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Bilingualism and inhibitory control: Possible confounds with the variables “profession” and “level of education”

Bilinguismo e controle inibitório: possíveis interferências das variáveis “profissão” e “escolaridade”

ABSTRACT - Recent studies have presented controversial results concerning the bilingual advantage (i.e., bilinguals' tendency to outperform monolinguals on nonlinguistic interference tasks measuring executive functions (EFs) such as executive control (EC), attention, inhibition, problem solving). Recent research has shown that bilinguals tend to show a more robust advantage in overall reaction times (RTs), rather than an advantage on the magnitude of the interference effect. Irrespective of nature, the so-called bilingual advantage has been found in different age groups, but sometimes no bilingual advantage is actually found. This study investigates the consequences of bilingualism on inhibitory control, focusing on two variables that may compete with the bilingual advantage: “profession” and “level of education”. Two groups of highly-educated middle-aged professionals, businesspeople and teachers/professors, divided into bi/monolinguals, were tested in a nonverbal cognitive task, the Simon task, in order to replicate previous studies which have found a bilingual advantage in the interference effect for the same age group. Although bilinguals outperformed their monolingual counterparts, no significant statistical differences were found in the interference effect, and both language groups were faster in the incongruent trials than in the congruent ones, resulting in null interference effects and thus countering the initial idea that participants always take longer to respond to incongruent trials. Results suggest that certain professional activities, as well as higher levels of education might act as confounds with the bilingual advantage.

Keywords: bilingualism, executive functions, inhibitory control.

RESUMO - Estudos recentes apresentaram resultados controversos quanto à vantagem bilingue (i.e., tendência de bilingues de superar monolíngues em tarefas de interferência não-linguística que medem funções executivas (FEs) como controle executivo (CE), atenção, inibição, resolução de problemas). Pesquisas recentes mostraram que bilingues tendem a apresentar vantagem mais robusta em tempos de reação (TRs) globais do que na magnitude do efeito de interferência. Independentemente de sua natureza, a chamada vantagem bilingue já foi achada em diferentes grupos etários, mas às vezes nenhuma vantagem bilingue é encontrada. Este estudo investiga as consequências do bilinguismo no controle inibitório, focando em duas variáveis que podem competir com a vantagem bilingue: “profissão” e “escolaridade”. Dois grupos de adultos de meia-idade com alta escolaridade, executivos e professores, divididos em bi/monolíngues, foram testados em uma tarefa cognitiva não-verbal, a tarefa de Simon, a fim de replicar estudos prévios que encontraram uma vantagem bilingue quanto ao efeito de interferência no mesmo grupo etário. Embora os bilingues tenham superado seus pares monolíngues, nenhuma diferença significativa foi encontrada no efeito de interferência, e ambos os grupos linguísticos foram mais rápidos nos ensaios incongruentes do que nos congruentes, resultando em efeitos de interferência nulos, contrariando a ideia inicial de que os participantes sempre demoram mais para responder aos ensaios incongruentes. Os resultados sugerem que certas atividades profissionais, bem como altos níveis de escolaridade, podem interferir com a vantagem bilingue.

Palavras-chave: bilinguismo, funções executivas, controle inibitório.

Introduction

The research on the effects of bilingualism on cognition has found a bilingual advantage concerning

executive functions (EFs)¹ such as inhibitory control and attention. According to Bialystok (2001), such functions are enhanced in bi/multilinguals due to the constant management of two or more competing language systems.

¹ EFs are a set of mental processes in charge of regulating, controlling and managing other cognitive processes, such as planning, inhibition, verbal reasoning, focusing and switching attention, multi-tasking, mental flexibility, working memory, problem solving, and initiation and monitoring of actions (Hamdan and Bueno, 2005).

However, the findings regarding the so-called bilingual advantage have been questioned recently and, for the time being, there are still no consistent answers.

Several studies have focused on different populations of bilinguals and different age groups. Some studies have indicated that it is more difficult to find a bilingual advantage in young adults given the fact that they are at the peak of their attentional abilities (Costa *et al.*, 2008). Concerning other age groups, fewer studies have focused on middle-aged adults. With that in mind, we decided to conduct this investigation including a population of middle-aged bilingual and monolingual adults with very high levels of education and specific professions (businesspeople and teachers/professors). We believe that the combination of such variables might generate some interesting discussions to the field of cognition and bilingualism.

Defining bilingualism

Bilingualism has been understood and categorized differently by different researchers along history. It was initially divided into two opposing views, the monolingual or fractional one, and the bilingual or holistic one (Baker, 2011; Grosjean, 1985). According to the fractional view, also known as the “double monolingual hypothesis” (Saer, 1924), bilinguals have two separate and isolable competences, as if they were the combination of two monolinguals in one person. In other words, bilinguals would be as competent and proficient in their L2 as in their L1. Such balance, however, is only possible in early stages when there is a low level of competence in both languages (Baker, 2011). Later on, when people finally reach a certain level of proficiency in one or both languages, they are used differently, according to the context, interlocutors and communicational purposes. In addition, the dominance of one language over the other depends on its frequency of use, and both L1 and L2, and even an L3, can, at a certain point in time, occupy a dominant position.

For the holistic view, bilinguals are a complex integrated whole, showing unique features and different levels of competences in both languages and in all four skills (listening, speaking, reading and writing). It is more plausible than the fractional view, and also allows researchers to be more careful when selecting their samples and to choose more appropriate criteria to compare them.

In the literature, bilinguals are classified into various categories: *simultaneous* or *infant* bilinguals are usually depicted as the ones who acquire two languages from birth; *consecutive* or *sequential* bilinguals are the children (or adults) who learn an L2 after three years of age; *emerging* bilinguals are the ones moving through the

early stages of acquiring a language; *incipient* bilinguals have one well-developed language while the other is in its early stages of development; *elective* bilinguals are the ones who choose to learn an L2 in a classroom without losing their L1; *circumstantial* bilinguals learn another language in order to function effectively, as in the case of immigrants in a host country; *productive* bilinguals actually speak and write in L2; and *receptive* or *passive* bilinguals only understand or read (Baker, 2011).

There is not an exact stage in which someone becomes bilingual, but rather a continuum, going from monolingualism to bilingualism through intermediate stages of processing and activation of languages (Grosjean, 1985, 1997). Regardless of nomenclature, what seems to be the key issue to consider someone bilingual is neither fluency, nor proficiency, but the regular use of two or more languages (or dialects) (Grosjean, 2010), and that is the view of bilingualism adopted in this investigation.

The bilingual advantage

Bialystok *et al.* (2012, p. 241) suggest that “lifelong experience in managing attention to two languages reorganizes specific brain networks, creating a more effective basis for executive control (EC)² and sustaining better cognitive performance throughout the lifespan”. This happens because language control in bilinguals relies on a neural system shared with more general cognitive control processes, that is, the dorsal anterior cingulate cortex, which is responsible for detecting and aiding the resolution of conflicts, not only in the verbal domain, but also in the nonlinguistic domain (Abutalebi *et al.*, 2011).

The effects of the continuous experience of code-switching (i.e., a normal product of bi/multilingual language use, in which speakers shift to another language for a word, phrase or sentence) (Grosjean, 2001) are reported to spread to other domain general systems, thus boosting EFs. This can be found especially in nonlinguistic cognitive tasks which depend heavily on EC, such as conflict resolution and attentional control (e.g., Bialystok, 2005, 2007), and seems to remain throughout the bilinguals’ lives, resulting in enhancement of neuroplasticity and cognitive reserve, i.e. the protective effects of experience against cognitive decline with aging (Bialystok, 2009).

Kroll and Bialystok (2013, p. 504) explain that

bilingualism forces language processing to be carried out differently than it is for monolinguals, primarily because of joint activation of the two languages, leading to a reorganisation of both linguistic and cognitive systems. Thus, the relation between the linguistic and cognitive outcomes of bilingualism is that they are both part of the reorganisation of complex mental structures in response to a particular linguistic experience. They are, in short, intimately interconnected and mutually interdependent.

² EC is a system or mechanism in charge of coordinating several processes involved in the realization of the EFs (Hamdan and Bueno, 2005).

A bilingual advantage has been found in different age groups and types of bilinguals. However, recent research (Hilchey and Klein, 2011) has shown that bilinguals tend to show a more robust advantage in overall RTs, rather than an advantage on the magnitude of the interference effect. It is assumed that bilinguals display domain-general executive functioning advantages, showing an equivalent performance on all conditions in nonlinguistic interference tasks. Such advantage is found in almost all age groups. In the case of young adults, though, it is found only when task difficulty is high (Bialystok, 2006; Costa *et al.*, 2009). As for the interference effects, not many experiments have found very large effects favoring bilinguals. Most experiments have found interference effects that are very small, and sometimes there is no bilingual advantage whatsoever, especially for children and young adults. Middle-aged adults and elders usually show larger interference effects, although not frequently observed.

Controversial results

Different studies carried out in several countries have not been able to replicate Bialystok *et al.*'s (2004) results regarding the bilingual advantage on inhibitory control in middle-aged and old-aged populations. Actually, several studies conducted in Brazil have found surprisingly contrasting results in what concerns the Simon effect³ (Bandeira, 2010; Finger *et al.*, 2011; Kramer, 2011; Martins, 2010; Pinto, 2009) assessing distinct age groups and different types of bilinguals. Such studies have even found negative scores for Simon effects, i.e., a null interference effect, not only countering the initial idea that participants always take longer to respond to incongruent trials, but also showing that certain populations of bilingual and monolingual participants can be even faster in trials considered to be more difficult.

Recently, a lot more has been added to the discussion on the controversial findings about bilingual advantage, adding to what had already been pointed out by Hilchey and Klein's (2011) review. Paap and Greenberg (2013) question the very nature of the executive processing (EP)⁴ that studies using nonlinguistic interference tasks claim to assess. According to Paap and Greenberg, different studies (Bialystok, 2006; Bialystok *et al.*, 2004; Bialystok *et al.*, 2008; Costa *et al.*, 2008) have found a bilingual advantage in tasks that seem to require EP. However, they recommend that such investigations be

grounded in a specific conceptual framework, one that can elucidate the nature of executive processes and guide operational definitions for manipulating and measuring them, for "there is very little evidence that the measures and tasks typically used to test for differences between bilinguals and monolinguals in inhibitory control are tapping into the same general ability" (Paap and Greenberg, 2013, p. 233).

The authors claim that compelling evidence for a bilingual advantage in inhibitory control requires that two or more tasks show significant advantages regarding interference effects, and that such effects correlate with one another, thus showing that all the tasks include a common component associated with a general ability to exercise inhibitory control. If the effects do not correlate, then a possible explanation would be to consider the bilingual advantage to be task specific, and not a shared and domain-general ability.

In their 2013 investigation, Paap and Greenberg reported their own results, and also mentioned the investigations by Kousaie and Phillips (2012a, 2012b) and by Humphrey and Valian (2012), who have all used a multiple-task approach with nonlinguistic interference tasks, adding up to a total of 17 new studies that have not found a bilingual advantage, plus one study that has found a bilingual disadvantage. The authors also claim that the global RT advantage for young adults, supposedly detected ubiquitously on spatial Stroop⁵ and flanker interference tasks (Hilchey and Klein, 2011), was not found in any of the 18 new tests (Humphrey and Valian, 2012; Kousaie and Phillips, 2012a; Paap and Greenberg, 2013), and that 14 of the 18 tests even showed a numerical advantage for the monolingual participants.

More recently, Paap's (2014) review on Kroll and Bialystok's (2013) paper proposes some considerations regarding the bilingual advantage. According to Paap (2014, p. 243),

it is clear from the neuroimaging results that the neural processing of bilinguals and monolinguals differs during the performance of the Simon and flanker tasks, in part, because some of the cortical areas recruited by bilinguals are not employed by monolinguals. All of this is consistent with the view that managing two languages leads to an organisation (or reorganisation) of neural networks in cortical areas involved in EF. However, a reorganisation to accommodate bilingualism does not logically need to result in more efficient performance. Alternatively, it could lead to comparable performance or even to a compromise that results in inferior performance.

³ According to Lu and Proctor (1995, p. 174), "the Simon effect refers to the fact that responses are faster when the stimulus location corresponds to the location of the assigned response than when it does not".

⁴ EP corresponds to the ability of monitoring goal-setting cues, switching attention to goal-relevant sources of information, and inhibiting the irrelevant or competing ones. It is usually understood as a set of interrelated component processes that involve the prefrontal cortex with each component recruiting other constellations of cortical function, with the possibility that all the related components are somehow anatomically and functionally independent.

⁵ Hilchey and Klein (2011) explain that the spatial Stroop task is occasionally referred to as the Simon Arrow task, as in the case of the study by Bialystok (2006).

In sum, Paap (2014) draws attention to the fact that the bilingual advantage should be carefully considered, once such phenomena could either prove to be ephemeral or constrained to very special types of bilingual experience. Having that in mind, this paper presents data regarding the performance of two groups of monolingual and bilingual participants. Considering the populations already investigated in previous studies, we decided to include an unusual one, made up of highly-educated professional individuals, businesspeople and teachers/professors on the Simon task, in order to verify whether professional activities that require high levels of task management, problem solving and attention, combined with high levels of education, might compete with the so-called bilingual advantage.

Method

Participants

Seventy-eight middle-aged adults participated in this study (39 bi/multilinguals and 39 monolinguals), among businesspeople (managers/directors) and teachers/professors. At the time of the data collection both professional groups were working at companies or schools/universities located in the state of Rio Grande do Sul, in the south of Brazil. They were matched in education (they all had at least one university degree) (most businesspeople had at least one MBA in Business, while most teachers/professors had at least a Master's degree or even a Doctorate), and they were all right-handed. They were also controlled regarding video game use⁶. No instruments were used to measure socioeconomic status (SES), but it was assumed to be equivalent among participants, considering their level of education and jobs. For a detailed description of the participants, see Table 1.

For the inclusion criteria, two questionnaires were administered: a screening questionnaire, with personal questions about handedness, level of education, history of health problems and medicine use; and a linguistic background questionnaire, containing questions about the participants' social life, exercising habits and the amount and frequency of use of their L1, L2 and L3 in terms of speaking, reading and writing, as well as travelling and intercultural experience, in order to classify them as monolinguals or bi/multilinguals. The bi/multilinguals in this study use their L2 and sometimes L3 for different purposes and in different situations: in frequent or sporadic business meetings and business trips (especially in the case of businesspeople), family trips, conference calls via Skype, phone calls, language lessons (especially in the case of language teachers/professors), international conferences, and at home with family members or friends.

Participants following a prescription of certain medicines such as antidepressants or anxiolytics, or anything else that could invalidate the results of the research, were ruled out at this stage. All the participants were asked to sign a free and informed consent form⁷.

Procedures and instruments

All the participants were selected according to the inclusion criteria. They were interviewed orally and then tested with the Simon task (Bialystok *et al.*, 2004) at their work places or homes, where they were placed in a quiet room so they could concentrate and focus only on the task. The data were collected with a Microboard Netslim 10" netbook, containing Windows XP and the software E-prime 1.2.

The Simon task is used to measure the effects of the EFs inhibitory control and attention, aspects of processing

Table 1. Description of the participants.

	Monolingual (n=39)	Bi/multilingual (n=39)
Male	28	30
Female	11	9
Age range	37-58	36-58
Mean age	46.69	47.36
Schooling	20.33 years	18.86 years
L1	BP (39)	BP (34) - EP (1) - Italian (1) - German/Pomeranian (3)
L2	-	English (29) - BP (5) - Spanish (4) - Italian (1)
L3	-	Spanish (6) - English (7) - German (1) - Italian (1)

Notes: BP = Brazilian Portuguese; EP = European Portuguese.

⁶ Video game practice promotes strong speed advantages to answer to the stimuli and should therefore be controlled for (Bialystok, 2006; Costa *et al.*, 2009).

⁷ The study was approved by the Ethics Committee of UCPel (RS), Brazil (document nr. 16028/2012).

which decline with aging. It is “based on stimulus–response compatibility and assesses the extent to which the prepotent association to irrelevant spatial information affects participants’ response to task-relevant nonspatial information” (Bialystok *et al.*, 2004, p. 291), thus reflecting the same type of cognitive control that is enhanced in development by bilingualism. With the Simon task, we can calculate the Simon effect (Bialystok *et al.*, 2004) by subtracting responses to congruent trials from those to incongruent ones. Since congruent trials offer no conflict, i.e., no irrelevant spatial information, faster RTs are expected, resulting in positive scores for Simon effects. When negative scores are obtained, though, one could assume that participants have learnt to deal with the conflict caused by the irrelevant location information, having internalized the task rules.

The design of the Simon task is as follows: participants see a sequence of stimuli in the shape of colored rectangles presented on either the left or the right side of a computer screen, arranged in four different conditions: center/2 colors, lateral/2 colors, center/4 colors and lateral/4 colors. Each color is associated with a response key that is on one of the two sides of the keyboard, aligned with the two stimulus positions. On congruent trials, the correct response key for that color is on the same side as the stimulus, while on incongruent trials, the correct response key is on the opposite side. In the 2-color conditions, participants are instructed to press 1 for blue and 0 for brown. In the 4-color conditions, participants must press 1 for green or pink, and 0 for red or yellow. Trials begin with a sound (a computer “bing”) and a fixation cross (+) that appears in the center of the screen for 300 ms. Immediately after the cue, the stimulus appears and remains on the screen until a response is made. The response clock starts at the onset of the stimulus. The fixation cross and the sound reappear 500 ms after the response signaling the next trial. When the stimuli are presented in lateral positions, the order of trials is randomized and divided equally between congruent and incongruent items. Participants must

press the right key as quickly and accurately as possible, since level of accuracy and RTs are measured.

The participants completed four conditions in one of four preset orders consisting of 24 trials per condition. The entire set of conditions was then repeated in the reverse order, producing 48 trials for each of them. Each condition was preceded by a set of practice trials, four for the 2-color conditions and eight for the 4-color conditions, which were identical to test trials. Participants had to complete all eight practice trials correctly to move on to test trials; if not, the program recycled until all practice trials were completed successfully.

Statistics

In the Simon task (Bialystok *et al.*, 2004), RT and level of “Accuracy” were taken as dependent variables, and “Language Group” (monolingual or bi/multilingual) was taken as an independent variable. In order to choose the appropriate statistical tests, we contrasted the normality hypothesis for all the pairs of samples with the Shapiro–Wilk and the Kolmogorov–Smirnov tests. Since we were dealing with independent factors, we also used the Levene test to see the homogeneity of variance. Results indicated that only one of our variables showed normality or homogeneity and could be measured by an Independent Samples t-test, while all the other variables were tested with non-parametric tests such as the Mann–Whitney. Because we were dealing with second language research, we used a p-value below 0.05 as a cut-off point for all the statistical tests. Data were analyzed using SPSS version 17.0 software.

Results

The mean RTs for the correct trials and accuracy scores in each of the Simon conditions are presented in

Table 2. Mean Reaction Time (in Milliseconds) and Accuracy (ACC) for Simon Task by Language Group.

Language Group	Colors	Side						
		Center (SD)	ACC (SD)	Congruent (SD)	ACC (SD)	Incongruent (SD)	ACC (SD)	Simon Effect
Monolingual	2	548.04 (104.61)	0.98 (0.08)	617.33 (108.66)	0.98* (0.05)	563.33 (106.68)	0.99 (0.04)	-54.00 (59.01)
	4	677.34 (155.05)	0.98* (0.03)	687.57 (139.63)	0.98 (0.03)	659.33 (126.33)	0.99 (0.02)	-28.24 (95.57)
Bi/multilingual	2	504.72* (103.98)	0.98 (0.03)	573.54 (107.86)	0.96 (0.05)	531.61 (104.310)	0.99 (0.03)	-41.93 (63.14)
	4	620.11* (145.23)	0.96 (145.23)	633.14 (116.83)	0.96 (0.05)	623.84 (142.06)	0.98 (0.03)	-9.31 (70.38)

Notes: Standard deviations are in parentheses. (*)Statistically significant differences ($p < 0.05$).
Source: Study data.

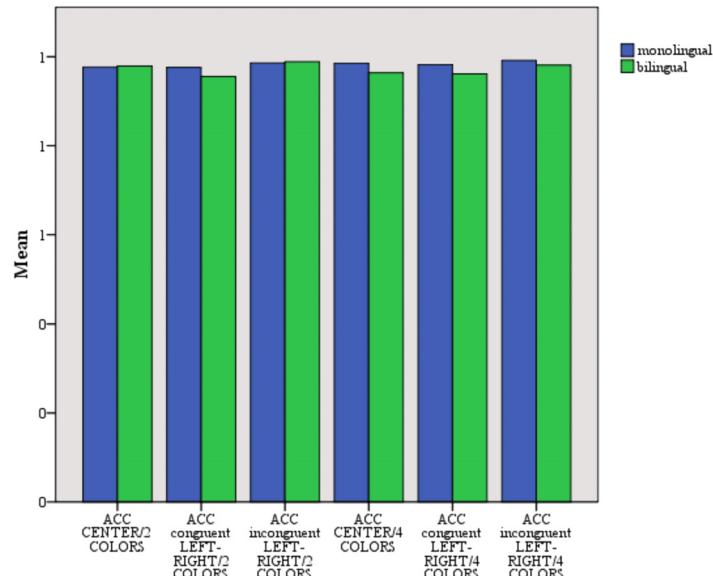


Figure 1. Mean accuracy (ACC) divided by language groups.

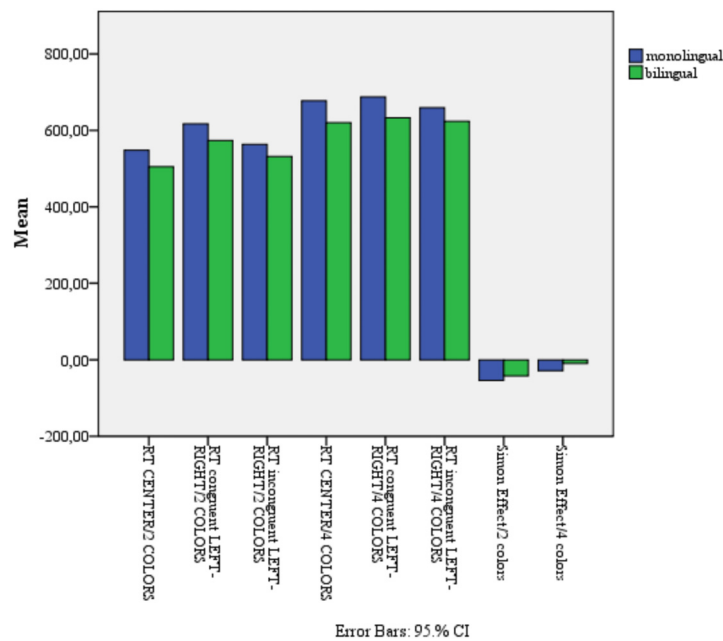


Figure 2. Mean reaction times (RTs) divided by language groups.

Table 2 (see also Figures 1 and 2). Mann-Whitney tests were run for all the accuracy scores. Both language groups made very few errors in all four conditions, with the percentage of errors ranging from 1% to 4% – bilinguals (3%) and monolinguals (2%). There were significant statistical differences in accuracy scores in two conditions, the center 4-color condition ($Z = -2.67$, $p = .008$), and the lateral congruent 2-color condition ($Z = -2.91$, $p = .004$), both favoring monolinguals.

Concerning RTs, bi/multilinguals outperformed monolinguals in all the conditions. However, an Independent Samples t-test was run for the lateral incongruent 4-color condition, revealing no significant statistical differences between the groups. Mann-Whitney tests were used for all the remaining conditions, revealing significant statistical differences favoring bilinguals in only two conditions, the center 2-color condition ($Z = -2.01$, $p = .045$), and the center 4-color condition ($Z = -2.06$, $p = .040$).

Regarding the 2-color and the 4-color Simon effects, there were no significant statistical differences between the groups, as revealed by Mann-Whitney tests. However, both groups were strikingly faster in incongruent trials, supposedly more difficult, than in congruent trials, which do not offer conflict between response and stimuli.

Discussion

Although favoring bilinguals, significant statistical differences in RTs were found only in the center 2- and 4-color conditions, which are neutral, thus requiring no conflict resolution. What was interesting and somehow unexpected was to find out that both groups, bilinguals and monolinguals, were faster in the incongruent trials than in the congruent ones, resulting in negative scores for the 2- and 4-color Simon effects. In face of negative results, one could claim that the Simon effect is null, once there is no increased time needed to respond to the incongruent trials, i.e., no interference effect⁸. Although participants are expected to take longer to respond to incongruent trials, negative scores for the Simon effect have been found in several other studies conducted in Brazil using different versions of the Simon task (e.g., Bandeira, 2010; Finger *et al.*, 2011; Kramer, 2011; Martins, 2010⁹; Pinto, 2009)¹⁰ to different age groups, and assessing different types of bilinguals, which means that such pattern does deserve a more careful investigation, especially because the design of the Simon task applied to our participants, and in some of the other Brazilian studies mentioned above, is the same one used by Bialystok *et al.* (2004) in Study 2. In sum, because we lack a theoretical construct that is able to account for such phenomenon, we can only assume that some populations learn to deal with the conflict caused by the irrelevant location information more quickly than others. In the case of our participants, that could be a result of their level of education, which is very high. That could also be due to their professional activities, which we see as cognitively demanding in terms of attention and inhibitory control, for such professionals have to ignore irrelevant stimuli on a daily basis, dealing with a lot of people and having to make online decisions.

In Bialystok *et al.* (2004), a bilingual advantage in the interference effect was found in Studies 1 and 2 for both middle-aged and old-aged participants, but it was more pronounced for the younger groups, showing that bilingualism “did not attenuate the age-related de-

cline in inhibitory effectiveness” (Bialystok *et al.*, 2004, p. 293), as the authors had expected. Other studies using the Simon task with different age groups have not been able to replicate Bialystok *et al.*'s results regarding the interference effect: children (Bialystok *et al.*, 2005a; Martin-Rhee and Bialystok, 2008); and young adults (Bialystok, 2006; Bialystok *et al.*, 2005b, Humphrey and Valian, 2012; Kousaie and Phillips, 2012a; Paap and Greenberg, 2013). Moreover, countering Hilchey and Klein's 2011 statement that older aged groups have been understudied, there are various Brazilian studies, such as Pinto's (2009) and Kramer's (2011), addressing middle-aged adults, and again Pinto's and Kramer's studies, plus Billig's (2009) and Martins's (2010) studies addressing elder individuals, which have not been able to replicate Bialystok *et al.*'s (2004) results either. Interestingly, a bilingual advantage was found by Brentano (2011) in a population of preteen¹¹ school-based bilinguals (students who had been in a bilingual school for at least 5 years) compared to home-based bilinguals and monolinguals. The results indicated that school-based bilinguals outperformed the other two groups in the Arrow task, suggesting that the complexity of the school environment, combined to the constant use of two languages, can strengthen inhibitory and attentional control, an aspect that had not been explored by previous studies on bilingualism.

The difficulty to replicate Bialystok *et al.*'s 2004 results might rely on the fact that their study presents methodological inconsistencies regarding demographic factors. The populations of Bialystok *et al.*'s Studies 1 and 2 included completely different nationalities, with certainly dramatic cultural differences, once the data were even collected in different countries. Subsequent studies have taken more appropriate measures to minimize as much as possible such differences, including type of bi(mono)lingualism and SES. The latter, as reinforced by Morton and Harper (2007) and Mezzacappa (2004), might have an impact on the bilingual advantage, and also covary with executive ability, for higher SES tends to be associated with better performance on measures of cognitive functioning.

Our study, contrary to Bialystok *et al.*'s (2004), investigated a much more homogeneous sample. First, all the participants were born and raised in Brazil, except for one who was born in Portugal, but moved to Brazil as a child. They all graduated from university, have high levels of educational degrees, are extremely familiar with

⁸ That is reinforced by Peter Hagoort's comment, during a communication on the bilingual advantage at the Language and Neuroscience Conference held in Florianópolis in December 2012, when he questioned the relevance of discussing negative scores for the Simon effect, if such effect corresponds to the increased time to respond to incongruent trials, and the negative scores were there to prove there had been no interference effect at all.

⁹ Martins (2010), on a footnote, reports having found a lot of negative scores for the Simon effect among the participants of her study; however, the means regarding the Simon effect for both language groups are positive.

¹⁰ Although the referred studies used different versions of the Simon task, the principle of the interference effect is the same in all cases: the responses to congruent trials are subtracted from the responses to incongruent trials.

¹¹ Between the ages of 9 and 12.

computers and were controlled for video game use. One more differing variable between Bialystok *et al.*'s 2004 study and ours refers to the instruments used to select the participants. While Bialystok and colleagues used instruments such as PPVT–III, Catell Intelligence task, Digit Span tasks, we focused on two types of questionnaires: the screening questionnaire and the linguistic background questionnaire. All the differences described above regarding control of variables might account for the difficulty found by us and other researchers to replicate Bialystok *et al.*'s findings. If not, one could be dealing with a problem of task validity.

Another important aspect has to do with the fact that the bilinguals of the present study did not significantly outperform¹² monolinguals in overall RTs, i.e., in both congruent and incongruent trials. Nonetheless, according to Bialystok (2009), bilinguals tend to perform the Simon task more easily than monolinguals and be faster in both congruent and incongruent trials, resulting in a bilingual advantage in overall RTs, rather than in the magnitude of the interference effect. Bialystok *et al.* (2004) found a bilingual advantage also in overall RTs in Studies 1 and 2 for both middle-aged and old-aged participants. The same happened to children in Bialystok *et al.* (2005a), Martin-Rhee and Bialystok (2008), and Bandeira (2010); to young adults in Bialystok (2006), Bialystok *et al.* (2005a, 2005b, 2008), Luk *et al.* (2010), among others. However, none of the Brazilian studies addressing young, middle-aged and old-aged adults found a bilingual advantage in overall RTs.

One final aspect to be viewed as unique in our bilinguals is the fact that they cannot be considered balanced bilinguals, but consist of people that use their L2 or L3 more sporadically or more frequently depending on different purposes, different situations, not only as part of their professional activities, but sometimes outside work as well. In fact, there are no guarantees that the studies carried out abroad actually investigated balanced bilinguals across their samples either, especially because it is too difficult a task to find a great number of bi/multilinguals with the same levels of fluency, accuracy or frequency of language use. Besides, as Zimmer *et al.* (2008) point out, there are high levels of individual variation as well, which can also compromise the homogeneity of a sample.

To the best of our knowledge, so far no other study has investigated populations with such high levels of education as the ones presented here. Neither have professional groups like ours ever been compared in the Simon task with the specific aim of investigating the effects of bilingualism on cognition. However, it is premature to assume that the cognitive demands of the two professions here observed are the reason for no bilingual advantage in the interference effect or for the lack of a

bilingual advantage in overall RTs. Despite the fact that no significant statistical differences between language groups were found, both bilingual groups outperformed their monolingual counterparts in all the conditions of the task. As already mentioned, a bilingual advantage for middle-aged adults was only found in studies such as Bialystok *et al.* (2004), and Emmorey *et al.* (2009). We must not forget that the bilingual advantage that researchers seek to find has been proven rather controversial, leaving a lot of questions still to be answered by future and even more thorough studies.

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¹² Despite the lack of statistical significance, we cannot ignore the fact that the bilinguals in the present study were faster than their monolingual counterparts in all the conditions of the Simon task.

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