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Do older Gaelic-English bilinguals show an advantage in inhibitory control?

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Abstract

We examined whether a bilingual advantage can be found in older bilinguals that share the same cultural background with monolinguals. Sixteen Gaelic-English bilinguals over the age of 60 years were compared with three monolingual control groups in performance on the Simon task, as well as in general intelligence and socio-economic status. Some of the monolinguals were bidialectal allowing us to also test whether switching between dialects can incur similar cognitive benefits as bilingualism. Results showed no group differences in overall reaction times as well as in the Simon effect suggesting that individuals that share a cultural background may not exhibit differences in inhibitory control even if they routinely use another dialect or another language. This opens up the possibility that other factors associated with bilingualism, like immigrant status, may be responsible for the bilingual advantage found in some but not in other studies.

Keywords: Bilingualism; bidialecticism; inhibitory control; Simon test.

Introduction

A considerable number of studies have demonstrated a bilingual advantage in executive processing (for a review see Bialystok, Craik, Green & Gollan, 2009), which seems to be most pronounced in young children and older adults (Bialystok, Martin & Viswanathan, 2005). It has been suggested that knowing and using two or more languages on a regular basis requires individuals to inhibit one language while using the other, both at the level of selecting the appropriate linguistic setting as well as on the level of selecting individual words (Hilchey & Klein, 2011). Thus, bilingualism has been causally linked to improved executive processing which transfers to non-linguistic domains. In older individuals, such improved executive processing may be beneficial for maintaining cognitive flexibility later in life (Bialystok et al., 2004) so much so as to even delay the onset of dementia (Bialystok, Craik & Freedman, 2007).

However, because random assignment is not possible in quasi-experimental studies with bilingual participants, there is always the possibility that bilingualism is confounded with differences in a variety of hidden factors (Hilchey & Klein, 2011), most notably socio-economic status (SES), but also educational and cultural background (Hakuta, Ferdman

& Diaz, 1986), variables that can affect cognitive functioning (Mezzacappa, 2004). While recent studies reporting a bilingual advantage try to match bilinguals and monolinguals on SES, it is often difficult to match participants in cultural background, and immigrant status especially for older participants. For example, in Bialystok et al. (2004), the older monolinguals resided in North America while the majority of older bilinguals resided in India. Similarly, in Bialystok et al. (2008), 20 out of 24 older bilinguals were immigrants who had arrived in North America as children or adolescents suggesting that they belonged to an immigrant community likely to differ culturally from monolingual North American controls. Finally, while Schroeder and Marian (2012) do not explicitly report immigrant status or age of arrival in North America for their bilinguals, the range of languages spoken by their participants suggests that they were predominantly first or second generation immigrants from different cultural backgrounds than the monolinguals.

There is evidence that differences in cultural background are associated with differences in executive processing (Sabbagh, Xu, Carlson, Moses & Lee, 2006). This can be attributed to culture-specific parenting attitudes or educational and leisure practices which influence exposure to activities that require and promote executive processing, such as musical training (Bialystok, 2011), playing of video games (Green & Bavelier, 2003) and a host of other, as of yet, unknown factors.

There is also the possibility that genetic effects may be responsible for cultural differences in executive processing: For example, population-genetic studies have shown that the prevalence of the 7-repeat allele of the dopamine receptor gene (DRD4), is markedly lower in East and South East Asia compared to North America (Chang, Kidd, Kivak, Pakstis, & Kidd, 1996). This allele has been associated with attention-deficit hyperactivity disorder (ADHD; Faraone, Doyle, Mick, & Biederman, 2001), which, in turn, often manifests itself in poor executive processing (Schachar, Tannock, Marriott, & Logan, 1995); although the relationship between DRD4 and ADHD itself seems to be subject to cross-cultural variation as culture may affect the

phenotypic realisation of this genotype (Nikolaidis & Gray, 2010). Somewhat contradictory, Chen, Burton, Greenberger & Dmitrieva (1999) have shown a link between the long alleles of DRD4 and population migration patterns, indicative of migration selecting for traits like novelty-seeking and openness. The personality trait of openness, in turn, has been associated with better performance in some aspects of executive functioning (Williams, Suchy, Rau, 2009). This may imply the possibility of a reverse causal relationship between bilingualism and executive processing: individuals with superior executive abilities might be more likely to be bilingual because of a potentially greater propensity to make life choices leading to migration or, when placed in a multi-lingual environment, greater success in maintaining use of multiple languages. Although reconciling these different findings is beyond the scope of this paper, they point to the intriguing possibility of a genetic origin of group differences in executive processing, which may co-vary with cultural background, immigrant status and bilingualism. Indeed, Morton and Harper (2007) failed to observe a superior inhibitory control when comparing non-immigrant bilingual with monolingual children matched for SES and cultural background. However, a similar study controlling for cultural background and immigrant status has not yet been conducted with older bilinguals. The present study therefore aims to test the bilingual advantage in executive processing in older bilinguals that share cultural background with the monolingual controls.

Studying Gaelic-English bilinguals allowed us to address this issue because Gaelic, a Celtic minority language, is spoken by a non-immigrant community of about 58,000 individuals residing mainly in the West of Scotland. Since Gaelic language schooling was abolished in 1872 and has been reintroduced only in 2006 there are no Gaelic monolinguals. Rather, older Gaelic-English bilinguals acquired Gaelic in early childhood before being introduced to English in school, and tend to use Gaelic in the home and in the local bilingual community. However, in terms of cultural attitudes and values, educational practices, leisure activities, media exposure and immigrant status, these bilinguals do not differ from English monolinguals.

In this study, we used the Simon test, closely modeled after Experiment 1 in Bialystok et al. (2004) to test whether Gaelic-English bilinguals exhibit benefits in inhibitory control compared to monolinguals recruited from the same cultural background. We restricted our exploration to the testing of inhibitory control, one component of executive processing, because this component had been examined in older bilinguals before (Bialystok et al., 2004; Bialystok et al., 2008; Schroeder & Marian, 2012). In the Simon Task, participants have to inhibit a pre-potent spatially cued response when responding to the colour of a stimulus. This requires inhibitory control (Lu & Proctor, 1995), which has been shown to be superior in bilinguals (Bialystok et al., 2004).

One issue that arises in a Scottish context is related to choosing appropriate monolingual controls: Britain is a country with extraordinary dialectal diversity and speakers of British English are often exposed to various local varieties of English. Specifically, in Scotland 85% of the population report using one of the local varieties of the Scots dialect to varying degrees (Scottish Government Social Research, 2010), in addition to Standard Scottish English (SSE). Even though dialects of the same language are traditionally considered to be mutually intelligible there is considerable variability rendering the boundaries between languages and dialects fluid. Consequently, the linguistic classification of Scots, a Germanic language variety, is subject to much debate with some considering it a separate language, while others classifying it as a dialect of English or as a register used in specific social contexts (see Aitken, 1985). Indeed, local varieties of Scots differ considerably from SSE in their phonetic, lexical and even some syntactic features (Smith & Durham, 2012). Thus, bidialectal speakers must monitor continuously who can or cannot be addressed in Scots, choose appropriate articulatory settings, and inhibit phonetic and lexical variants pertaining to the variety not currently used. It is therefore important to carefully control dialect use in the monolinguals. Moreover, the question as to whether use of multiple dialects can incur executive processing benefits similar to those observed in bilinguals is an interesting question in its own right, and will also be explored in this study. We tested three monolingual control groups: (1) *bidialectal* speakers who reported switching continuously between SSE and Dundonian, a local variety of Scots spoken in Eastern Scotland, (2) *monodialectal* speakers of SSE residing in the same locale as the bidialectals but who reported never or rarely using Dundonian, and (3) *monolingual* speakers of Anglo-English, a variety spoken in the South of England, for whom Scots was for the most part unintelligible. Note that the label *monodialectal* is used to refer to those monolingual participants who share a geographical and cultural background with the *bidialectal* participants. If inhibitory control advantages arise for different languages only then one would expect to find faster reaction times and a smaller Simon effect only in the Gaelic-English bilinguals. If regular switching to dialect also results in an inhibitory control advantage one would expect bidialectals to also exhibit shorter reaction times and a smaller Simon effect compared to monodialectals and monolinguals.

Method

Participants:

Sixty-four older adults ($M = 70.3$ years, $SD = 7.6$ years, range = 60.2 – 88.7 years) participated in the experiment. The 16 bilingual participants (6 men) were speakers of Gaelic and SSE, the 16 bidialectal participants (7 men) were speakers and regular users of both SSE and Dundonian Scots, the 16 monodialectal participants (5 men) were monolingual speakers of SSE who did not use Dundonian Scots, and the 16 monolingual participants (6 men) were

speakers of Anglo-English. The monodialectal and bidialectal participants were recruited from the Dundee area, the Gaelic-SSE bilinguals were recruited from the Western Isles and the West coast of Scotland, and the English monolinguals were recruited from different parts of England and Scotland (all but one had not lived in Scotland for any considerable length of time and were either visitors or had recently retired to the area).

The Background Questionnaires (described below) revealed that the bilinguals' daily use of Gaelic and the bidialectals' use of Dundonian Scots ranged between 30% and 70% of times. The monodialectals reported less than 25% use of Dundonian Scots. Three other participants reported predominantly using Dundonian Scots. As it proved impossible to recruit further monodialectal speakers of this type, these monodialectals were excluded from the study. One bilingual participant was excluded due to 90% SSE and only 10% Gaelic usage, and one participant failed to perform the Simon Task correctly and was also excluded.

Materials:

Background Questionnaire: A background questionnaire was used to gather relevant background information about the participants' educational background (including the age they left school, whether they continued to further or higher education and which qualifications they gained) as well as the occupations they had held throughout their working lives. It also inquired about their dialect usage and any second languages they had learned. The Gaelic-SSE bilinguals additionally received a modified version of the LEAP-Q (Marian, Blumenfeld & Kauschanskaya, 2007), a questionnaire designed to determine bilingual language status that has been validated using behavioural measures of language proficiency.

Wechsler Abbreviated Scale of Intelligence (WASI): Two subscales of the WASI were used to determine participants' verbal and non-verbal IQ. The Vocabulary subscale tested the participants' verbal reasoning ability and required them to give definitions of words with increasing difficulty. The Matrix Reasoning subscale consisted of patterns designed to measure abstract non-verbal reasoning ability. Participants' raw scores were converted to *t*-scores which are normalised for each age range and combined to give an overall score from which a final IQ score was determined.

Simon Task: The Simon Task was modelled after Experiment 1 in Bialystok et al. (2004). Participants were presented with red and blue squares, half of which appeared on the left side of the screen, and the other half on the right. Participants were asked to press a key on the left (the '1' key) or the right (the '0' key) of the keyboard depending on the colour of the square. Assignment of colours to keys was counterbalanced across participants.

In congruent trials, the response associated with the colour of the square corresponded to the presentation location; in incongruent trials, the square was presented on the opposite side of the location of the response key. Thus,

in these trials participants had to inhibit the pre-potent response of selecting the spatially congruent key, and instead had to select the key associated with the colour of the square. The reaction time difference between incongruent and congruent trials is considered to be a measure of inhibitory control. Participants were given 4 congruent and 4 incongruent practice trials with feedback before moving on to the 28 critical trials (7 each of congruent red, congruent blue, incongruent red, incongruent blue) presented without feedback.

Procedure:

Participants were first given the *Background Questionnaire*, which inquired about their knowledge and use of the various languages and varieties of English. The monolingual speakers were asked about their daily usage of different varieties of English and other foreign languages; for the Scottish participants these questions pertained to their use of Dundonian Scots. The responses indicated to what extent participants were fluent in one or two varieties and were using them on a daily basis. For the bilingual speakers, these questions pertained to their use of Gaelic and SSE. The bilinguals also received the LEAP-Q after the Background Questionnaire, to obtain information about their self-rated proficiency in each language, the age at which they starting learning each language, the age at which they became fluent and the proportion of time they currently use each language.

Participants were then given the Vocabulary and Matrix Reasoning subscale of the WASI. In the Vocabulary subscale, participants have to provide definitions of words. In the Matrix Reasoning subscale, participants were shown series of shapes instantiating a rule and were asked to identify which shape fits in the missing slot.

Finally, the Simon task was presented on a Toshiba laptop, with presentation controlled by Eprime. Participants first saw a fixation cross in the middle of the screen for 800 ms, followed by an interval of 250 ms. Half of the participants were randomly assigned to press the '1' key for 'red' and the '0' key for 'blue'; the assignment was reversed for the other half of participants. The keys were marked with white stickers on the keyboard. Then, a red or blue square appeared either to the left or the right of the screen, subtending five degrees of visual angle. The squares were visible for 1000 ms if there was no response. Timing began with the onset of stimulus, and was terminated with the response. The next item started after a 500 ms blank interval. The experiment began with 8 practice trials for which participants received feedback. Practice was followed by the 28 critical trials presented without feedback. Order of the 14 congruent and 14 incongruent trials was randomised.

Results

We first compared the four groups on linguistic, demographic and cognitive measures which are presented in Table 1.

Table 1: Means and standard deviations (in parentheses) for linguistic, demographic and cognitive measures (voc: Vocabulary subscale of WASI, matrix: Matrix Reasoning subscale of WASI, skill: skill level as measure of SES, %use: % daily use of Anglo-English or SSE). F denotes F-value in one-way ANOVAs with $df = 3,60$ for all conditions except the WASI subscales, where $df = 3,59$).

| | monolinguals | | | biling | F (3,60) |
|-------|----------------------|-------------------|----------------|----------------|-----------------|
| | monoling (AngloE) | monodial (SSE) | bidial | | |
| age | 70.3 (7.6) | 69.7 (7.6) | 72.4 (8.6) | 69.8 (5.5) | 0.5 n.s. |
| voc | 60.3 (9.6) | 57.1 (8.4) | 55.5 (6.7) | 57.9 (9.0) | 0.5 n.s. |
| mat | 61.0 (10.5) | 59.5 (10.3) | 59.1 (7.7) | 59.5 (5.7) | 0.1 n.s. |
| skill | 3.13 (1.20) | 2.88 (0.89) | 2.37 (0.89) | 3.37 (0.81) | 3.2 p<.05 |
| %use | 100.0 (0.0) | 94.6 (7.3) | 52.6 (9.7) | 44.3 (15.3) | 135.7 p<.001 |

Percent language use: Participants' self-reported percentages of daily use of either Anglo-English or SSE were submitted to a one-way ANOVA to compare the four groups. This analysis yielded a significant effect of Group (see Table 1). Post-hoc tests using Tamhane's T2 for unequal variances indicated that bilinguals and bidialectals reported significantly less use of English (i.e. only an average of 48% of time) than monolinguals and monodialectals, all p 's < .001.

Socio-economic status (SES): To determine SES, we used the 2010 Standard Occupation Classification (UK Office of National Statistics) to categorise participants' occupations into one of four skill levels based in the amount of formal qualifications or work-based training estimated to be necessary to perform the occupational tasks. These skill levels ranged from 1 (occupations requiring general education) to 4 (professional/managerial occupations requiring degree-level education). We disregarded participant income as another measure of SES as 75% of participants were retired.

A one-way ANOVA for skill levels yielded a significant effect of Group (see Table 1). Post-hoc comparisons using Tamhane's T2 for unequal variances indicated that the bilingual group had a significantly higher skill level than the bi-dialectal group, $p < .05$. No other significant differences were found.

WASI: WASI scores were missing for one monodialectal participant who was unable to complete the session. One-way ANOVAs comparing performance of the groups on each of the subscales separately yielded no significant effects (see Table 1).

Simon Task: Participants committed a total of 3.4% of errors. Error rates were submitted to a 4 (Group: bidialectal, monodialectal, bilingual, monolingual) x 2 (Trial Type:

congruent, incongruent) ANOVA, which yielded no significant effects.

For correct trials, reaction times greater than 2.5 standard deviations above the mean were excluded from the analysis (Ratcliffe, 1993), which affected an additional 56 (2.9%) of trials. For the reaction times, a 4 (Group: bidialectal, monodialectal, bilingual, monolingual) x 2 (Trial Type: congruent, incongruent) ANOVA yielded a main effect of Trial Type, $F(1, 60) = 80.3$, $p < .001$ (see Figure 1). There was no main effect of Group nor was there a significant interaction between Group and Trial Type. Thus, as expected, performance on incongruent items was slower indicating that inhibiting the incongruent spatial location of the stimulus required additional effort. However, overall reaction time and Simon effect did not differ between the groups.

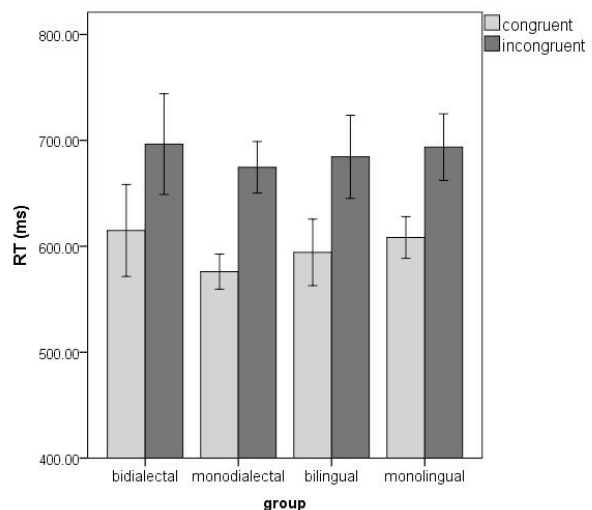


Figure 1: Reaction times for congruent and incongruent trials in the Simon task in bidialectal, monodialectal, bilingual and monolingual speakers. Error bars show 1 S.E.

One possible explanation for the discrepant findings between this and the Bialystok et al. (2004) study may be related to differential treatment of reaction time outliers. Bialystok et al. (2004) do not report any exclusion of outliers. To achieve comparability with that study, we repeated the ANOVA with all reaction times from the correct responses included. This analysis yielded a main effect of Trial Type, $F(1,60) = 9.29$, $p < .01$, but no effect of Group and no interaction between the two factors.

Because SES is associated with executive processing (Morton and Harper, 2007), we included skill level, our measure of SES, as a covariate in the ANOVA for the reaction times (outliers excluded), which did not change the outcome of the analysis. Moreover, an analysis ignoring language group and including only skill level as the between-subjects variable did not yield any significant effects either.

In sum, while all 4 language groups showed significantly slower reaction times for incongruent trials in the Simon Task, there were no significant differences between any of

the groups in global reaction time and levels of inhibitory control.

Discussion

Our findings did not show a bilingual advantage in non-linguistic inhibitory control for older Gaelic-English bilinguals, nor did we find such an advantage for bidialectal speakers who routinely switch between Dundonian Scots and SSE. Moreover, we also did not find a global reaction time advantage for bilinguals and bidialectals, which has been interpreted as an indicator of improved general executive processing. This is in contrast to a substantial body of evidence demonstrating a bilingual advantage in executive processing in general, and in inhibitory control specifically. We therefore carefully compared our findings to the three other studies that had tested older bilinguals and monolinguals to determine whether differences in administration of the Simon task may have resulted in these discrepant results.

Our experiment was closely modeled after Experiment 1 in Bialystok et al. (2004). For the monolinguals, that experiment showed mean reaction times of 1437 ms for the congruent trials, and 3150 ms for the incongruent trials. For the bilinguals, the reaction times were somewhat faster (congruent: 911 ms, incongruent: 1959 ms). These are unusually slow reaction times, in stark contrast to the much faster reaction times in our study (see Figure 1), which contained the same timing, the same number of trials, and a comparable sample size. Moreover, in Experiment 2 of the Bialystok et al. (2004) study, participants received a centered control condition and a 4-colour condition in addition to the standard 2-colour condition, as well as an increased number of trials. Still, reaction times in the comparable 2-colour condition were of a similarly large magnitude (older monolinguals: 1012 ms vs. 1595 ms, older bilinguals: 889 ms vs. 1101 ms, for congruent and incongruent trials, respectively). Again, these overall reaction times and the Simon effect are far beyond what is considered to be the standard Simon effect in older adults (Hilchey & Klein, 2011; Van der Lubbe & Verleger, 2002). This leaves open the possibility that group differences between older bilinguals and monolinguals emerge only for unusually long reaction times which may be indicative of a substantial slowing of cognitive performance in some older populations, perhaps due to diminished experience with computerised testing or due to sub-clinical effects of dementia. However, the fact that Bialystok et al. (2008) and Schroeder and Marian (2012) found a bilingual advantage in the Simon effect for older bilinguals with overall reaction times similar to the ones reported here suggests that the bilingual advantage is not an artifact of long reaction times but emerges when bilinguals and monolinguals differ in cultural background and immigrant status.

Although an analysis of other age groups is beyond the scope of this paper, it is worth mentioning that a similarly inconsistent picture emerges for studies of inhibitory control

in children, and in younger and middle-aged adults. While a considerable number of studies report a smaller Simon effect for bilinguals (Bialystok et al., 2004, 2005; Bialystok, 2006), others failed to find such a difference (Humphrey & Valian, 2012; Kosaie & Phillips, 2012a,b; Paap & Greenberg, 2013). Findings of a bilingual advantage also tend to be inconsistent for other tests of executive processing (e.g. Stroop task, Flanker task, anti-saccade task) and for different aspects of executive processing (e.g. response suppression, switching, monitoring, updating – for overviews see Hilchey & Klein, 2011, and Paap & Greenberg, 2013). We would like to suggest that differences in cultural background and immigrant status are likely candidates for explaining the differences between monolinguals and bilinguals.

It should be mentioned that our failure to find an executive processing advantage in older Gaelic-English bilinguals contrasts with the advantage of Gaelic-English bilingual children in various measures of verbal and non-verbal IQ such as the Block design, Vocabulary and Arithmetic sub-tests of the Wechsler Intelligence Scale for Children reported by Lachlan, Parisi and Fadda (2012). As the bilingual children were all schooled in Gaelic, the authors conclude that schooling in the minority language may have consolidated their bilingualism, in contrast to a group of Sardinian-Italian bilingual children who were not schooled in the minority language and did not differ from Italian monolinguals in performance on the same tests. We agree that Gaelic schooling may indeed have been a beneficial factor for children's intellectual development as considerable resources have been expended by the Scottish government on re-introduction of Gaelic-medium education, perhaps making it more compelling for more aspirational parents to enroll their children into the better funded Gaelic tracks. For these reasons, and because psychometric intelligence does not constitute a direct measure of executive processing, we are not convinced that this finding constitutes support for superior executive processing in Gaelic-English bilinguals.

In sum, our failure to replicate an inhibitory control advantage in older Gaelic-English bilinguals and Scots-SSE bidialectals points to the importance of controlling factors like cultural background and immigrant status when studying the link between bilingualism and executive processing.

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