Bilingual advantage, bidialectal advantage or neither?: Comparing performance across three tests of executive function in middle childhood.

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Research Highlights

1. This study provides the first test of a possible bidialectal advantage in childhood, comparing bilingual and bidialectal children's performance to that of a monolingual control group across three tests of executive function.

2. No bidialectal advantage was apparent. Further, the 'established' bilingual advantage was found only in one measure in one task.

3. A comprehensive review of previous developmental studies calls into question the robustness of the bilingual advantage in inhibitory control and cognitive flexibility.

4. This review reveals that any bilingual advantage is likely to be both task and sample specific, and highlights the importance of more systematically tracking the impact of linguistic environment on executive function across the lifespan.

Abstract

When bilinguals speak, both fluent language systems become activated in parallel and exert an influence on speech production. As a consequence of maintaining separation between the two linguistic systems, bilinguals are purported to develop enhanced executive control functioning. Like bilinguals, individuals who speak two dialects must also maintain separation between two linguistic systems, albeit to a lesser degree. Across 3 tests of executive function, we compared bilingual and bidialectal children's performance to that of a monolingual control group. No evidence for a bidialectal advantage was found. However, in line with a growing number of recent partial and failed replications, we observed a significant bilingual advantage only in one measure in one task. This calls the robustness of the bilingual advantage into question. A comprehensive review of studies investigating advantages of inhibitory control and cognitive flexibility in bilingual children reveals that the bilingual advantage is likely to be both task and sample specific, and the interaction between these factors makes qualification of the effect challenging. These findings highlight the importance of tracking the impact of dual linguistic systems across the lifespan using tasks calibrated for difficulty across different ages.

Keywords: bilingual advantage; dialects; executive function; middle childhood; cognitive development

When bilinguals speak, both fluent language systems become activated in parallel and exert an influence on speech production (De Bot, 1992; Costa, Caramazza & Sebastián-Gallés, 2000; Green, 1986; Hermans et al, 1998; Poulisse & Bongaerts, 1994; Poulisse, 1997). In order to prevent blending or catastrophic interference between the two language systems, it has been suggested that bilinguals inhibit the non-target language (e.g. Green, 1986). As a consequence of maintaining separation between the two linguistic systems, bilinguals are purported to develop enhanced executive control functioning (e.g. Bialystok et al, 2004; Costa, Hernández & Sebastián-Gallés, 2008; Costa & Santesteban, 2004). Speakers of distinct regional dialects also need to control selection processes across two lexica; controlling when to use the standard and when to use the regional variant. Like distinct but related languages, standard and non-standard dialects have phonetic, lexical and syntactic differences, as well as considerable systemic overlap. This means that bidialectal speakers theoretically share a similar burden to bilingual speakers, stemming from the heterogeneity of their linguistic input and the sociolinguistic constraints on using the dialects in different contexts. However, the possibility that bidialectal speakers might share the bilingual advantage in executive function has rarely been tested. The aim of the present study is to test whether bidialectal children demonstrate similar advantages in executive functions as reported for bilingual children (Bialystok, 2001).

For adult bilinguals, evidence for the cognitive benefits associated with bilingualism has been reported for a wide variety of tasks. For instance, bilinguals have been found to outperform monolinguals in tests of executive control such as the Simon task (Bialystok et al., 2004), the Stroop task (Bialystok, Craik, & Luk, 2008), the flanker task (Costa et al., 2008), task switching (Prior & MacWhinney, 2010), as well as computing false beliefs (Rubio-

Fernandez & Gluksberg, 2011). In cross-sectional studies, bilingualism has also been associated with a delay in cognitive decline/onset of dementia in the elderly (Bialystok, Craik, & Freedman, 2007), though the advantage is not always apparent (Clare et al, 2014) especially in longitudinal data (Crane et al, 2010; Lawton et al, 2014, Sanders et al, 2012; Zahodne et al, 2014). The dominant interpretation of these bilingual benefits attributes them to the fact that both languages of the bilingual are constantly active; a bilingual cannot simply turn the unwanted language off (cf. Colome, 2001; Hermans, Bongaerts, De Bot & Schreuder, 1998; Marian & Spivey, 2004; Marian, Spivey, & Hirsch, 2003). Consequently, bilinguals must develop cognitive control abilities to successfully select the words, structures, and phonetic instructions appropriate for the desired language (See Bialystok, 2011b for more extensive discussion).

The bilingual advantage has been documented for a wide range of populations, ranging from diachronically related language pairs such as Spanish-Catalan (Costa et al, 2008) and Italian-Sardinian (Lauchlan, Parisi, & Fadda, 2013) to unrelated and distinct language pairs such as English-Hebrew (Bialystok & Barac, 2011) or English-Gaelic (Lauchlan et al, 2013). It does not appear that the magnitude of the bilingual advantage is associated with the degree of similarity or overlap between the two languages, opening up the possibility that a similar advantage might be observed for monolingual speakers living in regions with distinct regional dialects, such as Scotland. If the contrast between languages and dialects are viewed as a continuum rather than a dichotomous categorical distinction, then dialectial variants of a language would be at one end of the spectrum while diachronically unrelated languages would sit at the other end, with closely related language pairs filling the middle section of the range. Poarch and Van Hell (2012) demonstrated the variable repercussions that different language acquisition histories may have upon language control by plotting a language development continuum, with monolinguals on one extreme, then second-language learners, bilinguals and lastly tri-/multi-linguals on the other extreme.

Only one previous study has compared bilingual, bidialectal and monolingual speakers on a test of executive control; in this case the ability to suppress interference was measured by the ‘Simon task’. Kirk et al (2014) focussed on Scottish bidialectal participants, who speak both Standard English and Dundonian, a regional variant of English spoken in the area around the city of Dundee. Kirk et al reported no dialectal advantage for elderly bidialectal speakers in Simon task performance. However, they also included bilingual (Scottish speakers of English and Gaelic) and monolingual (English participants and speakers of a range of Asian languages) age-matched controls and failed to observe the expected bilingual advantage in task performance. This null result was unexpected, since the bilingual advantage has previously been found to be clearest at points in the lifespan where executive control might otherwise be weak; for example, due to cognitive decline or developmental limitations (Bialystok, 2006; Costa et al, 2008). To explore this further, the current study samples bilingual, bidialectal and monolingual participants from the other end of the developmental spectrum, searching for bilingual and bidialectal advantages in middle childhood.

For children exposed to two languages from birth, the bilingual advantage in executive function is typically reported to onset between 3 and 6 years of age (Bialystok, 1999), though eye tracking studies show greater cognitive flexibility in bilingual infants as young as 7 months (Kovács & Mehler, 2009). However, the ontogeny of exposure to two dialects (standard and non-standard) may be different. For example, children may be immersed in the dialect of their geographical region from birth, and encounter Standard English only upon entering the education system. Therefore, allowing for a period of dialectal learning between the ages of 5 and 7 years, the first bidialectal benefits may become apparent by middle childhood. This would mirror the ontogeny of the bilingual advantage for populations exposed to second languages through school immersion programmes (Nicolay & Poncelet, 2013). Understanding the cognitive consequences of bidialectalism has wide reaching implications. Executive functions are strongly implicated in a number of social, cognitive, psychopathological and educational outcomes (see Hughes, 2002 for review), and the factors that influence the development of this skill set warrant thorough investigation. The discovery of a bidialectal advantage would also influence educational and public policy decisions regarding language inclusivity in schools, impacting on social identity and cohesion. Finally, investigation of bidialectal effects may allow more thorough assessment of the mechanism driving the 'bilingual' advantage, by determining if the advantage is specific to language.

Previous research has analysed bilingual children's executive control advantage in various ways. The most commonly used tasks are the Simon and/or Flanker tasks (Anton et al, 2014; Bialystok et al, 2010; Bialystok, Martin & Viswanathan, 2005; Carlson & Meltzoff, 2008; de Abreu et al, 2012; Gathercole et al, 2014; Kapa & Colombo, 2013; Martin-Rhee & Bialystok, 2008; Morton & Harper, 2007; Morales, Calvo & Bialystok, 2013; Poarch & Hell, 2012; Yoshida, et al, 2011); and the Dimensional Change Card Sort (DCCS) task (Bialystok, 1999; Bialystok & Martin, 2004; Bialystok & Shapero, 2005; Carlson & Meltzoff, 2008; Gathercole et al, 2014; Iluz-Cohen & Armon-Lotem, 2013). These tasks are thought to measure skills similar to those needed to appropriately suppress and select one grammar/lexica over another when producing language. Furthermore, they tap differentially into distinct components of executive functioning (Miyake et al, 2000; Friedman et al, 2006). Specifically, the Simon and Flanker tasks tap into one's ability to inhibit distracting stimuli whereas the DCCS task taps into one's ability to shift between mental sets. Both components of executive function have been identified as potentially important to effective error-free bilingualism (though see Calabria et al, 2015 for further discussion).

In Study one, we report a comparison between bilingual, dialectal and monolingual children's performance on age appropriate versions of the Simon task and Flanker task. Both tasks require children to suppress cognitive interference when making a productive response. In Study two, we compare bilingual, dialectal and monolingual children's performance in an age appropriate switching task. This task measures cognitive flexibility, as indexed by the ability to maintain and switch between rule sets. If bidialectalism carries the same cognitive demands as bilingualism, we would expect both bidialectals and bilinguals to show an advantage relative to monolinguals on our interference suppression and cognitive flexibility tasks. However, given the social and cognitive overlap between standard and non-standard dialects, it is also possible that bidialectals will exhibit a lesser advantage to bilinguals. In this case we would expect bidialectals to pattern between bilinguals and monolinguals, or equivalent to monolinguals, in task performance. Alternatively, it could be that the overlap between dialects makes separation of the systems more challenging, giving bidialectals the largest advantage.

In addition to having implications for child development and education, the results are potentially of both practical and theoretical benefit to our understanding of the bilingual advantage. Firstly, Kirk et al (2014) raise the possibility that some of the inconsistent results evident in the bilingual literature may have arisen from dilution of the 'monolingual' control group with bidialectal speakers. Secondly, the presence of a bidialectal advantage would add weight to the hypothesis that the bilingual effect arises from practise in suppressing and switching flexibly between two linguistic systems, as opposed to identified confounds such as the socio-economic status of bilinguals (Morton & Harper, 2007). Finally, comparison of bilingual and bidialectal performance should indicate whether the level of distinction between two linguistic systems, are important in conserving executive advantage.

Like Kirk et al (2014), we focus on Scottish participants for our bidialectal sample . In a recent survey of dialect usage and attitude funded by the Scottish Executive (Scottish Government Social Research, 2010), 85% of Scots claimed to use Scots dialect regularly. The degree of deviation between Scots and Standard English is greater than for other regional dialects in the UK (Hughes, Trudgill, & Watt, 2013). Trudgill (1983) notes that the linguistic differences between Standard and non-Standard variants of English increase as one moves away from the South-East of England. In Scotland, standard and non-standard dialects are so far apart that speakers are described as jumping between them (Trudgill, 1983). This notion of 'jumping' between dialects may be analogous to switching between languages, a key process thought to crucially underpin the bilingual advantage (cf. Prior & MacWhinney, 2010). Given the evidence for large dialectal contrasts in Scotland and 'trivial' dialectal contrast in the south-east of England (see Trudgill, 1983, p. 188), we compare Scottish bi-dialectal speakers to English mono-dialectal speakers from the south of England. However, it is important to emphasize that dialectal variation is a global phenomenon and not specific or special to Scotland.

Study 1

Methods

Participants

147 children aged between 6 and 9 years participated. 54 children were bilingual speakers, the majority living in Glasgow or Edinburgh, Scotland. 45 bilinguals had Gaelic as a second language to English. However, there were also isolated examples of children speaking English as a first language and Arabic, Czech, Chinese, Malay, Russian, Japanese, Zulu, Greek, or French as a second language. 48 children were bidialectal speakers, the majority living in Dundee, North-East Scotland. 45 children were monolingual/dialectal speakers of English, the majority living in Portsmouth, Southern England.

Prior to testing, all parents completed a language / dialect background questionnaire. Initial exposure to second languages/dialects ranged from zero to four years, meaning that children had a minimum of two years experience of the second language/dialect prior to participating. For both languages and dialects, parents were asked if they would describe their child as fluent, and how frequently the child used and listened to the second language/dialect at home and at school. Standard English was identified as dominant in all cases. All children included engaged in language switching, speaking one language/dialect more often in one context than the other (home or school). Table 1 shows that there were no significant differences between bidialectal and bilingual participants in terms of second language/dialect fluency. However, there was a difference in terms of frequency, such that parents reported less frequent use of dialects. Parents of monolingual English children were also asked about exposure to other languages/dialects in the home and at school. None of the monolingual children included were identified by their parents as speaking another language or using a regional dialect. Many English parents questioned whether there was a local dialect in their region. This highlights the contrasting metalinguistic awareness of regional dialects in Scotland compared to the south of England, where the monolingual children lived.

Table 1: Comparison of bidialectal and bilingual fluency and frequency

Second language/dialect	Bidialectal	Bilingual	Mann-Whitney comparison of dialect and second language
1. Fluency	*M* = 2.66 Median = 3	*M* = 2.81 Median = 3	*U* = 1121.50, *p* =.615
2. Frequency	*M* = 1.45 Median = 1	*M* = 2.57 Median = 3	*U* = 329, *p* < .001

Notes

1. *Fluency: Parents rated children as fluent, advanced, intermediate or beginner level in speaking in each language/dialect. For the purposes of comparing second language and dialect fluency, these ratings were scored on an ordinal scale as 4, 3, 2, 1 corresponding to the four fluency levels.*
2. *Frequency: Parents rated language/dialect as spoken 'often',' sometimes', or 'very little'. For the purposes of comparing second language and dialect frequency, these ratings were scored on an ordinal scale as 3, 2, 1 respectively.*

All participants came from schools and homes in areas ranked in the low to middle range for socio-economic deprivation as measured using publicly available government indices of multiple deprivation for Scotland and England (Scottish Government, 2010; Department of Communities and Local Government, 2011)[1].

The groups were evaluated on their age-equivalent vocabularies, as determined by the British Picture Vocabulary Scale (BPVT II; Dunn et al, 1997) and their chronological age in months. A multivariate analyses of variance was conducted to evaluate whether there were any significant differences between groups on either of these variables. The results show that groups did not differ reliably on chronological age (Bilingual: *M* = 92.1, *SD* = 7.0; Bidialectal: *M* = 91.1, *SD* = 7.7; Monolingual: *M* = 92.5, *SD* =7.6; F (2, 143) =.5, *p* =.61, n_p^2=.007). However, there was a small main effect of group on age-equivalent vocabulary (Bilingual: *M* = 88.5, *SD* = 21; Bidialectal: *M* = 95.5, *SD* = 17.8; Monolingual: *M* = 102.1, *SD* =17.8; F (2, 143) =6.2, *p* =.003, n_p^2=.079). Post hoc LSD comparisons indicated that monolinguals had better vocabularies as measured by the BPVT than bilingual speakers (*p* = .001), but not bidialectal speakers (*p* =.098) who patterned between the two (Bilingual*Bidialectal, p =.069). This monolingual advantage in vocabulary proficiency is the norm in developmental studies of the bilingual advantage, and is not considered to detract from the bilingual effect.

Materials and Procedure

Children completed two computer-based tasks designed to measure cognitive inhibition in counterbalanced order. Both tasks were programmed into DMDX (Forster & Forster, 2003) running on a laptop computer running Windows Vista. Stimuli were displayed on a 19”

[1] The Scottish sample (Bilingual and Bidialectal children) was matched for home deprivation ranks. Although the deprivation indices are not directly comparable, the English sample (Monolingual children) was selected from homes with an equivalent deprivation ranking for their country.

monitor at resolution of 1280x1024 set to 32bit color and a refresh rate of 60Hz. For both tasks, we examined both the speed and accuracy of the response[2].

SIMON TASK: In the Simon task (Simon & Wolf, 1963) we presented red and blue squares either on the right or left side of the monitor. Participants were instructed to respond to each colored square by pressing the shift key baring a label that matched in color. Location of the squares on the screen (left vs. right) was irrelevant to the response choice. Color-hand pairings were counterbalanced across participants. The task requires inhibition when the position of the stimulus (right or left side of the screen) conflicts the side of the response (right or left shift keys). We examined both the speed and accuracy of the response. There were 48 trials equally divided between the two colors and two locations, generating an equal number of trials in each condition (congruent and incongruent). Trials were randomised individually for each participant, producing a unique sequence of trials for each participant tested.

The task was introduced to the children as a game that tests how quickly they could identify the color of a square by pressing the appropriate button. 12 practice trials preceded the main test phase. No mention of the position of the color square was made in the instructions to the task. Each trial had the following structure: first, the words ‘Get ready’ were presented for 700ms. This warning was replaced by the colored stimulus, presented for 1700ms. When the child’s response was correct, a celebratory sound file was played before the next trial starts. No negative feedback was provided.

[2] To avoid confounding with any speed-accuracy trade off, reaction times are considered only for correct trials for all tasks. Since removal of outliers in the Simon and Flanker tasks (defined as trials faster than 300 ms, or slower than 1700ms) did not change the pattern of results, analysis is based on the raw data.

FLANKER TASK: A modified version of the flanker task (Eriksen & Eriksen, 1974; Rueda et al, 2004) was created with stimuli appropriate to the age of our target population. Specifically, rather than using arrows, e.g., <<< or <><, we used images of a fish. To create the experimental conditions we presented 5 fish either all facing in the same direction, *the congruent condition*, or with the middle fish faced in the opposite direction, *the incongruent condition*. Additionally, we had a *baseline condition* which consisted of only of 1 fish. Examples of the stimuli are presented in Figure 1. There were 144 trials equally divided between the 3 conditions. Trials were randomised individually for each participant, producing a unique sequence of trials for each participant tested.

Figure 1: sample stimulus in the incongruent condition

Children were familiarized with the task before testing began. They were introduced to the main character of the game, named Freddie. The children were told that sometimes Freddie swam by himself and other times he swam with his friends; Freddie always swam in the middle when swimming with his friends. Their task was to indicate which direction Freddie was swimming. Two buttons were identified on the keyboard for responding Left and Right. Children were explicitly told to ignore the direction of the other fish and only to attend to Freddie's swimming direction. 20 practice trials preceded the main test phase. Each trial had the following structure: first, the words 'Get ready' were presented for 700ms. This warning was replaced by a fish stimulus, presented for 1700ms. When the child's response was correct, a celebratory sound file was played before the next trial started.

Results

SIMON TASK: Figure 2 shows error rates and reaction times for the Simon task, split by congruency and linguistic group. A mixed measures ANOVA with congruency (congruent x incongruent) as a within subjects factor and linguistic group as a between subjects factor indicated moderate main effects of congruency on error rates (F (1, 144) =113.13, p < .001, n_p^2= .44) and reaction times (F (1, 144) = 180.7, p < .001, n_p^2=.56). For error rates, there was a marginally non-significant interaction between congruency and linguistic group (F (2, 144) = 2.43, p = .09, n_p^2= .03), and a small significant difference between linguistic groups (F (2, 144) = 3.65, p =.029, n_p^2= .05). Post hoc LSD comparisons on the significant result confirmed that bilinguals had significantly lower error rates than both monolinguals (p =.02) and bidialectals (p =.025), who performed similarly (p = .95). Analysis of the reaction times did not show a significant bilingual advantage, either in the size of the Simon effect (congruency*group F (2, 144) = .38, p =.68, n_p^2=.005), or in overall response latencies (F (2, 144) =.08, p =.92, n_p^2=.001).

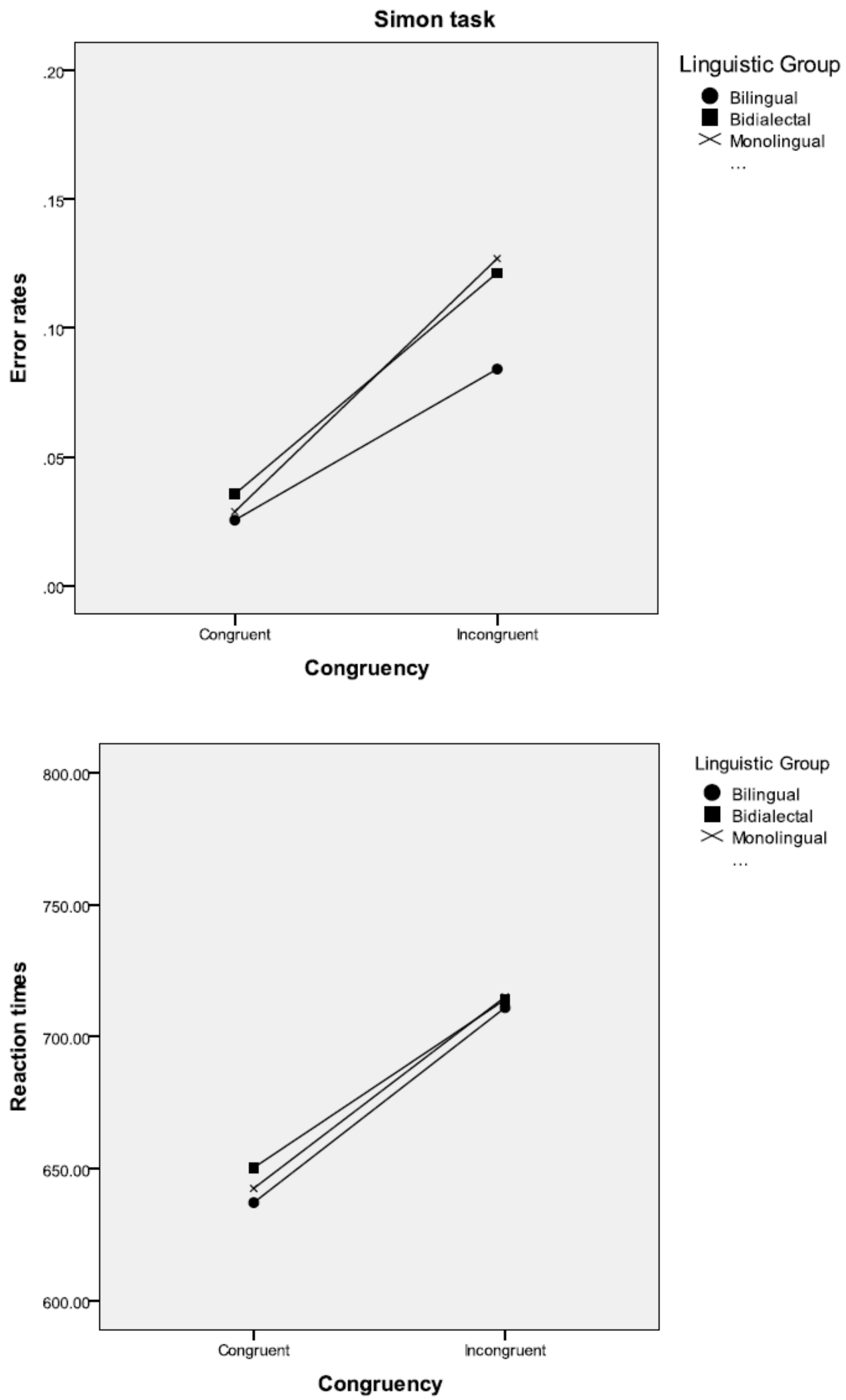

Figure 2: Simon task performance, split by congruency and linguistic group

FLANKER TASK: Figure 3 shows the error rates and reaction times for the Flanker task, split by congruency and linguistic group. A mixed measures ANOVA with congruency as a within subjects factor (neutral x congruent x incongruent) and linguistic groups as a between subjects factor confirmed a small main effect of congruency on error rates (F (2, 288) = 5.99, p =.03, n_p^2= .04) and a moderate effect on reaction times (F (2, 288) = 75.8, p < .001, n_p^2=.34). Post hoc LSD comparisons confirmed a significant conflict effect (congruent x incongruent) for both error rates (*p =.003*) and reaction times (p < .001). There was no significant interaction with linguistic group (errors rates: F (4, 288) = .71, p =.59, n_p^2=.01; reaction time: F (4, 288) = 1.1, p =.37, n_p^2=.015), or between subjects effect of linguistic group on performance (errors rates: F (2, 144) = .36, p =.69, n_p^2= .005; reaction time: F (2, 144) = .55, p =.57, n_p^2= .008).

RELATIONSHIP BETWEEN SIMON AND FLANKER TASKS: Pearson's correlation analyses confirmed that performance in the Simon and Flanker tasks was positively associated (congruent errors: r^2 =.168, p = .042; incongruent errors: r^2 =.295, p <.001; congruent RT: r^2 =.471, p < .001; incongruent RT: r^2 =.521, p <.001).

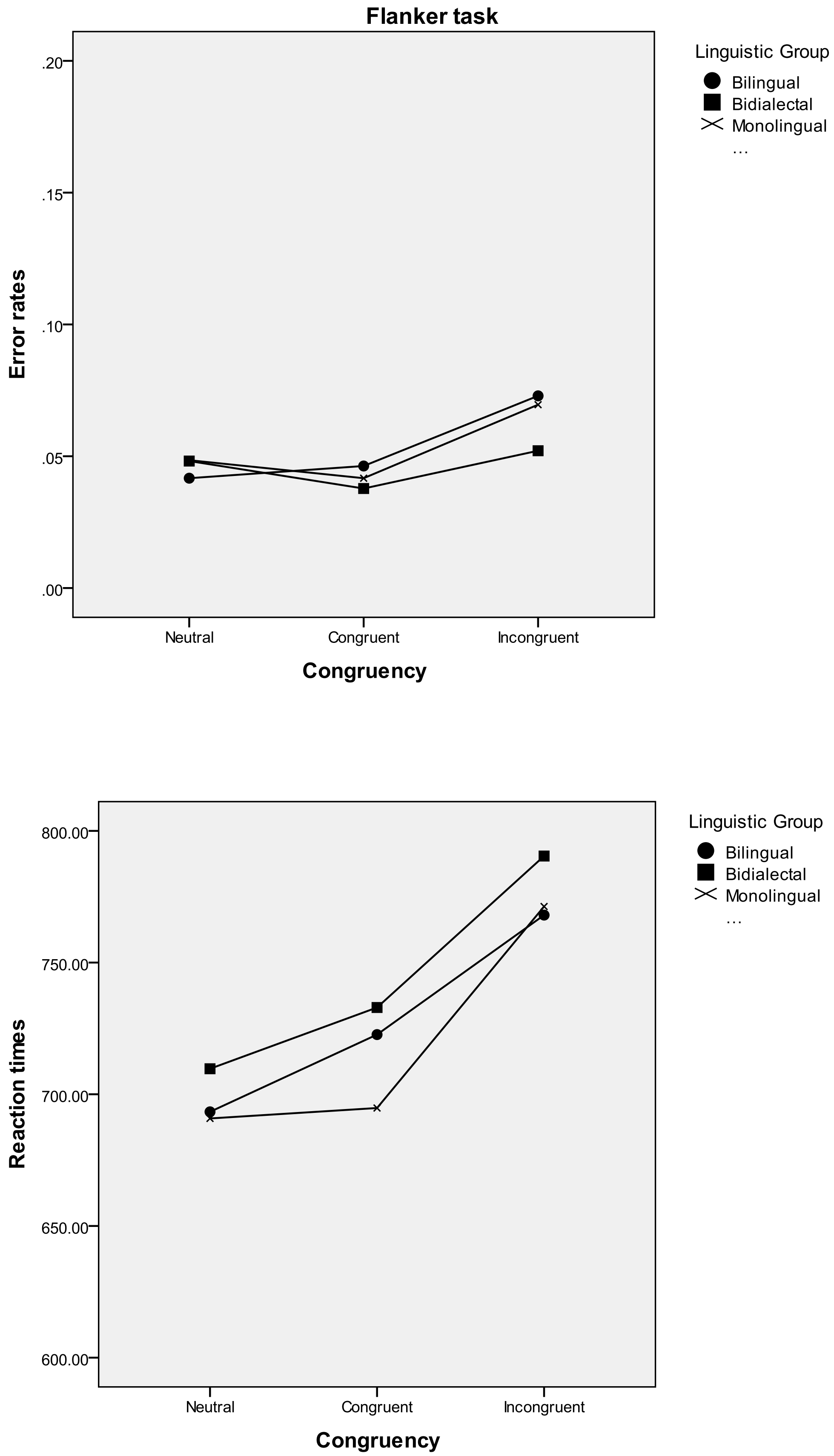

Figure 3: Flanker task performance, split by congruency and linguistic group

Discussion

In keeping with the bilingual advantage we found that bilinguals made fewer errors than both bidialectals and monolinguals in the Simon task. This isolated positive result contrasts with Gathercole et al (2014) who found no accuracy advantage in the Simon task for 8-year-olds. Like Gathercole et al (2014), we found no evidence for a bilingual reaction time advantage in middle childhood. This null result for reaction time in this age range fits fairly well with previous research. Poarch and Hell (2012) report that although 7-year-olds show a smaller increase in response time for incongruent items than monolinguals, this advantage is marginal. Likewise, Morton and Harper (2007) report no bilingual advantage for 7-year-olds' reaction times in the Simon task in a bilingual-monolingual sample closely matched for socio-economic status. Previous positive results for bilingual reaction time advantages in the Simon task appear to be specific to younger age groups. For example, Morales, Calvo and Bialystok (2013) find that bilingual 5-year-olds make fewer errors on the Simon task than their monolingual counterparts. Bialystok, Martin and Viswanathan (2005) and Martin-Rhee and Bialystok (2008) also find that bilingual 4- and 5-year-olds have a reaction time advantage on the Simon task. However, this referred to their overall speed in completing the task, regardless of congruency. Despite our positive result for accuracy, the overall pattern suggests that bilingual advantages in the Simon task may be weaker in middle childhood, and early effects may not be specific to incongruent items which require interference suppression.

The developmental pattern is far less consistent for the Flanker task, for which we find no evidence of a bilingual or bidialectal advantage in middle childhood, despite a positive association with the Simon task. Poarch and Hell (2012) report that 7-year-old bilinguals react more quickly to items requiring conflict resolution in the Flanker task, relative to monolingual children who have just begun to learn a second language. However, others report a more general bilingual advantage in the Flanker task, significant for 8-year-olds' (de Abreu et al, 2012) and 5- to 15-year-olds' (Kapa & Colombo, 2013) overall reaction times. Others find no advantage in a similar age-range. For example, a recent large scale study of the Flanker task (N = 360) found no evidence for a bilingual advantage in 7 to 13-year-olds (Anton et al, 2014)., Likewise, Carlson and Meltzoff (2008) report a significant bilingual advantage for 6-year-olds relative to monolinguals when considering children's error scores for incongruent trials on a variety of executive function tasks, including the Flanker task. However, the Flanker task alone did not reach significance. Fewer studies have been conducted with younger children, and the results here are equivocal; Yoshida et al (2011) find a bilingual advantage in 3-year-olds' overall Flanker task error rates, whereas Bialystok et al (2010) find no effect for either Flanker task accuracy or reaction time for 2- to 5-year-olds. Rather than revealing a strong developmental pattern then, the contrast between Simon task and Flanker task results suggests that the bilingual advantage may be better indexed by some tasks than others, and that the most effective tasks may vary by age range.

Although the Flanker task and the Simon task are commonly used in studies which claim to illustrate the bilingual advantage, and appear to have similar task demands, previous literature determining the effectiveness of these tasks in indexing a significant advantage for bilingual children is limited. Our sample has more power than previous studies (almost all of which had fewer than 30 Bilinguals), yet failed to find consistent effects across the tasks. One possibility is that the Flanker and Simon tasks are not the best indices of bilingual advantage. An alternative established measure is the Dimensional Change Card Sort (DCCS). Using this measure, 3- to 7-year-old bilingual children are regularly more successful in switching a card sorting rule mid task (for example, sort by color, now by shape; Bialystok, 1999; Bialystok & Martin, 2004; Carlson & Meltzoff, 2008); although significance sometimes depends on controlling age/socio-economic status (Carlson & Meltzoff, 2008) or on specific card dimensions (Bialystok & Martin, 2004). Importantly, this task provides perhaps the closest parallel to language switching, as both the DCCS task and language switching involve selecting one of two cognitively represented 'rule sets' depending on context. In contrast, the Flanker and Simon tasks involve inhibiting visually conflicting information. Thus, it may be that an age appropriate card sort task would be most appropriate to explore the bilingual advantage, and therefore any emergent bidialectal advantage. Since the DCCS task was designed for preschoolers rather than middle childhood, we instead used an adaptation of the Wisconsin Card Sort Task (Berg, 1948) known as the Berg Card Sorting Test (BSCT). This advanced card sorting task requires participants to identify and flexibly switch between several sorting criteria, based on trial by trial feedback.

Study 2

Methods

Participants

90 children who participated in Study 1 also completed the BSCT for Study 2. Of these children, 49 were from the bilingual group, 20 from the bidialectal group, and 21 from the monolingual group (giving a total of 41 non-bilinguals). Multivariate analyses of variance

indicated that these three groups did not differ reliably on chronological age (Bilingual: *M* = 92.3, *SD* = .96; Bidialectal: *M* = 91.8, *SD* = 1.5; Monolingual: *M* = 88.7, *SD* =1.4; F (2, 87) =1.1, *p* =.33, n_p^2=.025). However, the small main effect of group on age-equivalent vocabulary remained (Bilingual: *M* = 88.4, *SD* = 2.8; Bidialectal: *M* = 101.2, *SD* = 4.4; Monolingual: *M* = 102.5, *SD* =4.4; F (2, 87) =5.2, *p* =.008, n_p^2=.1). Post hoc LSD comparisons indicated that monolinguals (*p* =.008) and bidialectals (*p* =.018) had better vocabularies as measured by the BPVT than bilingual speakers. Bidialectal and monolingual speakers had equivalent vocabularies (*p* =.88).

Materials and Procedure

In addition to completing the tasks described for Study 1 above, children completed the Berg Card Sorting Task (BCST; Piper et al, 2012) implemented as part of the PEBLs test battery (http://pebl.sf.net). In this computerized version of the Wisconsin Card Sorting task, participants see four exemplar cards at the top of the screen and a sort card at the bottom of the screen. The sort card must be moved into one of the four exemplar piles, depending on which card it matches. The exemplars differ in shape (diamonds, stars, etc), color (yellow, blue, etc) and number (one diamond, two diamonds). If the sort card has three green diamonds, it could either match the green exemplar, the exemplar with diamonds, or the exemplar with three shapes. The participant must discover the sorting criterion through trial and error. They use the mouse to move the sort card into one of the four piles and the computer gives them feedback as to whether their match was correct. After ten sequentially correct responses, the rule is shifted. The participant must then return to trial and error, using the feedback to discover the new sort rule.

Children completed 128 trials of this task. All participants saw the same cards presented in the same order. The task was presented to children as a puzzle game. They were told that they would see four card piles and a set of cards that needed to be sorted into the piles. They were instructed to sort the cards on the basis of the pictures on the cards. They were told that the correct answer depended on a rule that they had to figure out. They were also told that the rule would change periodically and they would have to solve the puzzle afresh. Children were presented with visual feedback on each trial, indicating whether their sort decision was correct or incorrect.

Results

Table 2 summarises BCST performance for each linguistic group. A mulitivariate ANOVA indicated a very weak significant main effect of linguistic group on total error rates (F (2, 87) = 5.7, p = 0.005, n_p^2= .012), but no significant effect for perservative errors (F (2, 87) =1.2, p = 0.31, n_p^2= .03), the number of trials needed to achieve a category (F (2, 87) = .37, p = 0.69, n_p^2= .009), or reaction time for correct trials (F (2, 87) = 1.231, p = .297, n_p^2= .028). Post hoc LSD comparisons indicated that monolinguals had significantly fewer errors than bilinguals (p = .007) and bidialectals (p = .002), who performed similarly (p =.30). However, when the non-bilingual groups were collapsed (to create roughly even groups of bilinguals and non-bilinguals), this isolated significant result disappeared (total error: F (1, 88) = 1.1, , p = 0.29, n_p^2= .013 ; perservative error: F (1, 88) =.69, p = 0.41, n_p^2= .008; number of trials to reach category: F (1, 88) = .54, p = 0.46, n_p^2= .006; reaction time for correct trials: F (1, 88) = 1.303, p = .257, n_p^2=.015).

Table 2: BSCT performance, split by linguistic group.

	Bilingual (N = 49)	Bidialectal (N = 20)	Monolingual (N = 21)	**Non-Bilingual total (N = 41)**
% errors	***M* =34.5** ***SD* =13.9**	*M* =38.1 *SD* =14.4	*M* =25 *SD* =8.9	***M* =31.4** ***SD* =13.5**
% perservative errors	***M* =14.2** ***SD* =7.1**	*M* =14.5 *SD* =9.1	*M* =11.5 *SD* =4.9	***M* =12.9** ***SD* =7.3**
Trials needed to achieve category	***M* =18.2** ***SD* =11.5**	*M* =15.7 *SD* =12.5	*M* =17.3 *SD* =9.1	***M* =16.5** ***SD* =10.8**
Reaction time for correct response (ms)	***M* =4218.9** ***SD* =1730.3**	*M* =4340.9 *SD* =1177.2	*M* =4929.7 *SD* =2202.3	***M* =4642.5** ***SD* =1781.1**

Discussion

Using an age appropriate equivalent of the DCCS task (the BCST), we find no evidence that either bilinguals or bidialectals have an advantage in terms of flexibly switching rule sets; in fact, we find a small advantage for monolinguals in this task. Although our sample size is regrettably reduced relative to study 1, this result is contrary to previous research using similar sample sizes (Bialystok, 1999; Bialystok & Martin, 2004; Carlson & Meltzoff, 2008). Since each of these studies included younger children, one possibility is that this is a developmental effect, such that younger bilingual children have an edge in set shifting when these skills are first becoming established, but monolinguals and bidialectals ‘catch up’ in middle childhood. However, our sample evidently found the BCST challenging, performing below ceiling and within the norms for their age range (Somsen, 2007), so it would appear that the task was sufficiently difficult to have potentially indexed an effect. Moreover, Bialystok and Shapero (2005) and Gathercole et al (2014) found no bilingual advantage in a card sorting task for 3- to 5-year-olds, and IIuz-Cohen and Armon-Lotem (2013) found the effect only for high proficiency bilinguals, implying that a significant effect for younger participants is not a given. Another possibility is that the high working memory demands of our more challenging version of the card sort task (see Piper et al, 2012) masked any bilingual advantage, since bilingual and monolingual children typically perform similarly in tests of working memory (Bonifacci et al, 2011). Nonetheless, taken together, both current and previous results raise the possibility that the bilingual advantage is a relatively weak effect, showing up only in specific tasks or measures, at specific points in the lifespan, and within specific samples. Both possibilities would make assessment of any bidialectal advantage elusive, and are discussed further below.

General Discussion

Across three tests of executive functioning, using samples of between 40-60 children per group, we found only very weak support for a bilingual advantage and no evidence to suggest that bidialectal speakers benefit from their bidialectal upbringing. In the Simon task, bilingual children were significantly more accurate then monolingual or bidialectal children. While superficially supportive of the bilingual advantage, no other measures corroborated this finding. No measure from the Flanker task or the BCST supported the bilingual advantage. In this way, this study joins the rash of recent large scale studies which fail to find clear evidence of a bilingual advantage (e.g., Anton et al, 2014; Duñabeitia et al, 2014; Gathercole et al, 2014; Kirk et al, 2014).

Although the bilingual advantage in inhibitory control and cognitive flexibility has been reported across a number of published developmental studies, the methodology used to obtain effects has been repeated in relatively few. Moreover, results have rarely been replicated faithfully. What is crucially lacking is a broad overview perspective that allows patterns across tasks, dependent measures or sample to emerge. To this end, we conducted a comprehensive review of studies investigating the bilingual advantage in children, focussing on tasks that require inhibitory control. The summary of this review as pertains to the Simon, Flanker, and DCCS tasks are presented in Table 3. Additionally, the findings from an additional 24 relevant tasks are summarized in Appendix 1. These summary Tables capture at a glance the variability of findings within and across tasks.

For the Simon and Flanker tasks, some studies find effects specific to interference suppression in reaction time or error rates, others find a general advantage in one of these measures, whilst others find no advantage. Likewise for the DCCS some studies report a switching advantage, whilst others find none. Taken together, the studies summarised in Table 3 indicate that no single task or dependent variable has consistently been found to index an early bilingual advantage in cognitive inhibition or flexibility.

[Table 3, SEE SUPPLEMENTARY MATERIAL]

A similarly mixed pattern is evident for adults. For example, Bialystok (2006), and more recently Gathercole et al (2014), find no advantage on any measure in the Simon task for young adults, yet the effect is present in overall reaction time for young adults in Bialystok, et al (2005). Similarly, for older adults' (> 70 years) performance in the Simon task, Bialystok, Martin and Viswathan (2005) find an overall reaction time advantage, Bialystok et al (2004) report both overall and conflict specific advantages, yet Kirk et al (2014) find none in any measure. For the Flanker task, Costa, Hernández and Sebastián-Gallés (2008) find overall reaction time advantages in young adults. However, Costa et al (2009) demonstrate that this advantage is only found when an optimally difficult mix of congruent and incongruent trials are used (50-50 split, resulting in a need for high monitoring). Likewise for switching tasks, Prior and MacWhinney (2010) find that young adult bilinguals are more adept at mental set shifting as measured by a color-shape switching task. However, Bialystok, Craik and Ruocco (2006) find younger and older bilingual adults to conserve advantage only for certain switching rules and modalities; in this case, the 'easiest' of the tasks.

Indeed, systematic review of the adult literature indicates that bilingual advantages are the exception rather than the rule. For example, Paap, Johnson and Sawi (2015) report that the significant bilingual advantage in switching found by Prior and MacWhinney has been reproduced in only 1 of 20 published replications. Further, Paap, et al (2015) report that more than 80% of the published comparisons between bilinguals and monolinguals using nonverbal tasks have been null or negative, and the likelihood of significant results decreases with sample size. Such reviews have led several authors to argue that the bilingual advantage is not as robust as its established nature suggests, and that it is highly questionable if the effect is specific to inhibitory control (Costa et al, 2009; Colzato et al, 2008; de Bruin, Treccani & Della Sala, 2015; Hilchey & Klein, 2011; Paap & Greenberg, 2013; Paap, Johnson & Sawi, 2015; Paap & Sawi, 2014). Several independent research groups (exemplified in Paap et al, 2015; Morton & Harper, 2007; Hilchey & Klein, 2011; Duñabeitia et al, 2014) are clearly questioning whether bilingual advantages exist at all across all three components of executive functioning: inhibition, shifting, updating (Miyake et al, 2000). Nevertheless, there have been attempts to preserve the advantage through logical reasoning. For example, Costa et al (2009) attempt to systemise result differences by arguing that bilingual effects, particularly in the magnitude of the conflict effect, will only arise where the task is at an optimal level of difficulty.

For the developmental literature summarised in Table 3, direct comparisons of task difficulty are made difficult by the varied nature of tasks and dependent variables used across studies. However, as for the literature for adults, it is clear that Simon and Flanker effects are more often found to be general (Bialystok, Martin & Viswanathan, 2005; Martin-Rhee & Bialystok, 2008; Morales, Calvo & Bialystok, 2013; de Abreu et al, 2012; Kapa & Colombo, 2013; Yoshida et al, 2011) than conflict specific (Morales, Calvo & Bialystok, 2013; Poarch & Hell, 2012). Moreover, in keeping with Costa et al's (2009) explanation, there is some evidence that varying the difficulty of the task impacts on the whether and where an effect is found. For example, Martin-Rhee and Bialystok (2008) find a significant advantage in a Simon task requiring an immediate response, but not in less challenging delayed response tasks. Likewise, Morales, Calvo and Bialystok's (2013) positive result for a conflict specific effect in the Simon task accuracy measure is derived from the use of an 'advanced' task, where children needed to learn up to four rules rather than the standard two. Positive results for the DCCS also seem to be largely confined to a specific rule sets (color-shape) (Bialystok, 1999; Bialystok & Martin, 2004), advanced versions of which also produce positive results (Carlson & Meltzoff, 2008; Iluz-Cohen & Armon-Lotem, 2013). However, in the only study to directly compare different versions of DCCS tasks within the same age group (Bialystok & Martin, 2004), the superiority of the color-shape version could not be explained by task difficulty (children performed equivalently in color-shape and color-object DCCS).

In keeping with Costa et al’s (2009) explanation for mixed results, age has been cited as a factor determining whether the task will be sufficiently challenging to showcase a bilingual advantage (for example, Bialystok, Martin & Viswanathan, 2005). For the Simon task, Table 3 shows a fairly clear developmental pattern such that studies with younger children are more likely to report an advantage (Bialystok, Martin & Viswanathan, 2005; Martin-Rhee & Bialystok, 2008; Morales, Calvo and Bialystok, 2013) than studies including older children (Gathercole et al, 2014; Poarch & Hell, 2012; Morton & Harper, 2007). More success in samples including younger children has also been reported for the DCCS (Bialystok, 1999; Bialystok & Martin, 2004; Carlson & Meltzoff, 2008; Iluz-Cohen & Armon-Lotem, 2013). However, interpretation of this finding is compromised by a lack of independent data for younger and middle childhood groups; the only exception to this is provided by Gathercole et al (2014) who report null results for both younger (3- to 5- years) and older (8-year-old) children. Contrary to the Simon task and switching tasks, there is no suggestion of a developmental pattern for the Flanker task. Some studies report a general (de Abreu et al, 2012; Kapa & Colombo, 2013) or conflict specific advantage (Poarch & Hell, 2012) in the Flanker task in middle childhood; whilst others find no advantage in the same age range (Anton et al, 2014; Carlson & Meltzoff, 2008). The results for younger children’s Flanker task performance are also mixed (Bialystok et al, 2010; Yoshida et al, 2011).

The contrast between the Flanker and Simon task developmental patterns can be viewed as a problem for interpretation of the bilingual advantage, since both tasks are designed to focus on inhibitory control. Indeed, Paap & Sawi (2014) note that the inter-task correlations between adult’s performance in the Simon and Flanker tasks are near zero, calling into question the convergent validity of these measures. However, since the Flanker task can be viewed as a more challenging version of the Simon task for children, the distinction between these tasks in the developmental literature can potentially be explained in line with Costa et al's (2009) proposal that an optimal level of task difficulty may be necessary to demonstrate the advantage. On this reading, the bilingual advantage is more likely to be shown by the Flanker task than the Simon task in middle childhood since the latter task is less challenging for children. For younger age groups, the Flanker task might be too challenging to show effects. Importantly from a developmental perspective, this explanation doesn't imply that the bilingual advantage is stronger or weaker during certain points of childhood; rather that its measurement is elusive. In the only two studies to directly compare the performance of younger and older children (Bonifacci et al, 2011; Gathercole et al, 2014) no significant developmental difference in the magnitude of the advantage is found. Therefore, although there is some circumstantial evidence that children's capacity to complete difficult inhibition tasks may play a role in whether the bilingual advantage appears, the extant literature cannot be systemised into a clear developmental pattern, nor do the current results (where the only advantage was found for the Simon task) support this explanation. To pick apart the possibility of real developmental change versus a measurement effect, comparison of age groups performance on tasks scaled to the same level of difficulty would be necessary. To date, Gathercole et al (2014) are the only researchers to attempt to track the bilingual advantage across the lifespan using tasks calibrated for difficulty across different ages (3 to 90 years). They found no clear evidence of a bilingual advantage in either the Simon task or DCCS at any age range, other than some isolated positive results for 15-year-olds. However, it is possible that Gathercole et al (2014) did not scale to the optimal level of difficulty to showcase effects.

Our comprehensive review of the literature suggests that the bilingual advantage is likely to be both task and sample specific, and the interaction between these factors makes qualification of the effect challenging. Others go further, arguing that rather than being a genuine effect, the bilingual 'advantage' arises from chance and appears robust only due to a positive publication bias (de Bruin, Treccani & Della Sala, 2015). In keeping with this, only four of the 22 studies reviewed in Table 3 and Appendix 1 conclude that there is no strong evidence for a bilingual advantage (Anton et al, 2014; Duñabeitia et al, 2014; Gathercole et al, 2014; Morton & Harper, 2007), and only three report no positive results for bilinguals (Anton et al, 2014; Duñabeitia et al, 2014; Morton & Harper, 2007). This means that the majority of negative results described for the Flanker, Simon and DCCS tasks are only published as by-products of a positive result. Even with this publication bias, Table 2 shows that only 60% of DCCS tasks and half of the Flanker or Simon tasks run find any evidence of a bilingual advantage in childhood. Moreover, as evident in Appendix 1, on the rare occasions where alternative methods are repeated across papers (e.g. the reverse categorisation, ambiguous figures, embedded figures, opposite worlds, go/no-go, stroop and gift delay tasks) the results are negative or contradictory in all but one case (ambiguous figures).

Although the above review strongly suggests that the validity of the bilingual advantage in childhood warrants closer scrutiny, it would be premature to discard the bilingual advantage completely at this stage. Certainly the null results of our study alone cannot discredit the effect. However, in the future, the use of large scale systematic studies using a battery of similar tasks and dependent variables to measure bilingual effects throughout the lifespan and controlling for task difficulty (including working memory demands) and participant characteristics (such as SES, IQ and language proficiency) should reduce noise in results. This would allow for a clearer picture of the development of the bilingual effect across the lifespan and the importance of inhibitory competence. This cross-sectional paper takes a very tentative step in that direction by having children complete tasks directly adapted from the adult literature; thus facilitating a lifespan perspective. However, it is plain that longitudinal data carefully tracking individual's performance in executive function tasks, alongside their developing linguistic skills, from childhood to adulthood would make the most valuable contribution to the debate. In fact, it is difficult to see how the current controversy concerning the bilingual advantage could be resolved without a systematic longitudinal approach. Addressing the possibility of positive publication bias is also an important challenge for future debate.

In addition to a lack of evidence for the bilingual advantage, we uncover no evidence of an executive advantage for speakers of two dialects. However, in the current context, it is not possible to draw a strong conclusion from this null result. There are several possible factors that might have contributed to the null effect reported here, many of which could mask real benefits from bidialectalism. As discussed for bilingualism, it may be that the tasks or age range used are not optimal to show an effect. Moreover, although our study has superior power to other bilingual studies, it may be that any bidialectal advantage is smaller, and requires a larger sample to be detected. As noted, the size of the bidialectal advantage relative to the bilingual advantage is an open question. Greater similarity between dialects relative to languages could decrease the demands of switching, and the corresponding advantage. Moreover, the greater overlap in linguistic systems may mean that switching is less common, or less consequential. Note that, although fluent, bidialectal children in the current study spoke in dialect relatively rarely – at least as reported by their parents.

For both social and cognitive reasons then, the choice of dialect pairs could be crucial. For example, although language similarity does not appear to influence the magnitude or reliability of bilingual advantage effects, dialect similarity may. The dialect used in this study is substantially different from Standard English (Trudgill, 1983). However, it is important to note that Standard English, as defined by Trudgill, is not typically spoken in Scotland. Instead, Scots switch between their regional dialect and what is sometimes called *Scottish Standard English.* Thus, while the linguistic diversity evidenced in Scotland is still greater than in the South of England, it is perhaps not as great as bidialectal situations in other countries. Secondly, much of spoken Dundonian is largely comprehensible to speakers of non-Scottish dialects, especially after a bit of experience (Norris, McQueen, & Cutler, 2003; Scott & Cutler, 1984; Floccia, et al, 2006). Given the high degree of comprehensibility of Dundonian 'slang', it is possible that the linguistic pressure to monitor and control selection of one variant of English over another is insufficient to imbue cognitive advantages in our sample. Future research investigating parallels between bilingualism and bidialectalism might focus on more extreme dialect examples, such as Swiss German or Doric, the dialect of Scottish English spoken in the northeast of Scotland. These dialects differ greatly from the standard, and can be virtually incomprehensible to outsiders, possibly leading to a greater need for the form of cognitive separation thought to underlie bilingual effects.

Conversely, Albert and Obler (1978) suggested that the more similar two languages are, the more effort a speaker would need to invest in order to prevent interference. This argument would suggest that a second dialect, if represented as a distinct linguistic system in the minds of speakers, might imbue greater cognitive benefits than two languages with greater differences. But what evidence do we have that the two dialects of a bidialectal speaker are represented and switched between like two languages of a bilingual? These questions are crucial, as switching between mental sets is one of the core components of executive function thought to underpin the bilingual advantage (Prior & MacWhinney, 2010). The available evidence suggests that people systematically adjust their dialect usage to the social context (Alfonzetti, 1998; Beebe, 1981). However, it is currently unclear if switching between dialects, even if frequent, is cognitively equivalent to switching between languages (Hazen, 2001). Melinger (Submitted) compared bidialectal Scottish adults with monolinguals and bilinguals. In a language-switching task, both bidialectals and balanced bilinguals produced symmetrical switching costs, whereas late bilinguals and monolinguals produced asymmetrical switching costs. This result implies that switching between dialects is cognitively similar to switching between languages. However, studies of lexical selection and competition using the picture-word interference paradigm suggest that cross-dialect translations, e.g., flashlight – torch, are not representationally equivalent to cross-language translations, e.g., table – mesa (compare bilingual results in Costa, Miozzo, & Caramazza, 1999; Costa & Caramazza, 1999 to parallel bidialectal results in Melinger, in prep).

The cognitive implications of bidialectalism are underexplored, and deserve further attention; not least since the question of bidialectalism has potentially important consequences for qualification of the bilingual advantage. Like Kirk et al (2014), we would urge future research to take account of bidialectalism when selecting 'monolingual' control samples. Failure to do so may compromise clear measurement of any bilingual advantage, leading to null results. Further, the discovery of a bidialectal advantage would provide corroborating evidence for the argument that switching between lexica does confer executive advantage. For this reason, we suggest that bidialectalism should be actively explored in future studies. The idea here is that in addition to replicating across tasks and age ranges to establish the validity of the bilingual advantage, it will be important to replicate the bilingual advantage across similar linguistic environments. Ultimately, this extension of the effect will be necessary if we are to have confidence that any bilingual advantage arises from competing linguistic systems.

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Figure 1: sample stimulus in the incongruent condition

Figure 2: Simon task performance, split by congruency and linguistic group

Figure 3: Flanker task performance, split by congruency and linguistic group

Table 1: BSCT performance, split by linguistic group.

Table 2: Evidence for a bilingual advantage in childhood from Simon, Flanker, and DCCS tasks

Appendix: Evidence for a bilingual advantage in other inhibitory control and cognitive flexibility tasks in childhood