PRIFYSGOL BANGOR / BANGOR UNIVERSITY

PRIFYSGOL
BANGOR
UNIVERSITY

Teasing apart factors influencing Executive Function performance in bilinguals and monolinguals at different ages

Gathercole, Virginia C. Mueller; Thomas, E.M.; Viñas Guasch, Nestor; Kennedy, Ivan; Prys, C.; Young, N.E.; Roberts, Emily J.; Hughes, E.K.; Jones, Leah

Linguistic Approaches to Bilingualism

Cyswllt i'r cyhoeddiad / Link to publication

09. Oct. 2020

TEASING APART FACTORS INFLUENCING EXECUTIVE FUNCTION PERFORMANCE IN BILINGUALS AND MONOLINGUALS AT DIFFERENT AGES

Virginia C. Mueller Gathercole,
Florida International University
Miami, FL

Enlli Môn Thomas
Bangor University
Bangor, Wales

Nestor Viñas Guasch
Hong Kong University
Pokfulam, Hong Kong

Ivan Kennedy
Bangor University
Bangor, Wales

Cynog Prys
Bangor University
Bangor, Wales

Nia Young
Bangor University
Bangor, Wales

Emily J. Roberts
Bangor University
Bangor, Wales

Emma K. Hughes
Bangor University
Bangor, Wales

Leah Jones
Bangor University
Bangor, Wales

Abstract

This study attempts to tease apart a variety of factors that may contribute to performance on executive function tasks. Data from the Simon task is re-examined to determine the contributions of age, SES, language proficiency/vocabulary, general cognitive performance, and bilingualism on performance. The results suggest influence from a variety of factors, with a major contribution from relative age and from language proficiency, as measured by vocabulary. Bilingualism showed some effect in relation to older adults' accuracy of performance, in both congruent and incongruent conditions, but not to reaction time.

1. INTRODUCTION

The position that bilinguals demonstrate cognitive benefits from speaking two languages in realms that go beyond language, and especially in realms of executive functioning, is by now well-established and has gained considerable exposure and attention in both the academic and non-academic world. This position has been explored and supported in numerous works (Adesope, Lavin, Thompson, & Ungerleider, 2010; Bialystok, 2006, 2011; Costa, Hernandez, Costa-Faidella, & Sebastian-Galles, 2009; Costa, Hernandez, & Sebastian-Galles, 2008; Gollan, Sandoval, & Salmon, 2011; Hilchey & Klein, 2011; Weissberger, Wierenga, Bondi, & Gollan, 2012). At the same time, the position has not gone unchallenged. The advantage is not always observed (Clare et al., 2014; Duñabeitia et al., 2014; Gathercole et al., 2010, 2014b; Hindle et al., 2015; Kousaie, Sheppard, Lemieux, Monetta, & Taler, 2014; Paap & Greenberg, 2013), and the effects have sometimes been attributed, not to a difference between monolingualism and bilingualism per se, but to other confounding factors. Those include socioeconomic differences between groups (Calvo & Bialystok, 2014; Morton & Harper, 2007); geographical and cultural differences (Adesope et al., 2010; Sabbagh, Xu, Carlson, Moses, & Lee, 2006); children's perceptions of teachers' appreciation of home language differences (Goriot, Denessen, Bakker, & Droop, 2005); individual differences (Valian, 2015), such as intelligence, education, exercising, active social lifestyle, musical training, and the like; and even to faulty experimental design and control (Paap, Johnson, & Sawi, 2015). Recent work has also highlighted a possible publication bias for positive findings and against null findings (de Bruin, Treccani, & Della Sala, 2015; Paap et al, 2015).

In a recent conference that brought together many leaders in this field (Bilingualism and Executive Function: An Interdisciplinary Approach, CUNY, May 17-18, 2015), several researchers pointed out that executive function abilities are not a monolithic phenomenon, but are abilities that are reflected in different ways, with different patterns observable, in relation to distinct tasks (Friedman, 2015; Miyake & Friedman, 2012); also there appear to be many distinct factors that contribute to and help shape individuals' performance on executive function tasks. In addition, there is some debate concerning

whether a bilingual advantage is observed only in conflict situations or is reflected in an overall cognitive advantage (Hilchey & Klein, 2011). In a recent review, Valian (2015) has argued that superior executive function correlates not only with bilingualism, but also with higher participation in a wide variety of tasks, such as exercise, musical training, and video games, and that "consistent cognitive challenge, in any form, generally yields better performance on tests of executive function" (p. 4). She concludes that "bilingualism is one challenge out of many" (p. 4).

One theme that emerged very clearly at the CUNY conference is that we need a better handle on how we manage to tease apart the various factors that affect performance and identify and evaluate their relative contributions. Thus, for example, Marton (2015) examined the role of language proficiency in bilingual school-age children's performance on executive function tasks and found influence of language proficiency on speed of processing and on resistance to proactive interference in executive function tasks. Complementary to this, Sorace (2015) examined the influence of executive performance on bilinguals' syntactic abilities and reported that higher executive performance corresponded to better performance on referential ambiguity in syntax. These links between language proficiency and executive function performance are of importance to our assessment of the role of bilingualism, because there could be differences in language abilities in bilinguals and monolinguals that underlie observed differences on EF tasks. As noted in Gathercole (2015):

> There is no way, ever, that one can perfectly match a monolingual group and a bilingual group on all measures (Baker, 2011). The ideal match in any experiment equates groups on cultural, socio-economic, intellectual, educational, linguistic, and experiential backgrounds. But, by definition, bilinguals speak and use two languages. Thus, linguistically and experientially they can never be exactly matched with monolinguals (Hakuta, 1986). The difference is not only that the bilinguals are switching between two languages day in and day out, the key component linked with the executive function research of concern here. Just the fact that bilinguals know two languages makes them different--they have more words overall (two languages), they will not have the same

range of lexical items in each language (**"distributed characteristic"**, Grosjean, 2010; Patterson &

Pearson, 2004), there may be semantic and syntactic differences in their linguistic systems (Jarvis

& Pavlenko, 2008), the two languages are **"on line"** at all times (Dijkstra & Van Heuven, 1998),

there may be RT differences in accessing language (Soares & Grosjean, 1984), and fully fluent

bilinguals may even have a special flair for language (Macnamara, 1966). (pp. 345-346)

Klein (2105) comments, "it is just as likely that individuals with better executive functions [are] better

able to master two languages" (p. 341).

Furthermore, linguistic performance itself is highly correlated with socioeconomic status and with

general cognitive abilities. In a recent examination of factors influencing monolinguals' and bilinguals'

vocabulary and grammatical knowledge, both SES and cognitive abilities were clearly linked with

language performance (Gathercole, Kennedy, & Thomas, 2015). In relation to executive function studies,

Gathercole (2015) adds "the bilingual populations under consideration often come from different

[cultural, socioeconomic, and geographical] backgrounds from the monolinguals (and from one another),

[so] … any comparison is fraught with interpretive difficulties…" (p. 346).

Such confounds cloud the picture of which factors are the most important influences on executive

performance. If, for example, executive function performance correlates with SES and with general

cognitive abilities, but SES, in turn, correlates with language ability and with general cognitive

performance; and language proficiency correlates with general cognitive performance and level of

bilingualism; and general cognitive performance correlates with relative age within the group, and so on,

then it is important to determine which factor(s) is/are most predictive of performance on the executive

tasks. As Woumans and Duyck (2015) point out, the discussion should now turn to what factors moderate

the manifestation of a bilingual advantage.

In order to explore this, we will examine here a range of possible contributing factors more

closely, with more rigorous analyses than correlational analyses can provide, in a population of culturally

and geographically homogeneous monolinguals and bilinguals in North Wales. We demonstrate how

regression analyses, which factor out the influence of one factor when considering the influence of the next, can help to illuminate the relative contributions that such factors make. The data reveal that, under such analyses, a complex set of factors can be seen to differentially predict performance. This includes, in some cases, bilingualism, but the results also suggest that there are major contributions from language proficiency per se, relative age, and cognition, and when these are factored out, the effects of bilingualism are minimal.

2. THIS STUDY

The data re-examined here come from studies reported elsewhere (Gathercole et al., 2010; 2014b); those included data on Simon tasks (Gathercole et al., 2014b) from children and adults in the Welsh context. Performance on an adult Simon task and a child-friendly version of the Simon task (explained below) were analyzed to determine relative performance of bilinguals and monolinguals in a culturally and geographically homogeneous population, and, in an effort to determine whether relative language balance might affect performance, to examine possible differences across bilinguals who had had distinct experiences and different relative exposures to the two languages in the home. Bilinguals came from three distinct home language types: those with only English at home (OEH), with Welsh and English at home (WEH), or with only Welsh at home (OWH). In that study, we examined performance by 3-, 4-, and 5-year-olds, grade schoolers (mean age 8;2), teens (mean age 14;9), younger adults (mean age 25;5), and older adults (mean age 67;6).

Those analyses revealed, in general, some results that were consistent with expectations: everyone performed better in the congruent condition than in the incongruent condition, for both accuracy and RT; and there were some differences by age, with significant improvement from younger ages to age older ages.

But the results in relation to language background (monolingual vs bilingual) and experience (home language) were inconsistent and did not provide strong support for a bilingual advantage. In terms of accuracy, at times there was no significant difference across groups (e.g., among the preschoolers and

the school-age children), at times the monolinguals showed higher performance than the bilinguals (in the teens), and at times the bilinguals performed at a higher rate than the monolinguals (in the older adults). The RT results showed similar inconsistencies: Among the preschoolers, the monolinguals were faster than the OEH and WEH bilinguals, but so were the OWH bilinguals; among the young adults, WEH and OWH participants outperformed monolinguals. These results for the Simon are in line with those for tapping and Stroop tasks for the school-age children and teens, reported in Gathercole et al. (2010): Those tasks also showed mixed results-- namely, for accuracy on the tapping task, OWH participants showed superior performance, relative especially to Mon and OEH participants, but performance on the Stroop related to language dominance and fluency in the language tested. RTs in the Stroop task showed either no difference by home language (school age) or showed a global advantage (among teens) for the bilinguals over monolinguals that applied to all conditions, not just the Stroop condition. Furthermore, follow-up analyses showed some strong correlations in performance on the tapping and Stroop tasks with general cognitive abilities, and possible associations in performance with general language abilities and even SES status.

The analyses for the Simon tasks (Gathercole et al, 2014b) did not take into consideration participants' SES, language proficiency, or general cognitive performance, however. It is quite possible that individual differences within groups along these other variables may have obscured differences across language groups that might have appeared if these other factors had been taken into consideration and controlled for. Given the importance that has been highlighted for these factors in recent work, the following analyses take a fresh look at the Simon data with these factors in mind. The hypothesis was that if we factor out the possible influences of cognitive abilities, SES, and language knowledge on performance on the Simon task, this may help to isolate the influence of bilingual status per se on performance, and ultimately yield a clearer picture of the role that bilingualism may play separate from these other factors.

2. 1. METHOD

2. 1. 1. Participants

The participant groups chosen for these analyses were those age groups for whom we had the highest number of both monolingual ("MON"/"Mon") and bilingual ("BIL"/"Bil") participants with scores on the cognitive, language, and SES factors of relevance here. Because of slightly low numbers of monolinguals at ages 3 and school age with the full range of scores, we focus here on participants from the other age groups tested, including 4-year-olds, 5-year-olds, teens, younger adults, and older adults. The numbers of participants are shown in Table 1. Two sets of numbers are shown (the rationale for this is explained below): the number of participants for whom we had complete data, including SES information, and the number of participants when we include those for whom we had all information except SES.

PLACE TABLE 1 ABOUT HERE.

2. 1. 2. Stimuli

2. 1. 2. 1. Simon Tasks:

2. 1. 2. 1. 1. *Adult Version*

The adult version of the task involved a blue and a red square, which appeared either on the right or the left side of a computer screen. The participant's task was to press the Q on the computer if the blue square appeared and a P if the red square appeared.

2. 1. 2. 1. 2. *Child Version*

The child version of the task involved a rabbit and a pig, who appeared sitting on top of a rock either on the right or the left side of the computer screen. The child's task was to touch a "button" on a touch screen, to indicate whether the rabbit or the pig appeared. The "buttons" showed either the rabbit or the pig, and the rabbit button always appeared at the bottom left of the screen and the pig button always appeared at the bottom right of the screen.

2. 1. 2. 1. 3. Procedure

Participants were told, both verbally and in writing on the screen, to respond as quickly as

possible to indicate which item appeared. If the blue square/rabbit appeared, the Q or the button on the left was to be pressed, and if the red square/pig appeared, the P or the button on the right was to be pressed. Between trials a "+" appeared in the center of the screen. The target item appeared on the screen half of the time on the left, and half the time on the right: in "congruent" trials, the target item appeared on the same side of the screen as the key or button to be pressed; in "incongruent" trials, the item appeared on the side of the screen opposite to that on which the key or button to be pressed was located. Three practice trials were given first, and then the target trials.

School age children and adults received 48 trials, 24 congruent and 24 incongruent, in random order. The younger children received 16 trials, 8 congruent and 8 incongruent. Accuracy of responses and reaction times were recorded electronically.

2. 1. 2. 2. English Vocabulary:

The BPVS (Dunn, Dunn, & Whetton, 1982) was administered, following the normal test procedures. Detailed information on these participants' knowledge of English and Welsh vocabulary and grammar is reported in Gathercole, Thomas, Roberts, & Hughes (2013), Gathercole, Pérez-Tattam, Stadthagen-González, & Thomas (2014a), Thomas, Gathercole, & Hughes (2013), and Gathercole et al. (2015). All analyses show early differences in vocabulary and grammar across groups by home language, but eventual convergence of knowledge with age. Parity across groups is reached earlier for grammatical knowledge than vocabulary, and slightly earlier for English than for Welsh.

2. 1. 2. 3. Cognitive Abilities:

General cognitive abilities were assessed for children up to school age with McCarthy (1972), and for teens and adults, with Raven's Progressive Matrices (Raven, Court, & Raven, 1983).

2. 1. 2. 4. SES:

A composite SES score was calculated based on parents' education and professions (see Gathercole, Kennedy, & Thomas, 2015, for details).

2. 2. RESULTS

The participants' general performance on the Simon task, both accuracy and RTs, is shown in Figures 1 and 2. Figure 1 shows the monolinguals' and bilinguals' performance in terms of accuracy in each condition at each age, and Figure 2 shows their RTs per age and condition. (Note: These data are comparable to those reported in Gathercole et al (2014b), except that the bilinguals' data have been collapsed across home language groups here.)

PLACE FIGURES 1 AND 2 ABOUT HERE.

2. 2. 1. Correlations:

In order to examine this performance more closely, first, correlations were calculated at each age group for all of the measures. This included age in months, SES, English vocabulary scores, general cognitive scores, and the six dependent measures for the Simon task: accuracy ("ACC") in the congruent and incongruent conditions, reaction times in the congruent and incongruent conditions, and difference scores between the two conditions for accuracy and reaction times. For the correlations, we included both Home Language (0=Mon, 1=OEH, 2=WEH, 3=OWH) and Mon-Bil status, in which all bilinguals were grouped together (1=Mon, 2=Bil). The correlations are shown for each age group in Appendix A.

The correlations indicate that, first, as might be expected, many of the dependent measures correlate significantly with one another, especially the accuracy measures with each other and the RT measures with each other. But more crucially for the present purposes, each of the dependent measures correlates also with one or more of the independent measures, and each of the independent variables of interest are significantly correlated with one or more of the other independent variables at one or more ages, as follows:

Congruent ACC correlates with**:**

Age in months: older ~ higher Congruent ACC [teens, younger adults]

BPVS: higher BPVS ~ higher Congruent ACC [age 4 and teens, and near-significantly for the younger adults]

Cognitive scores: higher cognitive score ~ higher Congruent ACC [4, younger adults]

Home Language: more Welsh input in the home ~ higher accuracy [older adults]

Mon-Bil status: Bil ~ higher accuracy [older adults]

Incongruent ACC correlates with**:**

Age in months: older ~ higher Incongruent ACC [4, younger adults**]**

BPVS: higher BPVS ~ higher Incongruent ACC [4, teens, near-significant for younger adults]

Cognitive score: higher cognitive score ~ higher Incongruent ACC [4]

Bil-Mon status: Bil ~ higher ACC [older adults]

Congruent RT correlates with**:**

Age in months: older ~ slower [older adults]

BPVS: higher BPVS ~ faster [older adults]

Cognitive score: higher cognitive score ~ faster [teens]

Home Language: more Welsh ~ slower [younger adults]

Bil-Mon Status: Bil ~ slower [4, younger adults]

Incongruent RT correlates with**:**

BPVS: higher BPVS ~ faster [teens]

Cognitive score: higher cognitive score ~ faster [teens, younger adults]

Home Language: more Welsh ~ slower [younger adults]

Bil-Mon status: Bil ~ slower [younger adults; near-significant at 4]

Difference, ACC correlates with**:**

Age in months: older ~ lower difference [age 4]

Cognitive score: higher cognitive score ~ lower difference [age 4]

Difference, RT correlates with**:**

Age in months: older ~ greater difference [older adults]

Cognition: higher cognitive score ~ lower difference [teens]

Home Language: more Welsh ~ more difference [younger adults]

Mon-Bil: bilingual ~ more difference [younger adults]

The independent measures also correlate with one another:

BPVS:

Age in months: older ~ higher BPVS [ages 4, teens, younger adults]

SES: higher SES ~ higher BPVS [ages 5, teens, older adults]

Cognitive score (McCarthy or Raven's): higher cognitive score ~ higher BPVS [significant at ages 4, 5, teens, younger adults; near-significant in older adults]

Mon-Bil: Bil ~ lower BPVS [age 5; near-significant in teens]

Cognitive Score (McCarthy, Raven's):

Age in months: older ~ higher cognitive score [ages 4, teens, near-significant at age 5, younger adults]

SES: higher SES ~ higher cognitive score [near-significant at age 5]

BPVS: as noted above

SES:

BPVS: as noted above

Cognitive score: as noted above

Age in months:

BPVS: as noted above

Cognitive score: as noted above

Mon-Bil: Bil ~ older [younger adults]

Home Language and Mon-Bil: as noted above

Thus, nearly every factor is correlated at one or more age group with nearly every other factor, so it is difficult to disentangle which factor(s) are most predictive of performance on the dependent measures. To examine which factor(s) are more predictive of the dependent measures, regression analyses were conducted.

2. 2. 2. Regressions:

Multiple regression analyses were conducted for each age group for each dependent measure. Because Home Language and Mon-Bil status both correlated with performance, to different degrees, at various ages, analyses were conducted separately using Home Language versus Mon-Bil status as a participant measure. The results of these analyses were very similar, so the analyses with Mon-Bil as the measure are reported below. (Where there were differences, these will be noted.)

A first set of analyses was conducted in which SES was included: At the first step, the individual measures of Age in months and SES were entered as the independent measures. At step two, language proficiency, as measured by the BPVS, was entered. At step three, cognitive performance, as measured by either the McCarthy or the Raven's, was entered. And, finally, at step four, classification as Monolingual or Bilingual was entered. The factor SES was not a significant predictor of any measure at any age, except in one case: At age 4, SES contributed .249 to .255 of the variance ($p<.05$) to performance on Congruent ACC. Higher SES predicted lower accuracy. [But note: BPVS contributed .327 to .347 ($p<.01$) of the variance.] For this reason, and because of the additional participants we could enter if we did not include SES, a second set of analyses was conducted. For these, at the first step, only Age in months was entered. All the other steps in the regression were as in the first set of analyses.

The significant results for each age group are shown for each dependent measure in Appendices B to F. There are significant findings for each dependent measure, but the significant effects of the independent variables vary from age to age (with no significant predictors at age 5). The significant effects found are the following:

2. 2. 2. 1. ACCURACY:

2. 2. 2. 1. 1. Congruent Condition:

At age 4, Age contributes .224 of the variance when it is the only factor considered (Model 1), but when the other factors are considered, the most predictive factor is the BPVS vocabulary score, contributing .265 to .284 of the variance. Higher vocabulary predicts higher accuracy.

For the teen group, Age again contributes .222 of the variance if it is the only factor considered. But when the other factors are considered, BPVS contributes .271 to .297 of the variance. Again, higher vocabulary predicts higher accuracy.

For the younger adults, again if Age is the only factor considered, it contributes .243 of the variance. However, when the other factors are considered, cognitive performance (on the Raven's) contributes .233 to .235 of the variance (p =.051, Model 3). Higher cognitive performance predicts higher accuracy.

For the older adults, the only significant factor is Mon-Bil status, which contributes .425 of the variance. Bilinguals show higher accuracy.

2. 2. 2. 1. 2. Incongruent Condition:

At age 4, Age is the only significant predictor, at .321 to .465 of the variance. Older children have higher accuracy rates.

At the teen years, vocabulary (BPVS) is the only significant predictor, at .268 to .296 of the variance. Again, higher vocabulary predicts higher accuracy.

For the younger adults, Age is the only significant predictor, contributing .241 to .298 of the variance. Here, older participants had higher accuracy rates.

For the older adults, Mon-Bil status is the only significant predictor, contributing .453 of the variance. Again, bilinguals had higher accuracy rates.

2. 2. 2. 2. RT:

2. 2. 2. 2. 1. Congruent Condition:

For the teens, there are no significant predictors. However, Mon-Bil status provides .171 of the variance, with bilinguals being faster, near-significant at p = .083. (When Home Language is entered instead of Mon-Bil status, this becomes a significant predictor, accounting for .217 of the variance, p < .05. Examination of the data reveals that OWH teens (776 ms.) were faster than Mon teens (849 ms.), t (53) = 1.70, p = .015.)

For the younger adults, there are again no significant predictors, but Mon-Bil status provides .215 of the variance, with bilinguals this time being slower, near-significant at $p = .072$.

For the older adults, both age and vocabulary are significant predictors, with vocabulary knowledge a stronger predictor, accounting for .284 to .295 of the variance (those with higher vocabularies were faster). Age accounted for .219 to .247 of the variance, with older participants slower.

2. 2. 2. 2. 2. Incongruent Condition:

For the teens, the BPVS performance acts as a significant predictor, accounting for up to .200 of the variance, with those with higher vocabularies being faster. (And if Home Language is entered instead of Mon-Bil status, Home Language also acts as a significant predictor, $p < .05$, contributing .207 of the variance. Here, as in the congruent condition, the OWH teens were faster (816 ms.) than the Mon teens (879 ms.), $t (53) = 1.40, p = .012$.)

For the younger adults, both cognitive performance (Raven's) and Mon-Bil status contribute to performance, with the cognitive level accounting for a greater level of the variance, at .392 to .406 of the variance, with those with higher cognitive scores performing faster. Mon-Bil status contributes .267 of the variance, with bilinguals being slower.

2. 2. 2. 3. DIFFERENCE SCORES:

2. 2. 2. 3. 1. Diff ACC:

The only significant factor for the difference score in accuracy is age. For the 4-year-olds, age contributes .226 to .291 of the variance, with older children having lower accuracy difference scores. For the older adults, age also acts as a near-significant predictor (depending on the model, $p = .054$ up to $p = .084$), accounting for .192 to .222 of the variance, with the older participants having lower accuracy difference scores.

2. 2. 2. 3. 2. Diff RT:

The only factor that acts as a significant predictor is BPVS for the teens. It accounts for .209 to .216 of the variance, with those with higher vocabularies showing greater RT difference scores.

2. 2. 2. 4. Summary, Regression Analyses:

In sum, the following factors appear to be the most predictive of performance:

Age

Age (in months) relative to the others within the age group acts as a predictor of accuracy in the incongruent condition in the performance of the 4-year-olds and that of the younger adults (older more accurate); it also predicts RTs in the congruent condition and accuracy difference scores for the older adults (older slower, older lower accuracy difference scores).

Vocabulary, BPVS

Vocabulary performance is the greatest predictor of performance for Accuracy in the 4-year-olds (congruent condition) and the teens (both congruent and incongruent condition); it is also the greatest predictor of performance for RTs for the teens in the incongruent condition, and the older adults in the congruent condition.

Cognitive performance (McCarthy's, Raven's)

Cognitive performance on the Raven's is predictive of younger adults' accuracy in the congruent condition and their speed of responses in the incongruent condition.

Mon-Bil status

The one place where Mon-Bil status was a clear predictor of performance was in the older adults' accuracy, in both conditions. The bilinguals were more accurate.

Mon-Bil status was also predictive of performance for the younger adults' RTs in both conditions, but in this case, the bilinguals were slower than the monolinguals.

3. DISCUSSION

These results indicate contributions from several factors to performance. First, age seems most predictive at the youngest and oldest ends of the spectrum. At the youngest age here, the children are still developing cognitively, in the older adult group, age can be associated with possible cognitive decline.

Apart from age, the single most influential factor appears to be language ability, as measured here by vocabulary. This result is in keeping with Marton's (2015) findings with regard to children, and it is worthy of closer scrutiny, in the light of the fact that perhaps at least some of the effects observed for advantages in bilinguals in other work could possibly be attributed to the fact that bilinguals, by definition, have two languages--that is, more language, more vocabulary, as well as more knowledge of other aspects of language.

Apart from the effects of these factors, these analyses still show a possible effect of bilingualism. However, the direction is not always consistent with a bilingual advantage. In the younger adults, the effects are contrary to expectations, with the bilinguals showing slower **RTs** than the monolinguals. But among the older adults, bilingualism is associated here with more **accurate** performance, although not, it should be noted, with RTs. The high contribution of bilingualism to the accuracy performance in the older adults is of interest, as this supports Valian's (2015) suggestion that the most consistent evidence for a cognitive advantage for bilingualism may be in older people. Valian (2015) proposes that while "children and young adults engage in many cognitively challenging activities…at least equivalent to the cognitive challenges provided by bilingualism" (p. 19), older adults "have a less varied life…[and] fewer cognitively enriching experiences than younger adults" (p. 19). It is also of interest, in that the advantage of bilingualism for accuracy in the older group appears in both congruent and incongruent conditions, possibly supporting the view of an overall cognitive advantage for bilingualism, rather than one tied to conflict. However, it is of considerable note that Clare et al. (2014) failed to find such effects for a similar older group of Welsh-English bilinguals, and the absence of an effect for RTs here is contrary to some suggestions in the literature that the bilingual advantage may be more relevant to RTs than to accuracy (Hilchey & Klein, 2011).

These results are important because they reveal what bilingualism alone contributes to performance when other confounding factors are controlled for. Correlational analyses in previous work, including our own, have revealed links between the various factors examined here, but the regression

analyses conducted provide a much more stringent test of the individual contributions of those factors. It is primarily only in the accuracy performance of the older adults where bilingualism contributed positively to performance on top of the other factors, and it did so across the board, rather than only in relation to control conditions. While these results fail to provide evidence of a resounding role of bilingualism throughout, they do suggest that perhaps as other factors (language proficiency, cognitive performance) become less differentiating of older adults from one another, bilingualism may show some effects on performance. But the effects of bilingualism are not always in the expected direction, and the present data suggest that other factors, particularly relative age and language proficiency, as measured here through vocabulary performance, may play a more crucial role than has been recognized.

One factor that did not appear contributory to performance here was SES. There are at least two possible reasons for this: First, this may be because, while SES is highly correlated with the other measures, particularly vocabulary and general cognitive performance, any effects it may have on performance when considered in isolation may be proxies for more direct effects from linguistic and cognitive influences, which we know are correlated highly with SES (see Gathercole et al., 2015). A second possibility is that the population studied here was not varied enough in SES (e.g., none of them were growing up in poverty) to be able to capture any direct role SES may play in executive performance. Data from a more varied population may help to answer which of these possibilities is more valid.

These analyses help to demonstrate another way forward in the examination of this important area of research. Controlling the relative contributions of various factors in a single group, and especially in a relatively large and culturally and geographically homogeneous population like this one, and examining their relative impacts on the target performance can help tease apart the individual imports of each. The data here are suggestive of an important role of language per se in executive performance, as well as of relative age, but they do not rule out that bilingualism may be especially relevant to accuracy performance at older ages. Future research must be attentive to age, cognitive abilities, and language in the choice of participants and in the analyses of data.

REFERENCES

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

Baker, C. (2011). *Foundations of bilingual education and bilingualism* (5th ed.). Bristol: Multilingual Matters.

Bialystok, E. (2006). Effect of bilingualism and computer video game experience on the Simon task. *Canadian Journal of Experimental Psychology, 60*, 68-79. doi: 10.1037/cjep2006008

Bialystok, E. (2011). Reshaping the mind: the benefits of bilingualism. *Canadian Journal of Experimental Psychology, 65*, 229-235. doi: 10.1037/a0025406

de Bruin, A., Treccani, B., & Della Sala, S. (2015). Cognitive advantage in bilingualism: an example of publication bias? *Psychological Science, 26*, 99-107.

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

Clare, L., Whitaker, C.J, Craik, F. I. M., Bialystok, E., Martyr, A., Martin-Forbes, P. J., Bastable, A. J. M., Pye, K. L., Quinn, C., Thomas, E. M., Gathercole, V. C. M., Hindle, J. V. (2014). Bilingualism, executive control and age at diagnosis among people with early-stage Alzheimer's disease in Wales. *Journal of Neuropsychology.* Article first published online: 25 NOV 2014 DOI: 10.1111/jnp.12061

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* (2), 135–149.

Costa, A., Hernandez, M., & Sebastian-Galles, N. (2008). Bilingualism aids conflict resolution: evidence from the ANT task. *Cognition, 106*, 59-86. doi: 10.1016/j.cognition.2006.12.013

Dijkstra, T., & Van Heuven, W. J. B. (1998). The BIA-model and bilingual word recognition. In J. Grainger, & A. Jacobs (Eds.), *Localist connectionist approaches to human cognition* (pp. 189-225). Hillsdale, NJ: Erlbaum.

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*(3), 234-251. DOI: 10.1027/1618-3169/a000243.

Dunn, L. M., Dunn, L. M., & Whetton, C. (1982). *The British Picture Vocabulary Scale: Manual for the Short and Long Forms.* London: NFER-NELSON.

Friedman, N. (2015). What is (are) executive function(s)? Insights from individual differences research. Paper presented at Bilingualism and Executive Function: An Interdisciplinary Approach. CUNY, May 17-18, 2015.

Gathercole, V. C. M., Kennedy, I., & Thomas, E. M. (2015). Socioeconomic levels and bilinguals' performance on language and cognitive measures. *Bilingualism: Language and Cognition.* / *FirstView* Article / January 2016, pp 1 - 22 DOI: 10.1017/S1366728915000504, Published online: 06 August 2015

Gathercole, V. C. M., Pérez-Tattam, R., Stadthagen-González, H., & Thomas, E. M. (2014a). Bilingual construction of two systems: To interact or not to interact? In E. M. Thomas & I. Mennen (Eds.), *Advances in the study of bilingualism* (pp. 63–89). Bristol: Multilingual Matters.

Gathercole, V. C. M., Thomas, E. M., Jones, L., Viñas Guasch, N., Young, N., & Hughes, E. K. (2010). Cognitive effects of bilingualism: Digging deeper for the contributions of language dominance, linguistic knowledge, socioeconomic status, and cognitive abilities. *International Journal of Bilingual Education and Bilingualism, 13*, 617-665.

Gathercole, V. C. M., Thomas, E. M., Kennedy, I., Prys, C., Young, N., Viñas Guasch, N., Roberts, E. J., Hughes, E. K., & Jones, L. (2014b). Does language dominance affect cognitive performance in Bilinguals? Lifespan evidence from preschoolers through older adults on Card Sorting, Simon, and Metalinguistic Tasks. Special issue on the Development of Executive Function in Children, *Frontiers in Psychology: Developmental Psychology, 5*, article 11.

Gathercole, V. C. M., Thomas, E. M., Roberts, E., Hughes, C., & Hughes, E. K. (2013). Why assessment

needs to take exposure into account: Vocabulary and grammatical abilities in bilingual children. In V. C. M. Gathercole (Ed.), *Issues in the assessment of bilinguals*.   Bristol: Multilingual Matters. 20-55.

Gollan, T.H., Sandoval, T., & Salmon, D.P. (2011). Cross-language intrusion errors in aging bilinguals reveal the link between executive control and language selection. *Psychological Science, 22,* 1155-1164. doi: 10.1177/0956797611417002

Goriot, C., Denessen, E., Bakker, J., & Droop, M. (2015). Benefits of being bilingual? The relationship between pupils' perceptions of teachers' appreciation of their home language and executive functioning. *International Journal of Bilingualism*, 1–14. DOI: 10.1177/1367006915586470

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

Hakuta, K. (1986). *Mirror of language: The debate on bilingualism*. New York: Basic Books.

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*, 625-58.

Hindle, J., Martin-Forbes, P., Bastable, A., Pye, K., Martyr, A., Whitaker, C., Craik, F. I. M., Bialystok, E., Thomas, E., Gathercole, V. C. M., & Clare, L. (in press, 2015). Cognitive reserve in Parkinson's disease: The effects of Welsh-English bilingualism on executive function. *Parkinson's Disease*. Article ID 943572, 10 pages   http://dx.doi.org/10.1155/2015/943572

Klein, R. M. (2015). On the belief that the cognitive exercise associated with the acquisition of a second language enhances extra-linguistic cognitive functions: Is "Type-I incompetence" at work here? *Cortex 73*, 340-341.Jarvis, S., & Pavlenko, A. (2008). *Crosslinguistic influence in language and cognition*. N.Y.: Routledge.

Kousaie, S., Sheppard, C., Lemieux, M., Monetta, L., & Taler, V. (2014). Executive function and bilingualism in young and older adults. *Frontiers in Behavioral Neuroscience, 8*. doi: 10.3389/fnbeh.2014.00250

Macnamara, J. (1966). *Bilingualism and primary education.* Edinburgh: Edinburgh University Press.

Marton, K. (2105). Do bilingual children perform more efficiently in different experimental tasks than their monolingual peers? Paper presented at Bilingualism and Executive Function: An Interdisciplinary Approach. CUNY, May 17-18, 2015.

McCarthy, D. (1972). *McCarthy Scales of Children's Abilities*. New York: The Psychological Corporation.

Miyake, A., & Friedman, N. P. (2012). The nature and organization of individual differences in executive functions: Four general conclusions. *Current Directions Psychological Science, 21*(1): 8–14. doi:10.1177/0963721411429458

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

Paap, K. R., & Greenberg, Z. I. (2013). There is no coherent evidence for a bilingual advantage in executive processing. *Cognitive Psychology, 66*, 232-58.

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*, 265-78. doi: 10.1016/j.cortex.2015.04.014.

Patterson, J., & Pearson, B. Z. (2004). Bilingual lexical development: influences, contexts, and processes. In G. Goldstein (Ed.), *Bilingual language development and disorders in Spanish-English speakers* (pp. 77-104). Baltimore, MD: Paul Brookes.

Raven, J. C., Court, J. H., & Raven, J. (1983). *Manual for Raven's Progressive Matrices and Vocabulary Scales (Section 3) - Standard Progressive Matrices* (1983 edition). London: Lewis.

Sabbagh, M. A., Xu, F., Carlson, S. M., Moses, L. J., & Lee, K. The development of executive functioning and theory of mind: A comparison of Chinese and U.S. preschoolers. *Psychological Science, 17*(1): 74–81. doi:10.1111/j.1467-9280.2005.01667.

Soares, C., & Grosjean, F. (1984). Bilinguals in a monolingual and a bilingual speech mode: The effect on lexical access. *Memory and Cognition, 1*2, 380-386.

Sorace, A. (2015). Referring expressions and executive functions in child and adult bilinguals. Paper presented Bilingualism and Executive Function: An Interdisciplinary Approach. CUNY, May 17-18, 2015.

Thomas, E. M., Gathercole, V. C. M., & Hughes, E. K. (2013). Sociolinguistic influences on the linguistic achievement of bilinguals: Issues for the assessment of minority language competence. In V. C. M. Gathercole (ed.), *Solutions for the assessment of bilinguals* (pp. 175–193). Bristol: Multilingual Matters.

Valian, V. (2015). Bilingualism and cognition. *Bilingualism: Language and Cognition, 18* (1), 2015, 3–24. doi:10.1017/S1366728914000522

Weissberger, G.H., Wierenga, C.E., Bondi, M.W., & Gollan, T.H. (2012). Partially overlapping mechanisms of language and task control in young and older bilinguals. *Psychology and Aging, 27*, 959-974. doi: 10.1037/a0028281

Woumans, E., & Duyck, W. (2015). The bilingual advantage debate: Moving toward different methods for verifying its existence. *Cortex, 73*, 356-357.