LISANDRA RUTKOSKI RODRIGUES

COGNITIVE DIFFERENCES BETWEEN MONOLINGUALS AND BI/MULTILINGUALS: EXECUTIVE FUNCTIONS BOOSTED BY CODE-SWITCHING?

Dissertação de Mestrado submetida ao Programa de Pós-Graduação em Letras, Área de Concentração Linguística Aplicada, da Universidade Católica de Pelotas, como requisito parcial à obtenção do título de Mestre em Letras.

Orientadora: Prof[a] Dr[a] Márcia Cristina Zimmer

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____PROVADA

BANCA EXAMINADORA:

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Prof[a] Dr[a] Lilian C. Scherer (PUCRS)

_____

Prof[a] Dr[a] Mailce Borges Mota (UFSC)

_____

Prof[a] Dr[a] Márcia Cristina Zimmer (Orientadora – UCPEL)

Pelotas, _____ de _____ de 2013.

I dedicate this thesis to my husband Ricardo,
whose unconditional love and support made me stronger to face the
chaos and complexity of this long journey.

To my family.

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ABSTRACT

The bilingual experience of code-switching – using another language during speech production – demands a greater executive and attentional control than that required from monolinguals, and seems to spread to other nonlinguistic cognitive domains. Studies on bilingualism have shown that bilinguals tend to outperform monolinguals on nonlinguistic interference tasks measuring different executive functions (EFs) (mental processes in charge of regulating, controlling and managing other cognitive processes, such as inhibition, attention, problem solving, etc.). However, 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, among different types of bilinguals (e.g., Bialystok et al., 2004; Bialystok et al., 2005; Costa et al., 2008; Martin-Rhee & Bialystok, 2008), but sometimes, no bilingual advantage is actually found. The present study aims at replicating some of the experiments conducted previously with other populations of bilingual and monolingual participants regarding the EFs inhibitory control (Bialystok et al., 2004) and attentional networks (Costa et al., 2008). For that, I interviewed and tested 40 middle-aged businesspeople (20 bilinguals – mean age 48.1 – and 20 monolinguals – mean age 47.2) in two nonlinguistic interference tasks: the Simon task (Simon & Wolf, 1963), and the Attentional Network Task (ANT) (Fan et al., 2002). Businesspeople are naturally faced with strong cognitive demands in their daily lives, constantly having to solve problems by making administrative and financial decisions that involve a lot of responsibility and a lot of people, regardless of product or service being sold or offered by the company. Thus, their professional activity could strengthen their inhibitory control and problem solving skills, which could compete with the cognitive advantages brought out by bilingualism. For this reason, I also included a control group with a different professional activity, consisting of 38 middle-aged teachers/professors (19 bilinguals – mean age 46.6 – and 19 monolinguals – mean age 46.2), to be compared to the businesspeople in the Simon task. It is important to underscore the fact that no previous work has addressed such populations in these regards. Furthermore, I perceived that there are not enough studies on the effects of bilingualism on middle-aged adults regarding these EFs, as compared to the number of studies and findings on the bilingual advantage among other age groups. The results obtained with the businesspeople groups in both tasks showed no bilingual advantage in the interference effect or in overall RTs. However, I cannot assign the absence of a bilingual advantage to the variable "Profession" as a competitor with bilingualism, for the control group also presented equivalent performances across the mono and bilingual groups in the Simon task.

Keywords: Cognition, Bilingualism, Executive Functions, Inhibitory Control, Attentional Networks.

RESUMO

A experiência bilíngue de troca de código – o uso de uma outra língua no decorrer de uma conversação – exige um maior controle executivo e atencional do que o exigido de monolíngues, e parece espraiar-se para outros domínios cognitivos não linguísticos. Os estudos sobre bilinguismo têm mostrado que bilíngues tendem a ter um melhor desempenho do que monolíngues em tarefas de interferência não linguística que medem diferentes funções executivas (FES) (processos mentais responsáveis pela regulação, controle e gestão de outros processos cognitivos, tais como inibição, atenção, resolução de problemas, etc.). No entanto, pesquisas recentes têm mostrado que bilíngues tendem a apresentar uma vantagem mais robusta em tempos de reação (TRs) globais, ao invés de uma vantagem na magnitude do efeito de interferência. Independentemente de sua natureza, a chamada vantagem bilíngue já foi encontrada em diferentes grupos etários e entre diferentes tipos de bilíngues (e.g., Bialystok et al., 2004; Bialystok et al., 2005; Costa et al., 2008; Martin-Rhee & Bialystok, 2008), porém, às vezes, nenhuma vantagem bilíngue é de fato encontrada. O presente estudo tem o objetivo de replicar alguns dos experimentos já conduzidos com outras populações de participantes bilíngues e monolíngues quanto às FEs controle inibitório (Bialystok et al., 2004) e redes de atenção (Costa et al., 2008). Para isso, entrevistei e testei 40 executivos(as) de meia-idade (20 bilíngues – idade média 48,1 – e 20 monolíngues – idade média 47,2) em duas tarefas de interferência não linguística: a tarefa Simon (Simon & Wolf, 1963), e a tarefa de rede atencional (ANT na sigla em inglês) (Fan et al., 2002). Executivos(as) enfrentam, naturalmente, uma alta demanda cognitiva em suas vidas diárias, tendo que constantemente resolver problemas que requerem decisões administrativas e financeiras, as quais envolvem muita responsabilidade e muitas pessoas, independentemente do produto ou serviço vendido ou oferecido pela empresa. Dessa forma, sua atividade profissional poderia fortalecer suas habilidades de controle inibitório e de resolução de problemas, o que poderia competir com as vantagens cognitivas advindas do bilinguismo. Em função disso, incluí um grupo controle que tem uma atividade profissional diferente, composto de 38 professores(as) de meia-idade (19 bilíngues – idade média 46,6 – e 19 monolíngues – idade média 46,2), a fim de serem comparados aos executivos(as) na tarefa Simon. É importante ressaltar que nenhum estudo anterior investigou essas duas populações com esses mesmos propósitos. Além disso, percebi que há poucos estudos sobre os efeitos do bilinguismo quanto a adultos de meia-idade no que se refere a essas FEs, se comparados ao número de estudos e achados a respeito da vantagem bilíngue relativa a outros grupos etários. Os resultados obtidos com os(as) executivos(as) em ambas as tarefas não mostraram quaisquer vantagens bilíngues, seja no efeito de interferência ou em TRs globais. No entanto, não posso atribuir a ausência de uma vantagem bilíngue à variável "Profissão" como concorrente do bilinguismo, já que o grupo controle apresentou desempenho equivalente por parte de bilíngues e monolíngues na tarefa Simon.

Palavras Chave: Cognição, Bilinguismo, Funções Executivas, Controle Inibitório, Redes de Atenção.

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LIST OF ABBREVIATIONS AND ACRONYMS

ACC – anterior cingulate cortex
ANT – Attentional Network Task
BEPA – bilingual executive processing advantage
BICA – bilingual inhibitory control advantage
DST – Dynamic Systems Theory
EC – executive control
EF – executive function
EP – executive processing
fMRI – functional magnetic resonance imaging
IQ – intelligence quotient
L1 – first language
L2 – second language
L3 – third language
L4 – fourth language
MEG – magneto-encephalography
MS – milliseconds
PET – positron emission tomography
RT – reaction time
SAS – supervisory attentional system
SES – socioeconomic status
SLA – second language acquisition
WM – working memory

1 INTRODUCTION

Along its history, bilingualism has been understood and categorized differently by different researchers. The first studies in the late 19th and early 20th centuries found that bilinguals had lower scores in tests which measured their intelligence quotient (IQ) (Darsie, 1926; Gould, 1981; Saer, 1924), an idea which persisted along the first decades of the 20th century. It was only in the 1960s, especially due to Peal and Lambert's work (1962), that bilingualism acquired a positive status. Their work, considered a watershed change in the studies on bilingualism, showed that Canadian bilingual children had a better performance than monolingual ones, especially on tests requiring symbol manipulation and reorganization (Bialystok, Craik, & Luk, 2012).

In the last two decades or so, bilingualism has become a point of interest for cognitive sciences such as neurolinguistics and psycholinguistics. In neurolinguistics, experiments using neuroimaging devices such as functional magnetic resonance imaging (fMRI) (e.g., Abutalebi & Green, 2007), magneto-encephalography (MEG) (e.g., Bialystok, Craik, et al., 2005) and positron emission tomography (PET) (e.g., Halsband, 2006) have investigated which brain areas and cortical and subcortical structures are involved when using a first, second or third language, and how these languages are represented and controlled in the bi/multilingual brain. Besides, some of the studies have investigated not only typical bilinguals, but also aphasic bilinguals in order to understand the features and recovery patterns of languages compromised by a cerebrovascular accident (e.g., Abutalebi, Della Rosa, Tettamanti, Green, & Cappa, 2009).

In psycholinguistics, a substantial number of studies have consistently found significant cognitive differences between bilinguals and monolinguals in some age groups. Most of the differences tend to be advantageous and can affect both bilingual children and adults at almost all ages (Bialystok, Craik, Klein, & Viswanathan, 2004; Bialystok, Craik, & Freedman, 2007; Bialystok, Craik, & Luk, 2008; Martin-Rhee & Bialystok, 2008), ranging from a greater inhibitory and attentional control to a 4.1-year delay on the onset of the symptoms of dementia like Alzheimer's disease. In what concerns disadvantages, bilinguals show a difference in vocabulary size and they are slower than monolinguals in terms of lexical access.

The bilingual advantage concerning executive and attentional control is closely intertwined with the concept of code-switching. According to Soares and Grosjean (1984), when using the bilingual speech mode, bilinguals choose a base language but bring in

elements of their other language(s), and do so by introducing words, sometimes phrases, clauses or entire sentences to their speech. This obviously demands a greater executive and attentional control and probably has strong effects on nonlinguistic tasks as well, leading to an increase in cerebral plasticity.

The bilingual advantage might be not only related to the fact that bilinguals switch codes when they interact verbally with others with whom they share languages, but also to the fact that they switch cultural frames sometimes. The concept of frame switching belongs in the field of psychology and culture (Hong, Morris, Chiu, & Benet-Martínez, 2000), and can be described as the experience of seeing the world through another pair of cultural lenses. In other words, it means adapting and behaving according to the cultural context, and that is expected to happen in cross-cultural interactions.

It has been a while since the number of bilingual and multilingual speakers has outnumbered the total of monolingual speakers on the globe. As a matter of fact, in 1998, over two thirds of the world population was bilingual (Baker & Jones, 1998), and this number has increased significantly in the last years. According to The Associated Press (2001), 66% of the world's children are raised bilingual. Never before did so many people make use of different languages in their everyday life as they do now, for professional and academic reasons, or simply out of cultural interest. As a result, there are now entire new generations of bi/multilingual speakers, code and frame switchers in their verbal interactions, as a natural consequence of globalization, migration or travelling.

Considering the findings above, this study aims at investigating a population made up of monolingual and bi/multilingual businesspeople, matched in gender, age and education, in two nonverbal cognitive tasks, the Attentional Network Task (ANT) (Fan, McCandliss, Sommer, Raz, & Posner, 2002), for testing the three attentional networks (executive control, alerting and orienting networks), and the Simon task (Simon, 1969), for testing inhibitory control and attention. The reason why businesspeople were chosen as participants is because they are naturally faced with strong cognitive demands in their daily lives, constantly having to solve problems by making administrative and financial decisions that involve a lot of responsibility and a lot of people, regardless of product or service being sold or offered by the company. Therefore, I hypothesize that their professional activity could strengthen their inhibitory control and problem solving skills, which could compete with the cognitive advantages brought out by bilingualism. For this reason, I decided to include a control group, consisting of an equivalent population, but with a different professional activity, bilingual and monolingual teachers/professors, to be compared to the businesspeople, regarding their

performance in the Simon task, assessing their inhibitory control and attentional skills. Unfortunately, due to a restricted deadline, the control group was tested in only one of the tasks, the Simon task.

Another important aspect about the participants in this study is the fact that they are middle-aged, and such age group requires further investigation concerning the bilingual advantage in the executive functions (EFs) under investigation here. The few studies (Bialystok et al., 2004; Emmorey, Luk, Pyers, & Bialystok, 2009; Kramer, 2011; Pinto, 2009) including middle-aged adults do not provide information on the effects of bilingualism in terms of inhibitory and attentional control, as the wealth of studies on the bilingual advantage among the other age groups. Thus, my main goal is to replicate some of the experiments carried out previously with other populations and age groups, in order to assess whether middle-aged bi/multilingual businesspeople and teachers/professors present similar results. It is important to underscore the fact that, to the best of my knowledge, no previous work has addressed such populations in these regards, that is, profession and age, nor have some of the tasks used here been applied to such age group with the format and purposes adopted by me.

This thesis is organized in five chapters. Chapter 1 introduces the thesis, while 2 presents the review of literature, by introducing cognition, language and L2[1] acquisition as dynamic systems, providing an overview of the concept of bi/multilingualism along history, highlighting the cognitive differences between bi/multilinguals and monolinguals, presenting the construct code-switching, discussing models of bilingualism and EFs, discriminating the three-network model of attention, reviewing empirical studies carried out both abroad and in Brazil, and finally discussing their strengths, weaknesses and controversial issues concerning the bilingual advantage. Chapter 3 presents the method by describing the ethical aspects, participants, the sample selection instruments and the cognitive tasks used to assess the EFs under analysis. Chapter 4 presents the results and subsequent discussions, followed by chapter 5 with the final considerations in what regards the findings and possible weaknesses of the present study that might require further investigation.

[1] In this thesis I use the terms *L2* and *second language* (*SL*) interchangeably.

2 REVIEW OF LITERATURE

In this chapter I present and discuss the theoretical framework which has guided me along the present study. In section 2.1, I present the Dynamic Systems Theory (DST) in order to establish my view concerning cognition, language and L2 acquisition. Section 2.2 describes the history of bi/multilingualism concepts up to the present, covering both the fractional and wholistic views. Section 2.3 lists the cognitive differences between bi/multilinguals and monolinguals, highlighting advantages and disadvantages already found by previous empirical studies. Section 2.4 presents the construct code-switching. Section 2.5 discusses EFs and bilingualism, and it is subdivided as follows: subsection 2.5.1 introduces two models aimed at explaining how bilinguals select what language to use during speech production; and subsection 2.5.2 presents the three-network model of attention (alerting, orienting and executive control networks). Section 2.6 reviews the most significant empirical data collected by studies carried out abroad and in Brazil on the bilingual advantage in nonlinguistic interference tasks, and in section 2.7 I discuss the controversial issues concerning the bilingual advantage.

2.1 Cognition, language and L2 acquisition as dynamic systems

This section is aimed at discussing cognition, language and second language acquisition[2] (SLA) from the perspective of Dynamic Systems Theory (DST). DST developed as a branch of mathematics and is used to explain the interaction of variables in complex systems whose outcomes of development are unpredictable. Examples of such systems would be the movements of a pendulum, vehicle or satellite, as well as the prices of a product and the size of a population (Albano, 2012). According to Port and Van Gelder (1995, p. 574),

> a dynamical system is one whose state changes over time in a way that depends on its current state according to some rule. Mathematically, it can be thought of as a set of possible states (its phase space or state space) plus evolution rules which determine sequences of points in that space (trajectories).

The features of a dynamic system, then, may include nonlinearity, chaotic and unpredictable nature, sensitivity to initial conditions, along with the fact that it is open, self-

[2] In this paper I use the terms *learning* and *acquisition* interchangeably because I do not abide by Krashean dichotomies such as the *acquisition-learning* hypothesis (Krashen, 2003).

organizing, feedback sensitive, and also adaptive (Larsen-Freeman, 1997). Such features will be covered in more detail along this section.

Starting with cognition, Elman (1995) suggests that cognition should be understood as a dynamic system, for it is a view that not only acknowledges the similarity of the brain to other bodily organs, but also respects the evolutionary history of the nervous system, and acknowledges the very remarkable properties possessed by the brain as well. This view contrasts with more traditional ones, such as Fodor's *modularity of mind* (1983), or Chomsky's *generative grammar* (1965), in which the brain was compared to a computer. According to Kelso (1995, p. 26),

> the human brain is *fundamentally* a pattern-forming, self-organized system governed by nonlinear dynamical laws. Rather than compute, our brain 'dwells' (at least for short times) in metastable states: it is poised on the brink of instability where it can switch flexibly and quickly. By living near criticality, the brain is able to anticipate the future, not simply react to the present. All this involves the new physics of self-organization in which, incidentally, no single level is any more or less fundamental than any other.

Pattern formation is the core concept of DST. According to Kelso (1995), *self-organization* refers to spontaneous pattern formation, i.e., the system organizes itself. The pattern formation, therefore, is constrained by the following conditions: a) patterns arise spontaneously as the result of the nonlinear[3] interaction of large numbers of components; b) the system must be dissipative and far from equilibrium, resulting in the suppression of many of the system's degrees of freedom; c) relevant degrees of freedom are called *order parameters*, and they are created by the coordination between the parts, but in turn influence the behavior of the parts; d) order parameters are found near nonequilibrium phase transitions, in which loss of stability gives rise to new or different patterns and/or switching between patterns; e) fluctuations are continuously probing the system, allowing it to feel its stability and providing an opportunity to discover new patterns; f) *control parameters* lead the system through different patterns; and g) the order parameter dynamics may have simple or complicated solutions including deterministic chaos and stochastic (random) aspects, and so giving rise to enormous behavioral complexity.

Complete interconnectedness refers to the fact that all variables in a dynamic system are interrelated (De Bot, Lowie, & Verspoor, 2007); therefore the change in one variable will

[3] A nonlinear system is one that may react in a way that is all out of proportion to the cause, i.e., it is unpredictable. However, a nonlinear system can sometimes exhibit linearity. In addition, the future state of a nonlinear system relies heavily on its initial state (Larsen-Freeman, 1997).

inevitably affect the others. Furthermore, because the development of a dynamic system has a high dependence on its initial state, any minor difference at the beginning can have considerable consequences in the long run, a feature that is analogous to the *butterfly effect*[4] (De Bot et al., 2007).

A dynamic system is always part of another system (a subsystem), which tends to settle temporarily in an *attractor state*. According to Elman (1998, p. 27),

> an attractor is a state toward which, under normal conditions, a dynamical system will tend to move (although it may not actually get there). A child on a playground swing constitutes a dynamical system with an attractor that has the child and swing at rest in the bottom vertical position. The swing may oscillate back and forth if the child is pushed or pumps her legs, but there is an attracting force which draws the child back toward the rest position. The goal of a dynamical systems analysis of this situation would be to describe the behavior of the system using mathematical equations which tell us how the state of the system (e.g., the position of the child at any given moment) changes over time.

Moving on to language, it is important to say that a new paradigm was needed to try to understand such a complex system, since traditional or static approaches to language and SLA were not able to account for all the processes or phenomena involved. DST can provide us with such a framework that is able to combine both the cognitive and social aspects of SLA of apparently unrelated linguistic phenomena (De Bot et al., 2007; Ellis & Larsen-Freeman, 2009).

According to Port and Van Gelder (1995, p. 3), "dynamical models are increasingly prominent in cognitive psychology, developmental psychology, and even in some areas of linguistics". It was first proposed in the field of applied linguistics by the work of Larsen-Freeman (1997), who, along with other researchers such as Herdina and Jessner (2002) and Kramsch (2002), began to see language, SLA and language attrition as dynamic systems. Later, they were followed by researchers such as De Bot, Verspoor and Lowie (2005) and Ellis (2007). In Brazil, one of the first researchers to view second language learning as a complex adaptive system was Paiva (2011a, 2011b). Its validity to the field of applied linguistics is due to the fact that it can describe and explain how a complex system such as language emerges and develops over time.

[4] The term was introduced by the meteorologist Lorentz to refer to the fact that very small local effects can have a huge impact on global weather. Such concept reinforces the idea of nonlinearity, for there is a nonlinear relation between initial and end states (De Bot et al., 2005; De Bot et al., 2007; Larsen-Freeman, 1997).

One way to look at language as a complex system is by observing speech learning in L2 in constructs such as *interlanguage*, *accent* and *fossilization*, and taking the L2 of a low-proficient learner as an example. As suggested by Zimmer and Alves (2012, p. 244-245),

> the dynamic system of the L1, equipped with all the typical attractors of the L1, acts on the L2 system by modifying the dynamics of the task in the L2 production by biasing the typical attractors of the L2 articulatory state space of the nonmonolingual speaker, as to cause the speech with an accent.[5]

From a DST perspective, speech learning in L2 can be understood by taking into account the effects of language experience on L1 and L2 production, minimizing maturational mechanisms or the idea of a critical period (Zimmer & Alves, 2012). Furthermore, combined with emergentist theories, DST can explain both growth and decline in language development, as well as fossilization in SLA. Larsen-Freeman (1997, p. 152) suggests that "fossilization occurs when the learners' grammar system becomes closed and settles down to a fixed point attractor". She also suggests that interlanguages of speakers of different L1s learning English are constrained by the attractors of their L1s, and such attractors may be greater than the force of the strange attractor of English.

Blank and Zimmer (2011) recommend that DST be also used to explain multilingualism, because it is a far more complex phenomenon than bilingualism. The acquisition of an L3 or L4 combines all the processes implied in the acquisition of an L2, comprising all the effects associated to the interactions that might occur among the multiple languages being learned and used at the same time.

In sum, there is an intrinsic relation between language development (L1 or L2) and the development of other cognitive abilities (Zimmer, 2008). It is important to keep in mind that the regularities which are found in the linguistic input presented to the learner, combined to previous experience (frequency effects), may influence learning, and that the acquisition of an L2 or L3 is strongly influenced by the knowledge and experience a person has with an L1 or L2, with the possibility of interlinguistic transference of patterns in different levels: phonetic-phonological, morfossintatic, semantic and pragmatic (Zimmer, 2007).

To close this section, I would like to discuss the use of DST in assessing bilingual speech production from a neurolinguistic viewpoint. Abutalebi and Green are two

[5] "o sistema dinâmico da L1, dotado de todos os atratores característicos da língua materna, age sobre o sistema da L2, modificando a dinâmica da tarefa na produção da língua estrangeira ao enviesar os atratores característicos da L2 no espaço de estados articulatórios do falante não monolíngue, de modo a causar a fala com sotaque".

neurocognitive dynamicists who claim that "language production in bilinguals is a dynamic process involving cortical and subcortical structures that make use of inhibition to resolve lexical competition and to select the intended language" (Abutalebi & Green, 2007, p. 242). According to them, there is a single network which mediates the representation and the control of a person's L1 and L2. This network is modulated by the control structure made up of the following: the prefrontal cortex, the anterior cingulate cortex (ACC), the basal ganglia and the inferior parietal lobule (see Figure 1).

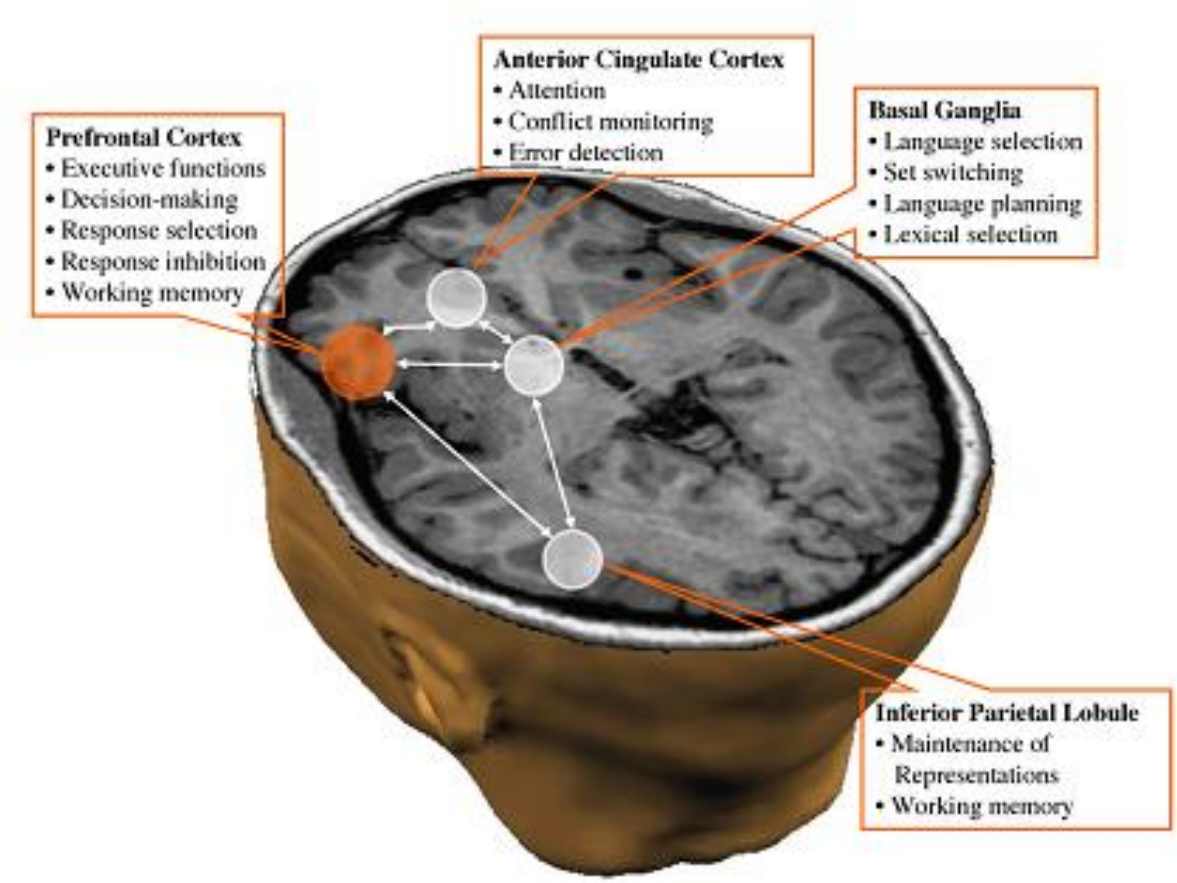

Figure 1: A schematic model of the areas involved in cognitive control.
Source: Abutalebi and Green (2007, p. 249).

The way this network operates depends heavily on the person's level of proficiency in the L2, and an increase in proficiency is followed by a shift from controlled to automatic processing, with a reduction in prefrontal activity (Abutalebi & Green, 2007). Thus, according to the authors, in order to validate the single network hypothesis, when interpreting neuroimaging data, it is important to consider the level of proficiency presented by bi/multilinguals in each of their languages. Later on, in subsection 2.5.1.1, I am going to

discuss in detail the inhibitory control model (IC Model) proposed by Green (1998a). In advance, I can already argue that the verbal experience of code-switching, performed naturally among bi/multilinguals, spreads to other nonlinguistic cognitive domains, and such a spreading constitutes one more example of a dynamic system.

Now I move on to describing the history of bi/multilingualism concepts up to the present moment, and to establishing the concept adopted when selecting the participants to the present study.

2.2 Defining bilingualism

As mentioned before, bilingualism has been understood and categorized differently by different researchers along history. Initially, bilingualism was thought to be harmful to people. According to Baker (2006, p. 139), the belief was that speaking two languages could cause "a burden on the brain, mental confusion, slowing down the acquisition of the majority language, identity conflicts, split loyalties, alienation and even schizophrenia". From the early 19th century to the 1960s, research on bilingualism and cognition focused on the detrimental effects that speaking a second language could have on thinking. Coincidentally, the studies carried out in this period found lower IQ scores for bilinguals in comparison to monolinguals (Darsie, 1926; Gould, 1981; Saer, 1924). However, such tests had weaknesses, since intelligence per se is a very controversial concept and cannot be fully defined or measured.

Baker (2006) lists six more methodological issues that, along with the difficulty to define or measure intelligence, made the first research studies on bilingualism simplistic and ambiguous: the language of the IQ tests given to bilinguals was usually their weaker one; simple averages were used instead of statistical tests; people were classified as bilinguals without taking into account the degree of fluency and use in each language; findings were generalized to all bilinguals, rather than restricted to the sample being investigated; language and cultural environment were left out of the equation, as if IQ and other cognitive tests were context-free circumstances; and groups sometimes presented other differences besides bilingualism and monolingualism, such as sociocultural class, gender, age and type of school attended. Some of these issues have been overcome in more recent studies. However, the difficulty in classifying bilinguals still remains, as a consequence of the variety of factors involved in this matter.

The concept of bilingualism was initially divided into two opposing views, the monolingual or fractional one, and the bilingual or holistic one (Baker, 2006; Grosjean, 1985;

Mitchell & Myles, 1998). The fractional view, also known as the "double monolingual hypothesis" (Saer, 1924), understands bilinguals as having 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, 2006). 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. Besides, the dominance of one language over the other depends on its frequency of use. Therefore, both L1 and L2, and even an L3, can, at a certain point in time, occupy a dominant position.

The holistic view, on the other hand, is closer to the principles of DST, for it understands bilinguals as 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 the samples for their studies 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, 2006).

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). Furthermore, 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) (see Figure 2).

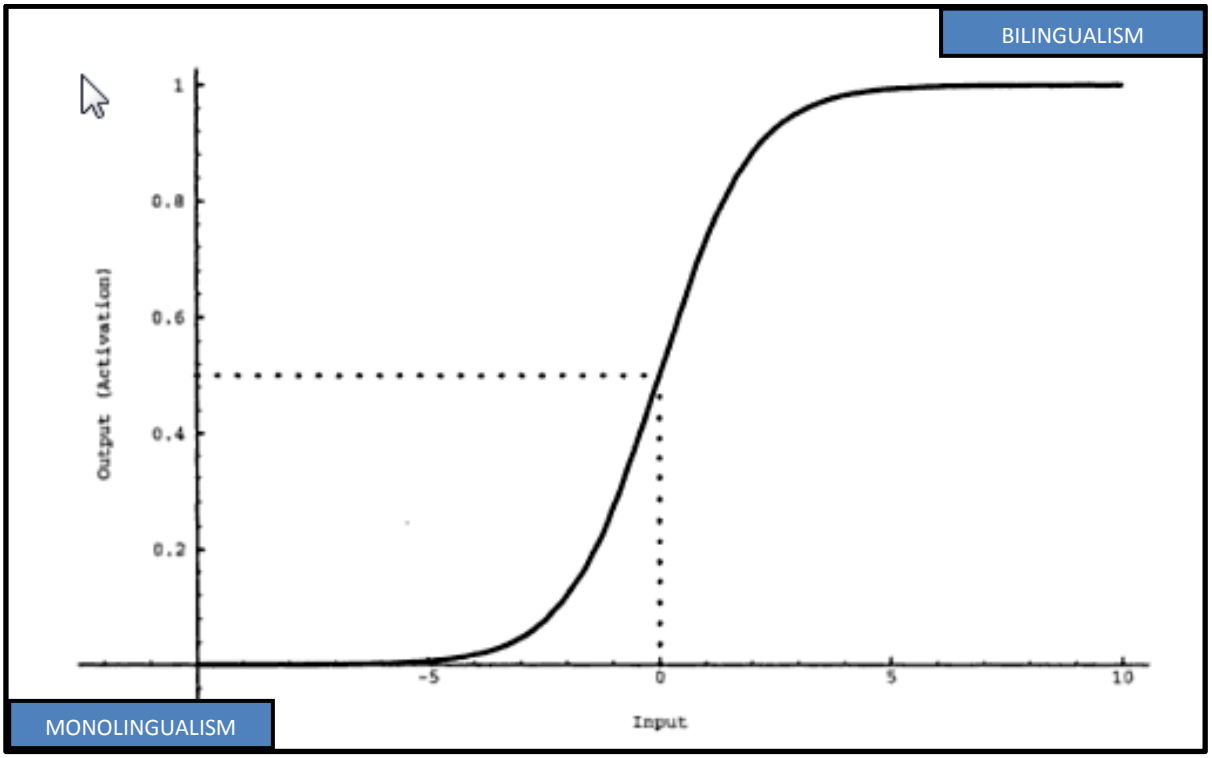

Figure 2: The sigmoid function and the bilingual continuum.

Source: adapted from Elman et al. (1996, p.53).

The sigmoid function presented in Figure 2 is the logistic function used to explain different natural processes, including the ones of complex system learning curves. Here the sigmoid function serves the purpose of illustrating cognition as a whole, as well as the nonlinear view of bilingualism adopted in this investigation, i.e., that becoming bilingual is something which does not have a clear beginning or a clear end state, showing a dependence on the initial conditions of the system, therefore presenting unpredictable outcomes. As suggested by De Bot et al. (2007), the directions of change in complex systems depend on the impact of internal and external resources, and nonlinearity seems to account for most of the linguistic phenomena involved in going from monolingualism to bi/multilingualism, or a dominant and a nondominant language switching places, depending on the frequency of use, and also the possibility of language attrition due to lack of use of one of the languages.

In the next section I intend to list and discuss the cognitive differences between bi/multilinguals and monolinguals already found by previous empirical studies.

2.3 Cognitive differences between bi/multilinguals and monolinguals

Concerning bilingualism, there is a lot about its effects that we are still not aware of. However, a considerable number of cognitive differences between bi/multilinguals and monolinguals have already been found. Starting with the disadvantages, it is important to highlight that they all have to do with linguistic performance. According to some experimental studies (Bialystok & Feng, 2011; Oller & Eilers, 2002; Perani et al., 2003; Portocarrero, Burright, & Donovick, 2007), bilingual children have a smaller vocabulary in each of their languages, although their total vocabulary is bigger than that of a monolingual child. Because they have a smaller vocabulary, children also present slower verbal fluency (Bialystok & Feng, 2011), which is naturally followed by a delay in rapid lexical retrieval tasks.

Similar disadvantages are found in adult bilinguals including the elderly. They all tend to be slower in picture naming tasks. The fact that bilinguals perform more poorly in this kind of task is due to the fact that they have more than one language system competing for the output (Green, 1998a); thus, they need to inhibit the one(s) that is(are) not being recruited in a given situation. That justifies the difference in reaction time (RT) presented by bilinguals in comparison to monolinguals in some studies (e.g., Costa, 2005; Gollan, Fennema-Notestine, Montoya, & Jernigan, 2007; Michael & Gollan, 2005).

Bilinguals are reported to obtain lower scores on verbal fluency tasks as well (Gollan, Montoya, & Werner, 2002; Portocarrero et al., 2007), to show slower semantic fluency (Gollan et al., 2002), and to experience more interference in lexical decision (Gollan, Montoya, Fennema-Nonestine, & Morris, 2005; Ransdell & Fischler, 1987). These deficits in lexical access and in lexical retrieval linger with aging. Furthermore, bilingual speakers are more susceptible to tip of the tongue states (Gollan & Acenas, 2004), which consist of "a temporary inaccessibility of information that one is sure exists in long-term memory and is on the verge of recovering" (Abutalebi & Green, 2007, p. 250).

The advantages, on the other hand, have to do with cognitive performance, for there seems to be an enhancement in executive functioning[6]. Bilingual children are reported to perform better than monolingual ones when faced with problems containing conflicting or misleading cues, especially on conditions in which the demands for inhibitory control are high (Bialystok, Martin, & Viswanathan, 2005; Martin-Rhee & Bialystok, 2008; Morton & Harper,

[6] EFs and executive control will be discussed in detail in the next section.

2007). This means that at an earlier age bilingual children are already better than monolinguals in skills that are supposed to be learnt or developed only after they start going to school. Furthermore, they show greater mental flexibility (Peal & Lambert, 1962), greater metalinguistic awareness (Cummins, 1978), greater creativity (Kessler & Quinn, 1987), as well as the fact that they are better at problem solving (Bain, 1975; Kessler & Quinn, 1980) and perceptual disembedding (Duncan & De Avila, 1979).

At this point, it is worth highlighting the fact that vocabulary size is taken as a central measure of children's progress concerning the oral and literate forms of language development (Bialystok, 2009). However, something that cannot be ignored is the fact that bilingual children, as well as bilingual adults, do have a larger sized vocabulary if both their languages are taken into consideration. Thus, to consider a smaller vocabulary in each of their languages disadvantageous is, to say the least, questionable, for, as a whole, bilingual children have more gains than losses if compared to monolinguals, since they profit so much from growing up with a second language, as demonstrated above.

It seems the same advantages found in bilingual children have also been found in bilingual adults, especially when it comes to nonlinguistic interference tasks requiring a lot from executive control. One example of such a task is the Simon task, usually performed better by bilinguals, with shorter RTs for both congruent and incongruent trials (Bialystok et al., 2004; Bialystok, Craik, et al., 2005; Bialystok, 2006). Another nonlinguistic interference task is the ANT, also performed better by bilinguals who usually show faster RTs, a smaller conflict effect and smaller switch costs (Costa, Hernández, & Sebastián-Gallés, 2008).

The bilingual advantage remains across the lifespan, leading to cognitive reserve, i.e., the protective effects of experience against cognitive decline with aging (Bialystok, 2009). Bialystok et al. (2007) found a 4.1-year delay on the onset of the symptoms of Alzheimer's, and that was confirmed by a subsequent study (Craik, Bialystok, & Freedman, 2010). Nonetheless, it is important to say that bilingualism is not the one and only factor which can lead to such a result. Experimental studies on cognition and aging have considered other lifestyle factors, such as level of education, social engagement, physical activity, leisure involvement and profession, which can also lead to similar cognitive reserve (e.g., Alexander et al., 1997; Bialystok et al., 2007; Scarmeas, Levy, Tang, Manly, & Stern, 2001; Scarmeas & Stern, 2003; Singh-Manoux, Richards, & Marmot, 2003; Stern, 2002). See Table 1 for a summary of the advantages and disadvantages already discussed in this section.

Table 1: Cognitive advantages and disadvantages of being bilingual

	ADVANTAGES	**DISADVANTAGES**
CHILDREN	Higher inhibitory control levels (Martin-Rhee & Bialystok, 2008) Greater mental flexibility (Peal & Lambert, 1962) Greater metalinguistic awareness (Cummins, 1978) Greater creativity (Kessler & Quinn, 1987) Better at problem solving (Bain, 1975; Kessler & Quinn, 1980) Better at perceptual disembedding (Duncan & De Avila, 1979)	Smaller vocabulary in each language compared to monolinguals (Bialystok & Feng, 2011) Slower in lexical access (Gollan et al., 2005) Slower verbal fluency (Bialystok & Feng, 2011)
ADULTS	Greater inhibitory and attentional control (Bialystok et al., 2004) Bigger promotion of cognitive reserves, i.e., increase of neuroplasticity (Bialystok et al., 2007)	Slower in lexical access (Gollan et al., 2005) More interference in lexical decision (Ransdell & Fischler, 1987). More susceptible to tip of the tongue states (Gollan & Acenas, 2004) Slower semantic fluency (Gollan et al., 2002)
ELDERLY	A 4.1-year delay on the onset of the symptoms of Alzheimer's (Bialystok et al., 2007)	Deficits in lexical access (Gollan et al., 2007)

In what regards memory, however, a general bilingual advantage cannot be assumed. Studies using memory tasks have proven a bilingual advantage when the focus was on executive control, but not when it was on verbal recall. According to Bialystok (2009, p. 6),

> it is not clear *a priori* whether bilingualism should affect the development and functioning of memory in general, and working memory in particular. Both language proficiency, especially in terms of lexical access, and attention control in terms of conflict resolution from competing systems are directly involved in bilingual speech production. Language use does not inherently seem to rest on memory, but working memory at least is normally considered to be part of the executive function. Therefore, an enhancement in executive control in general may have the consequences of also boosting the working memory system which is part of it.

Having considered most of the cognitive differences already found by previous studies, the bilingual advantage is still controversial, for reasons to be discussed more deeply in the sections to come.

Before moving on to discussing EFs, it is necessary to explain the construct code-switching.

2.4 Code-switching

The studies on code-switching date back to the 1940s and 1950s, when it was considered to be a sub-standard use of language (Weinreich, 1953). From the 1980s onwards, code-switching was recognized as a normal product of bi/multilingual language use. According to Grosjean (2001), code-switching is a complete shift to another language for a word, phrase or sentence, and is different from *borrowing*, which happens when a morpheme, word or expression is taken from the less activated language and is adapted morpho and sometimes phonologically to the base language. Conversational code-switching can also be defined as the juxtaposition within the same speech exchange of passages of speech belonging to two different grammatical systems or subsystems. This alternation usually takes the form of two subsequent sentences (as when a speaker uses an L2 either to reiterate his message or to reply to someone else's statement) (Gumperz, 1982).

Grosjean (2001, p. 2) explains that "the state of activation of the bilingual's languages and language processing mechanisms, at a given point in time, has been called the language mode". In the monolingual language mode, a bilingual person partially deactivates one language, whereas in the bilingual language mode, a base language is chosen, the other language is activated and called on in the form of code-switches and borrowings.

Code-switching is a linguistic tool that does is not used at random. There is usually purpose and logic in changing languages. A bilingual person uses the full language resources that are available, usually knowing that the listener understands the code-switches. One main language (the matrix language) provides the grammatical rules which govern how something is said when there is code-switching (Myers-Scotton, 2002). Thus, it involves a rule-bound (e.g. word order, verb endings) use of the 'other' language, as such language insertions will fit those matrix language rules (Baker, 2006).

Some of the reasons for switching codes include a need to convey a meaning that is better expressed in the other language, or to fill a linguistic need for a word or an expression that does not exist in the base language. It also works as a communicative strategy used by the

speaker to exclude someone from a conversation, to show expertise and it helps raise someone's status (Grosjean, 2010).

In the next section, I start explaining the EFs to be investigated in this paper, so that I can discuss the so-called bilingual advantage in more detail.

2.5 Executive functions and bilingualism

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 (WM), problem solving, and initiation and monitoring of actions. Executive control (EC), on the other hand, is a system or mechanism in charge of coordinating innumerous processes involved in the realization of the EFs (Hamdan & Bueno, 2005). Both the EFs and the EC are processed in the pre-frontal cortex.

According to Bialystok (2001), such functions are enhanced in bi/multilinguals due to the constant management of two or more competing language systems. 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 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 ACC, 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., 2012).

The effects of the continuous experience of code-switching, which is of verbal nature, are reported to spread to other domain general systems, thus enhancing some EFs. Such enhancement found in bilingual children seems to remain throughout their lives, lingering into adulthood and old age, and 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), resulting in cognitive reserve and neuroplasticity.

In the next section I start discussing two models of bilingualism regarding speech production.

2.5.1 Models of bilingualism and executive functions

In this section, I present the inhibitory control model (IC Model), proposed by Green (1998a), and the language-specific lexical selection model, presented by Costa (2005, 2006), both of which intend to explain how bilinguals select which language to use in speech production.

2.5.1.1 The inhibitory control model (IC Model) and code-switching

Bi/multilinguals are successful in using only one language in an interaction with a monolingual speaker. They can also code-switch, as well as achieve different degrees of success when translating between their languages (Green, 1998a). However, how they manage to avoid using one language while another one is being recruited in a conversational situation, or during translation, is still a controversial issue among researchers (Costa, 2005; Costa, La Reij, & Navarrete, 2006; De Bot & Schreuder, 1993; Poulisse, 1997; Poulisse & Bongaerts, 1994). The language systems possessed by bi/multilinguals appear to be potentially active and compete to control output (e.g., Brysbaert, Van Dyck, & Van de Poel, 1999; Colomé, 2001; Costa, Miozzo, & Caramazza, 1999; Hermans, Bongaerts, De Bot, & Schreuder, 1998). In order to choose the right words, a bilingual person would need to have a mechanism in charge of inhibiting the active lemmas with non-target tags.

The inhibitory control model (IC Model), proposed by Green (1998a), suggests that bi/multilinguals are equipped with such a mechanism of inhibition, being able to suppress the language system(s) and their correspondent lemmas or lexical nodes not required in a particular situation. According to Green (p. 68), "the regulation of language processes and the control of action have much in common: language is a form of communicative action". Such regulation is achieved through the modification of levels of activation of language networks (or items within those networks), and not via a simple switch mechanism.

Green's IC Model is derived from a model of action proposed by Norman and Shallice (1986), which posited distinct systems for controlling routine and non-routine behavior. The system in charge of a routine behavior would involve a process termed contention scheduling in which schemas[7] compete to control behavior by altering their levels of activation. A schema can be retrieved and adapted from memory in the case of a task previously performed.

[7] Schemas are "mental devices or networks that individuals may construct or adapt on the spot in order to achieve a specific task and not simply to structures in long-term memory" (Green, 1998a, p. 69).

In the case of novel tasks, though, automatic control is insufficient, demanding a contention scheduling to be modulated by a system capable of not only commanding a variety of processes, such as the construction or modification of existing schemas, but also of monitoring their performance in relation to task goals. This system is called the supervisory attentional system (SAS) (Shallice & Burgess, 1996) (see Figure 3).

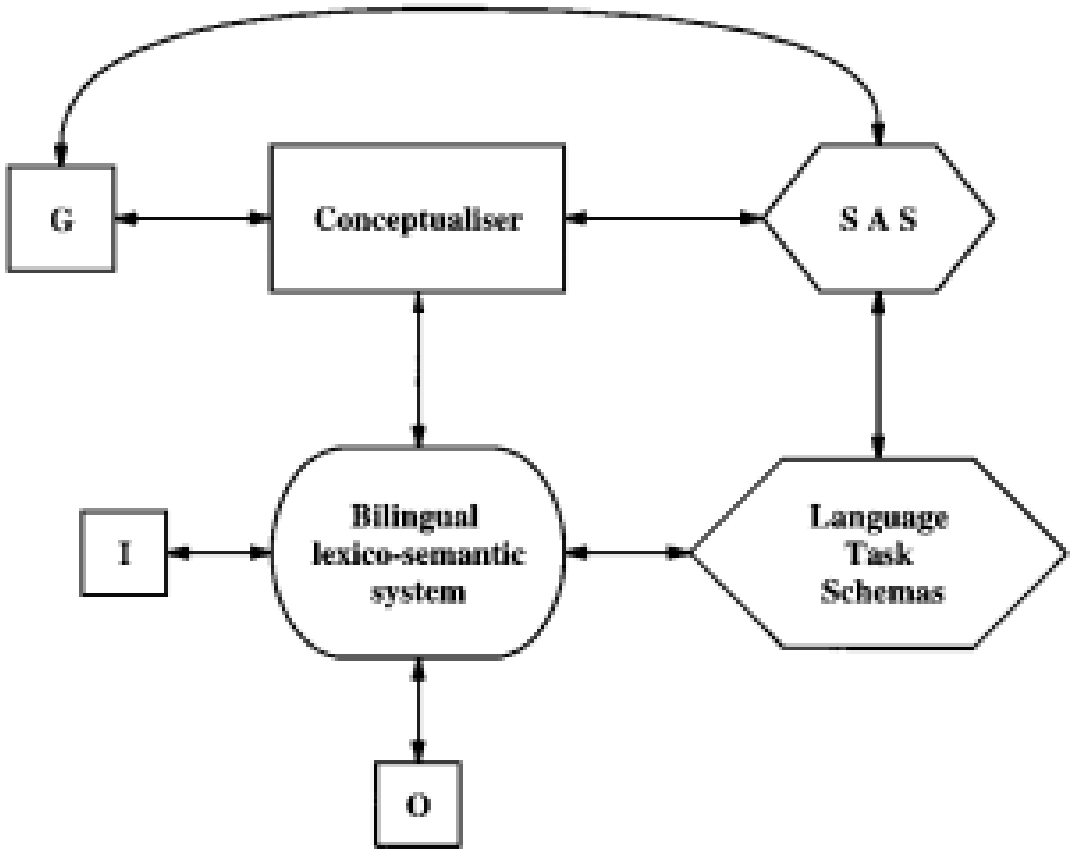

Figure 3: The inhibitory control model (IC Model).
Source: Green (1998a, p. 69).

Figure 3 illustrates the regulation of the bilingual lexico-semantic system displaying multiple levels of control. A conceptualiser builds conceptual representations which are driven by a goal (G) to achieve some effect through language. Such communicative and planning intention is mediated by the SAS, along with components of the language system, namely: the lexico-semantic system and a set of language task schemas. Translation schemas or word production schemas, for example, compete to control output from the lexico-semantic system. The intentional selection of a word for production requires specification of the required language to be transmitted by the SAS to the task schemas, and also conceptual

information to be transmitted to the lexico-semantic system from the conceptualiser. One schema, then, remains active until its goal is achieved (in which case it inhibits its own activity), or it is actively inhibited by another schema, or SAS has changed the goal (Green, 1998a).

According to Green (1998a, p. 74), "inhibiting a previously active schema and overcoming the inhibition of the previously irrelevant language will take time and so a switch cost is predicted". In fact, different costs are predicted on verbal tasks relying on language switch. The asymmetry in language proficiency implies greater effort of inhibition to suppress the dominant language, that is, usually, but not always, the L1 (see section 2.2 again). In order to change from L2 to L1, there is a greater switch cost, which is not present when the process goes from L1 to L2 (see Meuter & Allport, 1999). Such asymmetry disappears when there is equivalent proficiency between L1 and L2, and is not present between L1 and a weaker L3 (Costa et al., 2008).

In another paper, but in the same volume, Green (1998b) poses the question whether inhibitory control is irrelevant as a mechanism in code-switching. He starts by reinforcing the fact that the IC Model is right in predicting switching costs, and that during code-switching, lexical concepts from both languages are active (though one may act as the base language). He then suggests that the relationship between the language production schemas should be cooperative, and not mutually inhibitory. Green also emphasizes that being cooperative does not imply the general absence of inhibitory control. He is talking about a situation in which code-switching is desired. If that is the case, his suggestion seems plausible, considering the fact that, if the language production schemas were to be mutually inhibitory, both language systems (and their correspondent lemmas) would be suppressed, and conversation then, would not take place.

2.5.1.2 The language-specific lexical selection model

As mentioned at the beginning of the previous subsection, there is disagreement among researchers in terms of inhibition of the non-target language in speech production. The IC Model (Green, 1998a) is based on a language-nonspecific selection hypothesis, i.e., a domain general mechanism. Costa (2005) and Costa et al. (2006), however, suggest that there is a language-specific selection mechanism which would consider only the activation of lexical nodes belonging to the language being recruited to the task, that is, the more active ones. It means that there would not be a major interference from the nonresponse language.

According to Costa (2005), the way bilinguals choose words according to the intended language is similar to the way monolinguals choose among words with related concepts, such as when they need to say “dog” and have to deal with other lexical items that come to mind at the same time, such as “bark”, “cat”, and so on. As a matter of fact, Costa understands the experimental evidence as mixed, since some results point to the language specificity of the lexical selection mechanism, while others favor the non-specific lexical selection. He claims that a way to reconcile the contradictory data is by assuming that:

> in non-proficient bilinguals, the activation of the lexical nodes of the nonresponse language may affect production performance, but that bilinguals shift from language-nonspecific processing toward language-specific processing when they become more proficient bilinguals (Costa, 2005, p. 322).

According to Kroll, Boob, Misra and Guo (2008), there is strong evidence supporting the idea that both languages of a bilingual are active during speech production. The question that remains unanswered is how this parallel activation may influence performance. By contrasting the two models of lexical selection, it is important to bear in mind their implications. The language specific model assumes that bilinguals can effectively represent the intention to speak one language alone and that information about words in the unintended language may be activated but those words are not themselves candidates for selection (Kroll et al., 2008). The language non-specific model, on the other hand, assumes that words in the target and non-target languages are potential candidates for selection, and that candidates within and across languages actively compete with alternatives in the unintended language, being eventually inhibited to allow accurate production to proceed (Kroll et al., 2008).

The language-specific model suggested by Costa contrasts significantly with Green’s IC Model, since it postulates a more modular view, as expected in a computational or cognitivist view of language processing. Green’s, on the other hand, postulates a more global or unified view, in consonance with DST, and is the one adopted in this study.

Now I move on to discussing the three-network model of attention.

2.5.2 Attentional networks

According to Fernandez-Duque and Posner (1997), attention corresponds to a number of different cognitive abilities, such as orienting to sensory stimuli, maintaining the alert state, and orchestrating the computations needed to perform the complex tasks of daily life. Examples of such abilities are to switch between tasks and to inhibit prepotent responses.

Posner and Petersen (1990) suggested a three-network model of attention, divided in alerting, orienting, and executive control networks. These three networks have been traditionally understood as independent from one another (Fan et al., 2002), but researchers acknowledge the fact that they cooperate and work closely together.

The alerting network refers to the ability to increase and maintain response readiness in preparation for an impending stimulus. Its efficiency is usually measured by subtracting the RTs of a cue condition which provides temporal, but not location, information from the RTs of a non-cue condition. There are two types of alertness: phasic alertness (task specific) and intrinsic alertness (a general cognitive control of arousal) (Raz & Buhle, 2006).

The orienting network corresponds to the ability to select specific information from among multiple sensory stimuli. It can be measured by subtracting the RTs of a cue condition that gives location information from the RTs of a non-cue condition. There are two types of orienting: exogenous orienting (when the flash of a cue automatically captures attention to a specific location), and endogenous orienting (when a central arrow points to one of two lateralized target presentation locations) (Raz & Buhle, 2006).

The executive control network includes the monitoring and resolution of conflict between computations in different neural areas, such as planning or decision making, error detection, new or not well-learned responses, conditions judged to be difficult or dangerous, regulation of thoughts and feelings, and the overcoming of habitual actions. Conflict can be measured by subtracting RTs to congruent or neutral stimuli from those to incongruent ones (Raz & Buhle, 2006). Costa et al. (2008, p. 62) suggest that this network "seems to be the most likely candidate to be affected by bilingualism, because it is involved in the determination of the appropriate action in a goal-directed manner, and may involve inhibitory control". The most suitable tasks to measure this network are the ones involving incompatibility between the dimensions of the stimulus and the response, such as the ANT task and the Simon task.

According to Raz and Buhle (2006), genetics and specific experience are both involved in the development of attentional networks. The maturation of the alerting network

goes from adolescence into adulthood. The formation of the orienting network, in turn, appears as early as 4 years of age, while the executive control network shows a strong development from 4 to 7 years of age.

Next, I present a review of empirical studies about bilingualism abroad and in Brazil, focusing on experiments that have used versions of the Simon task and the ANT.

2.6 Empirical studies on the bilingual advantage in nonlinguistic interference tasks

In this section, I review and discuss some of the most relevant empirical studies on the bilingual advantage in nonlinguistic interference tasks carried out both abroad and in Brazil, focusing only on the ones which have used different versions of the nonlinguistic tasks used in the present study, the Simon task (Simon, 1969) and the ANT task (FAN et al., 2002). I start with Table 2 (studies carried out abroad) and continue with Table 3 (Brazilian studies). Each table provides number of participants in each experiment, mean ages or age ranges, the task versions[8] used, along with the aims and main findings of each study. Each table is then followed by some comments on methodological procedures, aims and main findings in terms of their implications and relevance to the scenario of psycholinguistic approaches to bilingualism. My purpose with this section and the next one is to establish correlations with the present study when I describe and discuss my own findings in chapter 4.

[8] The tasks applied in the studies listed in Tables 2 and 3 are described below. Some of the tasks have been renamed for the sake of the comparison across experiments, considering that, apart from some slight differences in number of trials, design and procedures were pretty much the same: *Simon task* – explained in detail in section 3.4.4.2; *Standard Simon* – the same as the Simon task, but with 2 colors only; *Control Simon task* – similar to the Standard Simon (2 colors), but only with the central condition, i.e., there are no congruent or incongruent trials; *Control-4 Simon task* – the same as Control Simon task, except that it includes 4 colors, i.e., 2 colors are associated to each response button, which supposedly would increase the WM load; *Arrow task* – in each trial an arrow is presented in either the left or right side of the screen. Participants are instructed to indicate the direction of the arrow by pressing a button. On congruent trials, the direction and location of the arrow match; on incongruent trials, the direction and location of the arrow mismatch; the conflict effect is calculated subtracting the RTs of the congruent trials from those of the incongruent trials; *Control Arrow task* – the same as the Arrow task, but only with the center condition, i.e., there are no congruent or incongruent trials; *ANT task* – explained in detail in section 3.4.4.1; *Flanker* combined with *go no-go task* – a singleton target chevron appears to the left or right of center of four horizontally flanking chevrons either matching (congruent) or mismatching (incongruent) the direction of the target chevron. On neutral trials, a target red chevron is centered and flanked on each side by two diamonds. For the go trials, a central red chevron was flanked by four red diamonds, two on each side, and for the no-go trials, the chevron was flanked by four red Xs. While on go trials the participants have to indicate the chevron direction, on no-go trials they are supposed to withhold response.

Table 2: Empirical studies on the bilingual advantage in nonlinguistic interference tasks

STUDIES	EXP.	SUBJECTS	TASKS (T), AIMS (A) AND MAIN FINDINGS (MF)
Bialystok et al. (2004)	1	10 M - 10 B M.A.: 43 10 M - 10 B M.A.: 71.9	**T: Standard Simon; Simon task** **A**: To determine if the bilingual advantage persists in adult life, and if bilingualism attenuates the effects of aging on cognitive control in older adults.
	2	32 M - 32 B M.A.: 42.6 15 M - 15 B M.A.: 70.3	**MF:** The bilingual advantage found in children persists in adulthood. Bilingualism acts as a defense against the decline of executive processes, expected in normal cognitive aging, and increases cognitive control, having a positive effect on WM costs.
	3	10 M - 10 B M.A.: 38.8 M – 40.6 B	
Bialystok, Craik et al. (2005)	1	10 M – 10 B (French) 9 B (Cantonese) M.A.: 29	**T: Standard Simon** **A:** To use MEG to determine the neural correlates of the bilingual advantage previously found in conflict tasks. **MF:** Correlations between RTs and activated regions showed that the two bilingual groups had faster RTs with more activity in superior and middle temporal, cingulate, and superior and inferior frontal regions, mainly in the left hemisphere. The monolinguals had faster RTs with activation in middle frontal regions. Results reveal that the management of two language systems leads to systematic changes in frontal EFs.
Bialystok et al. (2005)	1	17 M – 17 B M.A.: 5	**T: Standard Simon** **A:** To trace the bilingual advantage found for children on tasks requiring control of attention to inhibit misleading information into adulthood and aging.
	2	22 M – 18 B M.A.: 5	
	3	40 M – 56 B A.R.: 20-30	**MF:** Bilingual children, middle-aged adults and elders outperformed monolinguals. The performance of young adults, however, is at its peak efficiency, so bilingualism offers no further boost for this age group.
	4, 5	(Reported in Bialystok et al., 2004)	
Bialystok (2006)	1	17 M – 19 B (video-game players) M.A.: 21.6 M – 22.2 B 31 M – 30 B (video-game non-players) M.A.: 22	**T: Control Simon task; Simon task; Control Arrow task; Arrow task** **A:** To observe the effect of bilingualism and computer video game experience in two versions of the Simon task. **MF:** Video-game players had a better performance in most conditions, including control conditions without conflict from irrelevant position. Bilinguals were better than monolinguals only in a condition that required the most controlled attention to resolve conflict from the position and the stimulus. The results show the potential of experience to modify performance and point to subtle processing differences in various versions of the Simon task.

Morton & Harper (2007)	1	17 M – 17 B M.A.: 6.9	**T: Simon task** **A:** To apply the Simon task to bilingual and monolingual children of identical ethnic and socioeconomic backgrounds in order to see if the bilingual advantage remains. **MF:** Bilingual and monolingual children had equivalent performances. Socioeconomic status and ethnicity seem to attenuate the bilingual advantage in cognitive control.
Martin-Rhee & Bialystok (2008)	1 2 3	17 M - 17 B M.A.: 4.7 and 5 20 M - 21 B M.A.: 4.5 19 M - 13 B M.A.: 8	**T: Standard Simon; Arrow task** **A:** To replicate studies done with tasks which require inhibitory control to ignore misleading perceptual cues. **MF:** In study 1, the bilingual advantage is restricted to tasks with high demands for inhibitory control. Studies 2 and 3 show that bilingual children maintain their advantage on tasks that require control over attention to competing cues, but not on tasks that require response inhibition.
Emmorey et al. (2009)	1	15 M – 15 bimodal B (ASL) – 15 unimodal B M.A.: 50.1 M – 46.2 bimodal B – 47.0 unimodal B	**T: Flanker interference with a Simon component; Go no-go task** **A:** To investigate if the enhancement of executive control stems from a general effect of bilingualism or from a modality constraint which forces language selection. **MF:** Results trace the bilingual advantage in cognitive control to the unimodal bilingual's experience controlling two languages in the same modality.
Luk, Anderson, Craik, Grady & Bialystok (2010)	1	10 M – 10 B M.A.: 20 M – 22 B	**T: Combined flanker interference task and no-go task** **A:** To use fMRI to examine the effects of bilingualism on cognitive control. **MF:** Results indicate that bilingualism selectively affects neural correlates for suppressing interference, but not response inhibition, and the neural correlates associated with more efficient suppression of interference were different in bilinguals than in monolinguals, suggesting a bilingual-specific network for cognitive control.
Costa et al. (2008)	1	100 M – 100 B M.A.: 22	**T: ANT** **A:** To understand how the fact that bilinguals control two languages in speech production can affect their attentional networks. **MF:** Results reveal that bilingualism has a positive effect in the attainment of efficient attentional mechanisms, not only on the alerting network, but also of the executive control network of young adults who are supposedly at the peak of their attentional capabilities.
Carlson & Meltzoff (2008)	1	17 M - 12 B 21 immersion students M.A.: 5	**T: ANT (and a battery of other tests)** **A:** To examine the effect of the bilingual experience in the executive functioning of small children. **MF:** Results corroborate a significantly better bilingual performance on the EFs in tasks that require managing conflicting attentional demands. There was a relative significant advantage for tasks that seem to require managing conflicting attentional demands, but no advantage on impulse-control.

Costa, Hernández, Costa-Faidella, & Sebastián-Gallés (2009)	1	30 M - 30 B M.A.: 19.5 M – 19.9 B 30 M - 30 B M.A.: 20.5 M – 20.3 B	**T: ANT** **A:** To explore the bilingual advantage in conflict resolution tasks, focusing on the origin of the bilingual advantage on overall RTs. **MF:** It was possible to corroborate the hypothesis that in low monitoring experimental contexts, in which most trials are of one type, the differences in overall RTs disappear.
	2	31 M - 31 B M.A.: 20.4 M – 19.9 B 31 M - 31 B M.A.: 20.9 M – 20.3 B	

Note. Source: see data. M = monolingual; B = bilingual; M.A. = mean age; A.R. = age range; ASL = American Sign Language.

I start the discussion with Bialystok et al. (2004), since it was the inspirational study for most of the literature that came out later on the bilingual advantage on conflict resolution. Despite its importance, it has generated a lot of debate, for further studies have tried unsuccessfully to replicate all its results. One of the main reasons for that might have to do with differences in methodological procedures, considering that other studies have investigated mostly young adults, while Bialystok et al. focused on middle-aged adults and elders (see Pinto 2009 in this section), for whom the bilingual advantage seems to be more robust regarding the magnitude of the interference effects[9] (Hilchey & Klein, 2011). Another reason could be the eclectic cultural backgrounds of the participants. The monolinguals in the three studies were native Canadian residents. Bilinguals in Study 1, however, were native residents of Southern India, and in Study 2, they were Cantonese-English residents of Hong Kong, Tamil-English residents of India, and French-English residents of Canada. In this regard, the study by Morton and Harper (2007) was the first one to compare bilingual and monolingual children controlling for demographic factors, such as ethnicity and socioeconomic status (SES), and have shown that such factors may have an impact on the bilingual advantage. According to Mezzacappa (2004), SES covaries with executive ability, in the sense that higher SES tends to be associated with better performance on measures of cognitive functioning.

Another study which was also very relevant to the literature on the bilingual advantage was Bialystok's 2006 investigation, which underscored the practice with video games as yet

[9] The interference effects correspond to the difference in RTs between congruent (no conflict) trials and incongruent (conflict) trials. Subtracting responses to congruent trials from those to incongruent trials results in what is called the Simon effect, in the Simon task, and in the Conflict effect, calculated by means of the ANT task.

another experience that can modify executive processes. The author compared bilingual and monolingual video game players to non-players in two versions of the Simon task[10]. The findings suggest that video game practice and bilingualism have different effects on the performance in the Simon task. The former promotes strong speed advantages to answer to the stimuli, while the latter promotes more subtle processing advantages. A similar finding is reported in the study by Bialystok, Craik et al. (2005), who claim that the experience with computers may improve the efficiency of participants to such a degree that bilingualism can do little to further improve the RTs measured by the tasks. These studies, therefore, have helped to enlarge the understanding on the variables that compete with the bilingual advantage.

Another relevant aspect was introduced by Emmorey et al. (2009), who included a bimodal bilingual group to the discussion of inhibitory control processes. Code-switching and code-blending (the simultaneous articulation of sign and speech) were contrasted, and the findings suggest that the degree of control required for bimodal bilinguals in dealing simultaneously with signs and words is less than the one required for unimodal bilinguals dealing with two languages.

Now I move on to Table 3 in order to present the Brazilian studies.

Table 3: Empirical studies on the bilingual advantage in nonlinguistic interference tasks in Brazil

STUDIES	EXP.	SUBJECTS	TASKS (T), AIMS (A) AND MAIN FINDINGS (MF)
Pinto (2009)	1	15M – 15 B M.A.: 66.3 M – 68.5 B 15 M – 15 B M.A.: 36,8 M – 38 B	**T: Standard Simon; Simon task** **A**: To verify whether bilingualism can attenuate the negative effects of aging on older adults' EFs. **MF:** The statistical analysis did not confirm significant differences among age and language groups, even though a better performance was observed in the bilingual groups when compared to monolinguals in the same mean age.
Billig (2009)	1	21 M – 20 B A.R.: 40 – 55 21 M – 21 B A.R.: 60 – 71	**T: Arrow task; Control-4 Simon task** **A:** To investigate the influence of bilingualism in the performance of middle-aged and old-aged adults in tasks involving inhibitory control and WM. **MF:** The results reveal an age effect in terms of inhibitory control and WM, but not an effect of language experience. However, bilingual participants were slightly faster than monolinguals in all conditions regarding inhibitory control.

[10] In Costa et al. (2009), video game play was also a concern, thus computer video-game experience was balanced between language groups.

Bandeira (2010)	1	20 M – 20 B A.R.: 8 – 10	**T: Simon task** **A:** To compare the performance in EFs (inhibitory control and attention) of monolingual and multilingual children in accuracy and RT in a non-verbal task. **MF:** Significant differences were found for accuracy and RT in all conditions. The results suggest that bilinguals develop the processing related to EFs more quickly and with higher levels of accuracy than monolinguals.
Martins (2010)	1	20 M – 18 B A.R.: 60 – 75	**T: Simon task** **A:** To verify the existing differences in performance between healthy bilinguals and monolinguals in nonlinguistic cognitive tests related to EFs and WM. **MF:** No relevant differences were found regarding RT, but a subtle difference related to accuracy was significant in the statistics level.
Finger, Zimmer, & Fontes (2011)	1	19 M - 18 Multilingual A.R.: 21 – 24	**T: Simon task** **A:** To check if the frequent use of more than one language results in more efficient inhibitory control processes that can guarantee advantages in non-verbal tasks. **MF:** Multilingual advantage in incongruent RTs and in the Simon effect in the 2-color condition replicates previous findings. Absence of differences between groups in the 4-color condition does not corroborate the evidence found by Canadian studies. The results are similar to the results of other studies conducted with young adults (Costa et al., 2008; Costa et al., 2009), in which the bilingual advantage appears briefly in the beginning of the task and disappears rapidly.
Brentano (2011)	1	42 M – 57 home-based B – 75 school-based B A.R.: 9 – 12	**T: Arrow task** **A:** To replicate previous findings in the literature by showing bilinguals' enhanced inhibition control processes and to add new evidence to the field by demonstrating that school-based bilingualism can also enhance the process of inhibition control. **MF:** The results revealed that school-based bilingualism can also provide cognitive advantages.
Kramer (2011)	1	10 M – 10 B M.A.: 20.6 M – 22.6 B 14 M – 14 B M.A.: 46 M – 43.5 B 14 M – 14 B M.A.: 72.6 M – 72 B 14 M – 14 B M.A.: 20.7 M – 22.6 B	**T: Standard Simon; Arrow task** **A:** To investigate the performance of early and late bilinguals on inhibitory control and WM tasks; sex differences in the performance of these two types of bilinguals on inhibitory control and WM tasks, and a methodological issue concerning the assessment of inhibitory control by comparing the performance of participants on two different versions of the Simon task. **MF:** Early bilinguals: younger adults outperformed older adults. There was no statistically significant difference between language groups across the lifespan. Early bilinguals presented more efficient inhibitory processes and higher WM span than monolinguals. Late bilinguals: significantly faster than monolinguals on inhibitory control tasks.

Note. Source: see data. M = monolingual; B = bilingual; M.A. = mean age; A.R. = age range.

Five out of the eight Brazilian studies reviewed here investigated bilingual populations made up of speakers of Pomeranian (Bandeira, 2010) or Hunsrückisch (Billig, 2009; Brentano, 2011; Kramer, 2011; Pinto, 2009), dialects or immigration languages (Altenhofen, 1996) brought to Brazil by German immigrants in the 19th century. Now they are recognized as Brazilian languages of German origin (Altenhofen & Frey, 2006), and exist only in spoken variety. The interest in such populations relies on the fact that some of them are samples of early bilinguals. Some of the children investigated by Bandeira (2010), for example, speak both Pomeranian and German as L1s, Portuguese (L2) at school and with neighbors who are not German immigrants, and they are also studying a third language (English) at school.

Both Pinto (2009) and Billig (2009) focused on two groups of monolingual and bilingual middle-aged and old-aged adults, while Martins (2010) focused on mono and bilingual elders only. Pinto is among the researchers who have unsuccessfully tried to replicate the results of Bialystok et al. (2004). She claims that the lack of significant differences among age and language groups might be related to the small number of participants in her study (N = 60). However, Bialystok et al. have found significant differences with even smaller numbers (N = 40 in Study 1). It is important to keep that in mind, since more will be added to this discussion in the next section. Billig, on the other hand, found an age but not a language effect. One important aspect underscored by Billig's study refers to the lack of familiarity that her sample had with computers, leading to longer RTs, which was also an issue in Martins' study, contrasting with Bialystok (2006), already discussed above.

Brentano (2011) compared a population of school-based bilinguals (students who had been in a bilingual school for at least 5 years) to home-based bilinguals and monolinguals. There were interesting results, indicating 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. Kramer's 2011 study was especially relevant concerning gender differences in a bilingual context. Never before had bilingual males and females been compared in terms of executive control functions. The findings showed no statistically significant differences between males and females, but showed that the Standard Simon task tends to favor women.

As can be seen from Tables 2 and 3, the studies on bilingualism have investigated different types of population regarding age, as well as other factors, such as early and late bilingualism, home-based and school-based bilingualism, bimodal and unimodal bilingualism,

etc., in an attempt to either replicate previous studies, or to promote new discussions on this matter.

A great deal more could be said about each of these studies in this section, but I choose to move on to the next one, and discuss more deeply all the controversial issues related to the so-called bilingual advantage. In the next section, I will take a closer look at the *bilingual inhibitory control advantage* (BICA) hypothesis, and at the *bilingual executive processing advantage* (BEPA) hypothesis.

2.7 BICA, BEPA, both or none?

My goal, since the very beginning of this report, has been to compare two language and professional groups (monolingual and bilingual businesspeople and teachers/professors) regarding inhibitory and attentional control on two nonlinguistic interference tasks (the ANT task and the Simon task). So far, I have covered most of the review of literature I intended for this thesis, but now I turn my attention to the fact that the bilingual advantage that researchers seek to find has been proven to be a rather controversial issue. Thus, before I depict the methodological procedures used and present my own findings, it is advisable to take a closer look at the latest discussions regarding the so-called bilingual advantage.

I start by introducing Hilchey and Klein's 2011 review, in which they assume that the bilingual advantage on conflict resolution (supposedly mediated by inhibitory control), as proposed by Green's IC Model (1998a), is *relatively rare*, *sporadic at best*, and even *conspicuously absent* in some cases. They claim that a bilingual advantage on the interference effect occurs only under a restricted set of conditions. After reviewing the results obtained by a large number of studies (31 experiments in total, including the ones reviewed in section 2.6, Table 2) that have used nonlinguistic interference tasks (different versions of the Simon task, Arrow task, Flanker/ANT task), they realized that bilinguals tend to show a more robust global RT advantage, rather than an advantage on the interference effect. Therefore, in order to discuss that, they have coined two acronyms, BICA and BEPA, which respectively stand for *bilingual inhibitory control advantage* hypothesis, and *bilingual executive processing advantage* hypothesis.

Let me start with BEPA. In studies presented by Bialystok et al. (2004) and by Costa et al. (2009), for example, bilinguals outperformed monolinguals on both congruent and incongruent trials, which implies monitoring and managing trial to trial variation regarding the presence or absence of conflict. According to Hilchey and Klein (2011, p. 646),

> the classic conflict-monitoring theory, proposed by Botvinick and colleagues, suggests that a particular area in the frontal lobe, the anterior cingulate cortex (ACC), detects conflict, allowing for online shifts of attentional control that are regulated by the dorsolateral prefrontal cortex, which causes trial-by-trial modulations of cognitive control over the suppression of task-irrelevant input. More specifically, when task-relevant and task-irrelevant input automatically elicit competing responses, the conflict-monitoring system detects this discrepancy, and the level of cognitive control is consequently elevated to reduce the influence of the task-irrelevant dimension on response selection. The neuroscientific understanding of the conflict-monitoring system affords an opportunity to extend cognitive theoretical constructs for behavioral phenomena to specific brain regions or centers.

Therefore, the BEPA hypothesis assumes that bilinguals enjoy 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). According to Hilchey and Klein (2011), such equivalent performance on both congruent and incongruent trials is beyond the sphere of the inhibitory control model and, up to the present moment, lacks a stable theoretical foundation. Bialystok herself had reported similar findings in her 2009 paper, pointing to the fact that bilinguals tend to perform the Simon task producing shorter RTs for both congruent and incongruent trials. She even provided examples of her own studies for all age groups: Martin-Rhee and Bialystok (2008) for children, Bialystok (2006) for young adults, and Bialystok et al. (2004) for middle-aged and older adults.

The BICA hypothesis, on the other hand, suggests that:

> frequent use of the inhibitory processes involved in language selection in bilinguals will result in more efficient inhibitory processes, which will confer general advantages on nonlinguistic interference tasks – that is, those requiring conflict resolution. These advantages will be reflected in reduced interference effects in bilinguals as compared to monolinguals. In other words, bilinguals should show an advantage over monolinguals on trials with response conflict (Hilchey & Klein, 2011, p. 628).

According to Hilchey and Klein (2011), not many experiments have found very large interference effects favoring bilinguals. Most of them have found interference effects that are very small, and sometimes there is no bilingual advantage, especially for children and young adults. Middle-aged adults and elders usually show larger interference effects, although not frequently observed. Depending on the number of trials to which middle-aged and old-aged

adults are exposed, the interference effects disappear. Thus, Hilchey and Klein question whether the number of experimental trials could account for the presence or absence of the interference effects in different age groups. As a whole, they are questioning the applicability of the IC Model (Green, 1998a) to nonlinguistic domains of inhibitory control, although they do not deny that inhibitory control processes have a role in the brain, or that they play an important part in language management. The fact is that there is little to no direct evidence that such role is special when it comes to nonlinguistic interference tasks.

Hilchey and Klein's 2011 unanswered question, whether bilinguals enjoy a task-general inhibitory control advantage (supporting BICA), or a domain-general executive functioning advantage (supporting BEPA), has generated other concerns that might go further in the discussion about the BICA/BEPA dichotomy. A very recent study by Paap and Greenberg (2013) opens up questioning the very nature of the executive processing (EP)[11] that studies using nonlinguistic interference tasks claim to assess. According to them, 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 & 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 they 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 fact, Paap and Greenberg's 2013 investigation reinforces Hilchey and Klein's 2011 conclusion that bilingualism does not have a general positive effect on inhibitory control processes, i.e., BICA (as stated by Hilchey & Klein, 2011, p. 629). Paap and Greenberg reported their own 2013 results, and also mentioned the investigations by Kousaie and

[11] According to Paap and Greenberg (2013), 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.

Phillips (2012a, b) and by Humphrey and Valian (2012), who have all used a multiple-task approach using nonlinguistic interference tasks, adding up to a total of 17 new studies that have not found a bilingual advantage, plus 1 that has found a bilingual disadvantage.

Paap and Greenberg (2013) also claim that the global RT advantage for young adults, supposedly detected ubiquitously on spatial Stroop[12] and flanker interference tasks (Hilchey & Klein, 2011), was not found in any of the 18 new tests (Humphrey & Valian, 2012; Kousaie & Phillips, 2012a; Paap & Greenberg, 2013), and that 14 of the 18 tests even showed a numerical advantage for the monolingual participants.

Table 4 is an attempt to provide the reader with an overview of the number of empirical studies (including the Brazilian ones reviewed in section 2.6, Table 3) that fall in the BICA or BEPA categories regarding the nature of the bilingual advantage, as well as to indicate the studies whose different experiments fall in both categories, and the ones that have not found any bilingual advantage.

[12] 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).

Table 4: The nature of the bilingual advantage in studies with nonlinguistic interference tasks

	STUDIES			
	CHILDREN	**YOUNG ADULTS**	**MIDDLE-AGED**	**ELDERS**
BICA		Finger et al. (2011)		
BEPA	Bialystok et al. (2005) – Exp. 1 and 2 Morton & Harper (2007) – 50% C Simon task* Martin-Rhee & Bialystok (2008)	Bialystok, Craik et al. (2005) Bialystok et al. (2005) Bialystok (2006) – high-switch Arrow task* Bialystok et al. (2008) Costa et al. (2009) – Exp. 2* Bialystok & DePape (2009) Luk et al. (2010)	Emmorey et al. (2009)	
Both	Bandeira (2010)	Costa et al. (2008)	Bialystok et al. (2004) – Studies 1 and 2	Bialystok et al. (2004) – Studies 1 and 2
None	Carlson & Meltzoff (2008) Brentano (2011)	Billig (2009) Kramer (2011) Humphrey & Valian (2012) Kousaie & Phillips (2012a) Paap & Greenberg (2013)	Pinto (2009) Kramer (2011)	Bialystok et al. (2008) Pinto (2009) Billig (2009) Martins (2010) Kramer (2011)

Note. Source: see data. C = congruent; Exp. = experiment; BICA = bilingual inhibitory control advantage; BEPA = bilingual executive processing advantage.
*There were more experiments or conditions in the same study, but the bilingual advantage was found only in this one.

Closing up, Paap and Greenberg (2013) propose two possible explanations for the difficulty in replicating significant bilingual advantages. The first suggests that reports of the bilingual advantage are scattered across various tasks, which measure different components of EP, and also test different kinds of bilinguals. The second attributes the performance advantages to factors other than bilingualism enhancing EP, such as hidden demographic factors that were not matched, or other factors that may reflect task-specific performance differences on measures that lack convergent validity. However, Paap and Greenberg (p. 255) claim that:

> the evidence points in the direction of no genuine bilingual advantage in EP. But, we are open to new and compelling evidence that follows the protocol for the following hypothetical study: (1) identify the specific component(s) of executive processing that should be enhanced by managing two

> languages, (2) show a bilingual advantage in an indicator of that component across two different tasks, (3) show that the indicators correlate with one another and have some degree of convergent validity, (4) show no differences between the two groups on a pure block of easy choice-RT trials, (5) match the groups on SES and (6) minimize cultural differences between the groups.

Having considered the contributions provided by both Hilchey and Klein's 2011 and Paap and Greenberg's 2013 studies, I agree that the research on the bilingual advantage does lack a more thorough investigation. The protocol proposed above by Paap and Greenberg seems to account for all the controversial issues that have come up in the last years concerning the so-called bilingual advantage, and should be taken into account by researchers in future studies.

I close this section and chapter by summarizing my path up to the present moment. I began this review of literature talking about DST and its relation to cognition, language and L2 acquisition. I then discussed the different concepts of bi/multilingualism along history, and also listed the cognitive differences between bi/multilinguals and monolinguals already found by previous empirical studies. Next, I presented and discussed two opposing models regarding how bilinguals select what language to use in speech production. I also talked about the three-network model of attention. I ended this chapter reviewing empirical studies carried out both abroad and in Brazil on the bilingual advantage in nonlinguistic interference tasks, and discussing their strengths, weaknesses and controversial issues in search for an explanation of the so-called bilingual advantage.

Now I can move on to chapter 3, which presents the method used in this study, followed by chapter 4, which describes and discusses the results.

3 METHOD

This chapter, organized in 4 main sections, describes in detail the method used in the present study. In section 3.1, I introduce the general objective, and in section 3.2 the specific objectives drawn from the general one. In section 3.3, I present the research questions. Section 3.4 describes the methodological procedures and is subdivided into 5 subsections: 3.4.1 describes the ethical aspects; 3.4.2 describes the participants; 3.4.3 presents the sample selection instruments, followed by the data collection instruments in 3.4.4; and finally, subsection 3.4.5 describes the statistical procedures adopted in this study.

3.1 General objective

My main goal in this study was to replicate some of the experiments conducted previously with other populations of bilingual and monolingual individuals regarding inhibitory and attentional control in two nonlinguistic interference tasks. For that, I chose a population made up of middle-aged businesspeople. The purpose of focusing on such population was twofold, aiming at two different factors: 1) age; and 2) profession. Concerning age, I perceived that there are not enough studies on the effects of bilingualism on middle-aged adults regarding these EFs, as compared to the number of studies and findings on the bilingual advantage among the other age groups. Regarding profession, I believe businesspeople to be naturally faced with strong cognitive demands on a daily basis. They constantly have to negotiate and make online administrative and financial decisions that involve a lot of responsibility and a lot of people, regardless of product or service being sold or offered by the company. However, making such fast and important decisions can have a huge negative impact on the company, if not carefully thought. Thus, in order to fulfill such a task, they need to be not only problem solvers, but also multi-tasking, being able to manage a lot of pressure regarding deadlines, the accomplishment of goals and financial results. They are also people who might have to travel a lot, and that means being exposed to different contexts, countries and consequently different cultures. Regarding inhibitory control, they are required to be extremely objective when it comes to critical decisions, and for that they have to be able to focus on the tasks and problems and ignore distracting stimuli, not allowing themselves to be influenced by minor issues that are not urgent. Thus, their problem solving, multi-tasking and inhibitory control skills are constantly required. As a result, the cognitive demands of their professional activity could act as a natural competitor with bilingualism in

strengthening these EFs. If this is so, this particular population will not present any differences (indicating that profession could be a competing variable with bilingualism). For this reason, I decided to include a control group, consisting of an equivalent population in terms of age and bi(mono)lingualism, but with a different professional activity (teachers/professors). The choice for teachers/professors was made given the cognitive demands of their professional activity, which I believe to be different regarding problem solving, multi-tasking and inhibitory control, and consequently less demanding when compared to the ones faced by businesspeople. Thus, I expect bilingual teachers/professors to outperform their monolingual counterparts, so that such differences could be assigned to bilingualism only.

3.2 Specific objectives

From the general objective I have established 4 specific ones:

1. to compare the performance of bi/multilingual and monolingual businesspeople in the ANT task (Fan et al., 2002) regarding the three attentional networks – the alerting, orienting and executive control networks;
2. to compare the performance of bi/multilingual and monolingual businesspeople in the Simon task (Simon, 1969) regarding inhibitory control and attention;
3. to compare the performance of bi/multilingual and monolingual teachers/professors in the Simon task (Simon, 1969) in terms of inhibitory control and attention;
4. to check if the results obtained by both bilingual professional groups in the Simon task, as well as the ones of the bilingual businesspeople in the ANT task, support the BICA (*bilingual inhibitory control advantage*) and BEPA (*bilingual executive processing advantage*) hypotheses.

3.3 Research questions

For each of the specific objectives above, I have established the following research questions:

1. will bi/multilingual businesspeople suffer less interference from incongruent flankers, resulting in a smaller Conflict effect, profit more from the alerting cues (Alerting effect) and from the orienting cues (Orienting effect) than their monolingual counterparts in the ANT task?

2. will bi/multilingual businesspeople present significantly faster RTs in the Simon task, especially in incongruent trials, as well as significantly smaller Simon effects than their monolingual counterparts?
3. will bi/multilingual teachers/professors present significantly faster RTs in the Simon task, especially in incongruent trials, as well as significantly smaller Simon effects than their monolingual counterparts?
4. will the results obtained by both bilingual professional groups point to BICA (*bilingual inhibitory control advantage*), to BEPA (*bilingual executive processing advantage*), or none of the two hypotheses will be supported?

3.4 Methodological procedures

3.4.1 Ethical procedures

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

3.4.2 Participants

For this research, I have selected two groups of participants: 1) 20 bi/multilingual and 20 monolingual businesspeople; 2) 19 bi/multilingual and 19 monolingual teachers/professors. All the businesspeople occupy executive positions such as directors or managers in different kinds of companies in Porto Alegre, Canoas, São Leopoldo, Portão, Pelotas and Rio Grande, while the teachers/professors work at schools or universities in Pelotas and Rio Grande. All the cities are located in Rio Grande do Sul, Brazil. As can be seen in Table 5, there were approximately the same number of males in each professional and language groups as well as approximately the same number of females in each group. However, there were a lot more men than women, and that is due to the fact that I started collecting data among businesspeople, and came to realize that direction and management positions in Brazil are still mostly occupied by men. Thus, while collecting data among teachers/professors, I had to make sure to keep a similar percentage of men and women that I had in the other professional group.

The participants were also matched in age and 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.

The participants were controlled regarding video game use, but all of them are very familiar with computers, due to their professional activities. No instruments were used to measure SES, but it was assumed to be equivalent among participants, considering their level of education and jobs. No reward was offered to them, besides the opportunity to be part of an experiment which would investigate not only the cognitive differences resulting from the use of a second and maybe a third language on a regular basis, but also the possible cognitive effects as a consequence of their type of professional activity. As a matter of fact, the bilinguals 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, at home with family members or friends. For a detailed description of the participants, see Table 5.

Table 5: Description of the participants

	BUSINESSPEOPLE (n = 40)		**TEACHERS/PROFESSORS (n = 38)**	
	MONOLINGUAL	BI/MULTILINGUAL	MONOLINGUAL	BI/MULTILINGUAL
MEASURE	(n = 20)	(n = 20)	(n = 19)	(n = 19)
MALE	15	16	13	14
FEMALE	5	4	6	5
AGE RANGE	38-55	36-58	37-58	36-58
MEAN AGE	47.2	48.1	46.2	46.6
SCHOOLING (in years)	18.6	18.4	22.2	19.3
L1	BP	BP (18) – German/Pomeranian (1) – Italian (1)	BP	BP (16) – German/Pomeranian (2) – EP (1)
L2	-	English (15) – BP (2) – Spanish (3)	-	English (14) – BP (3) – Spanish (1) – Italian (1)
L3	-	Spanish (4) – English (3) – German (1)	-	Spanish (2) – English (4) – Italian (1)
SIMON TASK	X	X	X	X
ANT TASK	X	X	-	-

Note. Source: see data. n = number of participants. BP = Brazilian Portuguese; EP = European Portuguese.

Now that I have described the participants, I move on to the sample selection instruments, followed by the data collection instruments and the description of the statistical analysis.

3.4.3 Sample selection instruments and procedures

Most participants were first contacted via e-mail, phone or through a go-between, who could be a secretary, a psychologist or a Human Resources manager of the company, school or university, who would arrange for a meeting to happen, and were interviewed and tested at their work places, while some were contacted personally and interviewed at home.

The initial idea was to focus only on businesspeople, and a major difficulty was to find the minimum number of bi/multilingual and monolingual directors and managers who would

be willing and available to participate in this study. Sometimes the first challenge was to establish contact with the companies, and the second one was to convince people to find about two hours of their working day for the whole process of data collection, which could be eventually divided into two or three different meetings, either very early in the morning or at the end of the day. Regardless of daytime, they were always very busy and anxious to go back to their duties.

In order to interview and test the necessary number of businesspeople, I had to travel to different cities in Rio Grande do Sul and look for professionals in different types of companies. Another difficulty was to find people in the age range previously established. In some companies, the directors and managers were in their early thirties and that led to a pilot project, which was carried out after the data collection with all the businesspeople had been completed. The pilot project included 24 younger businesspeople (12 monolinguals and 12 bi/multilinguals) (age range 30-49). The results obtained motivated the inclusion of a control group with similar characteristics but a different professional activity. That was when the teachers/professors were included in the study. Because this decision was taken in November (three months before the deadline), there was not enough time to apply all the cognitive tasks to the control group, so only the Simon task was administered.

The next two subsections describe the instruments and the procedures used to select the participants of this study.

3.4.3.1 Free and informed consent form

I started by explaining what the study was about and the participants were asked to sign a free and informed consent form (see Appendix A), agreeing to be part of the experiment.

3.4.3.2 Interview

After signing the free and informed consent form, an interview was carried out. The interview was divided into two parts, and participants had to answer question by question orally. The first part was a screening questionnaire (see Appendix B) (Zimmer & Bonini, 2009), containing questions about the participants' personal information such as handedness, level of education, history of health problems and medicine use, as well as brief information about their L1, L2 and L3. Participants who were 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.

The second part of the interview was a linguistic background questionnaire (see Appendix C) (Zimmer & Bonini, 2009). It contained 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. This questionnaire was the instrument that allowed me to classify the participants as monolinguals or bi/multilinguals.

It is important to underscore that a proficiency test was not administered to the bi/multilingual participants because my understanding of bilingualism was based on the actual use of the languages, and proficiency tests tend to present an academic bias stemming from high proficiency written skills which are not operational variables in this study.

3.4.4 Data collection instruments

From now on I describe the design of the two data collection instruments performed by the participants, the ANT task, performed only by the bilingual and monolingual businesspeople, and the Simon task, performed by both professional groups. The order in which the tasks were applied to the businesspeople groups was not counterbalanced among the participants: the Simon task was applied first, followed by the ANT. However, for organizational reasons, the results of the tasks performed by the businesspeople are presented, in chapter 4, in the following order, ANT task, and then Simon task, followed by the results of the Simon task performed by the teachers/professors groups.

It is important to highlight the similarities and differences between the ANT task and the Simon task. Both of them involve a common component of the executive control network (inhibitory control), lead to the activation of two conflicting representations associated with two different responses, and also allow for assessing monitoring processes (they include congruent and incongruent trials). However, in the Simon task, participants have to hold the stimulus-response rule in WM (different colors refer to different keys), and they are supposed to respond according to the stimulus-response rule (colors and keys), and not according to location (central or lateral). In the ANT, however, both flankers and target elicit the same response type, and both dimensions have the same format (arrows) (Costa et al., 2008).

In order to do such experiments, participants were placed in a quiet room where they could concentrate and focus only on the task(s). The data was collected with a 10" netbook, containing Windows XP and the software E-prime 1.2.

3.4.4.1 Attentional Network Task (ANT)

The ANT was developed by Fan et al. (2002). It combines a cue reaction time task (Posner, 1980) and a flanker task (Eriksen & Eriksen, 1974). With the ANT, it is possible to assess the three attentional networks: the executive control, alerting and orienting networks. According to Costa et al. (2008, p. 65), this task "is especially appropriate to assess potential differences between monolinguals and bilinguals, since it relies minimally on linguistic and memory processes that may interact with bilingualism", and its multidimensionality allows drawing a set of interesting predictions in terms of the potential conditions that may be affected by bilingualism.

Participants are instructed to press the right button of the mouse[13] with their right hand if a central arrow points to the right (→), and press the left button of the mouse with their left hand if it points to the left (←). This must be done as quickly and accurately as possible, since level of accuracy and RTs are measured.

The central arrow is presented below or above a fixation point (+) with two flanker arrows pointing to the same (→→→→→) or different (←←→←←) direction than the target arrow (see Figure 4b). There is also a neutral condition (−−→−−). If they point to the same direction it is a congruent trial, if not, it is an incongruent one. Responses are usually slower for incongruent trials than for congruent ones, reflecting the time required to resolve the conflict between the target stimulus and the flanker information which must be ignored. This allows one to assess the executive control network.

In order to assess the alerting network, a cue in the form of an asterisk (*) is presented before the target stimulus. Responses tend to be faster if the target is preceded by an alerting cue. For the orienting network to be explored, the cue is presented (*) to signal the position in the screen where the target stimulus will appear. Again, responses tend to be faster when there is a cue signaling where the target will appear, below or above the fixation point (see Figure 4a).

[13] The mouse was located at the frontal part of the computer keyboard, in a fixed position, allowing for stability of movements.

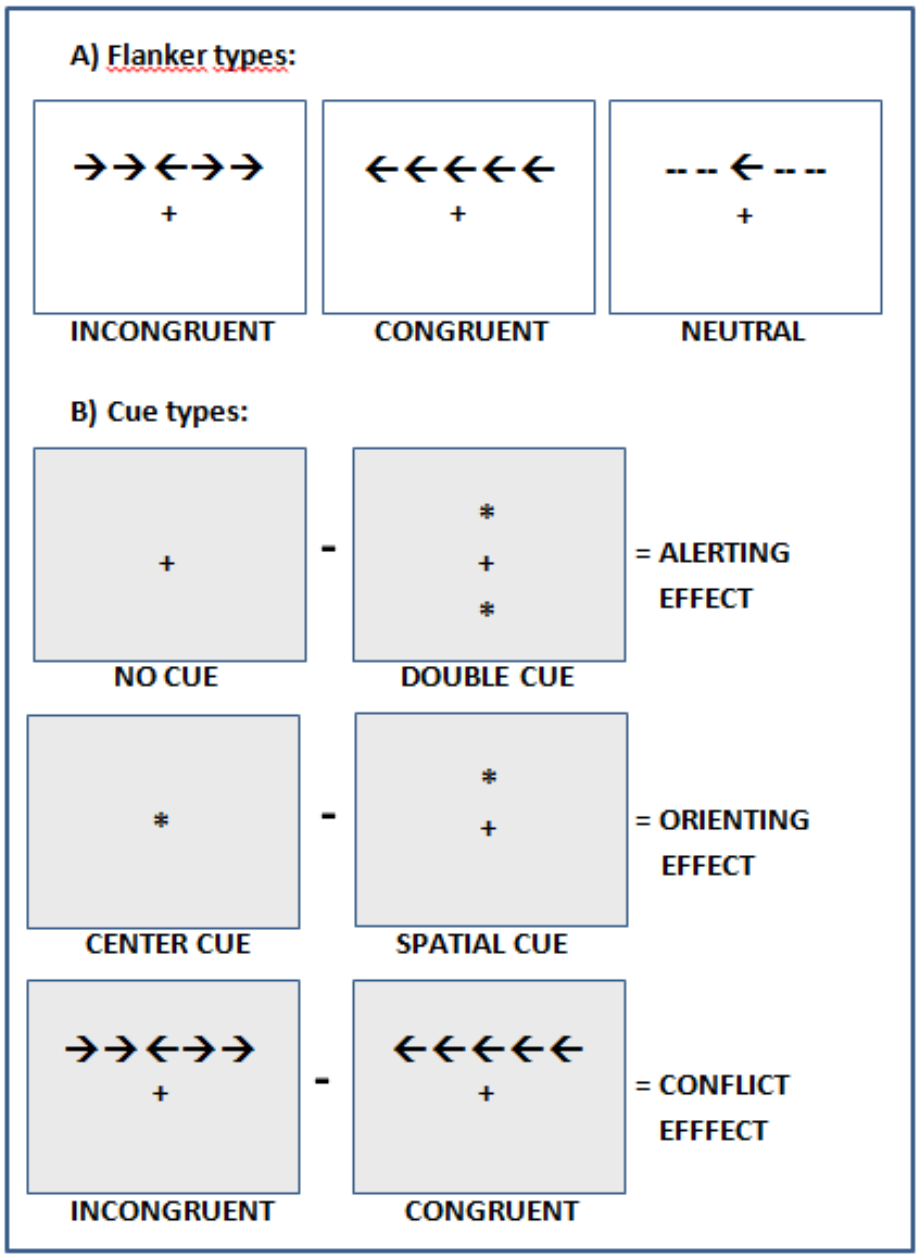

Figure 4: The Attentional Network Task (ANT): experimental design: (a) Flanker types; (b) Cue types

The actual experiment was preceded by a set of 24 practice trials (about 2 min). Then, participants did three experimental blocks of trials presented in random order (5 min each). There were two within factors: ‘‘Cue Type’’ (no cue, center cue, double cue and spatial cue), and ‘‘Flanker Type’’ (neutral, congruent and incongruent). The crossing of these values resulted in 12 experimental conditions. Each condition was represented by 8 trials in each block, leading to a total of 96 trials per block. Participants were instructed to rest between blocks.

The event presentation was as follows: (a) the fixation point (+) appeared in the center of the screen for 400 ms; (b) a cue (∗) was presented for 100 ms; (c) there was a fixation period for 400 ms after the cue; (d) the target arrow and the flankers were presented simultaneously until participant's response or up to 1700 ms; (f) the target and flankers disappeared after response and the next trial began. The fixation cross appeared at the center of the screen during the whole trial.

3.4.4.2 Simon task

The Simon task (Simon, 1969) was initially developed by Simon and Wolf (1963). Nowadays it is a task that can measure the effects of the EFs inhibitory control and attention, aspects of processing which decline with aging. According to Bialystok et al. (2005, p. 107), it is "simple enough for participants of all ages to solve, and adjusting some of the experimental parameters, for example making the trial sequences run faster or slower, allows the task to be adapted to different age groups". 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).

The design is as follows: what the participants see on the screen is a sequence of stimuli in the shape of colored rectangles (brown, blue, yellow, pink, green and red) that are 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 key that is the correct response for that color is on the same side as the stimulus, while on incongruent trials, the correct response key is on the opposite side. 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 four conditions was then repeated in the reverse order, producing 48 trials for each of the four conditions. Each of the conditions was preceded by a set of practice trials, four for the 2-color conditions and eight for the 4-color conditions. Practice trials and test trials had identical parameters. Participants had to complete all practice trials correctly to move on to test trials, if not, the program recycled until all trials were completed successfully.

The first condition presented 2 colors in a center position, serving as a control condition (see Figure 5). A series of brown or blue rectangles appeared in the middle of the screen. Participants were instructed to press 1 when they saw a blue rectangle and 0 when they saw a brown rectangle. The trial began with a sound (a computer "bing") and a fixation cross (+) that appeared in the center of the screen for 300 ms. Immediately after this cue, the stimulus appeared and remained on the screen until a response was made. The response clock started at the onset of the stimulus. The fixation cross and the sound reappeared 500 ms after the response to signal the next trial.

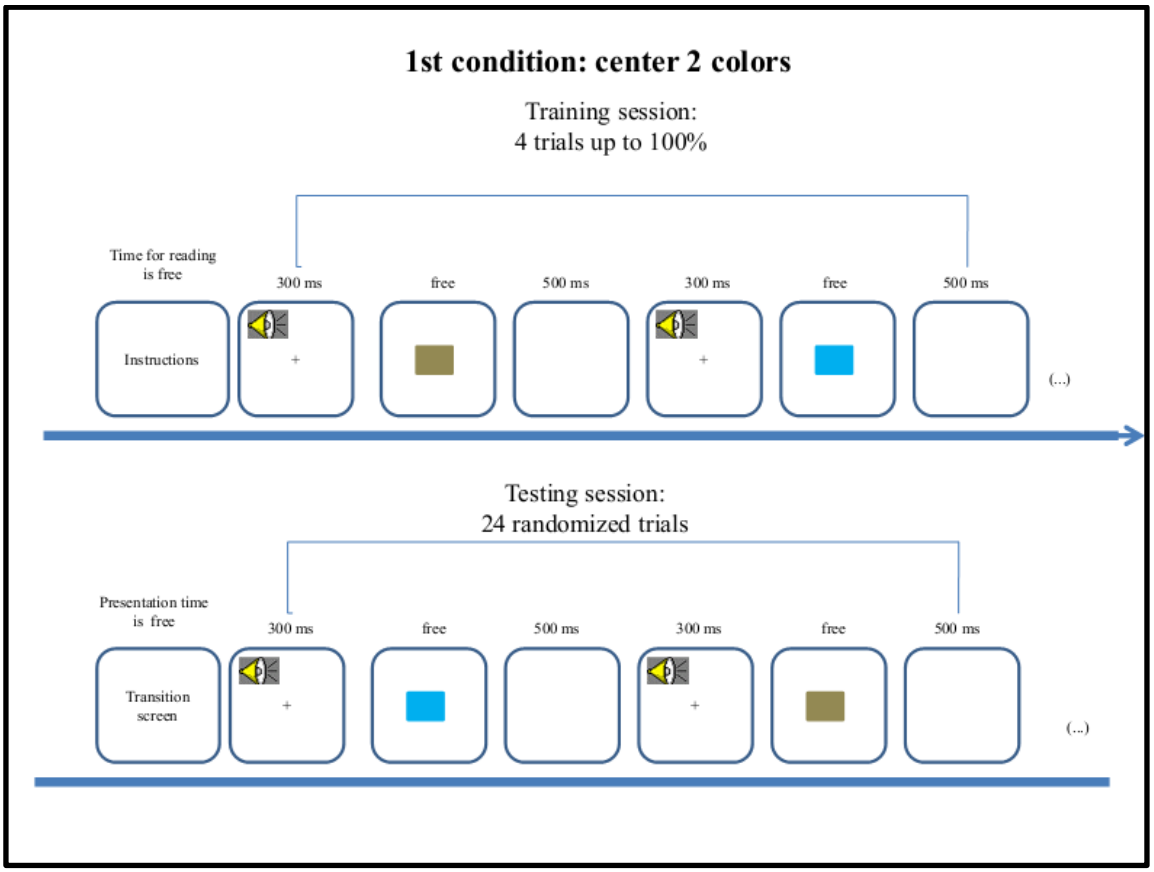

Figure 5: Experimental design of the first condition in the Simon Task.
Source: translated from Martins and Zimmer (2009).

The second condition presented 2 colors in lateral positions (see Figure 6). The parameters were the same as those in the control condition, but the blue and brown rectangles appeared on either the left or the right side of the screen. The order of trials was randomized and divided equally between congruent and incongruent items.

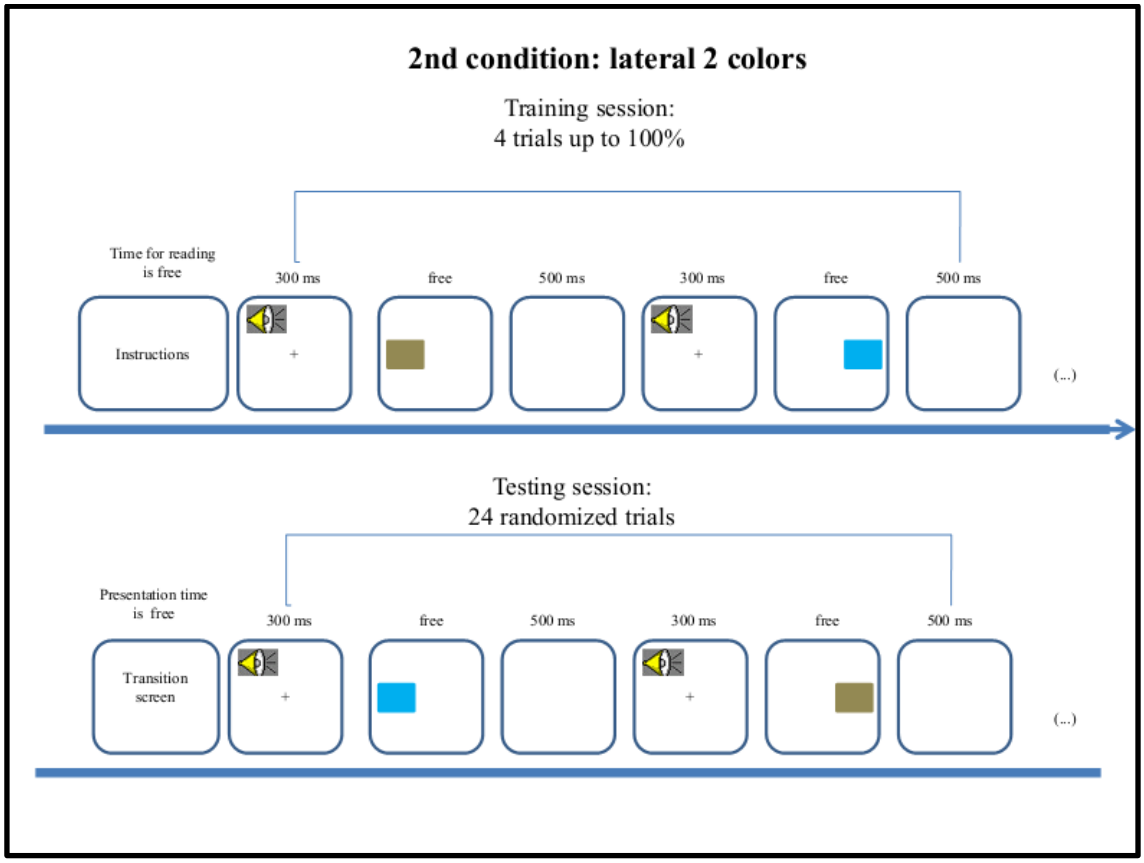

Figure 6: Experimental design of the second condition in the Simon Task.
Source: translated from Martins and Zimmer (2009).

The third condition presented 4 colors in a center position (see Figure 7). This condition was similar to the control condition, but this time participants had to choose from four colors: green, red, pink or yellow. Participants were instructed to press 1 for a green rectangle, 0 for a red rectangle, 1 for a pink rectangle and 0 for a yellow rectangle.

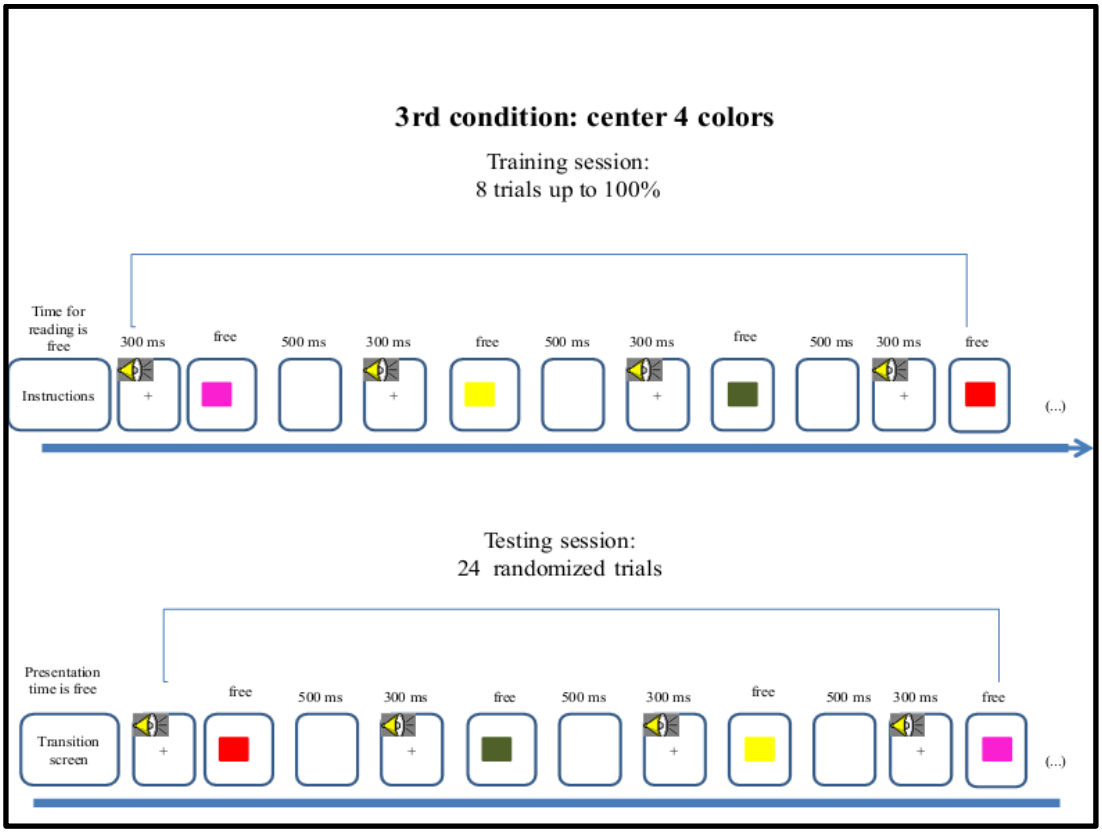

Figure 7: Experimental design of the third condition in the Simon Task.

Source: translated from Martins and Zimmer (2009).

The fourth condition presented 4 colors in lateral positions (see Figure 8). In this condition, the stimuli were the same four colors, but they appeared on either the left or the right side of the screen. The order of trials was randomized and again divided equally between congruent and incongruent items.

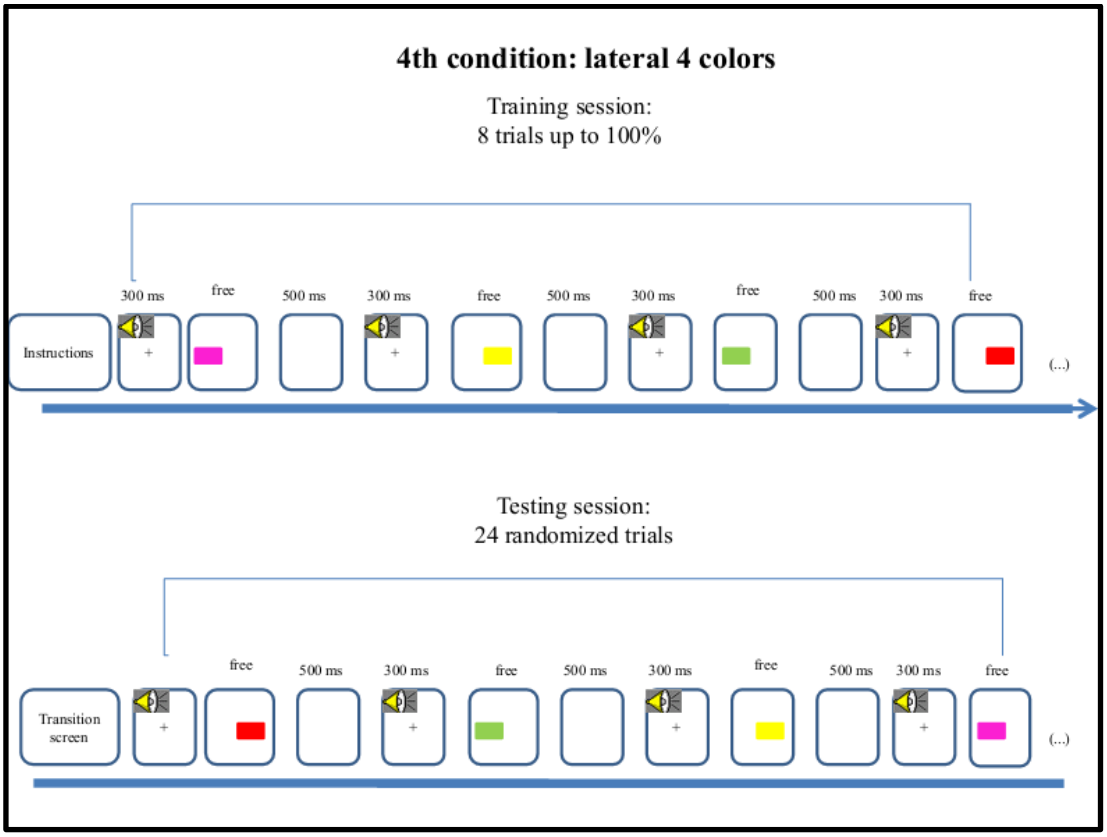

Figure 8: Experimental design of the four condition in the Simon Task.

Source: translated from Martins and Zimmer (2009).

In the Simon task, it is possible to calculate the Simon effect. 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". In other words, it is "the increased time needed to respond to the incongruent items" (Bialystok et al., 2004, p. 291). It is obtained 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. However, in face of negative results, one could also claim that the Simon effect is null, once there is no increased time needed to respond to the incongruent trials, i.e., no interference effect.

I move on now to describing the statistical procedures used to deal with the collected data.

3.4.5 Statistical analysis

The participants performed two cognitive tasks, the ANT task (Fan et al., 2002), and the Simon task (Simon, 1969). “RT” and level of “accuracy” were taken as dependent variables, and “language group” (monolingual or bilingual) was taken as an independent variable.

The first step in the statistical analysis was to eliminate outliers (trials that presented anomalously high or low values). Then, in order to choose the appropriate statistical tests, I contrasted the normality hypothesis for all the pairs of samples with the Shapiro-Wilk and the Kolmogorov-Smirnov tests. Since I was dealing with independent factors, I also used the Levene test to see the homogeneity of variance. Results showed that some of the variables did not show normality or homogeneity and could only be measured by non-parametric tests such as Mann-Whitney tests, while other variables could be measured by Independent Samples t-tests. Since I was dealing with second language research, I used a p-value below 0.05 as a cut-off point for all the statistical tests.

Now I move on to chapter 4, which aims at describing and discussing the results obtained in this study.

4 DATA ANALYSIS AND DISCUSSION OF FINDINGS

This chapter describes and discusses in detail the results obtained in this study, and is organized in four sections, according to each of the objectives and research questions previously established: section 4.1 presents the results of the ANT task, which was performed only by the businesspeople groups; section 4.2 introduces the results of the Simon task performed by the businesspeople groups, while section 4.3 introduces the results of the Simon task performed by the teachers/professors groups. Finally, in section 4.4, I check if the results obtained by both bilingual professional groups in the Simon task, as well as the ones of the bilingual businesspeople in the ANT task, support the BICA (*bilingual inhibitory control advantage*) and BEPA (*bilingual executive processing advantage*) hypotheses.

4.1 Results – first objective

As mentioned in section 3.3, the first objective was to compare the performance of bi/multilingual and monolingual businesspeople in the ANT task regarding the three attentional networks (alerting, orienting and executive control networks).

4.1.1 Descriptive statistics

The mean RTs (ms) for the correct trials and error rates (%) in each of the ANT conditions are presented in Table 6. The error rates (see Table 6b) ranged from 0% to 4% – bilinguals (1%) and monolinguals (2%) – for which Mann-Whitney tests were run, revealing no significant statistical differences between the businesspeople groups. Bilinguals were overall faster than monolinguals in all the 12 experimental conditions, including the neutral conditions which are not presented in Table 6. Mann-Whitney tests were run for two RT scores: the spatial cue congruent condition, which found no differences between the groups, and the double cue incongruent condition, revealing significant statistical differences favoring bilinguals ($Z = -2.27$, $p = .02$) (see Table 6a). All the other RT scores were examined with Independent Samples t-tests, but no differences were found between bilinguals and monolinguals.

Table 6: Mean Reaction Times (ms) (a) and Error Rates (%) (b) for the ANT Task Broken for Flanker Type and Cue Type

	Flanker						
	Congruent		Incongruent		CONFLICT EFFECT		
	Bil (SD)	Mon (SD)	Bil (SD)	Mon (SD)	Bil	Mon	Δ Bil-Mon
(a) Cue							
None	595 (85)	621 (69)	699 (119)	742 (74)	104	121	17
Double	549 (77)	571 (55)	668* (110)	725 (60)	119	154	35
Center	572 (96)	593 (66)	682 (118)	744 (86)	110	151	41
Spatial	511 (76)	538 (70)	591 (107)	654 (93)	80	116	36
ALLERTING EFFECT	46	50	31	17			
Δ Bil-Mon		4		14			
ORIENTING EFFECT	61	55	91	90			
Δ Bil-Mon		6		1			
(b) Cue							
None	0.01 (0.02)	0.01 (0.02)	0.02 (0.03)	0.03 (0.04)	0.01	0.02	0.01
Double	0.00 (0.01)	0.00 (0.01)	0.02 (0.03)	0.04 (0.04)	0.02	0.04	0.02
Center	0.01 (0.02)	0.01 (0.02)	0.02 (0.03)	0.04 (0.07)	0.01	0.03	0.02
Spatial	0.00 (0.01)	0.01 (0.02)	0.02 (0.03)	0.02 (0.05)	0.02	0.01	0.01
ALLERTING EFFECT	0.01	0.01	0	-0.01			
Δ Bil-Mon		0		-0.01			
ORIENTING EFFECT	0.01	0	0	0.02			
Δ Bil-Mon		0.01		0.02			

Note. Source: Study data. SD = Standard Deviation. *Significant differences ($p < .05$).

Both bilingual and monolingual participants had higher scores in all the incongruent conditions, resulting in positive scores for Conflict effects (incongruent trials vs. congruent trials) for both groups, revealing the expected difficulty to respond to trials with incongruent flankers. Even though bilinguals (103 ms, *SD* = 47.30) suffered less interference than monolinguals (135 ms, *SD* = 72.48) in terms of Conflict effect (Figure 9), a Mann-Whitney test revealed no significant statistical differences between the groups.

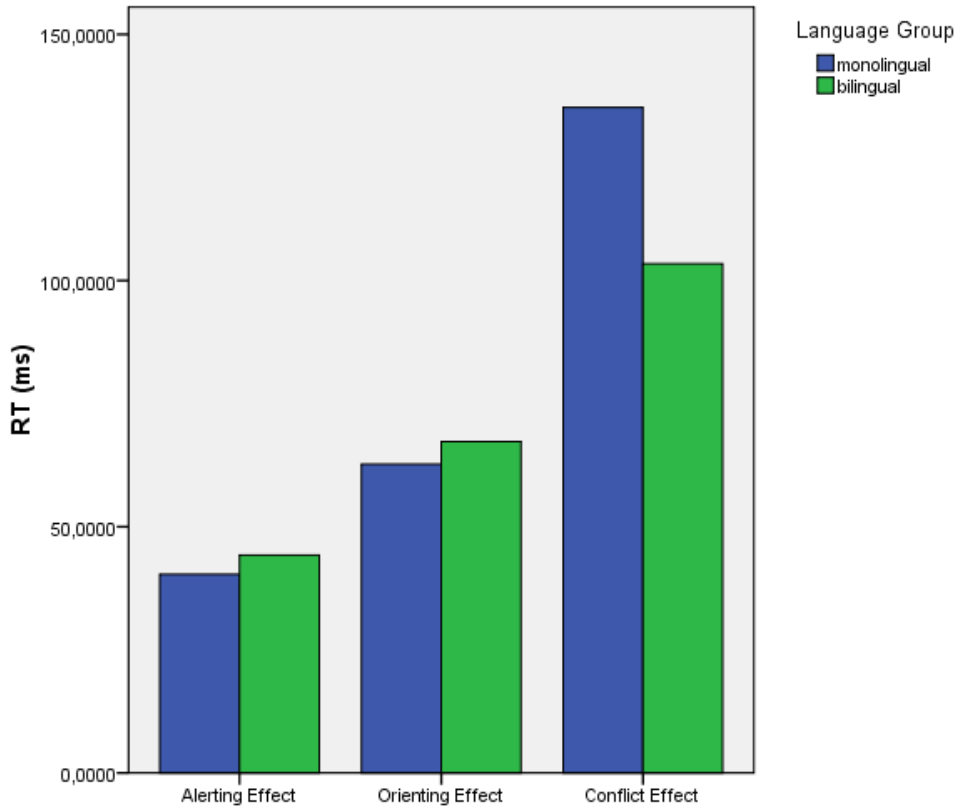

Figure 9: Magnitude of the three effects (ms) broken by language groups.

Concerning the Alerting effect, bilinguals (44.25 ms, *SD* = 26.00) benefited more from the alerting cues than their monolingual counterparts (40.37 ms, *SD* = 27.60), as can be seen in Figure 9. Finally, regarding the Orienting effect, bilinguals also (67.32 ms, *SD* = 28.33) benefited more from the orienting cues than their monolingual counterparts (62.74 ms, *SD* = 28.53). However, Independent Samples t-tests revealed no significant differences between the groups.

4.1.2 Discussion

In section 3.3, I established the research questions, and I wondered whether bi/multilingual businesspeople would suffer less interference from incongruent flankers (Conflict effect) and profit more from the alerting cues (Alerting effect) and orienting cues (Orienting effect) than their monolingual counterparts. The results showed that, as expected, incongruent trials were more difficult than congruent ones, resulting in longer RTs for both bilinguals and monolinguals. The same happened to both groups concerning alerting and orienting cues: trials offering no cues were more difficult than the ones offering double cues;

and trials offering center cues were more difficult than the ones offering spatial cues. However, the results of the three effects measured by the ANT task revealed that bilinguals did outperform monolinguals, but no significant statistical differences were found between the groups regarding the three attentional networks, thus the answer to the first research question is no.

Concerning the three effects measured, it is important to underscore that no study has ever reported a bilingual advantage on the Orienting effect, regardless of age group. However, in Costa et al. (2008), who investigated a population of young adults, a bilingual advantage was found for both Conflict effect (in Blocks 1 and 2), and Alerting effect (in all 3 blocks). The same age group was also investigated in Costa et al. (2009), but no bilingual advantage was found for the Alerting effect. The only bilingual advantage found was for Conflict effect, but it was restricted to Block 1 of the 75% congruent version. On this matter, it is important to highlight that Costa et al. (2008) and Costa et al. (2009) used different percentages of congruent trials. Costa et al.'s 2008 experiment was divided equally between neutral, congruent and incongruent trials (which was replicated in the present study). However, Costa et al.'s 2009 two experiments were divided as follows: the first one used two low-monitoring versions (92% and 8% congruent trials), while the second one used two high-monitoring versions (50% and 75% congruent trials). Such differences in number of congruent trials, also pointed out by Hilchey and Klein (2011), could serve as an explanation for the inconsistency of results found between these two studies, which focused on the same age group and similar bilinguals (early and highly-proficient), but the authors themselves claim they still cannot explain their own contrasting results (Costa et al., 2009, Appendix C).

Concerning other age groups, the study by Carlson and Meltzoff (2008), which used the children's version of the ANT task (plus a battery of other tests), assessed only the executive control network (alerting and orienting were not included in the design), but RTs for the ANT task results are not provided by the authors, thus it is not possible to assume a bilingual advantage regarding such effect in this particular study and age group.

So far, I know of no study using the ANT task that has included middle-aged adults as participants with the format and purposes adopted here. My investigation with middle-aged businesspeople did not find a bilingual advantage regarding any of the three attentional networks (alerting, orienting or executive control), although I used the same high-monitoring version as Costa et al. (2008). It is important to underscore that, due to methodological constraints, I did not compare the performance in RTs taking into consideration the variable "Block", which was one of the limitations of my study.

Differently from my study, Costa et al. (2008) and Costa et al. (2009) found not only a bilingual advantage in some attentional networks, as described above, but also a bilingual advantage in overall RTs. However, due to the different percentages of congruent trials, Costa et al. (2009) only found a significant bilingual advantage in overall RTs in Experiment 2, throughout the 50% congruent version, and only in Block 1 of the 75% congruent version. As suggested by Costa et al. (2009, p. 141), such results "cannot be attributed merely to a more efficient conflict resolution processing, given that no conflict resolution is required when dealing with congruent stimuli (target and flankers call for the same response)". In the presence of overall RTs favoring bilinguals, one can assume a more efficient monitoring system that is aided by bilingualism, and which is required in the case of high-monitoring demands, such as in the case of Costa et al. (2008). Although I used the same percentage of congruent trials as Costa et al. (2008), the middle-aged bilingual businesspeople of my study did not significantly outperform their monolingual counterparts in either congruent or incongruent trials.

In sum, when choosing to investigate businesspeople, I wondered whether the cognitive demands of their professional activity would be a natural competitor with bilingualism in strengthening EFs such as their attentional networks (with an inhibitory control component). So far, that seems to be the case, since they presented no bilingual advantage whatsoever in the ANT task.

4.2 Results – second objective

The second objective was to compare the performance of bi/multilingual and monolingual businesspeople in the Simon task regarding inhibitory control and attention.

4.2.1 Descriptive statistics

The mean RTs for the correct trials and accuracy scores in each of the Simon conditions are presented in Table 7. Mann-Whitney tests[14] were run for all the accuracy scores, revealing no significant statistical differences between the groups in most conditions, since both language groups made very few errors in all four conditions, with the mean

[14] Having compared the businesspeople to the teachers/professors using a One-Way ANOVA with a Bonferroni adjustment, I found no significant differences between the professional and language groups in the Simon task. Thus, I decided to run Mann-Whitney and Independent Samples t-tests in order to present the results of both professional groups separately: the businesspeople in section 4.2 and the control group in section 4.3.

percentage of errors ranging from 0% to 4% – bilinguals (2%) and monolinguals (1%). The only significant statistical difference in terms of accuracy was the lateral congruent 2-color condition, in which monolinguals outperformed bilinguals (Z = -2.12, p = .03) (see Table 7).

Table 7: Mean Reaction Times (ms) and Accuracy (%) for Simon Task by Language Groups – Businesspeople

				Side				
Language Groups	Colors	Center (SD)	ACC (SD)	Congruent (SD)	ACC (SD)	Incongruent (SD)	ACC (SD)	Simon effect
Monolingual								
(20)	2	570.67 (105.47)	0.99 (0.02)	648.04 (108.94)	0.98* (0.05)	578.85 (106.72)	1.00 (0.01)	-69.18
	4	711.47 (174.72)	0.98 (0.04)	698.77 (160.12)	0.99 (0.02)	669.76 (118.64)	1.00 (0.01)	-29.01
Bilingual								
(20)	2	517.44 (130.55)	0.98 (0.04)	571.57* (128.82)	0.96 (0.05)	533.90 (113.69)	0.99 (0.04)	-37.67
	4	622.20* (159.64)	0.97 (0.04)	634.13 (129.10)	0.96 (0.05)	630.20 (157.08)	0.99 (0.02)	-3.93

Note. Source: Study data. SD = Standard Deviation. ACC = Accuracy. *Significant differences (p < .05).

The RTs for the center 2-color and 4-color conditions, and the lateral congruent 2-color and 4-color conditions were also examined with Mann-Whitney tests. Significant statistical differences were found in the center 4-color condition, favoring bilinguals (Z = -2.07, p = .04), and in the lateral congruent 2-color condition, also favoring bilinguals (Z = -2.58, p = .01). The RT scores for the lateral incongruent 2-color and 4-color conditions were examined with Independent Samples t-tests, but no significant statistical differences were found.

Regarding the Simon effect (also shown in Table 7), which is "the increased time needed to respond to the incongruent items" (Bialystok et al., 2004, p. 291), no significant statistical differences were found, as revealed by an Independent Samples t-test for the 2-color Simon effect, and by a Mann-Whitney test for the 4-color Simon effect. As a matter of fact, both bilingual and monolingual businesspeople had faster RTs in incongruent trials than in congruent ones, resulting in negative scores for the Simon effects for both groups in the 2-

and 4-color conditions, thus revealing no interference effects, once there was no increased time to respond to the incongruent trials.

4.2.2 Discussion

Regarding the second objective, I wondered whether bi/multilingual businesspeople would present significantly faster RTs in the Simon task, especially in incongruent trials, as well as significantly smaller Simon effects than their monolingual counterparts. As described above, bilinguals did outperform monolinguals in all the conditions of the Simon task, including incongruent trials, but they presented significantly faster RTs only in two conditions, the center 4-color condition ($p = .04$), and the lateral congruent 2-color condition ($p = .01$). Concerning the Simon effect, no significant statistical differences were found either, thus the answer to the second research question is no.

Although there were no significant differences regarding the Simon effect, both monolingual and bilingual businesspeople presented faster RTs in both lateral incongruent 2- and 4-color conditions than in the lateral congruent ones, resulting in negative scores for the Simon effect. As suggested in subsection 3.4.4.2, 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 effect[15]. As E. Bialystok pointed out (personal communication, February 20, 2013), "the Simon effect is well documented in that participants take longer to respond to incongruent trials". She cannot explain why my results would go in the opposite direction, and claimed that such tasks are very sensitive to the parameters in the experiment, such as timing, stimuli characteristics, etc. Therefore, she recommends caution about any conclusions in this regard. However, negative scores for the Simon effect have been found in several studies conducted in Brazil using different versions of the Simon task (e.g., Bandeira, 2010; Finger, Zimmer & Fontes, 2011; Kramer, 2011; Martins, 2010[16]; Pinto, 2009)[17] to different age groups, and assessing different types of bilinguals, which means that

[15] 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.

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

[17] Although the referred studies used different versions of the Simon task, as described in Table 3, section 2.6, 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.

such pattern does deserve a more careful investigation, especially because the design of the Simon task applied to my participants, and in some of the other Brazilian studies reported here, is the same one used by Bialystok et al. (2004) in Study 2.

In Bialystok et al. (2004), a bilingual advantage in the interference effect (Simon 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 decline 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., 2005; Martin-Rhee & Bialystok, 2008); and young adults (Bialystok, 2006; Bialystok, Craik et al., 2005, Humphrey & Valian, 2012; Kousaie & Phillips, 2012a; Paap & 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), plus my own, 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.

I cannot ignore, in face of so many results pointing to no bilingual advantage in the interference effect, that the massive impossibility to replicate Bialystok et al.'s 2004 results might rely on the fact that their study presents methodological inconsistencies, like the ones already discussed in 2.6 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.

My 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, were extremely familiar with computers and were controlled for video game use. Differently from Bialystok et al., I do not have the same number of men and women in each group, given the difficulty to find women occupying

executive positions as directors or managers. Thus, I tried to have similar numbers of men and women in the teachers/professors groups as well.

One more differing variable between Bialystok et al.'s 2004 study and mine refers to the instruments used to select the participants. While they used instruments such as PPVT–III, Catell Intelligence task, Digit Span tasks, I focused on two types of questionnaires (Zimmer & Bonini, 2009): the screening questionnaire (asking about handedness, level of education, history of health problems and medicine use), and the linguistic background questionnaire (focusing on social life, exercising, language use and travelling experience involving code-switching). All the differences described above regarding control of variables might account for the difficulty found by me and the other Brazilian researchers to replicate Bialystok et al.'s findings. If not, one could be dealing with a problem of task validity.

Going back to my results, one final important aspect has to do with the fact that the bilinguals of the present study did not significantly outperform monolinguals in overall RTs, i.e., in both congruent and incongruent trials (see Table 7 again). 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 (see Table 4 again). Bialystok et al. (2004), for example, 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. (2005), Martin-Rhee and Bialystok (2008), and Bandeira (2010); to young adults in Bialystok (2006), Bialystok, Craik et al. (2005), Bialystok et al. (2005), Luk et al. (2008), Bialystok et al. (2008), among others. However, none of the Brazilian studies addressing young, middle-aged and old-aged adults found a bilingual advantage in overall RTs (see Table 4 again).

So far, I have described and discussed the data regarding the businesspeople groups in the ANT task and in the Simon task. The results of both nonlinguistic interference tasks pointed to no bilingual advantage whatsoever, neither in overall RTs, nor in interference effects, as I had predicted for such professional group. However, before describing and discussing the results of the control group, consisting of teachers/professors (a different professional activity), it is too early to claim that the variable "Profession" could represent a natural competitor with bilingualism. By including the control group, I expected they would act differently from the businesspeople in the Simon task, due to lower cognitive demands in their professional activity in terms of problem solving, multi-tasking and inhibitory control.

4.3 Results – third objective

The third objective was to compare the performance of bi/multilingual and monolingual teachers/professors in the Simon task (Simon, 1969) in terms of inhibitory control and attention.

4.3.1 Descriptive statistics

The mean RTs for the correct trials and accuracy scores in each of the Simon conditions are presented in Table 8. Mann-Whitney tests were run for all the accuracy scores. Both language groups made very few errors in all four conditions, with the mean percentage of errors ranging from 1% to 5% – bilinguals (3%) and monolinguals (2%). There were significant statistical differences in accuracy scores in two conditions, the center 4-color condition (Z = -2.08, p = .04), and the lateral congruent 2-color condition (Z = -2.05, p = .04), both favoring monolinguals.

Table 8: Mean Reaction Times (ms) and Accuracy (%) for Simon Task by Language Groups – Teachers/Professors

				Side				
Language group	Colors	Center (SD)	ACC (SD)	Congruent (SD)	ACC (SD)	Incongruent (SD)	ACC (SD)	Simon effect
Monolingual								
(19)	2	524.21 (100.95)	0.96 (0.11)	585.01 (101.22)	0.97* (0.05)	546.98 (107.04)	0.98 (0.06)	-38.03
	4	641.42 (126.00)	0.99* (0.02)	675.78 (117.52)	0.98 (0.03)	648.34 (136.33)	0.99 (0.02)	-27.44
Bilingual								
(19)	2	491.33 (66.82)	0.98 (0.02)	575.62 (83.88)	0.95 (0.04)	529.20 (96.52)	0.99 (0.02)	-46.42
	4	617.91 (132.74)	0.96 (0.06)	632.11 (105.92)	0.96 (0.04)	617.14 (128.32)	0.98 (0.04)	-14.97

Note. Source: Study data. SD = Standard deviation. ACC = Accuracy. *Significant differences (p < .05).

Concerning RTs, Mann-Whitney tests were used for the lateral congruent and incongruent 2-color conditions, revealing no significant statistical differences between the groups. Independent Samples t-tests were used to compare RT scores of the center 2-color

condition, and also the lateral congruent and incongruent 4-color conditions. Again, no differences were found between the bilingual and monolingual teachers/professors.

The scores for the 2-color Simon effects were compared using an Independent Samples t-test, while the scores for the 4-color Simon effects were compared with a Mann-Whitney test. Again there were no significant statistical differences between the groups, showing no interference effects, but like the businesspeople groups, both bilingual and monolingual teachers/professors presented faster RTs for the incongruent trials in comparison to the congruent ones, resulting in negative scores for the Simon effects.

4.3.2 Discussion

The research question concerning the third objective was whether bi/multilingual teachers/professors (the control group) would present significantly faster RTs in the Simon task, especially in incongruent trials, as well as significantly smaller Simon effects than their monolingual counterparts. As described above, the only significant differences found between bilingual and monolingual teachers/professors refer to accuracy scores in two conditions, the center 4-color condition ($p = .04$), and the lateral congruent 2-color condition ($p = .04$), in which monolinguals outperformed bilinguals. No significant differences were found regarding RTs, neither in the Simon effect, thus the answer to the third research question is no.

As pointed out in 3.1, I chose to investigate a population of businesspeople considering the possibility that the cognitive demands of their professional activity could compete with bilingualism in strengthening EFs such as inhibitory control and also attentional networks. The results obtained by such population in both nonlinguistic interference tasks seem to corroborate my prediction, once bilingual and monolingual businesspeople had equivalent performances regarding the three attentional networks (with an inhibitory control component) in the ANT task (see 4.1.2 again), and in the conflict offered by incongruent trials in the Simon task (see 4.2.2 again), resulting in no significant differences in interference effects, and no bilingual advantage in overall RTs either. However, when contrasting these results to the results of the control group (monolingual and bilingual teachers/professors) (see Table 8 again), I can no longer assign the absence of a bilingual advantage to the businesspeople to the variable “Profession” as a competitor with bilingualism, for the control group also presented equivalent performances across the mono and bilingual groups in the Simon task, despite the fact that their professional activity probably imposes lower cognitive demands in comparison to the cognitive demands usually faced by businesspeople.

Even considering the significant differences presented by both professional and language groups in some conditions regarding accuracy or RTs, as can be seen in Tables 7 and 8, none of them constitute a bilingual advantage in the interference effect or in overall RTs. Furthermore, the same pattern presented in the results of both businesspeople groups concerning negative scores for the Simon effect was also present for monolingual and bilingual teachers/professors, i.e., both professional and language groups presented faster RTs for incongruent trials, just like other populations investigated by the Brazilian studies already pointed out in 4.2.2. In this regard, I lack a theoretical construct that is able to account for such phenomenon (which seems to have happened only in the studies carried out in Brazil), thus, so far, I can only assume that some populations learn to deal with the conflict caused by the irrelevant location information more quickly than others.

Concerning the fact that neither of the professional groups presented a bilingual advantage in overall RTs, I can conclude that the results of this investigation replicate the findings garnered in other studies assessing the same age group – middle-aged adults (e.g. Kramer, 2011; Pinto, 2009); young adults (e.g. Billig, 2009; Finger et al., 2011; Humphrey & Valian, 2012; Kousaie & Philips, 2012a; Kramer (2011); Paap & Greenberg, 2013), and elders (e.g. Billig, 2009; Kramer, 2011; Martins, 2010; Pinto, 2009), including a variety of types of bi(mono)lingualism.

In that matter, what seems to be unique about these two professional groups is the fact that they must be the sample with the highest level of education ever investigated, at least among Brazilian studies. As described in 3.4.2, they all have at least one bachelor's degree, and most of them have at least one MBA or a Master's degree, or even a Doctorate. Besides, they are all very familiar with computer use, differently from the old-aged participants in studies such as Billig's (2009), Martin's (2010) and Pinto's (2009), whose unfamiliarity with computers might have compromised participants' performance in the computerized tasks.

One final aspect to be viewed as unique in these two populations of 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. As a matter of fact, there are no guarantees that the studies carried out abroad actually investigated balanced bilinguals across their samples either, especially because it is too hard a task to find a great number of bi/multilinguals with the same levels of fluency, accuracy or frequency of language use (as already pointed out in section 2.2, regarding the fact that languages can take turns to occupy a dominant position). Besides, as Zimmer, Finger and

Scherer (2008) point out, there are high levels of individual variation as well, which can also compromise the homogeneity of a sample.

4.4 Results – fourth objective

The fourth and last objective was to check if the results obtained by both bilingual professional groups in the Simon task, as well as the ones of the bilingual businesspeople in the ANT task, support the BICA (*bilingual inhibitory control advantage*) and BEPA (*bilingual executive processing advantage*) hypotheses.

4.4.1 Description

Starting with the results of the ANT task, which was performed only by the businesspeople groups, the bilingual advantage was not found in either of the effects measured by the task: alerting, orienting and conflict effect (i.e., interference effects), or in overall RTs. As a result, neither the BICA nor the BEPA hypotheses were corroborated.

Regarding the results of the Simon task performed by the businesspeople groups, again no bilingual advantage was found, thus not supporting any of the two hypotheses.

The control group (teachers/professors) presented no bilingual advantage whatsoever. Neither the BICA nor the BEPA hypotheses were supported again, since there were neither significant differences in terms of interference effects, nor a bilingual advantage in overall RTs.

4.4.2 Discussion

For the fourth and last objective, I had posed the research question concerning whether the results obtained by both bilingual professional groups would point to BICA (*bilingual inhibitory control advantage*), to BEPA (*bilingual executive processing advantage*), or none of the two hypotheses would be supported. Taking into consideration all that has been described and discussed along chapter 4, the results of the two professional groups did not support any of the two hypotheses.

I could see, from the performance of the first professional group, that bilingual businesspeople did outperform their monolingual counterparts in all the 12 experimental conditions of the ANT task, as well as in the 4 conditions of the Simon task. Actually, there

were faster RTs for the bilinguals even in the control conditions (i.e., conditions uncomplicated by congruity effects): the neutral trials in the ANT task, and the center conditions in the Simon task. That indicates that bilinguals do tend to outperform monolinguals in nonlinguistic interference tasks in all types of trials. However, in none of the cases, did bilinguals show a significant statistical difference in comparison to monolinguals in order to configure a bilingual advantage in the magnitude of the interference effect (favoring the BICA hypothesis), or in overall RTs (favoring the BEPA hypothesis).

Furthermore, the fact that there was no bilingual advantage in interference effects for the middle-aged businesspeople contradicts the assumption posed by Hilchey and Klein (2011) that larger interference effects should be more expected from middle-aged and old-aged adults. The authors agree, though, that such results are not frequently observed, which seems to be the case in this study.

The teachers/professors (the control group) presented equivalent performances if compared to the businesspeople in the Simon task, showing no bilingual advantage, thus neither BICA nor BEPA were supported again. The only bilingual advantages presented by the control group were related to accuracy in two conditions, but that was not the focus of this investigation. Nonetheless, the control group served its purpose, indicating that the absence of a bilingual advantage for the businesspeople groups cannot be assigned to the high cognitive demands of their profession as a competitor with bilingualism.

In sum, my review of several different studies, including the Brazilian ones in section 2.6 (Table 3), plus all the experiments reviewed by Hilchey and Klein (2011) and Paap and Greenberg (2013) (see section 2.7 again), demonstrate that the bilingual advantage can be at times in the magnitude of the interference effects (supporting BICA), but mostly in overall RTs (supporting BEPA), and sometimes no bilingual advantage is found. That also depends on age group and the percentage of congruent trials (Costa et al., 2009).

Thus, in order to close the discussion section, I decided to include Figure 10, as a way to illustrate and highlight the importance and volume of the studies carried out by Brazilian researchers. It is important to mention the fact that these were all conducted at universities in the states of Rio Grande do Sul and Santa Catarina. By splitting such studies according to type of bilingual advantage and age groups, I came up with 12 different experiments.

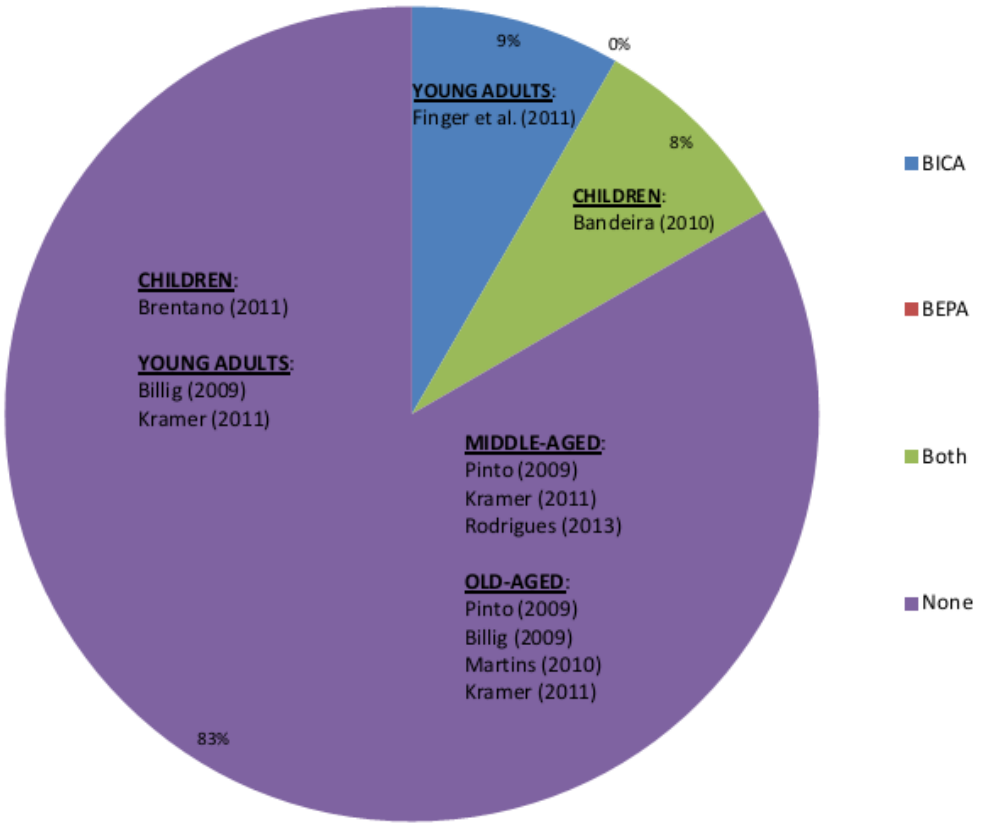

Figure 10: Brazilian studies divided by type of bilingual advantage in nonlinguistic interference tasks and age groups

Starting with the BICA hypothesis, the bilingual advantage in the magnitude of the interference effect was found in only one out of the 12 Brazilian experiments. Finger et al. (2011) focused on a population of multilingual Chinese exchange students who had been living in Brazil for about a year. Multilinguals were also investigated by Bandeira (2010), but she was able to find both types of bilingual advantage (BICA and BEPA), among a population living in the city Arroio do Padre, Rio Grande do Sul, where children speak German and/or Pomeranian as their L1s, Portuguese in the community, and are also studying English at school.

All the other experiments, including my own, found no bilingual advantage whatsoever, regardless of age group or type of bilingualism. Some of them even investigated more than one age group (e.g., Billig, 2009; Kramer, 2011; Pinto, 2009), not only looking for a bilingual advantage, but also for age-related advantages regarding inhibitory and attentional control. Billig, for example, found an age effect regarding inhibitory control and also WM. Kramer found that younger adults outperformed older adults. Pinto, on the other hand, found

no significant differences between middle-aged and old-aged participants. Interestingly, Brentano (2011) found significant differences in overall RTs between two types of bilinguals (school-based vs. home-based), but not between bilinguals in comparison to monolinguals.

The last two studies that found no bilingual advantage were Martins (2010), who focused on elderly individuals only, and mine (Rodrigues, 2013), which was the only study to investigate whether the cognitive demands of a particular professional activity could compete with bilingualism in strengthening certain EFs.

Two possible explanations for the difficulty in replicating the bilingual advantage have been provided by the recently published study by Paap and Greenberg (2013), pointing to a range of hidden demographic factors, as well as to the variety of tasks measuring different components of EP. In the case of this study, I tried to control for some demographic factors, as had been previously suggested by Hilchey and Klein (2011), as well as other factors that I also tried to control, such as the type of bilinguals who, if not balanced, are at least equivalent in both professional groups. Since I adhere to a nonlinear view of bilingualism, I counted on the impossibility to find balanced bilinguals across the whole sample, mainly because I was focusing on L2 or L3 speakers who need to speak a second or third language for professional reasons.

In the next and final chapter I present my final considerations regarding the present study.

5 FINAL CONSIDERATIONS

The objective of this chapter is to summarize the main findings of the present study, to acknowledge its limitations regarding methodological procedures, as well as to provide suggestions for further research.

5.1 Main findings

This study was an attempt to replicate previous experiments on the so-called bilingual advantage concerning inhibitory and attentional control, which has been already observed in the performance of bilingual participants in nonlinguistic interference tasks. However, differently from other studies with bilingual adult participants, my main goal was to investigate a professional group that is faced with very high cognitive demands on a daily basis, so I chose bilingual and monolingual businesspeople to be the main groups, and be tested on two nonlinguistic interference tasks: the Simon task and the ANT task. In order to look for an effect of the variable "Profession" as a possible natural competitor with bilingualism in strengthening such EFs, I included a control group with a different professional activity, one that I believe to be less demanding in terms of problem solving, multi-tasking and inhibitory control. The control group consisted of bilingual and monolingual teachers/professors, who were compared to the businesspeople only on the Simon task. The two professional groups had middle-aged adults, corresponding to the age group less investigated by the previous studies associating bilingualism and cognition, both abroad and in Brazil.

Because my main expectation was to find an effect of "Profession", I did not pose any other hypotheses, but instead, I elaborated four research questions. The first one asked whether bi/multilingual businesspeople would suffer less interference from incongruent flankers (Conflict effect) and profit more from the alerting cues (Alerting effect) and orienting cues (Orienting effect) than their monolingual counterparts. The second one was whether bi/multilingual businesspeople would present significantly faster RTs in the Simon task, especially in incongruent trials, as well as significantly smaller Simon effects than their monolingual counterparts. The third one was the same as the second one, but regarding the bi/multilingual teachers/professors. For the fourth and last research question, I expected to check whether the results obtained by both bilingual professional groups would support the

BICA (*bilingual inhibitory control advantage*) and BEPA (*bilingual executive processing advantage*) hypotheses.

Because I see cognition, language, SLA, and consequently bilingualism as examples of dynamic systems, I could not have predicted the outcomes of this study, but I expected to find at least some sort of bilingual advantage. Nonetheless, all the results obtained by both professional groups were contrary to the expectations: neither the BICA nor the BEPA hypotheses were corroborated, for there was no type of bilingual advantage for neither professional group, thus refuting my primary expectation that the very high cognitive demands faced by the businesspeople would answer for the absence of a bilingual advantage in such professional group, as can be illustrated by Table 9.

Table 9: Summary of findings

	RESEARCH QUESTIONS	**ANSWERS**
1	Did bi/multilingual businesspeople suffer less interference from incongruent flankers, resulting in a smaller Conflict effect, profit more from the alerting cues (Alerting effect) and from the orienting cues (Orienting effect) than their monolingual counterparts in the ANT task?	NO
2	Did bi/multilingual businesspeople present significantly faster RTs in the Simon task, especially in incongruent trials, as well as significantly smaller Simon effects than their monolingual counterparts?	NO
3	Did bi/multilingual teachers/professors present significantly faster RTs in the Simon task, especially in incongruent trials, as well as significantly smaller Simon effects than their monolingual counterparts?	NO
4	Did the results obtained by both bilingual professional groups point to BICA (*bilingual inhibitory control advantage*), to BEPA (*bilingual executive processing advantage*), or none of the two hypotheses was corroborated?	None of them was corroborated
	Could the absence of a bilingual advantage for the businesspeople groups be assigned to the high cognitive demands of their profession as a competitor with bilingualism when contrasted to the results obtained by the control group (teachers/professors)?	NO

However, 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 tasks. As already described and discussed extensively along all the chapters of this thesis, a bilingual advantage for middle-aged adults was only found in studies such as Bialystok et al. (2004), supporting both the BICA and BEPA hypotheses, and Emmorey et al. (2009), supporting BEPA.

5.2 Limitations and suggestions for further research

I start this section by highlighting the limitations of this study. The initial one was to find the necessary number of businesspeople (the first and main population) who would be willing and available to participate. In order to find enough people to complete the sample, I had to travel a lot, going to cities such as Porto Alegre and others in the nearby area, and also look for more professionals in Rio Grande and Pelotas. The main obstacle was to convince such professionals to participate in a data collection process that required around two hours of their time, usually their working hours. Another problem was to arrange for a time to meet and proceed with the interview and cognitive tests. There was no homogeneity of day time, since some businesspeople could only participate early in the morning, before they started working, while others preferred to be interviewed and tested at the end of their working day, and others only agreed to participate if the data collection process could be split into two or three different meetings. However, despite the difference in daytime for the interview and cognitive tests, I could notice that such participants were always under the pressure of going back to their duties, as managers or directors of a company. Phone calls were on hold, as well as clients or employees who were waiting outside for a meeting or other appointments. Given the irregularity of the whole process among these participants, I tried to maintain at least the same order of procedures: interview first, Simon task second, and then the ANT task.

The control group, consisting of teachers/professors, was included only when I had already finished collecting and analyzing the data with the other professional group and had carried out a pilot project. Thus, because of a restricted deadline, I reduced the data collection instruments to the interview and Simon task, leaving aside the ANT task, which requires considerably more time, but I wish I had had time to test them using the ANT task as well.

The number of participants in each of the groups was also a concern. Costa et al.'s 2008 sample consisted of 200 individuals (100 bilinguals and 100 monolinguals), while Bialystok et al.'s 2004 Study 2 consisted of 64 middle-aged adults (32 bilinguals and 32 monolinguals) and 30 old-aged adults (15 bilinguals and 15 monolinguals). It is sometimes difficult to make generalizations considering very small samples.

One more limitation regards the type of bilinguals of the sample. I was aware, from the very beginning, of the impossibility to find balanced bilinguals across the whole sample, once my main focus was to conduct an investigation on the bilingual advantage associating to the cognitive demands of a professional activity. I did not try to satisfy classifications such as early or late bilinguals, bicultural bilinguals, etc. As explained in 3.4.2, their use of an L2 or

L3 varied from daily to sporadic, depending on different purposes and different situations. Even so, both bilingual populations presented faster RTs than their monolingual counterparts, regardless of significance.

Among the suggestions for further investigations, I recommend that future studies try and follow the protocol proposed by Paap and Greenberg (2013) carefully, by using a multiple-task approach, making sure they know what exact component of EP they are trying to assess, and that all the tasks used are appropriate for that, as well as controlling for all the demographic factors, including SES and other cultural differences that could create any type of confounding results. I also think that psycholinguistic studies should be combined with neurolinguistic ones, for neuroimaging devices can help elucidate a lot more that goes on in the bi/multilingual brain, especially in Brazil now, where this type of resource is becoming more available for academic research, rather than only for medical reasons.

Regarding further investigations, I would like to investigate the executive function of problem solving, and try to dwell on the idea that the experience of frame switching could have a stronger impact on such EF, for I believe frame switching to be a more complex experience than code-switching. I am aware, though, that up to the present moment, frame switching has been investigated only in studies focusing on cultural priming among bicultural populations, but it is only food for thought right now. If I decide to pursue such an idea, I should investigate a truly bicultural population, making sure to include more than one instrument whose indicators correlate with one another, as recommended by Paap and Greenberg (2013).

To conclude, I do hope my study has contributed somehow to the scenario of research on the effects of bilingualism on cognition. I was fully aware, from the very beginning, of the complexity and controversy involved in this type of research, and also that such project would require a lot of work and commitment. These things considered, I am truly glad I have been able to accomplish my task within the parameters and deadline established for this to happen.

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APPENDIX A - FREE AND INFORMED CONSENT FORM

UNIVERSIDADE CATÓLICA DE PELOTAS
PROGRAMA DE PÓS-GRADUAÇÃO EM LETRAS

TERMO DE CONSENTIMENTO LIVRE E ESCLARECIDO

Antes de sua participação neste estudo, é preciso esclarecer alguns detalhes importantes, para que possíveis dúvidas sejam resolvidas.

Qual o objetivo desta pesquisa?
Verificar se a vantagem constatada entre bi/multilíngues envolvendo funções executivas relativas ao controle inibitório e às redes de atenção pode ser estendida a tarefas relacionadas à resolução de problemas.

Que tipos de testes serão aplicados?
Os participantes deste estudo serão avaliados por meio de questionários, um teste escrito e dois testes computadorizados que irão verificar sua atenção, concentração, capacidade de ignorar estímulos irrelevantes e a de resolver problemas usando suas habilidades numéricas e espaciais. Os dados deste estudo serão codificados e mantidos em sigilo.

Quais os riscos em participar?
Não há qualquer tipo de risco na participação deste projeto.

Quais são os seus direitos?
Os seus dados serão sempre tratados confidencialmente. Os resultados deste estudo poderão ser usados para fins científicos, mas você não será identificado por nome. Sua participação no estudo é voluntária, de forma que você tem liberdade para abandonar esta pesquisa a qualquer momento.

Eu,..... (participante), fui informado dos objetivos da pesquisa acima de maneira clara e detalhada. Sei que em qualquer momento poderei solicitar novas informações e modificar minha decisão se assim eu o desejar. A pesquisadora Lisandra Rutkoski Rodrigues (pesquisadora responsável) certificou-me de que todos os dados desta pesquisa serão confidenciais e terei liberdade de retirar meu consentimento de participação nesta pesquisa.

Em caso de qualquer outra dúvida quanto à pesquisa ou sobre os seus direitos, você poderá contatar a pesquisadora Lisandra Rutkoski Rodrigues (lilica_rig@yahoo.com.br – telefone: (53) 32357203), responsável pelo estudo.

Número do estudo: _____ Cód. de ident. do indivíduo:_____

Declaro que recebi cópia do presente Termo de Consentimento.
Data: ____/___/____

_____ _____
Assinatura da Pesquisadora Assinatura do Participante

APPENDIX B - SCREENING QUESTIONNAIRE

UNIVERSIDADE CATÓLICA DE PELOTAS
PROGRAMA DE PÓS-GRADUAÇÃO EM LETRAS

Pesquisa: Cognitive differences between monolinguals and bi/multilinguals: executive functions boosted by code-switching?

Questionário de rastreio

Esta é uma pesquisa que pretende avaliar o quanto falar outra(s) língua(s) pode influenciar nas práticas das suas atividades diárias. Agora faremos algumas perguntas a respeito da sua vida que são importantes para o estudo. Os dados obtidos neste questionário serão mantidos em segredo absoluto.

Identificação
Quest __ __ __ __
Data entrevista __ __/__ __/__ __ __ __
1. Nome:
2. Data de nascimento: __ __ / __ __ / __ __ __ __
3. Telefone para contato:
4. Endereço:
5. Endereço de familiar:
6. Telefone de familiar:
7. Sexo: (1) Feminino (2) Masculino
8. Lateralidade: (1) Destro (2) Canhoto
9. O (A) sr(a) estudou? (1) sim (2) não (3) só assina
10. SE SIM: até que ano o sr(a) completou? (1) Primário incompleto (2) Primário completo (3) Ginásio completo (4) Ginásio incompleto (5) Segundo grau (6) Universidade e pós-graduação
11. Quantos anos o sr(a) estudou?

(1) 1 ano (2) 2 anos (3) 3 anos (4) 4 anos

(5) 5 anos (6) 6 anos (7) 7 anos (8) 8 anos

(9) 9 anos ou mais → se mais do que 9 anos, quantos no total?

12. Agora vou dizer uma lista de outros problemas de saúde e o sr(a) me diga se tem ou já teve algum?

a) Convulsão/ataques	(0) Não (1) Sim (2) Não sei
b) Diabetes	(0) Não (1) Sim (2) Não sei
c) Doença de Parkinson	(0) Não (1) Sim (2) Não sei
d) Doença de Alzheimer	(0) Não (1) Sim (2) Não sei
e) Derrame cerebral	(0) Não (1) Sim (2) Não sei
f) Alcoolismo	(0) Não (1) Sim (2) Não sei
g) Cisticercose (tênia na cabeça)	(0)Não (1) Sim (2) Não sei

13. O sr(a) tem problema de visão?

(0) Não

(1) Sim, não enxergo direito

(2) Sim, mas uso óculos e enxergo bem.

14. Você tem alguma dificuldade para falar?

(0) Não

(1) Sim, por causa dos dentes

(2) Sim, porque tenho problemas de articulação da fala.

15. O sr (a) toma remédios? Qual o nome do(s) remédio (s)?

Dados Língua Materna

16. Além de falar português, o sr(a) fala alguma outra língua?

(0) Não (1) Sim

17. SE SIM. Qual língua?

(1) Espanhol (2) Alemão (3) Italiano (4) Francês (5) outra

18. Com que frequência você fala a outra língua que não o português?

1. Nunca falo
2. Falo todos os dias
3. Falo 3 ou 4 dias por semana

APPENDIX C - LINGUISTIC BACKGROUND QUESTIONNAIRE

UNIVERSIDADE CATÓLICA DE PELOTAS
PROGRAMA DE PÓS-GRADUAÇÃO EM LETRAS

Pesquisa: Cognitive differences between monolinguals and bi/multilinguals: executive functions boosted by code-switching?

Questionário linguístico

Esta é a segunda fase da pesquisa que você participou. Gostaria de saber mais informações.

IDENTIFICAÇÃO
Quest __ __ __
Data da entrevista: __ __/ __ __/__ __ __ __
1. Nome:
2. Local de Nascimento: (1) Brasil (2) Outro país
3. Profissionalmente ativo: (1)Sim (2) Não
4. Profissão ou atividade:
5. Situação: (1) Empregado (2) Autônomo (3) Do lar (4) Empregador
6. Se mulher, faz reposição hormonal? (1) Sim (2) Não
7. Na última semana, você praticou atividade física no seu tempo livre? (1) Sim (2) Não Se sim, na questão anterior: Quantos dias na última semana você praticou atividade física no seu tempo livre? ( ) 1 ( ) 2 ( ) 3 ( ) 4 ( ) 5 ( ) 6 ( ) 7 Por quanto tempo você praticou atividade física nesses dias? __ __ __ minutos (somatório de todos os dias) *OBS: nesse recordatório não entra deslocamento, trabalho e atividades domésticas.*
8. Gostaria de saber, em geral, com que frequência você faz as seguintes coisas: *("0" para nunca*) Tomar chimarrão/conversar vizinho __ __ dias por (1) semana (2) mês (3) ano

Visitar amigos fora do bairro	__ __ dias por	(1) semana (2) mês (3) ano
Visitar família fora do bairro	__ __ dias por	(1) semana (2) mês (3) ano
Receber visita em casa	__ __ dias por	(1) semana (2) mês (3) ano
Ver TV	__ __ dias por	(1) semana (2) mês (3) ano
Sair à noite (para jantar, festa)	__ __ dias por	(1) semana (2) mês (3) ano
Passear/festejar com a família	__ __ dias por	(1) semana (2) mês (3) ano
Ir a Igreja, terreiro, ou culto/templo	__ __ dias por	(1) semana (2) mês (3) ano

10. Qual língua materna?

11. Língua: (1) monolíngue (2) bilíngue (3) multilíngue

LÍNGUA MATERNA:

12. Língua Materna: (1) Português (2) Outra língua. Qual?

13. Fala esta língua: (1) Sim (2)Sim, raramente (3) Não **(Se não, pule para a 17)**

14. Horas por dia que fala a língua materna: _ _horas

15. Onde fala a língua materna:

Casa (0) Não (1) Sim
Rua (0) Não (1) Sim
Trabalho (0) Não (1) Sim
Outro lugar (0) Não (1) Sim
Se outro local especifique qual?

16. Com quem fala a língua materna:

Pais (0) Não (1) Sim
Filhos (0) Não (1) Sim
Amigos (0) Não (1) Sim
Colegas (0) Não (1) Sim
Cônjuge (0) Não (1) Sim
Irmãos (0) Não (1) Sim

17. Lê na língua materna: (1) Sim (2) Raramente (3) Não **(Se não, pule para a 20)**

18. O que lê na língua materna:

Jornais (0) Não (1) Sim
Revistas (0) Não (1) Sim

Bíblia (0) Não (1) Sim Outros (0) Não (1) Sim Quais?
19. Quantas horas que lê por dia na língua materna:_ _ horas
20. Escreve na língua materna: (1)Sim (2) Raramente (3) Não
21. Se o sujeito fala mais de 2 línguas, pedir para ele responder as questões 22 à 40, referentes à segunda língua (que fala mais) (0) Não (1) Sim
SEGUNDA LÍNGUA:
22. Segunda Língua: (1) Português (2) Outra língua.
23. Com que idade aprendeu a segunda língua? _ _ anos
24. Fala esta língua? (1) Sim (2) Sim, raramente (3) Não
25. Com quem fala a segunda língua: Pais (0) Não (1) Sim Filhos (0) Não (1) Sim Amigos (0) Não (1) Sim Colegas (0) Não (1) Sim Cônjuge (0) Não (1) Sim Irmãos (0) Não (1) Sim
26. Onde aprendeu a segunda língua: Casa (0) Não (1) Sim Escola (0) Não (1) Sim Trabalho (0) Não (1) Sim Outro lugar (0) Não (1) Sim
27. Onde fala a segunda língua: Casa (0) Não (1) Sim Escola (0) Não (1) Sim Trabalho (0) Não (1) Sim Outro lugar (0) Não (1) Sim
28. Horas por dia que fala a segunda língua: __ __ horas
29. Lê: (1)Sim (2) Raramente (3) Não (**Se não, pule para a 32**)
30. O que lê na segunda língua:

Jornais (0) Não (1) Sim Revistas (0) Não (1) Sim Bíblia (0) Não (1) Sim Outros (0) Não (1) Sim Quais?
31. Quantas horas lê na segunda língua: __ __horas
32. Escreve na segunda língua: (1) Sim (2) Raramente (3) Não
33. Já viajou para o exterior: (1) Sim (2) Não **(Se não, pule para a 37)**
34. Quantas vezes: _ _ _ vezes
35. Por quanto tempo viajou: _ _ _ _ dias
36. Línguas que falou durante a(s) viagem(ns): Alemão/dialetos (0) Não (1) Sim Inglês (0) Não (1) Sim Francês (0) Não (1) Sim Italiano/dialetos (0) Não (1) Sim Árabe/dialetos (0) Não (1) Sim Português (0) Não (1) Sim Espanhol/dialetos (0) Não (1) Sim Outra. (0) Não (1) Sim. Qual?
37. Viajou dentro do Brasil? (1) Sim (2) Não **(Se não, pule para a 40)**
38. Por quanto tempo viajou: _ _ _ _ dias
39. Falou outra língua que não fosse o Português? (0) Não (1) Sim. Qual?
40. O senhor fala alguma outra língua além desta? (0) Não (**Se não, passe para questão 53**) (1) Sim
41. TERCEIRA LÍNGUA (somente se a pessoa for multilíngue):
42. Que outra língua o(a) senhor(a) fala?
43. Fala esta língua? (1) Sim (2) Sim, raramente (3) Não
44. Com que idade aprendeu a terceira língua: _ _ anos
45. Com quem fala a terceira língua: Pais (0) Não (1) Sim

Filhos (0) Não (1) Sim Amigos (0) Não (1) Sim Colegas (0) Não (1) Sim Cônjuge (0) Não (1) Sim Irmãos (0) Não (1) Sim
46. Onde aprendeu a terceira língua: Casa (0) Não (1) Sim Escola (0) Não (1) Sim Trabalho (0) Não (1) Sim Outro lugar (0) Não (1) Sim. Qual?
47. Onde fala a terceira língua: Casa (0) Não (1) Sim Escola (0) Não (1) Sim Trabalho (0) Não (1) Sim Outro lugar (0) Não (1) Sim. Qual?
48. Horas por dia que fala a terceira língua: _ _ horas
49. Lê: (1) Sim (2) Raramente (3) Não
50. O que lê na terceira língua: Jornais (0) Não (1) Sim Revistas (0) Não (1) Sim Bíblia (0) Não (1) Sim Outros (0) Não (1) Sim Quais?
51. Quantas horas que lê na terceira língua: _ _horas
52. Escreve na terceira língua: (1) Sim (2) Raramente (3) Não