

## **“Mental workouts for couch potatoes”: Executive function variation among Spanish-English bilingual young adults.**

### **Abstract**

Research has yet to reach a definitive consensus on whether or how bilingualism confers benefits on Executive Function (EF): numerous studies show an EF advantage for bilinguals over monolinguals, while others indicate no significant differences. These inconsistencies demonstrate that the mechanisms behind a potential bilingualism-to-EF relationship remain unclear. Multiple factors likely impact EF outcomes among bilinguals, including proficiency and extent, type and environment of language usage. The current study explored EF skills among a relatively homogeneous sample of 50 Spanish-English bilingual young adults to provide insights into the environmental and individual characteristics that contribute to EF diversity. Hierarchical regression modeling revealed that more balanced bilingual language usage in specific home-based tasks (particularly TV watching), and higher self-reported ability in Spanish and English significantly predicted higher EF. Results support the developing empirical consensus that greater engagement in dual-language contexts bears a positive relationship to EF. The finding that watching TV with a balanced language ratio has a significant positive relationship to EF opens strong potential opportunities for bilinguals to access EF benefits with minimal effort.

### **Introduction**

Executive Function (EF) is associated with learning and academic success from childhood through adulthood (Mischel et al., 2010) and recent evidence indicates that bilingualism may confer certain EF advantages as compared to monolinguals, possibly linked to context-specific suppression of the non-target language (see Kroll & Bialystok, 2013 for a review; Akhtar, Menjivar, Hoicka & Sabbagh, 2012; Barac, Bialystok, Castro & Sanchez, 2014; Kapa & Colombo, 2013). Other findings contest the link between bilingualism and higher EF skill (Anton et al., 2014;

Duñabeitia et al., 2014; Hilchey & Klein, 2011). These inconsistencies demonstrate that the exact mechanisms behind this potential positive relationship remain unclear. A contributing factor may be treatment of bilingualism as a categorical variable when compared to monolingualism, despite evidence that the bilingual experience is extremely varied: “bilinguals differ in ways that matter” (Baum & Titone, 2014, p. 875). Multiple individual factors such as frequency and type of language use, the age at which each language was learned, or the level of proficiency in each language may contribute to diversity in EF outcomes among bilinguals, differentiating those experiencing EF advantages from those who do not (Baum & Titone, 2014). Notably, varying levels of activation of both languages - even in monolingual settings - has been seen in highly proficient balanced bilinguals and even very advanced second language users (Kroll & Bialystok, 2013); thus suggesting that language usage is a key within-group variable and one which has the potential to explain findings of no advantage among heterogeneous participant samples labeled “bilingual” based on self-identification (Paap & Greenberg, 2013). Additionally, a positive relationship between general language ability and EF has been found among both monolinguals and bilinguals (Bialystok & Feng, 2009; Iluz-Cohen & Armon-Lotem, 2013; Luo, Luk, & Bialystok, 2010) and second language learners (Segalowitz & Frenkiel-Fishman, 2005). EF advantages may, therefore, be stronger for bilinguals with more balanced usage of, and higher proficiency in, their two languages.

The exercise of using two or more languages on a daily basis has been shown to produce changes in cognitive performance (Bialystok, 2009). However, a balanced, dual use environment may not be representative for many minority language bilinguals living in majority language environments, which includes approximately one third (36%) of the estimated 55 million Latinos living in the US who are bilingual in Spanish and English (Pew Research Center, 2013; United

States Census, 2014). In order to elucidate relationships between EF and specific environmental and individual characteristics among bilinguals, the current study explored EF skills among a population of Spanish-English bilingual university students. Participants are relatively homogeneous with similar SES, educational background, and geographic origin, allowing insights into how daily language use, language behavior and language environment contribute to EF diversity among bilinguals.

### *Executive Function*

Executive Function (EF) is an umbrella term used to describe the various skills needed to manage and allocate cognitive resources during activities such as high-level thought, multitasking, focusing attention, ignoring distractions, and suppressing impulses; it plays a key role in individual differences in self-control and ability to regulate thoughts, impulses, and behavior. Also known as cognitive control, EF is fundamental for successful learning and goal-oriented behavior from childhood to adulthood. This unitary cognitive capacity is built on complex underlying skills of attention, inhibition, flexibility, memory, and long-range planning (Miyake et al., 2000; Miyake, 2012). A strong body of research has linked EF to higher education performance and it also has been more broadly implicated in overall quality of life (Mischel et al., 2010; Moffitt et al., 2011).

EF first manifests in infant ability to direct attention, and slowly progresses into the ultimate combination of complex capacities required for the sustained goal-oriented behavior found in typical adults (Garon, Bryson & Smith, 2008; Wiebe, 2014), following a generally predictable developmental timeline (for a review, see Hughes, 2013; Rueda, 2013; Diamond, 2013; Miyake & Friedman, 2012). Planning prospective actions is the final step in the EF maturation process, and develops during adolescence and young adulthood (Diamond, 2013; Friedman et al., 2014). While EF development follows a broadly predictable maturational trajectory,

developmental rate and eventual ability levels are positively and negatively influenced by environmental variables (Farah et al., 2006). Challenges during childhood such as poverty, chronic stress, traumatic events, and deprivation are associated with lower levels of EF in adulthood (Farah et al., 2006; Hackman, Gallop, Evans, & Farah, 2015). These factors may impact EF development directly and/or be mediated by parental response (Blair, Granger & Razza, 2005; Evans & Kim, 2013). On the positive side, environmental factors can also result in higher EF skill levels for adults and children, as demonstrated in particular academic environments designed explicitly to train EF (Baker et al., 2015; Skibbe, Connor, Morrison, & Jewkes, 2011; Yeniad et al., 2014).

### *Bilingualism and EF*

There is not yet a definitive consensus on how, or even whether bilingualism confers benefits for EF. A substantive number of studies have found EF advantages in both bilingual adults (see Kroll & Bialystok, 2013 for a review) and children (see Akhtar et al., 2012; Barac, Bialystok, Castro & Sanchez, 2014; Kapa & Colombo, 2013 for reviews), while other studies have failed to find greater skill among bilinguals compared to monolinguals (Anton et al., 2014; Duñabeitia et al., 2014; Hilchey & Klein, 2013). The posited increased EF ability is referred to as the “Bilingual Benefit” (Bialystok, Craik & Luk, 2012). It is hypothesized that bilinguals manage their attention between two (or more) jointly activated languages at all times, diverting attention away from the language not in use (Bialystok et al., 2012; Luk et al., 2010). The increased cognitive demands of consistent multilingual coordination may result in higher EF performance because the language control region where this management takes place (for example, left prefrontal cortex) involves the same areas activated for other non-language tasks requiring attention and ignoring distractions. Specifically, researchers posit that EF skills are implicated in bilingual activities such as selectively attending to a broader range of linguistic and social cues (Friesen, Latman, Calvo &

Bialystok, 2014), the ability to inhibit lexical and semantic representations in a non-target language while using another (e.g., Bialystok & Viswanathan, 2009; Gandolfi, Viterbori, Traverso & Usai, 2014; Martin-Rhee & Bialystok, 2008; Poarch & van Hell, 2012), and constraining language production to the target language (Kovács, 2007). In particular, lifelong bilinguals are shown to have greater ability to ignore distracting/interfering stimuli when completing a task, attributed to their daily task of managing multiple languages competing for attention, and greater control in response inhibition tasks, both of which are likely related to constant context-specific suppression of one language (Bialystok et al., 2012; Luk et al., 2010). If the mechanism behind an EF advantage for “balanced” bilinguals is the regular higher demand on domain-general skills from managing two languages, then this active, dual use may be required for developing or maintaining advantage.

Much of the previous research on potential EF benefits has focused on comparing bilinguals to monolinguals, treating the population of individuals who speak more than one language as categorical and homogeneous, despite evidence that bilingual experience is extremely varied and that the degree to which languages are used likely impacts cognitive outcomes (Bialystok et al., 2012; Luk et al., 2010). Previous research suggests language balance may be one of the elements needed to access EF advantages. For example, Carlson and Meltzoff (2008) found that balanced bilingual children performed better on EF tasks requiring attention management as compared to sequential emergent bilingual children in immersion programs (children who spent half the school day in the new target language and had a minimum of 6 months of exposure) and to monolingual children, suggesting that early exposure and language mastery may play a role in EF benefits conferred by multiple language use (Carlson & Meltzoff, 2008). Ricciardelli (1992) found better performance among English-Italian bilinguals over monolinguals and English

speakers with limited Italian on geometric design tasks. Bialystok and Majumder (1998) found the meta-linguistic advantages conferred by bilingualism to be linearly dependent on degree of bilingualism among children: balanced, fully bilingual children performed best, after controlling for age and language proficiency. Taken together, this research suggests a high level of bilingualism may help access cognitive benefits from bilingualism, possibly including EF advantages.

Research which focuses on EF benefits from bilingualism among speakers who would be considered “balanced” (i.e. people of comparable ability level in both languages who use those languages actively and regularly for an extended period of time) may not speak to the reality of numerous bilinguals in the U.S., many of whom, such as speakers of minority or heritage languages, do not live in “balanced” environments. Some bilinguals do not have access to resources such as schooling or literacy support in one of their languages, resulting in “imbalanced” spheres of language proficiency (for example, higher writing abilities in English than in their home language). However, it is unclear if “bilingual benefits” are experienced by bilingual populations who have only had formal education in one of their languages (e.g. English) and may not be comparably proficient in the other, or indeed bi-literate. Additionally, there is increasing evidence indicating that variation in language experience and environment has an impact on cognitive development among young bilinguals (Guerrero, Smith & Luk, 2016). It is therefore likely that these within-population differences would be equally reflected in young adults. Green & Abutalebi’s (2013) adaptive control model posits that EF demands for bilinguals vary based on language environments: bilinguals who live in a mixed language environment with two widely used languages mixed through daily life in a number of settings (e.g. Montreal) will need to attend to environmental language cues and correspondingly suppress one language, switching rapidly

between languages as needed based on interlocutor. In contrast, minority language children and young adults in majority language schooling inhabit two functionally monolingual contexts, with languages exclusively used in home or school environment. Consequently, these learners may have high demand on inhibitory EF, as they must constantly suppress one language in each context. For such learners, EF development may also be significantly impacted by language proficiency, since stronger language proficiency produces stronger activation of a language and consequently increased inhibitory demands for a setting in which that language is suppressed. For both of these scenarios, daily language use and environment can impact EF development.

Differences between bilingual individuals may thus be the result of many different factors. It is not yet clear why some studies find bilingualism to confer EF benefits while others do not; frequency and type of language use appear to play a role, but the specific language experiences of “balanced” bilinguals that positively impact EF development are not yet known. A further mitigating factor is that a bilingual’s language environment may shift over a lifetime, moving from balanced during some time periods to nearly monolingual during others (Grosjean & Li, 2013). The degree and duration of bilingual activity “required” for benefits, possible attrition rates, and moderating individual factors remain under research.

Current research has identified additional aspects of bilingual heterogeneity that may also impact EF development, including onset age of second language acquisition (AOA) and second language proficiency. AOA is defined either as age of first exposure to a second language, or the age when the child produces that language (Kapa & Columbo, 2013, Bialystok & Visnawathan, 2009; Carlson & Meltzoff, 2008; Poarch & van Hell, 2012). Frequency of use is relevant in combination with AOA; for example, many US bilinguals might speak a minority language in the home and have first significant exposure to English at the onset of schooling. This population of

learners has little diversity of AOA but their language experiences may still be varied. Learners in bilingual programs may develop both languages throughout schooling while learners in English-only programs could experience attrition of their home language. Language proficiency also is posited to play a role. Based on psycholinguistic models of bilingualism such as Kroll's Revised Hierarchical Model (Kroll & Stewart, 1994; Kroll & Tokowicz, 2005) and the Bilingual Interactive Activation Model (Dijkstra & van Heuven, 2002), we hypothesize that as proficiency in a language increases, so too does activation of that language. The BIA proposes that bilinguals have hierarchically organized word representations, all activated and competing for attention. From these models, we infer a possible link between proficiency and activation: the BIA proposes that competition occurs within and across languages, as such, a greater number of representations total suggests greater competition. We posit that if representation for a target lexical item exists in only one language (example: the language user knows the word for "accountancy" in only English, not Spanish), less competition will occur.

Given the hypothesized influence on EF of the variables previously discussed, there is a strong need for empirical research that isolates specific aspects of bilinguals' language use, experience, and proficiency with reference to their individual and combined relationship to EF. Such research would be a means of identifying the mechanisms that enable bilingualism to confer benefits to EF for the many millions of bilinguals across the globe. The current research explores specific aspects of EF impacted by bilingualism among young adults. Specifically this study asks: RQ1: What are the environmental language (daily language environment, language used by others at work, home and school) use factors that show a relationship with Executive Function scores among Spanish-English Bilinguals? RQ2: What are the individual language factors (self reported proficiency, reading behaviors, television and music listening behaviors,



produced language) that show a relationship with Executive Function scores among Spanish-English bilinguals?

## **Methods**

### *Participants*

Fifty Spanish-English bilingual undergraduate students from a four-year public university on the west coast of the United States of America took part in the current study. Participants were between 18 and 30 years of age,  $M = 21.8$  years,  $SD = 2.47$  years. Students were recruited via emails and physical signs for opt-in participation. All participants report learning Spanish as their first language from birth, and all learned English sequentially after, between ages 2 and 5. All participants reported no diagnosis of developmental or learning disability. Forty-four females and 6 males participated. All identify as Chicano/a, Hispanic, or Latino/a. Forty-eight participants were full-time students, 2 were part-time students. Thirty-four also work part-time in addition to schooling, 10 work full-time in addition to schooling. Participants generally came from lower-socio economic familial backgrounds, as 36 received government Pell Grants (government financial assistance for low-income students whose calculated expected financial contribution, a figure calculated using annual family income, falls significantly below cost of university attendance), and 26 received government student loans. Participants came from geographic regions of northern and central California, had been educated in state-funded (public) schools in this region before attending University. All participants had 12 years of English language schooling in the US, 14 report having been exposed to Spanish in school bilingual programs ( $M = 0.54$  years Spanish bilingual schooling, maximum 2 years). Participants' declared academic majors were in the domains of Liberal Studies, Health Sciences, Social Sciences, Business and Engineering. No participants were majoring in a foreign language or language arts. Participant background

information on maternal educational achievement is presented in Table 1. [TABLE 1 NEAR HERE]

### *Procedures*

Pearson Q-active tablet testing was used to administer five standardized assessments to the participants. These were: (1) Delis-Kaplan Executive Function System (D-KEFS); (2) Trails and Color-Word Inhibition subtest; (3) Wechsler Individual Achievement Test Third Edition (WIAT III) Reading Comprehension (English); (4) Wechsler Adult Intelligence Scale Fourth Edition (WAIS IV) Working Memory (WM); and (5) Matrix Reasoning (non-verbal IQ). In addition, participants completed a measure pertaining to language environment and language behaviour, which was an adaptation of the Language and Social Background Questionnaire (LSBQ: Luk & Bialystok, 2013). The adapted LSBQ captured language contact by skill (Speaking/Listening/Reading/Writing) and by environment (School/Work/Home). All measures were completed in English.

#### *D-KEFS, Trails and Color-Word Inhibition subtests (Delis, Kaplan, & Kramer, 2001)*

The D-KEFS Trail-Making subtest is comprised of four connect-the-dots activities and a cancellation task (Conditions 1-5). Four of the conditions enable the investigator to establish normative data such as visual scanning, number sequencing, letter sequencing, and motor speed. The participant first completes the cancellation task (Condition 1), requiring them to visually scan a page of numbers and letters and mark each instance of a designated number or letter; any omission errors are recorded. The following two tasks, Conditions 2 and 3, entail connecting marked dots in alphabetical and numerical order, respectively. The operative task, Condition 4, requires the test taker to sequentially connect a series of points while switching between letters and numbers in order to test cognitive flexibility in visual-motor tasks. In Condition 5, participants

quickly trace a dotted line connecting the points.

Designed to measure inhibition of the dominant and automatic response, D-KEFS Color-Word Inhibition subtest utilizes the Stroop effect (Stroop, 1935). The first two measures establish the basic ability to properly read from a list of written colors as well as visually identify a series of colors. The third task requires the participant to name the color of the ink in which each word is printed; the ink colors are all incongruent to the corresponding written color (e.g. the word 'red' printed in green ink). The participant must therefore inhibit the dominant response (to read the word rather than name the mismatched ink color) in order to successfully complete this task. Combining inhibition and switching, the final task in this measure requires participants to switch between naming the ink colors and reading the written colors; this measures mental flexibility in addition to inhibition of the dominant response. Scores for both subtests are scaled at 10.

*WIAT III Reading Comprehension subtest (Wechsler, 2008)*

The WIAT III reading comprehension subtest measures the extent to which a test taker has understood four different texts, such as stories or letters. The 12<sup>th</sup> grade version of the subtest was administered in the current research. The four texts were presented to the participants on a tablet. Participants were allowed an unlimited time period in which to read the texts, either silently or aloud. After completion of reading, respondent answered conceptual and factual questions about the text content, with the option of referring back to the relevant text should they wish to. The standardized scores were scaled at 100, representing 50<sup>th</sup> percentile at 12<sup>th</sup> grade reading for individuals in the US.

*WAIS IV, Working Memory and Matrix Reasoning subtests (Wechsler, 2008)*

The Working Memory section of WAIS IV includes a Digit Span subtest which measures attention, auditory processing and working memory. This test was administered in three stages:

(1) a series of numbers was read aloud to the participant and they were required to repeat back the same numbers in the same order; (2) a series of numbers was read aloud to the participant and they were required to repeat back the same numbers in reverse order; and (3) a series of numbers was read aloud to the participant and they were required to restate the same numbers in order from least to greatest. The test administrator was not permitted to repeat any one number or sequence of numbers.

The Perceptual Reasoning section of WAIS IV includes a Matrix Reasoning subtest which was administered to the participants and which measures perceptual organization, nonverbal abstract reasoning and fluid intelligence. The test items comprise patterns and sequences of images, with respondents tasked to select an image they believe logically completes the sequence/pattern. The scores for this subtest were scaled at 10.

*Language and Social Background Questionnaire (LSBQ)* (Luk & Bialystok, 2013)

Participants completed a modified version of the LSBQ (Luk & Bialystok, 2013). This previously validated language and social background questionnaire was designed to explore the heterogeneity within bilingual populations (Luk & Bialystok, 2013). The LSBQ addressed aspects of daily bilingual experience including frequency of use in a range of home and community settings. Participants report their proportion of Spanish or English use in various settings (e.g. home, university, work), interlocutors (e.g. family, friends, co-workers, clients/customers) and activities (e.g. talking, reading, writing, watching TV) using sliding scales between 0% and 100%. Participants also self-report perceived ability level in English and Spanish for reading, writing, speaking, and listening.

## **Results**

Assessment performance means are presented in Table 2. Performance was normally distributed, with means falling around 50th percentile (i.e., a score of 10) of the general population over age 18 for EF tasks and below 50th percentile of general population over age 18 and for the WAIS (i.e., a score of 10) and below 50th percentile of US high school 12th graders for the WIAT (i.e., a score of 100). To test the relationships between environmental and individual variables, hierarchical regression analyses were conducted. Models controlled for IQ and WM to allow estimation of the unique effects on EF. [TABLE 2 NEAR HERE]

LSBQ results revealed language environment differences between university life, which is mainly carried out in English, and home and work life, which both contain a mixture of Spanish and English. [TABLE 3, TABLE 4 NEAR HERE]

#### *D-KEFS Trails Subtests*

##### *Visual scanning*

Participants who reported themselves to have higher skill in English also showed higher performance in the Trails visual scanning test. A composite variable of English language ability made by averaging all 4 scores significantly predicted D-KEFS Trails visual scanning subtest,  $F(1,48) = 15.01$ ,  $p < .001$ ,  $r^2 = .24$ . After controlling for IQ and WM, three of the four English language components ability self-reports had a significant correlation with higher performance on the D-KEFS Trails visual scanning subtest: speaking, listening/understanding, and reading; writing was approaching significance. See Table 5 for contributions of self-reported English ability components. [TABLE 5 NEAR HERE]

However, a model with IQ, WM, and English reading comprehension, as measured by the standardized WIAT reading assessment administered in the battery, did not account for significant variance in outcomes,  $F(3,46) = 1.59$ ,  $p = .21$ ,  $r^2 = .09$ . Performance on the WIAT itself made a unique

significant contribution,  $p=.05$ ,  $R^2\Delta=.07$ , much smaller than the self-reports of English speaking, listening/understanding, and reading.

#### *Number-Letter switching*

When controlling for IQ and working memory, reported language of radio listening significantly accounted for variance in DKEFS trails number letter switching outcomes,  $p=.01$ , change in  $r^2=.11$ ; this combined model predicted 21% of variance in outcomes,  $F(3,45) = 4.02$ ,  $p=.013$ ,  $r^2=.21$ . Participants who reported less radio in English (in a sense, more mixed radio usage) had higher DKEFS trails number letter switching outcomes.

Home TV watching behavior uniquely significantly accounted for variance in DKEFS trails number letter switching outcomes, when controlling for IQ and working memory,  $p=.013$ ,  $R^2\Delta=.12$ ;  $F(3,44) = 4.13$ ,  $p=.01$ ,  $r^2=.22$ . TV watching behavior, IQ, and working memory account for 22% of variance in DKEFS trails number letter switching outcomes, such that participants who report watching more TV in Spanish show significantly higher DKEFS trails number letter switching outcomes. Self-reported amount of daily TV watching did not make a significant contribution to DKEFS trails number letter switching,  $p=.10$ ,  $R^2\Delta=.07$ . Home TV watching behavior uniquely significantly accounted for variance in DKEFS trails number letter switching outcomes, when controlling for IQ, working memory, and amount of daily TV watching,  $p=.02$ ,  $R^2\Delta=.13$ . The entire model (IQ, WM, amount of daily TV, TV watching language) accounted for 29% percent of variance,  $F(4,32) = 3.34$ ,  $p=.02$ ,  $r^2=.29$  indicating a clear relationship with language of TV watching, not quantity.

A model combining IQ, WM, radio listening and TV watching accounts for the greatest amount of variance DKEFS trails number letter switching outcomes, 24%;  $F(4,43) = 3.31$ ,  $p=.02$ ,  $r^2=.24$ .

To investigate the role of language used for TV watching, participants were split into 3 groups: 1) participants who report watching TV 90% in English or more,  $n=15$ ; 2) participants who report watching TV between 85% and 65% in English,  $n=15$ ; 3) participants who report watching between 60% and 45% in English, or roughly half in Spanish half in English,  $n=15$ . A one-way ANOVA revealed significant DKEFS trails number letter switching performance differences between the three groups,  $F(2,42)=3.82$ ,  $p=.03$ . Participants with around a 50/50 split in language of TV watching showed the highest performance ( $M=10.8$ ,  $SD=1.37$ ), followed by those who watched mostly in English ( $M=9.67$ ,  $SD=2.35$ ) and lastly those who reported almost entirely (90% or more) English TV watching ( $M=8.8$ ,  $SD=2.1$ ). Tukey's HSD post hoc tests revealed a significant difference between the participants with an approximate 50/50 split and those who reported almost 90% or more TV watching in English ( $p=.023$ ). There was no significant difference between participants with around a 50/50 split in language of TV watching and those who watch TV between 85% and 65% in English ( $p=.274$ ); nor between participants who watch TV between 85% and 65% in English and those who reported almost 90% or more TV watching in English ( $p=.46$ ).

### *Motor*

When controlling for IQ and working memory, reading comprehension in English, as measured by the WIAT III Reading Comprehension significantly accounted for variance in DKEFS trails motor outcomes,  $p=.034$ ,  $R^2=.08$ ; the entire model (IQ, WM, English reading comprehension) accounted for 22% of variance,  $F(3,46)=3.15$ ,  $p=.034$ ,  $r^2=.22$ .

### *D-KEFS Colors Subtests*

#### *Color-Word Reading*

Performance on the D-KEFS Color-Word Reading subtest showed a significant relationship with a number of environmental factors, possibly overlapping. More reported English use in certain settings uniquely accounted for significant variance in Color-Word reading outcomes, after controlling for IQ and WM, including: speaking at school with classmates [ $p=.029$ ,  $R^2\Delta=.09$ ;  $F(3,46) = 4.27$ ,  $p=.01$ ,  $r^2=.22$ ], speaking at work with coworkers [ $p=.022$ ,  $R^2\Delta=.10$ ;  $F(3,44) = 4.78$ ,  $p=.006$ ,  $r^2=.25$ ], and listening to clients/customers at work [ $p=.02$ ,  $R^2\Delta=.10$ ;  $F(3,44) = 4.86$ ,  $p=.005$ ,  $r^2=.25$ ].

### *Inhibition*

When controlling for IQ and working memory, reported language of reading at home significantly accounted for positive variance in DKEFS color inhibition subtest outcomes,  $p=.017$ ,  $R^2\Delta=.09$ . The entire model (IQ, WM, home reading language) accounted for 27% percent of variance,  $F(2,47) = 8.19$ ,  $p=.001$ ,  $r^2=.27$ . Participants who reported less reading at home in English and more Spanish reading at home (in a sense, more mixed reading usage, in that reading in the college environment is largely in English) had higher DKEFS color inhibition subtest outcomes.

### *Inhibition switching*

Higher self-reported Spanish reading abilities significantly accounted for variance in D-KEFS Color inhibition switching performance,  $F(1,47) = 5.31$ ,  $p = .026$ ,  $r^2=.10$ ; working memory and non-verbal IQ did not account for any variance.

## **Discussion**

Our results identify two types of factors linked with higher EF abilities among this sample: 1) having more Spanish or closer to balanced language usage in specific home language environment activities (TV watching, radio listening, reading), and 2) having higher self-reported language abilities (in Spanish or English). These home activities all tap in to receptive language



skills, supporting previous findings from Martin-Rhee & Bialystok (2008) that bilingual benefit is specific to increased suppression of interference, as opposed to also including inhibition of responses. Increased suppression of interference as an underlying mechanism for bilingual relationship with EF may also explain why no significant role of speaking was found.

Our findings provide further support for the developing empirical consensus that higher engagement in dual-language contexts bears a positive relationship to higher EF in bilinguals. Among this sample, the home and work environments were dual-language contexts for participants who use enough Spanish to have a more balanced 50/50 language environment. This is in line with findings from other recent research studies, such as Hartano & Yang (2016), whose work among Singaporean university students revealed that bilinguals whose environments are mainly dual-language demonstrate lower switch costs in comparison to bilinguals who operate in single-language contexts. Guerrero, Mesite, Serrain & Luk (2015) found that for bilingual school children, the closer toward 50/50 language use in the home, the lower the switch costs on trail making tasks. Similarly, Verhagen, Mulder & Leseman (2015) found that on EF tasks (Stroop and gratification delay), bilingual children whose parents used different language(s) from the language of the child's school setting outperformed bilingual children whose parents used the child's majority environment language(s). Yow & Li (2015) found that bilingual adults who had more balanced usage of and more balanced proficiency in their two languages had better performance on executive control tasks (a Stroop task and a number-letter task) than "imbalanced" bilinguals. Wu & Thierry (2013) found that among English-Welsh adult bilinguals a dual-language context induced more EF processing, as measured by a simplified flanker task, when compared with a single language context.

It is important to note that the specific home language environment activities which showed a predictive relationship to EF benefits in the present study (TV watching, radio listening and reading) are activities over which bilinguals are likely to exert the greatest control in terms of choice of language(s) used. That is to say, language choice in the home environment is not subject to the influence of linguistic norms as is the case in more formal settings (such as at university or work, where a particular language may be prescribed for a particular activity). Likewise, TV-watching, radio listening and reading at home are often or usually carried out individually, denoting that the source of the activity (e.g. the specific TV/radio channel/program or reading material) – and thus the language(s) of the activity – is selected by the individual themselves. The receptive nature of these home environment activities further underscores a lack of influence from external sources (such as interlocutors in spoken dialogue) over language usage choice. Therefore, one could argue that receptive home-based activities offer a key opportunity for bilinguals to manipulate their environment such that they operate in a more balanced dual-language context, which may in turn facilitate EF benefit. However, this assertion is likely to hold true only for relatively balanced bilinguals, given that language preferences while watching TV, listening to the radio and reading might point to language dominance, with more balanced participants showing more dual-language usage and thus more EF benefit.

Green & Abutalebi's (2013) adaptive control model posits that EF demands for bilinguals vary based on language environments. The minority language young adults in the current study inhabit one functionally monolingual context (university) and one to two mixed contexts (home and potentially work), with one of their two languages, Spanish, only frequently used in the home and/or work environment. Consequently, these participants may have high demand on inhibitory EF, with a consistent need to suppress Spanish in the university environment. The current study

found a similar relationship between higher self-reported Spanish reading ability and higher performance on the EF Stroop color-switching task. If stronger language proficiency produces stronger activation of that language, there may be resulting higher need to inhibit that language in settings in which it is not used, in this case, a higher need to inhibit Spanish.

Measures relating to English language ability (reading comprehension) and usage (speaking and listening) also showed a relationship with EF outcomes. The present study found higher performance on the WIAT English reading comprehension measure predicted higher scores in DKEFS trails motor outcomes, supporting existing research that higher skill levels in both languages confer EF benefits. Previous work from Blumenfeld & Marian (2013) found that English-Spanish bilinguals who had a higher proficiency in their second language (Spanish) exhibited a greater extent of parallel language activation during spoken word recognition activities, and also demonstrated lower Stroop effects (higher EF performance). Greater use of spoken English in specific settings (speaking with classmates, speaking with coworkers, listening to clients/customers) also had a significant relationship with performance on the D-KEFS Color-Word Reading subtest. This particular finding of more English use in these English settings could potentially reflect greater English ability; conversely, participants who report speaking in Spanish with classmates while in English language university settings, could be indicating a desire to switch away from English or a need to supplement with Spanish.

The current study contributes to the developing body of research supporting a positive relationship between more balanced, active dual-language contexts and higher EF outcomes for bilinguals. There are a number of implications, both for bilinguals as individuals and for educational institutions, such as universities, interested in supporting bilingual young adults. Bilingual individuals could prioritize active use of both languages, emphasizing activities,

environments, or relationships that accommodate dual language use. Educational support for both languages could be offered so that bilinguals are better able to access benefits conferred from having a high level of proficiency in each language. If increased regular usage of multiple languages helps to maximize potential cognitive benefits of speaking more than one language, effort could be placed on creating opportunities for students to have enriching environments; possibilities include bilingual housing options or social settings allowing students to regularly use a minority language.

This is the first study, to our knowledge, to demonstrate a relationship between TV watching behavior specifically and EF outcomes. The current data are limited to a single time point and thus cannot provide insights regarding directionality of the demonstrated relationships, but they do provide insights for further exploration. TV watching is sometimes considered an unproductive, even detrimental activity. It is also a prevalent one, with 2.8 hours per day watched by the average American over age 15 (United States Department of Labor, 2015). If future examination confirms that watching TV with balanced language ratios enhances or even supports existing EF benefits, this would provide opportunities for bilinguals to intentionally access potential cognitive advantages with minimal extra effort. Bilinguals who live in majority language contexts or who may not have a language community could by adjusting TV habits still maintain some degree of active bilingual environment. Future research could also explore how this relationship may change with age just as EF development changes with age; it could be robust among adolescents and young adults like those included in the current study but have no impact on younger and/or older bilinguals. Further research could shed light on quantity or quality of TV viewing needed, or if TV watching might serve to supplement a lack of other language interactions. The current study has a participant population that is in many ways homogeneous,

with similar social environments and an English language schooling background. While this makes generalization difficult, it also permits honing in on the factors that differentiate these individuals. It is possible that bilinguals who have no daily use of one language would not confer benefits from bilingual TV watching, or that TV watching behavior is only relevant for individuals in majority language settings. It may also be the case that bilinguals who already live in highly dynamic multilingual environments would not see any differences related to TV watching language. However, the finding that watching TV with a 50/50 language ratio shows a predictive relationship to greater EF outcomes for bilinguals not only offers insight into the benefits conferred by a bilingual environment, it also opens the door to opportunities for bilinguals to access EF advantages with minimal effort.

Table 1: Participant maternal education	<i>n</i>
Less than high school	25
High school diploma or equivalency (GED)	16
Associate degree (junior college)	6
Bachelor's degree	3
Master's degree	0
Doctorate	0
Professional (MD, JD, DDS, etc.)	0
Don't know/prefer not to say	0

Table 2: Task performance means		
<i>D-KEFS Trail Making (scores scaled at 10)</i>	M	SD
Visual scanning	11.42	1.72
Number sequencing	10.76	2.12
Letter sequencing	10.36	2.46
Number & letter switching	9.84	2.09
Combined switching	11.12	2.38
Motor	9.84	2.67
<i>D-KEFS Color-Word Inhibition (scaled at 10)</i>		
Color naming	9.4	2.7
Color reading	10.52	2.3
Inhibition	10.44	2.48
Inhibition switching	10.4	2.02
<i>WAIS IV (scores scaled at 10)</i>		
Working Memory	7.92	2.35

Matrix Reasoning	8.32	2.26
<i>WIAT III Reading Comprehension (score scaled at 100)</i>	92.58	7.94

Table 3: Language Environment (% in English presented)	M	SD
<i>Home</i>		
Speaking	45.4	29.1
Listening	40.2	29.9
Reading	74.3	28.25
Writing	75.5	28.6
Listening to music	55.4	21.3
Listening to radio	55.5	23.3
Watching TV	70.6	22.23
<i>School</i>		
Speaking	90.4	14.4
Listening	92.6	11.6
Reading	97.3	7.83
Writing	97	10.2
<i>Work</i>		
Speaking to coworkers	76.88	24.79
Speaking to clients/customers	71.35	26.37
Listening to coworkers	74.89	27.89
Listening to clients/customers	73.85	28.36
Reading	87.6	19.7
Writing	86.15	23.16

Table 4: Self-reported ability (scale from 0-100 “ <i>native or native-like</i> ”)	M	SD
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<i>Spanish</i>		
Speaking	88.36	13.05
Listening/Understanding	94.18	6.88
Reading	82.65	15.38
Writing	72.65	23.58
<i>English</i>		
Speaking	97.04	6.28
Listening/Understanding	98.06	3.93
Reading	97.35	4.9
Writing	96.33	5.9

Table 5: Self-reported English ability unique contribution to D-KEFS Trails visual scanning			
	F(3,45)=	p	R <sup>2</sup> Δ
Speaking	6.56	.001	.28
Listening/Understanding	3.56	.02	.17
Reading	5.68	.002	.25
Writing	2.72	.055	.13



## References

- Akhtar, N., Menjivar, J., Hoicka, E., & Sabbagh, M. A.** 2012. 'Learning foreign labels from a foreign speaker: The role of (limited) exposure to a second language,' *Journal of Child Language* 39/5: 1135-1149. DOI: 10.1017/S0305000911000481
- Anton, E., Duñabeitia, J. A., Estévez, A., Hernández, J. A., Castillo, A., Fuentes, L. J., Davidson, D. J., et al.** 2014. 'Is there a bilingual advantage in the ANT task? Evidence from children,' *Frontiers in Psychology* 5: 398. DOI: 10.3389/fpsyg.2014.00398
- Baker, D. P., Eslinger, P. J., Benavides, M., Peters, E., Dieckmann, N. F., & Leon, J.** 2015. The cognitive impact of the education revolution: A possible cause of the Flynn Effect on population IQ. *Intelligence*, 49: 144–158. DOI: 10.1016/j.intell.2015.01.003
- 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* 29/4: 699-714. DOI: 10.1016/j.ecresq.2014.02.003
- Baum, S. & Titone, D.,** 2014. 'Moving toward a neuroplasticity view of bilingualism, executive control, and aging,' *Applied Psycholinguistics* 35/05: 857-894.  
DOI:10.1017/S0142716414000174
- Bialystok, E.** 2009. 'Bilingualism: The good, the bad, and the indifferent,' *Bilingualism: Language and Cognition* 12/1: 3-11. DOI:10.1017/S1366728908003477
- Bialystok, E., Craik, F. I. M., & Luk, G.** 2012. 'Bilingualism: consequences for mind and brain,' *Trends in Cognitive Sciences* 16/4: 240-250. DOI: 10.1016/j.tics.2012.03.001
- Bialystok, E. & Feng, X.,** 2009. 'Language proficiency and executive control in proactive interference: Evidence from monolingual and bilingual children and adults,' *Brain and Language* 109/2: 93-100. DOI: 10.1016/j.bandl.2008.09.001

- Bialystok, E. & Majumder, S.** 1998. 'The relationship between bilingualism and the development of cognitive processes in problem solving,' *Applied Psycholinguistics* 19/1:69-85. DOI: <https://doi.org/10.1017/S0142716400010584>
- Bialystok, E. & Viswanathan, M.** 2009. 'Components of executive control with advantages for bilingual children in two cultures,' *Cognition* 112/3: 494-500. DOI: 10.1016/j.cognition.2009.06.014
- Blair, C., Granger, D., & Razza, R. P.** 2005. 'Cortisol reactivity is positively related to executive function in preschool children attending head start,' *Child Development* 76/3: 554–67. DOI: 10.1111/j.1467-8624.2005.00863.x
- Blumenfeld, H. K. & Marian, V.** 2013. 'Parallel language activation and cognitive control during spoken word recognition in bilinguals,' *Journal of Cognitive Psychology* 25/5: 547-567. DOI: 10.1080/20445911.2013.812093
- Carlson, S. M. & Meltzoff, A. N.** 2008. 'Bilingual experience and executive functioning in young children,' *Developmental Science* 11/2: 282-298. DOI: 10.1111/j.1467-7687.2008.00675.x
- Delis, D. C., Kaplan, E., & Kramer, J. H.** 2001. *Delis-Kaplan executive function system (D-KEFS)*. Psychological Corporation.
- Diamond, A.** 2013. 'Executive functions,' *Annual Review of Psychology* 64: 135–168. DOI: 10.1146/annurev-psych-113011-143750
- Dijkstra, T. & Van Heuven, W. J. B.** 2002. 'The architecture of the bilingual word recognition system: from identification to decision,' *Bilingualism: Language and Cognition* 5/3: 175-197. DOI: 10.1017/S1366728902003012

- Duñabeitia, J. A., Hernández-Cabrera, J. A., Antón, E., & Carreiras, M.** 2014. 'The inhibitory advantage in bilingual children revisited,' *Experimental Psychology* 61/3: 234-251. DOI: 10.1027/1618-3169/a000243
- Evans, G. W. & Kim, P.** 2013. 'Childhood poverty, chronic stress, self-regulation, and coping,' *Child Development Perspectives* 7/1: 43-48. DOI: 10.1111/cdep.12013
- Farah, M. J., Shera, D. M., Savage, J. H., Betancourt, L., Giannetta, J. M., Brodsky, N. L., Malmud, E. K., & Hurt, H.** 2006. 'Childhood poverty: Specific associations with neurocognitive development,' *Brain Research* 1110/1: 166-174. DOI: 10.1016/j.brainres.2006.06.072
- Friedman, S. L., Scholnick, E. K., Bender, R. H., Vandergrift, N., Spieker, S., Hirsh Pasek, K., Keating, D., Park, Y. & The NICHD Early Child Care Research Network.** 2014. Planning in middle childhood: Early predictors and later outcomes. *Child Development*, 85/4: 1446–1460. DOI: 10.1111/cdev.12221
- Friesen D. C., Latman V., Calvo A., & Bialystok E.** 2014. Attention during visual search: the benefit of bilingualism. *International Journal of Bilingualism* 19/6: 693-702. DOI: 10.1177/1367006914534331
- Gandolfi, E., Viterbori, P., Traverso, L., & Usai, M. C.** 2014. 'Inhibitory processes in toddlers: A latent-variable approach,' *Frontiers in Psychology* 5: 381. DOI: 10.3389/fpsyg.2014.00381
- Garon, N., Bryson, S. E., & Smith, I. M.** 2008. 'Executive function in preschoolers: A review using an integrative framework,' *Psychological Bulletin* 134/1: 31-60. DOI: 10.1037/0033-2909

- Green, D. W. & Abutalebi, J.** 2013. 'Language control in bilinguals: The adaptive control hypothesis,' *Journal of Cognitive Psychology* 25/5: 515-30. DOI: 10.1080/20445911.2013.796377
- Grosjean, F. & Li, P.** 2013. *The Psycholinguistics of Bilingualism*. Oxford: Wiley-Blackwell.
- Guerrero S. L., Mesite L., Surrain S., & Luk G.** 2015. Mixed language use and cognitive flexibility in young bilinguals, in Poster presented at the CUNY workshop on Bilingualism and Executive Function: An Interdisciplinary Approach (New York, NY).
- Guerrero, S. L., Smith, S., & Luk, G.** (2016). Home language usage and executive function in bilingual preschoolers. *Cognitive Control and Consequences of Multilingualism*, 2, 351. DOI: 10.1075/bpa.2.15leo
- Hackman, D. A., Gallop, R., Evans, G. W., & Farah, M. J.** 2015. 'Socioeconomic status and executive function: developmental trajectories and mediation,' *Developmental Science* 18/5: 686-702. DOI: 10.1111/desc.12246
- Hartanto, A. & Yang, H.** 2016. 'Disparate bilingual experiences modulate task-switching advantages: A diffusion-model analysis of the effects of interactional context on switch costs,' *Cognition* 150:10-19. DOI:10.1016/j.cognition.2016.01.016
- 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 & review* 18/4: 625-658. DOI: 10.3758/s13423-011-0116-7
- Hughes, C.** 2013. Chapter 24 - Executive function: development, individual differences, and clinical insights. J. L. R. R. Rakic (Ed.), *Neural Circuit Development and Function in the Brain* (pp. 429–445). Oxford: Academic Press.

- Iluz-Cohen, P. & Armon-Lotem, S.** 2013. 'Language proficiency and executive control in bilingual children,' *Bilingualism: Language and Cognition* 16/4: 884-899. DOI: 10.1017/S1366728912000788
- Kapa, L. L., & Colombo, J.** 2013. 'Attentional control in early and later bilingual children,' *Cognitive Development* 28/3: 233–46. DOI: 10.1016/j.cogdev.2013.01.011
- Kovacs, A. M.** 2007. *Beyond Language: Childhood Bilingualism Enhances High-Level Cognitive Functions*. I. Kecskes & L. Albertazzi, (Eds.). Dordrecht: Springer.
- Kroll, J. F. & Bialystok, E.** 2013. 'Understanding the consequences of bilingualism for language processing and cognition,' *Journal of Cognitive Psychology* 25/5: 497-514. DOI: 10.1080/20445911.2013.799170
- Kroll, J.F. & Stewart, E.** 1994. 'Category interference in translation and picture naming: Evidence for asymmetric connections between bilingual memory representations,' *Journal of Memory and Language* 33/2: 149-174. DOI: 10.1006/jmla.1994.1008
- Kroll, J. F. & Tokowicz, N.** 2005. Models of bilingual representation and processing. Kroll, J. F. & A.M.B. De Groot. (Eds). *Handbook of Bilingualism: Psycholinguistic Approaches* (p. 531–553). New York, NY; Oxford University Press.
- Luk, G., Anderson, J. A., Craik, F. I., Grady, C., & Bialystok, E.** 2010. 'Distinct neural correlates for two types of inhibition in bilinguals: Response inhibition versus interference suppression,' *Brain and Cognition* 74/3: 347-357. DOI: 10.1016/j.bandc.2010.09.004
- Luk, G., & Bialystok, E.** 2013. 'Bilingualism is not a categorical variable: Interaction between language proficiency and usage,' *Journal of Cognitive Psychology* 25/5: 605–621. DOI: 10.1080/20445911.2013.795574

- Luo, L., Luk, G. & Bialystok, E.** 2010. 'Effect of language proficiency and executive control on verbal fluency performance in bilinguals,' *Cognition* 114/1: 29-41. DOI: 10.1016/j.cognition.2009.08.014
- Martin-Rhee, M. M. & Bialystok, E.** 2008. 'The development of two types of inhibitory control in monolingual and bilingual children,' *Bilingualism* 11: 81-93. DOI: 10.1017/S1366728907003227
- Mischel, W., Ayduk, O., Berman, M. G., Casey, B., Gotlib, I. H., Jonides, J., Kross, E., Teslovich, T., Wilson, N. L., & Zayas, V.** 2010. 'Willpower over the life span: Decomposing self-regulation,' *Social Cognitive and Affective Neuroscience* 6/2: 252-256. DOI: 10.1093/scan/nsq081
- Miyake, A., & Friedman, N. P.** 2012. 'The nature and organization of individual differences in executive functions four general conclusions,' *Current Directions in Psychological Science* 21/1: 8-14. DOI: 10.1177/0963721411429458
- 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* 41/1: 49-100. DOI: 10.1006/cogp.1999.0734
- Moffitt, T. E., Arseneault, L., Belsky, D., Dickson, N., Hancox, R. J., Harrington, H., Houts, R., Poulton, R., Roberts, B. W., & Ross, S.** 2011. 'A gradient of childhood self-control predicts health, wealth, and public safety,' *Proceedings of the National Academy of Sciences* 108/7: 2693-2698. DOI: 10.1073/pnas.1010076108

- Paap, K.R. & Greenberg, Z.I.** 2013. 'There is no coherent evidence for a bilingual advantage in executive processing,' *Cognitive psychology* 66/2: 232-258. DOI: 10.1016/j.cogpsych.2012.12.002
- Pew Research Center.** 2013. *National Survey of Latinos*. Retrieved July 7, 2016 from <http://www.pewhispanic.org/category/datasets/http://www.pewhispanic.org/category/datasets/http://www.pewhispanic.org/category/datasets/>
- Poarch, G. J., & van Hell, J. G.** 2012. 'Executive functions and inhibitory control in multilingual children: Evidence from second-language learners, bilinguals, and trilinguals.' *Journal of Experimental Child Psychology* 113/4: 535-551. DOI: 10.1016/j.jecp.2012.06.013
- Ricciardelli, L.A.** 1992. 'Bilingualism and cognitive development in relation to threshold theory', *Journal of psycholinguistic research* 21/4: 301-316. DOI: 10.1007/BF01067515
- Rueda, M. R.** 2013. *Development of Attention*. Oxford: Oxford University Press.
- Segalowitz, N. & Frenkiel-Fishman, S.** 2005. 'Attention control and ability level in a complex cognitive skill: Attention shifting and second-language proficiency,' *Memory & Cognition* 33/4: 644-653. DOI: 10.3758/BF03195331
- Skibbe, L. E., Connor, C. M., Morrison, F. J., & Jewkes, A. M.** 2011. 'Schooling effects on preschoolers' self-regulation, early literacy, and language growth,' *Early Childhood Research Quarterly* 26/1: 42-49. DOI: 10.1016/j.ecresq.2010.05.001
- Stroop, J. R.** 1935. 'Studies of interference in serial verbal reactions,' *Journal of Experimental Psychology* 18/6: 643-662. DOI: 10.1037/h0054651
- U.S. Census Bureau.** 2014. Percentage of 18- to 24-year-olds enrolled in degree granting institutions, by level of institution and sex and race/ethnicity of student: 1967 through

2013. Retrieved July 7, 2016 from  
[http://nces.ed.gov/programs/digest/d14/tables/dt14\\_302.60.asp?current=yes](http://nces.ed.gov/programs/digest/d14/tables/dt14_302.60.asp?current=yes)  
[http://nces.ed.gov/programs/digest/d14/tables/dt14\\_302.60.asp?current=yes](http://nces.ed.gov/programs/digest/d14/tables/dt14_302.60.asp?current=yes)  
[http://nces.ed.gov/programs/digest/d14/tables/dt14\\_302.60.asp?current=yes](http://nces.ed.gov/programs/digest/d14/tables/dt14_302.60.asp?current=yes)
- U.S. Department of Labor Bureau of Labor Statistics.** 2015. American Time Use Survey – 2015 Results. Retrieved August 13, 2016 from  
<http://www.bls.gov/news.release/pdf/atus.pdf>
- Verhagen, J., Mulder, H., & Leseman, P. P. M.** 2015. 'Effects of home language environment on inhibitory control in bilingual three-year-old children,' *Bilingualism: Language and Cognition*. DOI: 10.1017/S1366728915000590
- Wechsler, D.** 2008. *Wechsler adult intelligence scale-fourth*. San Antonio, TX: The Psychological Corporation Google Scholar.
- Wiebe, S. A.** 2014. 'Modeling the emergent executive: implications for the structure and development of executive function,' *Monographs of the Society for Research in Child Development* 79/2: 104-115. DOI: 10.1002/mono.12093
- Wu, Y.J. & Thierry, G.** 2013. 'Fast modulation of executive function by language context in bilinguals,' *Journal of Neuroscience* 33/33: 13533-13537.  
 DOI:10.1523/JNEUROSCI.4760-12.2013
- Yang, H., Hartanto, A., & Yang, S.** 2016 'The importance of bilingual experience in assessing bilingual advantages in executive functions,' *Cortex* 75: 237-240. DOI: 10.1016/j.cortex.2015.11.018



**Yeniad, N., Malda, M., Mesman, J., Ijzendoorn, M. H. V., Emmen, R. A., & Prevoo, M. J.**

2014. 'Cognitive flexibility children across the transition to school: A longitudinal study,'

*Cognitive Development* 31: 35–47. DOI: 10.1016/j.cogdev.2014.02.004

**Yow, W. Q., & Li, X.** 2015. 'Balanced bilingualism and early age of second language

acquisition as the underlying mechanisms of a bilingual executive control advantage:

why variations in bilingual experiences matter,' *Frontiers in Psychology* 6:164. DOI:

10.3389/fpsyg.2015.00164