Martin, M.M., & Viswanathan, M. (2005). Bilingualism across the lifespan: The rise and fall of inhibitory control. *International Journal of Bilingualism, 9,* 103-119.

Bialystok, E., & Majumder, S. (1998). The relationship between bilingualism and the development of cognitive processes in problem solving. *Applied Psycholinguistics*, *19*(1), 69-85.

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

Blom, E., Küntay, A. C., Messer, M., Verhagen, J., & Leseman, P. (2014). The benefits of being bilingual: Working memory in bilingual Turkish–Dutch children. *Journal of Experimental Child Psychology*, *128*, 105-119.

California Department of Education (2014). Income eligibility scales for 2014-2015. *Retrieved November 15, 2014, from* https://www.cde.ca.gov/ls/nu/rs/scales1415.asp

Calvo, A. & Bialystok, E. (2014). Independent effects of bilingualism and socioeconomic status on language ability and executive functioning. *Cognition, 130*, 278-288.

Carlson, S.M. (2005). Developmentally sensitive measures of executive function in preschool children. *Developmental Neuropsychology, 28*(2), 595-616.

Carlson, S.M. & Meltzoff, A.N. (2008). Bilingual experience and executive functioning in young children. *Developmental Science, 11*, 282-298.

Chagnon, J., & McKelvie, S. J. (1992). Age differences in performance at concentration: A pilot study. *Perceptual and Motor Skills*, *74*(2), 412-414.

Coderre, E.L., Smith, J.F., van Heuven, W.J.B., & Horwitz, B. (2016). The functional overlap of executive control and language processing in bilinguals. *Bilingualism, 19*(3), 471- 488.

Costa, A., Hernández, M., Costa-Faidella, J., & Sebastián-Gallés, N. (2009). On the bilingual advantage in conflict processing: now you see it, now you don’t. *Cognition, 113*, 135-149.

Costa, A., Hernández, M., & Sebastián-Gallés, N. (2008). Bilingualism aids conflict resolution: Evidence from the ANT task. *Cognition*, *106*(1), 59-86.

Crivello, C., Kuzyk, O., Rodrigues, M., Friend, M., Zesiger, P., & Poulin-Dubois, D. (2016). The effects of bilingual growth on toddlers' executive function. *Journal of Experimental Child Psychology*, *141*, 121-132.

Daubert, E. N., & Ramani, G. B. (2019). Math and memory in bilingual preschoolers: The relations between bilingualism, working memory, and numerical knowledge. *Journal of Cognition and Development*, *20*(3), 314-333.

Desjardins, J.L. & Fernandez, F. (2018). Performance on auditory and visual tasks of inhibition in English monolinguals and Spanish-English bilingual adults: Do bilinguals have a cognitive advantage? *Journal of Speech, Language, and Hearing Research, 61*, 410-419.

Diamond, A. (2013). Executive functions. *Annual Review of Psychology*, *64*, 135-168.

Duñabeitia J. A., Hernández J. A., Antón E., Macizo P., Estévez A., Fuentes L. J., Carreiras, M. (2014). The inhibitory advantage in bilingual children revisited: myth or reality? *Experimental Psychology, 61*, 234–251.

Dunn, L. M., & Dunn, L. M. (1981). Peabody Picture Vocabulary Test-Revised (PPVT-R). Circle Pines, MN: American Guidance Service.

Dunn L.M., & Dunn L.M. (2007). Peabody Picture Vocabulary Test-Fourth Edition. Bloomington, MN: Pearson Assessments.

Dunn, L. M., Padilla, E. R., Lugo, D. E., & Dunn, L. M. (1986). Test de Vocabulario en Imagenes Peabody [Peabody Picture Vocabulary Test]. Circle Pines, MN: American Guidance Service.

Emmorey, K., Luk, G., Pyers, J. E., & Bialystok, E. (2008). The source of enhanced cognitive control in bilinguals: Evidence from bimodal bilinguals. *Psychological Science*, *19*(12), 1201-1206.

Engel de Abreu, P. M., Cruz-Santos, A., Tourinho, C. J., Martin, R., & Bialystok, E. (2012). Bilingualism enriches the poor: Enhanced cognitive control in low-income minority children. *Psychological Science*, *23*, 1364-1371.

Eskritt, M., Lee, K., & Donald, M. (2001). The influence of symbolic literacy on memory: Testing Plato's hypothesis. *Canadian Journal of Experimental Psychology/Revue canadienne de psychologie expérimentale*, *55*(1), 39-50.

Gathercole, V. C. M., Kennedy, I., & Thomas, E. M. (2016). Socioeconomic level and bilinguals' performance on language and cognitive measures. *Bilingualism: Language and Cognition*, *19*(5), 1057-1078.

Gathercole, V. C. M., Mon Thomas, E., & Hughes, E. (2008). Designing a normed receptive vocabulary test for bilingual populations: A model from Welsh. *International Journal of Bilingual Education and Bilingualism*, *11*(6), 678-720.

Gellatly, A., Jones, S., & Best, A. (1988). The development of skill at concentration. *Australian Journal of Psychology*, *40*(1), 1-10.

Gerstadt, C. L., Hong, Y. J., & Diamond, A. (1994). The relationship between cognition and action: performance of children 3–7 years old on a stroop-like day-night test. *Cognition*, *53*, 129-153.

Gibson, T. A., Jarmulowicz, L., & Oller, D. K. (2018). Difficulties using standardized tests to identify the receptive expressive gap in bilingual children's vocabularies. *Bilingualism: Language and Cognition*, *21*(2), 328-339.

Goral, M., Campnelli, L., & Spiro, A. (2015). Language dominance and inhibition abilities in bilingual older adults, *Bilingualism, 18*, 79-89.

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

Grundy, J.G. & Timmer, K. (2017). Bilingualism and working memory capacity: A comprehensive meta-analysis. *Second Language Research, 33*, 325-340.

Hart, B., & Risley, T. R. (1995). Meaningful differences in the everyday experience of young American children. Paul H Brookes Publishing.

Hilchey, M. D., & Klein, R. M. (2011). Are there bilingual advantages on nonlinguistic interference tasks? Implications for the plasticity of executive control processes. *Psychonomic Bulletin and Review, 18*, 625-658.

Hoff, E., Core, C., Place, S., Rumiche, R., Señor, M., & Parra, M. (2011). Dual language exposure and early bilingual development. *Journal of Child Language, 39*, 1-27.

Hornung, C., Brunner, M., Reuter, R. A. P., & Martin, R. (2011). Children's working memory: Its structure and relationship to fluid intelligence. *Intelligence, 39*, 210–221.

Kapa, L. L., & Colombo, J. (2013). Attentional control in early and later bilingual children. *Cognitive Development*, *28*(3), 233-246.

Kerrigan, L., Thomas, M.S.C., Bright, P., & Filippi, R. (2017) Evidence of an advantage in visuo spatial memory for bilingual compared to monolingual speakers. *Bilingualism: Language and Cognition, 20*, 602-612.

Kester, E.S. & Peña, E.D. (2002). Language ability assessment of Spanish-English bilinguals: Future directions. *Practical Assessment, Research, & Evaluation, 8*(4), 1-5.

Kroll, J.F., Dussias, P.E., Bice, K., & Perrotti, L. (2015). Bilingualism, mind, and brain. *Annual Review of Linguistics, 1*, 377-394.

Kroll, J. F., Dussias, P. E., Bogulski, C. A., & Kroff, J. R. V. (2012). Juggling two languages in one mind: What bilinguals tell us about language processing and its consequences for cognition. *Psychology of Learning and Motivation, 56,* 229–262.

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

Lesniak, A., Myers, L., & Dodd, B. (2014). The English phonological awareness skills of 5;0 6;0-year-old Polish–English, Portuguese –English bilingual speakers and English monolingual children. *Speech, Language and Hearing, 17*, 37–48.

Luk, G., Anderson, J.A., Craik, F.L., Grady, C., & Bialystok, E. (2010). Distinct neural correlates for two types of inhibition in bilinguals: response inhibition versus interference suppression. *Brain and Cognition, 74*, 347-357.

Luk, G., Green, D. W., Abutalebi, J., & Grady, C. (2012). Cognitive control for language switching in bilinguals: A quantitative meta-analysis of functional neuroimaging studies. *Language and Cognitive Processes*, *27*(10), 1479-1488.

Lukasik, K.M., Lehtonen, M., Soveri, A., Waris, O., Jylkkä, J. & Laine, M. (2018) Bilingualism and working memory performance: evidence from a large-scale online study. *PLoS ONE, 13*. doi:10.1371/journal.pone.0205916.

Martin-Rhee, M. M., & Bialystok, E. (2008). The development of two types of inhibitory control in monolingual and bilingual children. *Bilingualism*, *11*(1), 81-93.

McAfoose J., & Baune, B.T. (2009). Exploring visual-spatial working memory: a critical review of concepts and models. *Neuropsychological Review, 19*, 130-142.

McLoyd, V. C. (1998). Socioeconomic disadvantage and child development. *American Psychologist, 53*, 185–204.

Meir, N., & Armon-Lotem, S. (2017). Independent and combined effects of socioeconomic status (SES) and bilingualism on children's vocabulary and verbal short-term memory. *Frontiers in Psychology*, *8*, 1442.

Mezzacappa, E. (2004). Alerting, orienting, and executive attention: developmental properties and sociodemographic correlates in an epidemiological sample of young, urban children. *Child Development, 75*, 1373-1386.

Miyake, A., & Friedman, N. P. (2012). The nature and organization of individual differences in executive functions: Four general conclusions. *Current Directions in Psychological Science*, *21*, 8-14.

Miyake, A., Friedman, N. P., Emerson, M. J., Witzki, A. H., Howerter, A., & Wager, T. D. (2000). The unity and diversity of executive functions and their contributions to complex "frontal lobe" tasks: A latent variable analysis. *Cognitive Psychology*, *41*, 49-100.

Morales, J., Calvo, A., & Bialystok, E. (2013). Working memory development in monolingual and bilingual children. *Journal of Experimental Child Psychology, 114*, 187-202.

Morton, J.B., & Harper, S.N. (2007). What did Simon say? Revisiting the bilingual advantage. *Developmental Science, 10*, 719-726.

Naeem, K., Filippi, R., Periche-Tomas, E., Papgeorgious, A., & Bright, P. (2018). The importance of socioeconomic status as a modulator of the bilingual advantage in cognitive ability. *Frontiers in Psychology, 9*, 1818.

Nayak, S., Salem, H. Z., & Tarullo, A. R. (2020). Neural mechanisms of response-preparation and inhibition in bilingual and monolingual children: Lateralized Readiness Potentials

(LRPs) during a nonverbal Stroop task. *Developmental Cognitive Neuroscience*, *41*, 100740.

Noble, K. G., Norman, M. F., & Farah, M. J. (2005). Neurocognitive correlates of socioeconomic status in kindergarten children. *Developmental Science*, *8*(1), 74-87.

Paap, K. R., & Greenberg, Z. I. (2013). There is no coherent evidence for a bilingual advantage in executive processing. *Cognitive Psychology, 66*, 232–258.

Paap, K. R., Johnson, H. A., & Sawi, O. (2015). Bilingual advantages in executive functioning either do not exist or are restricted to very specific and undetermined circumstances. *Cortex*, *69*, 265-278.

Paap, K. R., & Sawi, O. (2014). Bilingual advantages in executive functioning: problems in convergent validity, discriminant validity, and the identification of the theoretical constructs. *Frontiers in Psychology*, *5*, 962.

Park, M., O'Toole, A., & Katsiaficas, C. (2017). *Dual language learners: A demographic and policy profile for California*. Washington, DC: Migration Policy Institute.

Santillán, J., & Khurana, A. (2018). Developmental associations between bilingual experience and inhibitory control trajectories in Head Start children. *Developmental Science*, *21*(4), e12624.

Timmermeister, M., Leseman, P., Wijnen, F., & Blom, E. (2020). No bilingual benefits despite relations between language switching and task switching. *Frontiers in Psychology*, *11*, 1832.

Turkheimer, E., Haley, A., Waldron, M., d'Onofrio, B., & Gottesman, I. I. (2003). Socioeconomic status modifies heritability of IQ in young children. *Psychological Science*, *14*(6), 623-628.

Van Heuven W.J.B., Schriefers, H., Dijkstra, T., & Hagoort, P. (2008). Language conflict in the bilingual brain. *Cerebral Cortex*, *18*, 2706–2716.

Weissberger, G.H., Gollan, T.H., Bondi, M.W., Clark, L.R., & Wierenga, C.E. (2015). Language and task switching in the bilingual brain: Bilinguals are staying, not switching, experts. *Neuropsychologia, 66*, 193-203.

Wiseheart, M., Viswanathan, M., & Bialystok, E. (2016). Flexibility in task switching by monolinguals and bilinguals. *Bilingualism, 19*, 141-146.

Woodcock, R.W., Muñoz-Sandoval, A., Ruef, M., Alvarado, C. (2005). *Woodcock–Muñoz Language Survey— Revised.* Itasca, IL: Riverside.

Xie, Z. & Pisano, T.S. (2018). Second language (L2) proficiency, socioeconomic status (SES), and intelligence (IQ) are significant predictors of cognitive control differences among young adult unbalanced Chinese-English bilinguals. *Bilingualism: Language and Cognition, 22*(4), 866-882.

Yang, E. (2017). Bilinguals' working memory (WM) advantages and their dual learning practices. *Brain Sciences, 7*(7), 1-21.

Yang, S., & Lust, B. (2004, November). Testing effects of bilingualism on executive attention: comparison of cognitive performance on two non-verbal tests. In *Boston University Conference on Language Development* (Vol. 1, pp. 5-7).

Yang, S., Yang, H., & Lust, B. (2011). Early childhood bilingualism leads to advances in executive attention: Dissociating culture and language. *Bilingualism: Language and Cognition, 14*(3), 412-422.

Yoshida, H., Tran, D. N., Benitez, V., & Kuwabara, M. (2011). Inhibition and adjective learning in bilingual and monolingual children. *Frontiers in Psychology, 2,* 210.

Zelazo, P. D. (2006). The dimensional change card sort (DCCS): A method of assessing executive function in children. *Nature Protocols*, *1*(1), 297-301.

Zimmerman, I. L., Steiner, V. G., & Pond, R. E. (2011). Preschool language scales–fifth edition (PLS-5). *Bloomington, MN: Pearson*.