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EFFECTS OF BILINGUALISM ON INHIBITORY CONTROL AND WORKING MEMORY: A STUDY WITH EARLY AND LATE BILINGUALS

ROSSANA KRAMER

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UNIVERSIDADE FEDERAL DE SANTA CATARINA
Pós-Graduação em Letras/Inglês e Literatura Correspondente

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Susana Borneo Funck
Coordenadora

BANCA EXAMINADORA:

Mailce Borges Mota
Orientadora e Presidente

Augusto Buchweitz
Examinador

Raquel Carolina Souza Ferraz D'Ely
Examinador

Adja Baldino Amorim Barbieri Durão
Examinador

Celso Henrique Soufen Tumolo
Examinador

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To my family, for the support throughout these years.

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ABSTRACT

EFFECTS OF BILINGUALISM ON INHIBITORY CONTROL AND WORKING MEMORY: A STUDY WITH EARLY AND LATE BILINGUALS

ROSSANA KRAMER

UNIVERSIDADE FEDERAL DE SANTA CATARINA
2011

Supervising Professor: Dr. Mailce Borges Mota

The study of the relationship between bilingualism and aging is a relatively recent area of research. The aging process brings with it cognitive declines in a number of functions, including attention, memory, reasoning, and problem-solving (Park and Schwarz, 2000). Recently, however, Bialystok, Craik, Klein & Viswanathan (2004) have provided evidence that bilingualism aids in offsetting age-related losses in executive function. The present study aims at: 1) investigating the performance of early bilinguals, i.e., those who have used two languages on a daily basis across the lifespan, and late bilinguals, i.e., those who have learned a second language through instruction in the classroom, on inhibitory control and working memory tasks; 2) investigating sex differences in the performance of these two types of bilinguals on inhibitory control and working memory tasks, and 3) investigating a methodological issue related to the assessment of inhibitory control by comparing the performance of participants on two different versions of the Simon task (the Simon task 2 Colors and the Simon Arrow task). One hundred and four participants, with ages ranging from 18 to 84 years, took part in the study. These participants were divided into 4 control groups of Brazilian Portuguese monolingual speakers and 4 experimental groups consisting of 3 groups of Brazilian Portuguese/ Hunsrückisch speakers and 1 group of Brazilian Portuguese/English speakers. Before performing the inhibitory control and working memory tasks, each participant answered a language background questionnaire and a general questionnaire and was given the Mini-Mental State Exam and the Beck Depression Inventory. Late bilinguals were also submitted to a proficiency test. Results of statistical analyses showed significant age-related losses in executive functions: younger adults outperformed older adults in the tasks. Although there was not a statistically significant difference between language groups across the lifespan, early bilinguals presented more efficient inhibitory processes and higher working memory span than monolinguals. As regards late bilingualism, late bilinguals' performance was significantly faster than monolinguals on inhibitory control tasks. Moreover, the statistical analysis did not show any statistically significant differences between males and females concerning inhibitory control and working memory, but the 2 Color version of the Simon task tends to favor women. The results are discussed in light of the theoretical and empirical literature on bilingualism, aging, and cognitive decline.

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RESUMO

EFEITOS DO BILINGUISMO NO CONTROLE INIBITÓRIO E MEMÓRIA DE TRABALHO: UM ESTUDO COM BILÍNGUES DE INFÂNCIA E BILÍNGUES TARDIOS

ROSSANA KRAMER

UNIVERSIDADE FEDERAL DE SANTA CATARINA
2011

Supervising Professor: Dr. Mailce Borges Mota

O estudo da relação entre o bilinguismo e envelhecimento é uma área de pesquisa relativamente recente. O processo de envelhecimento produz alterações cognitivas em uma série de funções. A memória, atenção, raciocínio e resolução de problemas são algumas das funções que sofrem declínios relacionados ao envelhecimento (cf. Park e Schwarz, 2000). Pesquisas recentes conduzidas por Bialystok, Craik, Klein e Viswanathan (2004) forneceram evidências de que o bilinguismo poderia atenuar alguns efeitos negativos do envelhecimento e atuar como uma proteção às funções cognitivas ao longo da vida. O presente estudo se propôs a investigar (1) o desempenho de bilíngues de infância ou precoces (bilíngues que aprenderam as duas línguas quando crianças) e bilíngues tardios (indivíduos que aprenderam a segunda língua após os 12 anos de idade em contexto de sala de aula) em tarefas de controle inibitório e de memória de trabalho; (2) o desempenho de homens e mulheres em tarefas de controle inibitório e memória de trabalho e (3) o desempenho dos participantes em duas versões da tarefa Simon (quadrados e flechas) para tratar de questões relacionadas à metodologia de mensuração de funções cognitivas. Para alcançar os objetivos propostos, 104 participantes entre 18 e 84 anos divididos em 4 grupos de monolíngues, falantes de português brasileiro (PB) e 4 grupos de bilíngues – 3 grupos de bilíngues precoces (Hunsrückisch/PB) de Iporã do Oeste e Mondaí em Santa Catarina e 1 grupo de bilíngues tardios (PB/Inglês) selecionados na Universidade Federal de Santa Catarina – realizaram tarefas de controle executivo (Tarefa Simon) e de memória de trabalho (Tarefa Alpha Span). Além das tarefas, questionários sobre experiência linguística e informações gerais, o Mini Exame do Estado Mental (MEEM) e o inventário Beck de depressão foram aplicados aos participantes. Os bilíngues tardios, além de responderem aos questionários e testes, foram submetidos a um teste de proficiência em língua inglesa. As análises estatísticas demonstraram perdas cognitivas significativas relacionadas à idade, uma vez que adultos jovens foram melhores que os idosos nas tarefas de controle inibitório e memória de trabalho. Apesar de não ter sido verificada uma diferença estatisticamente significativa entre monolíngues e bilíngues precoces nas mesmas faixas de idade, bilíngues precoces apresentaram maior eficiência nos processos inibitórios e pontuaram mais que os monolíngues na tarefa de memória de trabalho. Os resultados confirmaram que bilíngues tardios foram significativamente melhores que os monolíngues em controle inibitório. As análises estatísticas não confirmaram diferenças com relação ao desempenho de homens e mulheres nas tarefas. No entanto, a versão Simon de quadrados tende a favorecer as mulheres. Os resultados são discutidos à luz de estudos teóricos e empíricos sobre bilinguismo, envelhecimento e perdas cognitivas.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDIXES

CHAPTER I

INTRODUCTION

1.1 Preliminaries

Although I was raised in a family in which many members were early bilinguals, I learned my second language only at the age of 17. My grandparents spoke Hunsrückisch, an immigration language. Two of them were immigrants who moved to Brazil during World War I. My parents had the chance of being early bilinguals, but, unfortunately, they did not teach Hunsrückisch to me because they believed that learning it would bring me disadvantages at school. In their view, learning Hunsrückisch would influence my accent and I would have to struggle to learn Portuguese. When spending my summer vacation with my grandparents in the West of Santa Catarina, I remember being very disappointed at not understanding what most people were saying on the streets and at markets. I remember having the feeling I was anywhere else but Brazil.

In 2009, I came across an article published by Bialystok, Craik, Klein, and Viswanathan (2004), in which they investigated the relationship between bilingualism and cognitive changes across the lifespan in early bilinguals. Bialystok and her colleagues argued that early bilingualism can bring age-related cognitive advantages. I became fascinated with this finding and decided to pursue further the idea that lifelong bilingualism has a positive influence in cognitive functions. So far, the study of bilingualism and cognitive changes carried out by Bialystok and colleagues and by researchers in Brazil (e.g., Billig, 2009 and Pinto, 2009) has been conducted with early bilinguals. The present study goes a step further and aims at investigating cognitive changes on inhibitory control and working memory in two types of bilinguals. In the light of Bialystok et al.'s (2004) findings, the present study investigates not only the benefits of lifelong bilingualism in early bilinguals (Hunsrückisch / Portuguese), but it also aims at verifying whether the cognitive advantage observed by Bialystok and her colleagues in early bilinguals can be also seen in bilinguals who have acquired a second language[1] through formal instruction.

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[1] In the present study, the term second language and foreign language will be used interchangeably (De Bot, Lowie, Verspoor, 2005, p. 7).

Much mental effort is required for us to make use of central cognitive abilities such as attention, perception, thinking, planning, reasoning, memory, language, and decision making (Reed, 2007). It is well documented that a number of cognitive functions decline during the aging process (Park and Schwarz, 2000; Bialystok and Craik, 2006; Hofer and Alwin, 2008) which, according to Buckner, Head, and Lustig (2006), begins to show declines by the age of 30. As stated by Buckner et al. (2006), normal brain aging decline comes in two manners: a) associated to declarative memory and b) associated to executive abilities and attention. The effects of aging on executive processes and memory can be seen in the ability to retain information, in difficulties in acquiring new habits, and in a decline in syntactic production (Schrauf, 2008). Due to these declines, adults, especially older adults, need to make more effort in order for their performance to be similar to that of younger adults (Reuter-Lonrez, 2002).

The present study will address cognitive mechanisms - inhibition, working memory, and speed of processing - which are influenced by normal aging. Differences in speed of processing (Salthouse, 1996; 2000), working memory (Salthouse, 1994; Park, Lautenschlager, Hedden, Davidson, Smith & Smith, 2002; Park & Payer, 2006), and inhibitory control (Zacks, Hasher & Li, 2000; Butler & Zacks, 2006; Hasher, Lustig & Zacks, 2008) have been extensively investigated and pointed out as essential cognitive mechanisms which begin to decline from adulthood on. Reuter-Lorenz (2000) explains that these aspects of cognition change as we age because of the activation in the prefrontal cortex, which decreases, contributing to cognitive deficits. According to Bialystok (2007), the frontal cortex is the last region to develop in childhood and one of the first to atrophy in aging.

The relationship between bilingualism and aging is a relatively recent area of research. In a series of studies, Bialystok and some colleagues have proposed that lifelong bilingualism enhances attentional control (Bialystok, Craik, Klein & Viswanathan, 2004; Bialystok, Martin & Viswanathan 2005; Bialystok, 2007; Bialystok, Craik & Freedman, 2007). According to these researchers, managing two languages through the lifespan accelerates the development of executive control functions in children, increases functioning in adults, and delays decline in older adults. A number of studies (Bialystok, 2001; Bialystok et al., 2004; Bialystok, Martin, & Viswanathan, 2005a; Bialystok, Craik & Luk, 2008a; Bialystok, Craik & Luk, 2008b; Bialystok, 2010) have investigated the performance of bilinguals and monolinguals (children, young, adults, and old adults) on many tasks involving attentional control and results have revealed that bilinguals outperform monolinguals on these tasks. The suggestion is that the regular use of two different languages can bring positive effects to cognitive functioning.

A variety of different tasks are used to assess working memory and inhibitory control. Working memory is usually measured by complex span tasks (e.g. reading span task), which require storage and manipulation of information (see Park et al., 2006 for WM tasks). Inhibitory control is assessed by tasks which must involve information/stimulus that has to be inhibited in order for an appropriate response to be produced (Miyake, Friedman, Emerson, Witzki, Howerter & Wager, 2000). In the bilingualism and cognitive aging field, working memory is measured by span tasks such as the Alpha span task (Bialystok et al., 2004; Craik & Bialystok, 2006). As regards inhibitory control, which require controlled inhibition, researchers who have investigated bilingualism and aging have often relied on the Stroop task (Bialystok, Craik & Luk, 2008b) and on versions of the Simon task (Bialystok, Craik & Luk, 2008b; Bialystok et al., 2004).

According to Bialystok, Martin, and Viswanathan (2005a) developing tasks to measure cognitive control is a challenge because besides assessing the cognitive skill, the task has to be appropriate to the group being investigated. Furthermore, task contents should be considered, once they may favor males or females. As observed by Kimura (1999a), men and women perform differently on a variety of cognitive tasks. That is, because males and females differ in cognitive abilities, they may solve cognitive tasks in different ways, which can influence results. Despite the number of studies carried out on gender differences, to the best of my knowledge, no studies have been conducted comparing bilingual males and females to monolinguals. In the present study, as will be seen below, besides the investigation of the performance of two types of bilinguals on the execution of inhibitory control (the Simon task) and working memory (the Alpha Span task) tasks, the relationship between gender differences and bilingualism will be also investigated in these two cognitive abilities. Furthermore, concerning methods for the assessment of inhibitory control, two versions of the Simon task will be compared.

1.2 The present study

The present study aims at investigating the performance of both early and late bilinguals on inhibitory control and working memory tasks. In the present study, early bilinguals are those who have acquired their two languages in early childhood and late bilinguals are those who have become bilinguals later than childhood and have learned their second language through instruction in classroom settings.

As already mentioned, aging is associated with cognitive decline that affects executive control and memory (Buckner et al., 2006). However, Bialystok, Craik, Klein, and Viswanathan (2004) have recently provided evidence that bilingualism aids in offsetting age-related losses in executive function. In order to verify the effects of aging on cognitive processes and to verify whether bilingualism can help offsetting aging effects on executive function, two cognitive tasks were applied to early bilinguals: an inhibition control task (the Simon task 2 Colors) and a verbal working memory task (the Alpha Span task). Based on compelling support that being an early bilingual can enhance cognitive abilities in executive functions, the present investigation attempts to verify whether bilinguals who have learned a second language in a formal context will also show positive effects on executive functions. Two inhibitory tasks (the Simon task 2 Colors and the Simon Arrow task) and a verbal working memory task (the Alpha Span task) were administered to young late bilinguals (Brazilian-Portuguese / English speakers) in order to verify whether the advantages reported by Bialystok et al. (2004) can be also observed in those who have acquired an L2 through formal instruction.

Moreover, as already stated, gender differences have been reported by Kimura (1999a) in a variety of cognitive tasks (e.g. spatial and verbal tasks). The present study will investigate gender differences related to early and late bilingualism in the execution of executive function tasks, the Simon task as a measure of inhibitory control and the Alpha Span task, applied to assess verbal working memory.

Another objective of this study is motivated by a methodological issue, which is the assessment of inhibitory control. The performance of participants on two different versions of the Simon task (the Simon task 2 Colors and the Simon Arrow task) will be compared. The Simon Arrow task was included in this research in order to verify whether participants who performed the Simon task 2 Colors would have similar performance on the Simon Arrow task. As will be seen in section 4.3, these two tasks, although highly related, make slightly different cognitive demands on participants and may, therefore, yield different results for cognitive control.

Based on the assumptions presented above, the present study pursued five research questions:

1. Will early and late bilinguals outperform their monolingual peers on measures of inhibitory control and verbal working memory?
2. From a cognitive perspective, does bilingualism across the lifespan help in offsetting age-related losses in inhibitory control and verbal working memory?
3. Does a second language learned late in life (late bilingualism) through instruction in the classroom lead to the same pattern of enhancement of executive control, reported by Bialystok and colleagues (2004), obtained in natural learning environments (early bilingualism)?
4. Are there differences between the performance of females and males on inhibitory control and verbal working memory tasks?
5. Considering that both Simon tasks (2 Colors and Arrow) assess inhibitory control, will the performance of the participants on these tasks differ in a way that we could predict which task would seem better to measure inhibitory control?

1.3 Significance of the Research

The relationship between bilingualism and cognition has drawn the attention of many researchers. The studies in this area initially focused on bilingual children and their cognitive development compared to monolingual children (Bialystok, 2001). Recently, this type of research has been extended to the cognitive processing of adult and older adult bilinguals (Bialystok et al., 2004), indicating that bilingualism brings more benefits than just the ability to express oneself in two different languages. The present study will contribute to the research program on bilingual cognitive processing in the following ways. First, this study is relevant to the area because two types of bilingual populations are investigated. A population of Brazilian-Portuguese/ Hunsrückisch speakers (early bilinguals) and a population of Brazilian-Portuguese/English speakers (late bilinguals) are compared to monolinguals (Brazilian-Portuguese speakers) - in an attempt to find evidence for the view that both early and late bilingualism can provide benefits to two executive control functions: inhibitory control and working memory.

Second, bilingualism is a common phenomenon all over the world. It is independent of social class or group of age (Grosjean, 1994). Despite the fact that the majority of the population in Brazil speaks only Portuguese, there are other languages spoken in specific regions of the country. Some languages, such as Korean and Chinese, are spoken by immigrants who have recently moved to Brazil (Oliveira & Masiero, 2005), whereas other languages, for example German, are spoken by descendants of immigrants who brought their languages some decades ago during different historical periods of immigration (Spinassé, 2008). According to Altenhofen and Frey (2006), there are about 210 different languages spoken in Brazil: 180 autochthonous[2] and 30 allochthonous[3], indicating that linguistic diversity in our country cannot be ignored. Bilingualism used to be thought of as one of the main reasons that caused children to underperform in school (Aquino, 2009). Nowadays, bilingualism is better accepted as a factor that brings benefits in terms of communication, opportunities, and cognition (Colzato, Bajo, van der Wildenberg, Paolieri, Nieuwenhuis, LaHeij, & Hommel, 2008). The present study is also relevant because it takes into account the fact that Brazil offers a great linguistic diversity, which creates opportunity to conduct cross-linguistic research.

Third, the present study will contribute with data to the field of gender differences in a bilingual context. To the best of my knowledge, researchers have been comparing males and females in a variety of cognitive tasks (Kimura, 1999a), but no studies have been carried out comparing bilingual males and females in executive control functions. This study, thus, aims at verifying whether early and late bilingualism confer similar cognitive effects on inhibitory control and verbal working memory functions in both males and females.

Last, but not least, the current study will contribute with a discussion on the design of cognitive tasks, which seem to be an challenge which many researchers face when choosing tasks to apply. In the case of this study, two Simon task versions (inhibitory control tasks) were used providing the opportunity to scrutinize further whether both would assess inhibitory control in a similar way. This discussion aims at shedding light on the types of tasks developed and applied in cognitive research in the area of language studies.

1.4 Organization of the Thesis

This thesis is organized in 5 major chapters. Chapter I is this introduction. Chapter II reviews the theoretical and empirical literature

[2] Autochthonous languages are languages found in locations where they were formed, that is, native to that place (http://www.merriam-webster.com).

[3] Allochthonous languages are languages found somewhere else than where they were formed (http://www.merriam-webster.com).

found relevant to the present study. In this chapter, age-related changes in cognitive functions with a focus on the constructs inhibition, working memory, and speed of processing are described. In addition, some cognitive tasks which assess inhibitory control, working memory, and speed of processing are presented and carefully explained. Then, an account of gender differences in some cognitive functions is provided. In addition to that, the chapter presents the definition for the term "bilingual", which is followed by a review of empirical studies on the effects of bilingualism for cognitive development carried out abroad and in Brazil.

In chapter III, the objective and research questions that guided this study are presented. This chapter also presents a detailed description of the participants, design, procedures and instruments used for collecting and analyzing data.

Chapter IV reports the results obtained in this study, which is followed by a discussion of the results. The descriptive analyses of the performance of bilinguals and monolinguals on three cognitive tasks are presented first, followed by statistical analyses and discussion. Then, I turn to the comparison of males and females' performance. Next, the correlations between the two Simon tasks are introduced. Last, this chapter also readdresses the research questions.

Finally, chapter V presents the conclusions drawn from the present study. First, a summary of the main findings of this investigation is presented. Then, some limitations of this study and recommendations for further research are pointed out. In the last section of this chapter, methodological and pedagogical implications are presented.

CHAPTER II

REVIEW OF LITERATURE

This chapter is divided into three main sections: the first reviews research that has investigated changes in the normal decline of some cognitive functions due to aging. The second reviews sex-related differences in cognition and the third section presents studies related to bilingualism across the lifespan and the effects of bilingualism on cognitive processing. Section 2.1 is dedicated to issues related to cognitive changes during aging. This section is further divided into three subsections, which provide explanation about cognitive functions, such as inhibitory control, working memory capacity, and speed of processing (sections 2.1.1, 2.1.2, and 2.1.3, respectively), that seem to become less efficient as we age. Section 2.2 presents an account of cognitive differences between the performance of males and females on a number of cognitive tasks. Section 2.3 addresses the issue of bilingualism. This section is divided into two subsections: one, subsection 2.3.1, defines the term "bilingual" and another, subsection 2.3.2, reviews empirical research on the relationship between bilingualism and executive functions, such as inhibitory control and working memory, across the lifespan.

2.1 Explaining age-related cognitive changes

According to Bialystok (2007), "the executive functions are basic to all cognitive life" (p. 219). Executive functions involve a collection of processes, such as planning, decision making, inhibition of irrelevant information, coordination and monitoring of information, cognitive flexibility in problem solving, and the regulation of behavior (Daniels, Toth & Jacoby, 2006; Luszcz & Lane, 2008). In order to give an account of executive functions, Luszcz et al. (2008) explain that executive function includes three executive control processes for cognition: a) processes that draw on working memory, such as monitoring and coordination; b) processes that require selective attention, such as inhibiting inappropriate responding, and c) processes that draw on divided attention, such as switching between different tasks or sources. Likewise, Verhaeghen and Cerella (2002) state that executive control includes processes, such as selection of information and switching between distinct activities or subjects.

As explained by Buckner, Head and Lustig (2006), throughout the years we not only experience physical changes, but also cognitive ones. Changes do not happen from one day to the other, that is, the changes which occur to our body and brain, are gradual and constant. Gradually, we start to observe wrinkles in our skin, gray hair, and muscles tone change. Some cognitive changes, such as a decline in the ability to store new items or retrieve information, are also noticed. According to Buckner et al. (2006), brain volume starts to reduce 0.2 % per year by the age of 30 and accelerates its loss in advanced aging.

As already mentioned in the beginning of this section, cognitive processes, such as the ability of controlling attention, ignoring interference from competing stimuli, and setting plans, are attributed to executive functions, which are fundamental in our cognitive lives. According to researchers (Bialystok, 2007; Reuter-Lorenz, 2000), areas of the frontal cortex, particularly the prefrontal cortex, subserve executive functions. Recently, studies have shown that the frontal lobe is probably the most affected area in the brain with advancing age (e.g. Rabbit, 2005). Some areas of the brain, such as the prefrontal cortex, amygdala, and hippocampus, undergo age-related changes earlier than others (Rabbit, 2005).

As Salthouse, Atkinson, and Berish (2003) explain, deficits in executive functions led to the *frontal lobe hypothesis* of cognitive aging. The frontal lobe hypothesis proposes that many changes related to aging that occur in cognition are due to the deterioration of the frontal lobe. It is also relevant to mention that the frontal lobe comprises a large part of the brain; therefore, according to Daniels, Toth, and Jacoby (2006), the frontal lobe hypothesis fails to point out which specific region in the frontal cortex underlies the performance of which cognitive function. Despite such lack of specificity, when compared to other regions, the frontal lobe indicates greater structural changes in the aging brain not only in size and number of neurons, but also in cortical thickness (Phillips, MacPherson, & Sala, 2002).

Moreover, differences between the performances of younger and older adults are seen in a number of cognitive processes. Researchers (Park, 2000; Old & Naveh-Benjamin, 2008) suggest that mental process slows down with aging in some major cognitive functions, including inhibitory control, processing speed, and working memory capacity. In what follows, these three cognitive functions will be discussed and accounts of how these functions seem to change in normal aging and influence performance, based on empirical studies, will be provided.

2.1.1 Inhibitory control

Inhibitory control is the ability to focus on relevant cues by suppressing irrelevant information or stimuli while performing any day-to-day task which involves attentional control (Miyake, Friedman, Emerson, Witzki, Howerter & Wager, 2000). Hasher, Zacks, and May (1999) state that inhibitory control has three main functions: a) the controlled inhibition function, which allows the access of relevant information to working memory, preventing the entrance of irrelevant information; b) the delete function of inhibition, which deletes or suppresses inappropriate information from working memory, and c) restrain strong responses, which is the inhibitory function that allows the evaluation of the appropriateness of responses before responses are provided.

More recent work carried out by Butler and Zacks (2006), who investigated eye movement control of 32 younger adults and 32 older adults, reported that the three functions mentioned above diminish with age. According to these researchers, eye movement tasks, such as the antisaccade task, in which the ability of overcoming a strong response is measured, involve executive control processes. In the antisaccade task, subjects have to avoid looking at the location where the cue appears; instead, subjects have to move their eyes to the opposite direction to where the stimulus is presented. Butler and Zacks (2006) reported that older adults performed slowlier than younger adults due to the reduced ability of inhibiting misleading cues. Such finding suggests that executive processing deficits are associated with advanced age and can be considered as a support for the inhibitory deficit hypotheses of aging (Hasher et al., 1999; Zacks, Hasher & Li, 2000). This hypothesis posits that, with normal aging, the ability to ignore and delete irrelevant information in working memory declines, and the ability to retain and control strong responses is reduced.

As already said, inhibition is one of the executive functions which deteriorates with normal aging (Nielson, Langenecker & Garavan, 2002). Consequently, age-related deficits in inhibitory control functions diminish the ability of ignoring inappropriate items (McDowd & Shaw, 2000). As the control over attention declines, it is assumed that irrelevant information enters working memory, which impairs its efficiency (Zacks, Hasher & Li, 2000; Salthouse & Meinz, 1995; Alain & Woods, 1999; Zellner & Bäuml, 2006). Likewise, Hasher, Lustig, and Zacks (2008) state that as the ability to maintain attention focused on relevant information diminishes across the lifespan, the performance on tasks that require speed of processing and working memory are also influenced.

A classical task that has been used in age-related declines in inhibitory processes is the Stroop Color task (Kane & Engle, 2003). In the Stroop Color task, participants have to read the word printed irrespective of the ink color it is presented. If the word displayed and the color of the ink match - for example, 'blue' is written in 'blue' ink - this is a congruent trial. In contrast, if the word printed and the color of the ink displayed do not match, this is an incongruent item - for example, 'blue' is written in 'red' ink - the conflict between the relevant information and the information to be ignored has to be solved. Researchers (West & Alain, 2000; Langenecker, Nielson & Rao, 2004; Spieler, Balota & Faust, 1996) who have used the Stroop task in order to investigate inhibitory control decline across the lifespan have observed an impairment of inhibitory processing with aging. In Langenecker et al. (2004), for instance, age-related differences were observed in the frontal cortex. These researchers compared the performance of 13 younger and 13 older adults and used functional magnetic resonance imaging (fMRI) with a Stroop task. The study showed that both younger and older adults had greater activation of the prefrontal area of brain while performing the Stroop task. However, older adults activated more areas in the frontal cortex than younger adults in order to accomplish the task. The recruitment of multiple areas of the frontal cortex was interpreted as a reduction of inhibitory functioning efficiency during aging.

Another task used in the investigation of the relationship between inhibitory control functions and cognitive aging is the Simon task, which was the task used in the present study. This task, like the Stroop task, involves congruent and incongruent trials besides requiring controlled inhibition; however, instead of words, the Simon task may present squares of distinct colors (the Simon task 2 Colors), arrows pointing to different directions (the Simon Arrow task)[4], or letters (A and B). Using the letter version of the Simon task, Van der Lubbe and Verleger (2002), carried out an event-related potential (ERP) study on aging in which 11 younger adults and 11 older adults were compared. Van der Lubbe and Verleger (2002) observed that younger adults not only outperformed older adults in reaction time, but had a smaller Simon effect, that is, the difference between reaction times to incongruent stimuli (the response key and the position of the stimuli do

[4] The Simon task 2 Colors and the Simon Arrow task are fully detailed in chapter III, section 3.4.4)

not correspond) and congruent stimuli (the response key and stimuli are on the same side) was smaller for younger adults than for older adults. Responses to congruent trials are usually faster and more accurate than to incongruent trials in which the stimuli and response locations do not match. Older adults are more disrupted from the incongruent trials than younger adults due to the decline in the efficiency of inhibitory processing, increasing the Simon effect. Furthermore, the researchers argue that motor processes in visual tasks, which are controlled by an inhibitory process, change with age. Such change in motor activation affects the ability to react fast to any stimulus presented.

Having presented some of the most used inhibitory control tasks – the Stroop task and the Simon task - in the field of selective attention (Bialystok, 2006), some methodological issues regarding the design of tasks which assess inhibitory control functions will now be considered. As observed by Bialystok, Martin, and Viswanathan (2005a) tasks should be developed or selected according to the population being investigated. According to these researchers, in order to design a task that assesses inhibitory control functions, the task must involve a conflict to be solved. In addition to that, when a study involves a wide range of ages or different language groups, finding a suitable inhibitory task that can be performed by all participants is essential. Considering these two aspects, the Simon task was selected to be used in the present study.

Furthermore, according to Bialystok et al. (2005a), the Simon task is appropriate to all ages because it is content-free, that is, it does not involve linguistic material. Furthermore, like the Stroop task, the Simon task offers a conflict: participants have to press the button which corresponds to the color presented on the screen. Half of the trials are incongruent, that is, they appear on the opposite side of the corresponding button. As already mentioned, such conflict is expected to generate slower responses to incongruent stimuli compared to congruent ones. The difference of response time in reacting to congruent and incongruent stimuli is called the 'Simon effect', which measures the efficiency of inhibitory control. A reduced Simon effect reflects inhibitory function efficiency, that is, the smaller the difference between incongruent and congruent items, the more efficient inhibitory processes are (Bialystok et al., 2004, Bialystok et al., 2007).

Considering age-related differences, older adults, compared to younger adults, perform poorly on tasks or situations that require inhibition. Park (2000) explains that as we age, we have much more trouble concentrating on only one item. That is, we easily fail in inhibiting distractions or conflicts. The difficulty in maintaining attention on a goal and quickly inhibiting competing stimuli affects many everyday activities.

In the present study, as already mentioned, the Simon task (the Simon task 2 Colors and the Simon Arrow task) was the measure used to investigate inhibitory control function. The Simon task 2 Colors was applied to a population of early and late bilinguals with ages ranging from 18 to 84, while the Simon Arrow task was administered only to late bilinguals. The Simon Arrow task was included in this research as another measure of inhibitory control, in addition to the Simon task 2 Colors, in order to verify whether the two versions of the Simon task assess inhibitory control in a similar way.

2.1.2 Working Memory Capacity

In this section, selected literature on working memory (WM), a system, which plays an important role in our everyday lives, will be reviewed. Working memory is involved in tasks that allow us to make sense of what we read and speak and is essential for mental calculation and problem-solving, reasoning, and planning (Conway, Jarrold, Kane, Miyake, and Towse, 2008, p. 3). WM tasks involve the "manipulation, storage, and transformations of held material" for a short period of time (Craik, 2000, p. 81). According to Conway and colleagues (2008, p. 3), the ability to maintain and process information depends on the working memory capacity of each individual. As Engle (2002) postulates, "greater WM capacity does mean that more items can be maintained, but this is a result of greater ability to control attention […] greater WM capacity also means greater ability to use attention to avoid distraction" (p. 20).

The term working memory was introduced by Baddeley and Hitch in 1974 (Baddeley, 2000). In an attempt to understand the relation between short- and long-term memory, Baddeley and Hitch conducted a study using the dual task methodology. The result showed that we have a memory system where information is held for a short period of time; however, this system is not only responsible for information held in mind, but also for processing information simultaneously. For that reason, Baddeley and Hitch introduced the term working memory (Baddeley, 2007, p. 6). These two researchers proposed one of the most influential models of working memory, the multicomponent model (Fortkamp, 2000; McCabe, 2008). The model consists of a central executive, which is responsible for the attentional capacity, and two other subsystems: the visuo-spatial sketchpad and the phonological loop. The first subsystem, the visuo-spatial sketchpad, is concerned with storing and processing visual information, while verbal and acoustic information is stored temporally by the other system, the phonological loop (Baddeley, 2000, p. 418). According to this model, WM can hold a limited amount of information and for a brief period of time (Baddeley, 2000, p. 418)

According to Bopp and Verhaeghen (2005), memory span tasks are widely used in the field of cognitive psychology. Span tasks can be categorized as simple or complex to assess short-term memory and working memory, respectively. Furthermore, memory span tasks can be presented orally (to assess verbal working memory) or visually (to assess visuospatial working memory) to participants. Short-term memory is measured by simple span tasks, which include a series of words, digits or letters (Bopp et al., 2005). In simple span tasks, participants are required to repeat the stimuli back in the same order the stimuli were presented (Kane, Conway, Miura & Colflesh, 2007; Unsworth & Engle, 2007). For example, in the letter span task, participants listen to a list of letters (e.g., D, J, U, P) and have to recall the sequence of letters in the same order it was presented to them (Unsworth & Engle, 2007). Complex span tasks, like simple tasks, require participants to recall items in the correct serial order. However, complex span tasks require storage and processing of information (Park et al., 2006).

In the 1980s, Daneman and Carpenter developed a complex measure of working memory, the Reading Span Test (Daneman & Carpenter, 1983). This test reflects the Baddeley and Hitch’s idea of information storage and simultaneous processing of new information in WM. In this task, the participant is presented with lists of comprehensible sentences instead of lists of words. The participant is asked to read the sentences aloud and to recall the last word presented in each sentence. Participant’s working memory is generally measured by the number of words the participant can recall.

Furthermore, another task used to assess working memory is the computational span designed by Salthouse and Babcock in 1991 (Salthouse, 1994). In the computational span task, a series of simple arithmetic problems are presented to participants. They have to provide the correct answers for the series of the arithmetical problems and, simultaneously, to remember the final digit in each problem solved (Salthouse, 1994). Tasks may also include digits and letters, such as the Wechsler Memory Scale Letter-Number Sequencing task developed by

Wechsler in 1997 (Park et al., 2006). This task involves presenting the participants with both letters and numbers; an example of a string is R5AL82. In order to accomplish the task subjects are asked to repeat the sequence in alphanumeric order, which is ALR258.

According to Baddeley and Hitch's model, then, more complex tasks require executive processes to store and manipulate information before an answer is given back. Executive processing plays an important role in working memory tasks. As stated by Engle (2002), executive control comes into play to maintain information active and avoid irrelevant items in working memory. Yet, Reuter-Lorenz and Jonides (2008) argue that attentional control is involved in any type of working memory task that requires storage of information for a period of time.

Since its introduction into the cognitive field, WM has been important construct in the study of cognitive aging. Reuter-Lorenz et al. (2008) point out that older adults assess executive control when performing even simple working memory tasks. Thus, when older adults have to perform more complex working memory tasks, they perform poorly because a great part of their attentional control is devoted to the first stage of the process, which includes storage and retrieval. Thereby, the second stage, which consists of manipulating information, would be affected by the first stage. In this sense, as explained by Reuter-Lorenz et al. (2008), despite the level of complexity of the working memory task, every working memory task recruits some degree of attentional control.

Furthermore, as already explained in section 2.1.1, the ability to inhibit irrelevant information becomes impaired with aging, that is, inhibitory processes cannot efficiently remove information no longer relevant (Hasher, Zacks & May, 1999). As regards working memory, due to the inability to inhibit and remove irrelevant information, working memory becomes overloaded with misleading information (Oberauer, 2001).

As already said, both visuospatial and verbal tasks are used to measure working memory capacity. One relevant study was conducted by Park and colleagues (2002), who tested 345 individuals, ranging from 20 to 92 years, in tasks involving visuospatial and verbal of short-term memory and working memory. Visuospatial short-term memory was measured by Corsi blocks tasks[5]. Visuospatial working memory

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[5] In the forward Corsi blocks, participants try to replicate the same series of raised blocks presented by the experimenter. In the backward Corsi blocks, participants try to present the blocks in the same order presented by the experimenter, however, the blocks have to be

capacity consists of the ability to maintain and process visual images. Park and colleagues (2002) included two visuospatial working memory tasks - line span[6] and letter rotation[7] – and two verbal short-term memory tasks – forward and backward digit span[8]. Verbal working memory included reading span and computation span tasks, in which, as already explained, participants are required to answer questions or solve arithmetical problems, respectively. Simultaneously, participants have to recall the last word from each sentence - in the reading span - or the last digit from each problem - in the computation span. Park et al. (2002) report that research has demonstrated that although both working memory and short-term memory measures decline with aging, older adults are more impaired on working memory tasks because these tasks are more complex and demand more attention than short-term memory span tasks.

Moreover, changes in working memory performance can be clearly noticed from early adulthood on (Craik, 2000, p. 81). It is well documented by Park et al. (2002) that the ability to maintain information active for processing in working memory begins to decline in the 20s and that such ability gradually declines across the lifespan. In relation to visuospatial and verbal working memory, there is some controversy as to whether both working memory functions decline equivalently or one function declines more than the other as people age. Comparing old and young adults' performance on visuospatial and verbal working memory tasks, Jenkins, Myerson, Joerding, and Hale (2000) found that older adults showed more deficits when performing visuospatial tasks. In contrast, Park et al. (2002) report that both functions are affected by aging at an identical rate. Similar equivalence was supported by Reuter-Lonrez and colleagues (2000) using neuroscience data. These researchers found asymmetrical shrinkage of left and right frontal cortex. As mentioned earlier, humans rely heavily on the frontal cortex

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presented backward. As the number of blocks increases by one after two trials per block, the tasks end when participants fail in both trials of a particular block (Park et al., 2002).

[6] In the line span task participants are shown some irregular shapes and a line segment simultaneously. Participants have to indicate whether the shapes presented are the same, in addition to that, they have to remember the position of the line (Park, et al., 2002).

[7] The letter rotation task involves the presentation of letters in two matters: normal form or mirror-imaged, besides that, the letters are presented in different angles. The task requires that participants decide whether the letter was presented in the normal form or as mirror image. At the same time, they answer the angle the letter was displayed (Park, et al., 2002).

[8] In the forward digit span, the strings of presented digits are to be recalled in the same order they were presented. In the backward digit span, like the forward, participants have to repeat the numbers in the pattern they were presented to them, however, in reverse order (Park et al., 2002).

to perform cognitive tasks; unfortunately, the frontal cortex shrinks with age. As observed by Reuter-Lonrez et al. (2000), considering that verbal processes rely on the left hemisphere and visuospatial processes on the right hemisphere and that both hemispheres have equivalent decline with age, these researchers conclude that visual and verbal working memory decline at the same rate with normal aging.

As reported by Park and colleagues, aging seems to affect more working memory than short-term memory. More recently, Bopp and Verhaeghen (2007) conducted a meta-analysis of the effects of aging on eight verbal span measures - short-term memory and working memory. The data set included 123 studies, which investigated the relationship between aging and verbal memory span. The verbal short-term memory included the following task: forward and backward digit span, letter span, and word span. The measures investigated for verbal working memory were reading span, listening span, sentence span[9], and computational span. According to Bopp and Verhaeghen (2007), the analysis of these studies indicated that all measures of verbal short-term memory and working memory decline with aging. A small age difference is noticed in simple tasks – the short-term memory tasks. In contrast, a larger age difference was found in verbal working memory tasks - older adults were more impaired on tasks that required simultaneous storage and processing of information than younger adults. Thus, considering that working memory span tasks require a higher degree of executive attentional-control (Kane, Conway, Hambrick & Engle, 2008, p. 25) and that WM span tasks are more age sensitive than short-term memory span tasks (Bopp et al., 2007; Craik, 2000), the present study uses the Alpha Span task as a measure of verbal working memory. The Alpha Span task, created by Craik in 1986, presents the subjects with a list of random words (e.g., floor, sun, cow). Subjects have to repeat the sequence back in alphabetic order (e.g., cow, floor, sun). Gradually the number of words in each string increases, the task begins with a series length of two stimuli and increases by one after two trials (the Alpha Span task is fully detailed in section 3.4.4, Chapter III).

Due to age-related changes in the frontal cortex, a greater amount of executive control and other executive functions are recruited to better perform working memory tasks (Reuter-Lorenz & Jonides, 2008). Younger adults and older adults' brain regions differ in activation in WM tasks. According to Reuter-Lorenz and Jonides (2008), in order to compensate for age-related declines, bilateral activation is recruited by

[9] Sentence span involves reading span and listening span data combined.

older adults to perform verbal and nonverbal working memory tasks. Executive processing recruitment seems to be a way of compensating prefrontal regions deficits, in order for older adults to come with a suitable response. In sum, as we age, we have more difficulties in holding, manipulating, and dealing with incoming information, especially if the task involves all these processes simultaneously. In this sense, accomplishing a task under time pressure becomes a challenge to older adults.

2.1.3 Speed of processing

Defined as the ability to process information efficiently and formulate an appropriate answer as quickly as possible, processing speed is one of the cognitive mechanisms that changes with normal aging and is believed to influence people's performance on other cognitive functions (McCabe, Roediger, McDaniel, Balota & Hambrick, 2010). In this sense, performance on complex cognitive functions may be affected due to slow processing associated with advanced age. For this reason, the present study provides an account of the relationship between processing speed, and two other cognitive functions, inhibitory control and working memory, which are the two cognitive functions investigated in the current study.

As observed by Salthouse (1996), tasks developed to assess other cognitive functions such as attention, memory, and problem-solving involve processing speed. Even though some tasks do not seem to be related to speed of processing, cognitive slowing may interfere in functions ranging from reasoning to memory (Salthouse, 1996).

Salthouse (1996) proposed the processing-speed theory, in which he explains that processing speed is an important element involved in age-related decline in general cognitive abilities. The theory proposes that two mechanisms are involved in the relationship between aging, cognition, and speed. These are a) a limited time mechanism and b) a simultaneity mechanism. According to the processing-speed theory, the limited time mechanism is related to the level of difficulty of a task and the time available for its performance. Because of the decrease in the speed of processing in normal aging, the time devoted to earlier information processing results in less time to perform later operations. The simultaneity mechanism refers to the loss of items presented earlier over items presented later, that is, after later stimuli are processed and performed, earlier ones are not available anymore for further processing and interpretation (Old & Naveh-Benjamin, 2008).

Moreover, as observed by Cavanaugh and Blanchard-Fields (2006), when associated with increased age, processing is one of the greatest contributors for cognitive changes performance on attention and memory. Verhaeghen and de Meersman (1998) examined data of 20 studies, in which the Stroop effect produced by younger and older adults on the Stroop task[10] was investigated. Results indicated that the poor performance of older adults on this task could be related to other kinds of cognitive deficit such as speed of processing. According to Salthouse (1994), normal aging leads to slow processing of information which affects working memory functioning, that is, working memory capacity decreases when processing is slow and increases with fast processing.

Salthouse (1995) compared the performance of 242 participants with ages ranging from 20 to 89 years on inhibitory control, speed of processing, and working memory tasks. According to Salthouse (1995) results indicated that age-related variance in processing speed lead to more decrements in working memory than in inhibitory control functions. This researcher strongly believes that speed of processing plays an important role in age differences in working memory.

In contrast, in a more recent study, Nettelbeck and Burns' (2010) study revealed that age-related decrease of processing speed directly affects reasoning ability. These researchers suggest that working memory capacity reduces due to cognitive changes related to normal aging not directly mediated by processing speed. In their study, Nettelbeck and Burns (2010) investigated the relationship between processing speed, working memory, and reasoning in 240 children aged 8 to 14 years and 238 adults ranging in age from 18 to 87 years. According to them, processing speed increases during childhood and declines linearly with aging. These researchers observed that the performance of people among 18 to 45 years old was better than that of 55 to 87 years old on processing speed tasks.

In a similar vein, Gregory, Nettlbeck, Howard, and Wilson (2009) investigated the performance of 150 older adults on a perceptual speed task – digit symbol – and a working memory task – reading span. Gregory et al. (2009) concluded that although the results confirm that working memory is affected by age-related changes in processing speed, there is strong evidence that working memory, independent from speed of processing, is directly affect by age-related changes in other cognitive functions. Taken together, the studies conducted by Nettelbeck and Burns (2010) and Gregory et al. (2009) suggest that due to age-related

[10] The Stroop task was described in section 2.1.1 as an inhibitory control task

cognitive changes, the relationship between processing speed, working memory, reasoning, and age is more complex to be understood among the elderly population than among younger adults and children. That is, although working memory is affected by general age-related cognitive changes, age-related decline in processing speed does not seem to have direct impact in the efficiency of working memory if compared to other cognitive functions which also decline, such as attention.

Borella, Ghisletta, and de Ribaupierre (2011) carried out another study investigating the role of three cognitive mechanisms which change with aging - working memory, inhibition, and speed of processing - in text processing. The performance of 89 younger adults and 102 older adults was compared on a battery of tasks, which assessed these three cognitive mechanisms followed by a text comprehension task. These researchers concluded that speed of processing and inhibition indirectly contribute to a decline in text processing with aging. According to Borella et al. (2011), age-related differences in text processing are directly affected by working memory.

The present study will not only contribute with data to the field of the effects of early and late bilingualism on inhibitory control and verbal working memory, but it will also contribute to the field of gender differences by verifying whether early and late bilingualism confer similar cognitive effects on inhibitory control and verbal working memory functions in both males and females. Now, I will briefly address cognitive differences in males and females.

2.2 Sex differences and cognition

Males and females are constantly compared in their cognitive abilities. According to Kimura (1999a), males and females solve cognitive tasks - problem-solving tasks – in a different manner. Such cognitive differences have shown that men tend to have more ability with problem-solving tasks, which include spatial tasks (Geary & DeSoto, 2001; Lejbak, Crossley & Vrbancic, 2011, Kimura 1999a), such as mental object rotation, navigation, mathematics, and motor skills as shooting targets. Women are better at problem-solving when it involves verbal ability (Weiss, Ragland, Brensinger, Bilker, Deisenhammer & Delazer, 2006), object location (Voyer, Postma, Brake, & Imperato-McGinley, 2007), manual speed (Bryden & Roy, 2005), calculation, and motor abilities as tasks that require manual precision (Kimura 1999a).

Recently, Lejbak, Crossley, and Vrbancic (2011) investigated gender differences in spatial, object, and verbal working memory tasks. Thirty-six adults – 18 males and 18 females – performed spatial, common object, and verbal versions of the n-back working memory task[11]. Lejbak et al. (2011) found a male advantage for spatial and object working memory. As regards verbal working memory, although males and females did not statistically differ on the verbal version of the n-back task, males performed more poorly on the verbal working memory task than females. In addition, these researchers reported that women performed at similar rates across the three conditions (verbal, spatial, and object), suggesting that verbal and spatial working memory are connected processes for females, but not for males.

Kimura (1999a) explains that even though men are typically better than women in spatial measures, male advantage is not always found for all spatial abilities, for example in tasks which involve object location. Duff and Hampson (2001) found that men were less accurate than women at locating which objects were moved within an array of objects for color and shape stimuli. According to Duff and colleague (2001), such women advantage in object location is due to gender difference in verbal ability. That is, in spatial task which uses stimuli that are easy to name, such as shapes, a verbal strategy may be employed in order to solve the spatial problem. In this sense, the ability to verbally process information can enhance women's performance on spatial tasks.

Another study conducted by Lejbak, Vrbancic and Crossley (2009) investigated 20 males and 20 females' performance on object location memory tasks. Object location memory consists of the ability to remember the location of objects and this memory system is typically assessed by tasks which require subjects to decide whether objects have been moved, to remember the location of a specific object among other objects, and to determine whether an object has been already introduced in an array of objects. Lejbak et al. (2009) Results supported an advantage for females on object location memory, concluding that

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[11] The n-back working memory tasks require subjects to make decisions about the items presented to them. The n-back task can be verbal or nonverbal and consists of presenting participants with a variety of stimuli. Participants are required to focus attention on the stimulus presented in order to identify whether this stimulus is the same as the one presented previously. In Lejbak's et al. (2011) study, three versions of the n-back working memory task were selected, the verbal version, which used a sequence of letters, the spatial task, which consist of black circles presented in 20 different positions, and the common object task in which images were used to assess working memory.

women are superior to men at remembering the location of the objects. Lejbak et al. (2009) reported that regardless of the type of stimuli (common objects, common shapes, and novel shapes), women made fewer errors than men on the object location memory tasks.

Furthermore, Voyer, Postma, Brake, and Imperato-McGinley (2007), who conducted a meta-analysis of 36 studies examining gender difference, also reported an overall women advantage for object location memory. As observed by Voyer et al. (2007), the ability to remember the locations of specific objects depends on explicit encoding. Although the explicit memory system is not the focus of the current study, it seems relevant to review some well documented research on the relationship between gender differences and two distinct memory systems - implicit memory and explicit memory. According to Paradis (2004) implicit competence/knowledge is represented in procedural memory and explicit competence/knowledge in declarative memory. Craik (2000) explains that implicit memory underpins learned skills, such as motor (driving a car) or cognitive (solving a puzzle) skills. When learning something or performing an activity in which procedural memory is involved, especially those that include sequences (e.g. motor sequences), we are not consciously aware of how we go about accomplishing the task (Ullman, 2005, p. 146). With regard to declarative memory, this system involves memories that may be explicitly (consciously) retrieved (Ullman, 2001). Although it refers to knowledge of which we are explicitly aware of, Ullman (2005, p. 143) states that the memories in declarative memory are not completely consciously available - in other words the knowledge stored in declarative form is not explicit in its totality. As Old and Naveh-Benjamin (2008) explain, there are two basic forms of declarative memory: semantic knowledge, which refers to knowledge about the world and general facts, and episodic knowledge, which refers to memory of events and is based on personal experiences. According to Ragland, Coleman, Gur, Glahn, and Gur (2000), women outperform men on verbal episodic memory tasks, which may be related to the verbal advantage found for women in some verbal tasks.

A strong predictor of gender difference is attributed to sex hormones (Duff et al. 2001). According to Kimura (1999a), sex hormones as androgen (testosterone) and estrogen influence human behavior, not only exerting influence on reproductive behavior, but changing cognitive abilities that involve problem-solving behavior. Both sexes produce these hormones. However, during adult life, despite the variations in hormone levels across individuals (Kimura and Hampson, 1994), women produce higher levels of estrogen while men produce higher levels of testosterone. Such hormone differences influence cognitive abilities. Testosterone influences performance on spatial tasks, which should favor men (Kimura, 1999b), while estrogen seems to enhance verbal abilities in women (Kimura, 1999a).

Due to the strong evidence that estrogen exerts an influence on verbal skills, and since estrogen is considered a female hormone, it is suggested that women are superior to men on tasks that involve explicit memory (Maki & Resnick, 2000). Recently, researchers observed that women have advantages compared to men in tasks involving the explicit memory system (Ullman, Estabrooke, Steinhauer, Brovetto, Pancheva, Ozawa, Mordecai & Maki 2002). Explicit memory is also implicated in the storage of new words (forms and meanings). Women, then, tend to demonstrate more ability at memorizing new words and more complex forms than men do (Ullman, 2005, p. 149). Such advantage at explicit memory is applied to second language learning context as well. Females should learn and memorize the lexicon easier than males. In contrast, it seems that males perform better on grammar, which depends on procedural memory system. All in all, the higher levels of estrogen in women would enhance their declarative memory, but inhibit their procedural memory. Men also produce estrogen, but in lower levels, which leads to an advantage at procedural memory (Ullman, 2004, p. 256).

In summary, the influence of sex on cognitive performance seems to be well established, with women performing better in tasks involving verbal abilities (Weiss et al., 2006; Lejbak et al., 2011) whereas men excel in spatial abilities (Lejbak et al., 2011; Kimura, 1999a). To the best of my knowledge, there is not research which investigates the relationship between sex-related differences on executive functions in a bilingual context. The present study investigates gender differences related to early and late bilingualism in inhibitory control and verbal working memory.

In the next section, first, the term “bilingual” will be defined. Then, in section 2.3.2, a number of studies comparing monolinguals and bilinguals on verbal and nonverbal tasks will be described.

2.3 Bilingualism

According to the IBGE (Instituto Brasileiro Geográfico e Estatístico) 2010[12], in 2000, 5.9% of the total population of Brazil was over 65 years old. In 2010, the population of elderly increased to 7.4% of the total Brazilian population. As in Brazil, the world population is growing old and such increase in the number of older adults has motivated research in the field of cognitive aging. Valenzuela (2008) explains that a large number of factors that contribute to cognitive decline are biological. However, there is strong evidence that some environmental factors, also known as lifestyle factors, can help to preserve cognitive functioning in elderly individuals (Valenzuela, 2008; Bialystok et al, 2007). As pointed out by Valenzuela (2008), complex mental activities, which promote mental stimulation, contribute to cognitive maintenance. Education and occupation status may also help to reduce cognitive decline (Valenzuela, 2008). According to Rowe and Kahn (1999) physical activities and social relations are also predictors of cognitive maintenance. Recently, studies (Bialystok et al., 2004; Bialystok et al., 2005a; Bialystok et al., 2007) of the relationship between bilingualism and aging have found that bilingualism can be considered a complex mental activity and that age-related cognitive losses in executive control may be attenuated by bilingualism across the lifespan.

2.3.1 Defining Bilinguals

A common definition most people use to define a bilingual is the one usually found in dictionaries: "a person fluent in two languages"[13]. This definition does not take into consideration that bilinguals cannot be considered a homogenous group, that is, despite the fact that bilinguals share the experience of using two or more languages,

> "there are many other dimensions along which bilingual speakers differ from each other besides degree of proficiency or dominance – context of acquisition (age and manner); context of use (relative frequency, purpose, modalities, sociolinguistic status); structural distance between

[12](http://www.ibge.gov.br/home/estatistica/populacao/censo2010/sinopse.pdf)

[13]The definition of bilingual was taken from an online dictionary: http://oxforddictionaries.com/

> languages; amount and type of interference; fluency; lexical, morphosyntactic, and phonological accuracy; auditory and reading comprehension; speaking, writing, translating abilities- each with the possibility of influencing the organization of the grammar." (Paradis, 2004, p. 3).

In that sense, Paradis (2004) suggests that there is no consensus about what a bilingual is. In other words, a monolithic concept does not exist because defining bilinguals can involve a wide category of concepts. For this reason, defining a bilingual is considered a difficult task. Thus, considering that there are bilinguals of many types, in the present study, the definition adopted is the one proposed by Grosjean (1994). The author defines bilinguals as those who speak at least two languages regularly and can produce utterances in both languages in a meaningful way.

As regards the definition of bilingualism, Baker (2006) agrees with Paradis (2004), and explains that there is controversy about the term "bilingual". According to Baker (2006) since balanced bilinguals - those who have the same abilities equally developed in their two languages - are rare, bilinguals can be distinguished and analyzed by some aspects. The first aspect is their ability in their two languages, which includes linguistic competence or dominance. Usually one of their languages is dominant. The second aspect is the age of acquisition. Paradis (2004) states, for instance, that some bilinguals acquire both languages by the age of five or seven, others, after the acquisition of a first language, learn another language in a formal context.

The third aspect is related to the context of use. Baker (2006) explains that some bilinguals live in communities where their two languages are used regularly. Other bilinguals live in a monolingual context and only use their other language in more specific situations, for example, during their vacations. Finally, the context in which their languages are acquired is another aspect to be considered. According to Weinreich (1953), cited in Ijalba, Obler, and Chengappa (2004), the context of acquisition determines the organization of the languages of bilingual individuals. Having this in mind, Weinreich, also cited by Paradis (2004), divided bilinguals into 3 groups: coordinate, compound, and subordinate. Coordinate bilinguals are those who learn languages simultaneously, but in distinct contexts. For example, one language is learned at home and another at school. Compound bilinguals learn different languages in the same environment and use them at the same time. Finally subordinate bilinguals are those who learn a second language (L2) after they have learned their mother tongue (L1).

Baker (2006) states that it is impossible to define bilinguals in a single sentence, therefore categorizations are necessary. According to Ehlers-Zavala (2010), although bilinguals can be classified in many different ways, initially, two basic terms are widely used to distinguish bilinguals: simultaneous and sequential bilinguals. Simultaneous are those bilinguals who usually are born in a bilingual context and are exposed to their two languages from birth, whereas sequential bilinguals acquire one language first and later on they acquire their second language. Within the definition of sequential bilingualism, other types of bilingualism have been proposed, such as early bilingualism, an individual who acquired his/her both languages in infancy, but not simultaneously, late bilingualism, to refer to subjects who acquired a second language after they have acquired their mother tongue, and adult learning of a second language, where a foreign language is learnt in adulthood (Fabbro, 1999).

Based on the review on types of bilinguals, in the present study, an individual was considered an early bilingual if s/he was raised speaking Hunsrückisch and learned Brazilian Portuguese by the age of 6. An individual was considered a late bilingual if s/he was raised speaking Brazilian Portuguese and started learning English over 12 years old.

Next, a review of studies that have investigated bilingualism and its effect on cognitive development follows.

2.3.2 Effects of bilingualism for cognitive development

Early research addressing the effects of bilingualism on cognitive functions found that bilinguals performed more poorly than monolinguals on a variety of tasks, which ranged from verbal abilities to intelligence; therefore, bilingualism was believed to bring only disadvantages (Bialystok, 2009, p. 418). Bialystok and her colleagues carried out various studies which postulate that early bilingualism might bring benefits to cognitive functions, mainly to executive control functions (Bialystok et al., 2004; 2005a; 2007; 2008a; 2008b; Bialystok, 2010). Evidence of such enhancement of executive control was found for bilingual children and adults first (Bialystok et al., 2004; Bialystok et al., 2005a). Then, Bialystok et al. (2004) decided to conduct studies with older bilingual adults – over 60 years old - in order to verify whether similar cognitive benefits would persist into aging. According to Bialystok et al. (2004), the effects of bilingualism could help attenuate age-related declines in executive control functions. The next subsections are devoted to a review of studies carried out comparing monolingual and bilingual children, adults, and older adult performance on tasks which assesses executive control, lexical abilities, short-term memory, and working memory. As already mentioned, research with adult bilinguals conducted by Bialystok and her colleagues (2004) were motivated by results showing that bilingualism provides executive control advantages in bilingual children. In this sense, although the present research does not investigate the performance of bilingual children on executive control tasks, in the next subsection, an account of the effects of bilingualism on children will be provided.

2.3.2.1 Effects of bilingualism on children

The ability to cope with two or more different languages in a meaningful way is not the only benefit bilinguals seem to possess. The present subsection will present some recent studies on the effect of bilingualism on children which suggest that the alternate use of different languages brings positive effects for cognitive processes. These benefits can range from creativity to enhancement of inhibitory control in which bilinguals, when compared to monolinguals, seem to perform better.

Most research related bilingualism has been conducted with children and have shown evidence that bilingualism influences cognitive development from early on in life (Bialystok, 2001) Furthermore, Bialystok (2001, p. 217) states that executive control functions develop earlier in bilingual children than in monolingual children. Kessler and Quinn (1980, 1987 cited by Bialystok, 2001) showed evidence that dealing with two languages and two cultures at once would enhance bilingual children's ability to offer more solutions to a given problem from different views, which would not only involve problem-solving, but also creativity. Bialystok (1991) applied tasks to monolingual and bilingual children in order to investigate whether bilingualism has an effect on children's cognition. One of the tasks was the Moving Word task. In this task, children were presented two simultaneous pieces of information: a printed word and a pictured object. Children were asked to identify whether there was a relationship between the words and the pictures presented to them. The Moving Word task requires selective attention for possible semantic matches - for instance, children have to ignore perceptual features of a stimulus. Results showed that bilingual children outperformed monolingual children and that selective attention develops earlier in bilingual children than in monolingual ones. According to Bialystok, bilinguals performed better than monolinguals probably because bilinguals have the ability to move from one task to another in a more effective way.

Precocious development of executive control functions in bilingual children has been usually assessed by inhibitory control tasks. For example, in Martin-Rhee and Bialystok's (2008) study, bilingual and monolingual children were compared on two types of inhibitory control – interference suppression and response inhibition - in three distinct experiments. Results show bilingual advantages in tasks that required controlled attention over competing items, that is, in interference suppression. However, no advantages were found in response inhibition. As bilingual children are superior to monolinguals only in one type of inhibitory control, Martin-Rhee and Bialystok (2008) concluded that the same control of attention required to manage two languages is involved in interference suppression.

Carlson and Meltzoff (2008) also investigated bilingual children performance on a variety of executive control and verbal tasks. The research was carried out with 50 kindergarten children arranged into 3 groups: monolinguals, simultaneous bilinguals, and children who had been exposed to an L2 for six months in kindergarten. According to these authors, monolinguals outperformed the two other groups on tasks that involved verbal abilities. However, the authors found great evidence for a bilingual advantage in conflict solving - conflict executive function tasks - which indicates differences in cognitive development. As regards children who were exposed to their L2 only in the kindergarten, Carlson and Meltzoff (2008) concluded that 6 months exposure to a L2 was not enough to enhance cognitive development.

Consistent with the view that executive control develops more rapidly in children who extensively use two languages, a more recent study carried out comparing 6-year-old monolingual and bilingual children on cognitive and language tasks (Bialystok, 2010). Experiments were conducted with 151 - monolingual and bilingual – children who performed 5 tasks, assessing executive control (Trial-making task, Global-local task), vocabulary (Peabody Picture Vocabulary Task, Category fluency), and working memory (Digit span). The author reported that the performance of monolingual and bilingual children did not differ on working memory and vocabulary tasks. However, a bilingual advantage was reported in two tasks that assessed executive control. Furthermore, bilinguals outperformed monolinguals on both conditions, that is, for trials which involved conflict and for those which did not.

A suitable explanation for more developed inhibitory control reported in bilinguals would be that bilinguals have the capacity to ignore stimuli that are not relevant, which suggests that inhibitory function is protected by the experience of managing two languages (Bialystok, 2001; Bialystok et al., 2004). In the next subsection I will provide a review of studies which investigated bilingualism and cognitive aging.

2.3.2.2 Lifelong bilingualism and cognitive aging

The advantage observed in bilingual children in attentional control and tasks presenting cognitive conflict, presented in the previous subsection, led to research with bilingual adults and older adults. In order to verify whether cognitive benefits of bilingualism endure into adulthood and older adulthood, the performance of monolinguals and bilinguals were compared in tasks, such as inhibitory control, working memory, and lexical tasks.

Research on cognitive aging shows that both memory and attentional performance decrease with age (Grady & Craik, 2000). As already said, aging brings with it deficits in cognitive functions of two types: a) one associated with memory, mainly seen in declarative memory, and b) one associated to executive abilities and attention (Buckner et al., 2006). Buckner and colleagues (2006) explain that although the decline in these functions can occur simultaneously, one function usually declines before the other, because one function does not depend on each other to decline. The ability to access mental resources is reduced, that is, the speed to process information slows down and this constrains the ability to perform mental tasks more effectively. Therefore, it is common to observe age-related deficits in lexical retrieval, syntactic production, comprehension, declarative memory, and implicit memory (Schrauf, 2008). However, according to Schrauf (2008) there are no considerable losses related to vocabulary levels, the use of language, and background knowledge.

Recent studies of bilingualism have investigated the relationship between bilingualism and aging. In three studies conducted by Bialystok et al. (2004), adults and older adults, both monolinguals and bilinguals, were compared in terms of their performance on cognitive tasks. The bilingual participants answered a language background questionnaire before the experiments, which determined where and in what circumstances each language was used and if both languages were regularly used. The researchers also controlled for similar socioecomonic backgrounds. In the three experiments conducted in Bialystok et al. (2004), inhibitory control was assessed with the Simon task. The first experiment consisted of 40 monolingual and bilingual participants – adults and older adults. In the first experiment, Bialystok et al. (2004) reported that although bilinguals were superior to monolinguals in reaction time and incongruent trials, the reaction time of all participants was longer than expected. For this reason, these researchers carried out a second experiment replicating the first experiment, in which the number of trials of the Simon tasks increased from 28 to 192 trials. Ninety-four adults and older adults divided into monolinguals and bilinguals performed the Simon task in the second experiment. In this experiment, bilinguals showed a smaller Simon effect than monolinguals. This result was taken as evidence that bilingualism enhances the efficiency of inhibitory processing.

Another task employed in this experiment was the Alpha Span task, already described in Section 2.1.2, which is a verbal working memory task. Language differences were noticed in the performance of the Simon task, but not on other tasks, such as the Alpha Span task. The researchers reported an advantage for bilinguals whose performance, compared to monolinguals, was faster with the Simon effect smaller. Furthermore, older participants – monolinguals and bilinguals – showed longer reaction time than younger participants, which reflects the slowing associated with aging. Then, a third experiment, which was built on the second experiment, was conducted in order to verify whether 20 adults - monolinguals and bilinguals - would obtain similar results after practicing the trials for 10 times in the Simon task. For this experiment, Bialystok et al. (2004) concluded that the difference between monolinguals and bilinguals' performance reduces with sufficient practice. According to these researchers, the three experiments show strong evidence that the benefits observed in executive control processes in bilingual children and adults are also seen in older bilinguals, once older bilinguals outperformed their monolingual peers.

Furthermore, in another study, Craik and Bialystok (2006) reported that older adults were outperformed by younger adults on most of the tasks due to age-related deficits. After answering background and language questionnaires, sixty participants divided into younger and older adults, monolingual and bilinguals, performed tasks which assessed planning and executive control, vocabulary, working memory, and short-term memory. Monolinguals scored higher in measures of working memory, which was assessed through the Alpha Span task. This task was more poorly performed by older bilinguals. These results were interpreted as vocabulary deficits, not as cognitive impairment. In addition, results also indicated that, despite the fact that inhibition is reduced with age, older bilinguals were better at some tasks involving planning than older monolinguals. Together, these findings suggest that although as we age our cognitive abilities decline, mastering two languages across the lifespan can attenuate the decline of executive control functions (Craik & Bialystok, 2006).

Moreover, two other experiments were conducted by Bialystok, Craik, and Luk, (2008b), who investigated the performance of 96 younger and older participants arranged into monolinguals and bilinguals on lexical retrieval, executive control, and working memory. One of the tasks used in both experiments was the letter fluency task. In the first experiment, in order to accomplish the letter fluency task, which is a verbal task, participants - 48 young and older monolinguals and bilinguals - had one minute to produce as many words as they could, starting with a specific letter. In the second experiment, the letter fluency task was adapted to assess participants' executive control. In the adapted letter fluency task, participants - 50 young and older monolinguals and bilinguals - were presented with a list of words from which they had to exclude words which ended with different letters. Results show that, in the first experiment, monolinguals retrieved more words than bilinguals in the letter fluency task. In the second experiment, high level bilinguals outperformed monolinguals on the adapted letter fluency task. For Bialystok et al. (2008a), these results confirm bilinguals' advantage in tasks which make demands on executive processes.

In addition, Bialystok, Craik, & Freedman, (2007) postulated that bilingualism across the lifespan might serve as a protective factor against cognitive decline in older adults. In order to test this hypothesis, they carried out a study with elderly patients in a clinic in Toronto, Canada. During four years, these researchers investigated 228 patients with cognitive complaints. Some patients were excluded and the final sample was of 184 patients. The patients were divided into monolinguals and bilinguals. The bilingual group included speakers of 25 different first languages and the bilinguals' second language was English. The monolinguals were English speakers. Between 2002 and 2005, these patients were frequently assessed with CT[14], SPECT[15], and

[14] A Computed tomography (CT) provides cross-sectional images of the brain.

blood tests. The data also included their medical history evaluation, physical and mental examination, years of schooling, and occupational status. The age of onset of symptoms of cognitive decline was determined by an interview with the patients and their families. By the end of the research, the authors reported that "bilinguals showed symptoms of dementia 4 years later than monolinguals" (p. 459).

As observed by Bialystok and colleagues (2005a), a bilingual advantage in inhibitory control processing has been found in children, middle, and older adults, but no evidence was found for younger adult bilinguals compared to monolinguals of the same age (Bialystok, 2006). According to Bialystok et al. (2005a), "the subtle advantage in inhibitory control that comes from bilingualism is irrelevant for individuals who are already in control of efficient processing" (p. 117). In order to investigate such absence of reaction time difference between younger bilinguals and monolinguals, Bialystok, Craik, Grady, Chau, Ishii, Gunji, and Pantev (2005b) compared the performance of 30 younger adults (two bilingual groups – French/Cantonese and French/English - and one monolingual group) on the Simon task using Magnetoencephalography (MEG)[16]. Two groups of bilinguals were selected to the experiment in order to verify whether groups, which shared bilingualism, also shared similar types of activation when performing an executive control task. Both bilingual groups showed the same pattern of activation in the left prefrontal cortex and the anterior cingulate for faster responding in the task, whereas faster monolinguals showed activation in the middle frontal cortex (left hemisphere). The authors interpret these results as evidence that bilinguals and monolinguals differ in cortical activation: bilinguals' brain activity was in regions typically used for language, such as BA 45[17], while monolinguals relied on areas related to conflict solution (BA 9)[18] (Bialystok, 2007). According to Bialystok et al. (2005b), the experience

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[15] Single photon emission computed tomography (SPECT) was used in Bialystok et al. (2007) to provide information about how blood flows into the brain.

[16] Magnetoencephalography is a non-invasive technique which measures magnetic fields provided by electrical currents in the brain. For instance, this technique can be used to determine which part of the brain is activated while a cognitive task is performed (Ullman, 2006).

[17] Brodmann area 45 (BA45) refers to the triangular part of the inferior frontal gyrus, in the left frontal gyrus. According to Ullman (2006, p. 258), BA45 underlies the retrieval and maintenance of lexicon.

[18] Brodmann area 9 (BA9) is in the dorsal prefrontal cortex. BA9 sustains attention and working memory (Clark, Egan, McFarlane, Morris, Weber, Sonkkilla, Marcina & Tochon-Danguy, 2000).

of managing two languages provides bilinguals with the possibility to use a brain structure which normally subserves verbal tasks to solve a nonverbal task (an inhibitory control task). Despite the difference in activation between monolinguals and bilinguals, young bilinguals do not show advantages in inhibitory control functions, that is, monolinguals and bilinguals perform similarly on tasks that require executive control. Such finding is interpreted as evidence that bilingualism does not promote an advantage for younger bilinguals, because humans reach the peak of cognitive performance in the younger adulthood. Therefore, a bilingual advantage will be only noticed again from the middle age on when inhibitory control efficiency reduces.

As can be observed, strong evidence for effects of bilingualism on the efficiency of executive control has been found by Bialystok and colleagues (2004, 2005a, 2008a, 2008b). However, bilingualism seems to enhance only some components of executive control. In this vein, Costa, Hernández, and Sebastián (2008) tested the performance of 200 younger participants – both early bilinguals and monolinguals, ranging in age from 17 to 32 years - on the attentional network task[19], which involves different attentional networks: alerting, orientation, and executive control. In contrast to Bialystok (2006), Costa and colleagues (2008) reported that, although attentional control capacity is at its peak in young adulthood, they have found evidence that early bilingualism brings benefits in alerting and executive control (monitoring and conflict resolution) for younger bilinguals compared to monolinguals.

Colzato, Bajo, van der Wildenberg, Paolieri, Nieuwenhuis, LaHeij, and Hommel (2008) also compared the performance of younger bilinguals and monolinguals on one component of executive control: inhibitory control, which was distinguished between active and reactive inhibition mechanisms. While active inhibition involves selecting a relevant item and ignoring a competing item in order to solve a conflict, the reactive inhibition refers to the ability to maintain goal task in order to provide relevant responses to a conflict. These researchers concluded that bilinguals are superior to monolinguals on reactive inhibition. Taken together, these two studies show that components of executive control, which are modified by bilingualism, need to be identified in order to understand the effect of bilingualism on cognitive functions.

[19] The attentional network task (ANT) was developed by Fan, McCandliss, Sommer, Raz, and Posner in 2002 (Costa et al., 2008). This task combines two tasks: the cue reaction time task and the flanker task.

Research on the effects of bilingualism across the lifespan on executive functions has also been investigated in Brazil. Billig (2009) and Pinto (2009) carried out studies comparing adult and older Hunsrückisch/Portuguese speakers to monolinguals of the same age on tasks that required inhibitory control processing. Billig's participants - 83 adults and older adults arranged into monolinguals and bilinguals – answered a language and background questionnaire and were assessed with screening tests (a Depression test and Mini-Mental State Examination). Three tasks were applied to participants: the Stroop task and two versions of the Simon task. Billig (2009) revealed significant age-related decline, that is, adults performed the tasks better than older adults. Along the same lines, Pinto (2009) compared the performance of 60 monolingual and bilingual participants – adults and older adults. Pinto's participants were assessed with the Simon task, the Peabody Picture Vocabulary Test, and The Raven's Standard Progressive Matrices (see Bialystok et al. (2004), for details on the tasks). Although significant language group differences were not found in either Billig (2009) or Pinto (2009), Pinto (2009) observed that bilinguals performed better than monolinguals on the tasks.

From these reviews, it seems that managing two languages through the lifespan enhances the development of executive control functions. In other words, lifelong bilingualism may offset the effects of aging in cognitive processing, mainly in inhibitory functioning.

To summarize, the issues discussed in the current chapter are relevant to the present study because they present a view of the area of age-related changes in cognitive functions and effects of bilingualism on tasks that involve executive control. Cognitive impairment due to normal aging was reported in inhibitory control, speed of processing, and working memory capacity. Such cognitive functions decline with age influencing day-to-day activities. As can be noticed, Bialystok and other researchers (Bialystok et al., 2004; Bialystok et al., 2005a; Bialystok et al., 2008a; Bialystok et al., 2008b; Colzato et al., 2008) carried out a series of studies investigating the effects of bilingualism on executive control functions. These investigators have found strong evidence that early bilingualism not only brings cognitive advantages to children and adults, but can attenuate the effects of cognitive changes in advanced age. Nevertheless, there might be a period in which the effects of bilingualism are not noticed. The present study brings not only early bilinguals, but late bilinguals into investigation. In the next chapter, the design of the present study will be described.

CHAPTER III

METHOD

The present chapter describes in detail the method used in conducting the present study. The chapter is organized into 5 sections. Section 3.1 presents the objective of the study and the research questions; in section 3.2, the general design of the study is portrayed. Section 3.3 presents information about the participants of the research. The materials of data collection are presented in section 3.4, followed by the description of procedures of data collection presented in section 3.5. Section 3.6 is devoted to the method adopted for data analysis. Finally, the last section of this chapter, 3.7, presents the pilot study carried out prior to the current study.

3.1 Objective and research questions

As already explained in the review chapter, Bialystok et al. (2004), Bialystok et al. (2005a), and Bialystok et al. (2008b) have provided evidence that early bilingualism aids in offsetting age-related losses in executive control. The present study is based on this empirical research on bilingualism and pursues three objectives: 1) to investigate the performance of not only early but also late bilinguals in inhibitory control and working memory tasks, 2) to investigate gender differences related to early and late bilingualism in inhibitory control and working memory tasks, and 3) to investigate a methodological issue related to the assessment of inhibitory control by comparing the performance of participants on two different versions of the Simon task (the Simon task 2 Colors and the Simon Arrow task).

The present study pursues the following questions:

1. Will early and late bilinguals outperform their monolingual peers on measures of inhibitory control and verbal working memory?
2. From a cognitive perspective, does bilingualism across the lifespan help in offsetting age-related losses in inhibitory control and verbal working memory?
3. Does a second language learned late in life (late bilingualism) through instruction in the classroom lead to the same pattern of enhancement of executive control, reported by Bialystok and colleagues (2004), obtained in natural learning environments (early bilingualism)?

4. Are there differences between the performance of females and males on inhibitory control and verbal working memory tasks?
5. Considering that both Simon tasks (2 Colors and Arrow) assess inhibitory control, will the performance of the participants on these tasks differ in a way that we could predict which task would seem better to measure inhibitory control?

In order to answer these questions, attentional and working memory tasks were applied to early bilinguals (Portuguese / Hunsrückisch speakers), late bilinguals (Portuguese / English speakers), and to monolinguals (Portuguese speakers) recruited in four cities in Brazil: Iporã do Oeste, Mondaí, and Florianópolis in the state of Santa Catarina, and Porto Alegre in the state of Rio Grande do Sul.

3.2 General research design

This study comprised two main phases. The first phase consisted of the data collection conducted in Iporã do Oeste and Mondaí in the west of Santa Catarina and in Porto Alegre in Rio Grande do Sul. In this first phase, which was carried out from May to June 2010, I personally contacted most of the participants of this research. Early bilinguals and monolinguals – younger, adult, and older participants - answered two questionnaires: the language background questionnaire (Appendixes A and C) and the general background questionnaire (Appendix D). There was a specific language background questionnaire for bilinguals (Appendix A) and a specific language questionnaire for monolinguals (Appendix C). After having answered the questionnaires, two screening tests were administrated to the participants: the Mini-Mental State examination (Appendix E) and the Beck Depression Inventory (Appendix F). The questionnaires and the screening tests were designed and administered in Portuguese to all participants. In addition, the questionnaires and tests were applied orally by this researcher who filled them out with the answers provided by the participant. After the participants had answered the questionnaires and gone through the two screening tests, they were asked to perform the Simon task 2 Colors and the Alpha Span task (see section 3.4.4, in this chapter, for a full detail of the tasks). The tasks were applied on the same day or the day after the questionnaires and screening tests were applied.

The second phase was conducted in Florianópolis, with UFSC students, from October to November 2010. Late bilinguals (Portuguese/English) and Brazilian Portuguese monolinguals answered the language background questionnaire (Appendix B), the general background questionnaire (Appendix D), and the screening tests (Appendix E and F). Furthermore, the late bilingual group took an English proficiency test (Appendix H). After that, they were asked to perform the two versions of the Simon task and the Alpha Span task (see details about each task in this chapter, section 3.4.4).

3.3 Participants

One hundred and four participants ranging from 18 to 84 years took part in the present research. Participants were divided into 4 groups of monolinguals (Brazilian Portuguese speakers), and 4 groups of bilinguals. The 4 groups of bilinguals consisted of 3 groups of Brazilian Portuguese/Hunsrückisch speakers and one group of Brazilian Portuguese/English speakers. Participants were all right-handed and were matched for sex in each group. Sixty-eight participants were from the west of Santa Catarina: 54 participants were from Iporã do Oeste and 14 from Mondaí. Twenty-eight participants were from Florianópolis, also in Santa Catarina, and 8 participants were from Porto Alegre, in Rio Grande do Sul. The data was collected in quiet and well-lighted rooms in all the places. All the participants signed a consent form (Appendix G) agreeing to take part in this research as volunteers.

Next, a full description of the 8 groups, which took part in this study, will be provided. The description of the groups is arranged into two subsections. Subsection 3.3.1 presents the monolingual participants and subsection 3.3.2, the bilingual participants.

3.3.1 Monolingual participants

Half of the participants were monolinguals, native speakers of Brazilian Portuguese, that is, 52 monolingual subjects participated in this study. These participants have reported in the language background questionnaire not being fluent in any other language, but Portuguese. The monolingual participants were divided into 4 groups: younger monolinguals, adult monolinguals, older monolinguals (from the west of Santa Catarina and Porto Alegre), and younger monolinguals from UFSC. Participants from the first three groups, that is, younger, adult, and older monolinguals, were personally contacted by this researcher in their houses. Participants in the last group, younger monolinguals from UFSC, were first contacted during their coffee break at the university. The four monolingual groups will be described below.

3.3.1.1 Younger monolinguals

This group consisted of 10 young monolinguals, 5 males and 5 females, with ages ranging between 18 and 26 years with a mean of 20.6. According to the information gathered in the general background questionnaire, two participants had just finished high school, five participants were college students and three had already completed an undergraduate degree. The average number of years of schooling for these participants was 13 years. Nine participants were from Iporã do Oeste and one from Mondaí, in the western Santa Catarina.

3.3.1.2 Adult monolinguals

Fourteen young adult monolinguals (7 males and 7 females) participated in the study. Their age ranged from 30 to 54 years old with a mean of 46. According to the general background questionnaire, participants had an average of 9.9 years of schooling in this group. Only two participants had completed an undergraduate course. All participants in this group were from western Santa Catarina: 11 were from Iporã do Oeste and three from Mondaí.

3.3.1.3 Older monolinguals

There were 14 older adult monolinguals (7 males and 7 females) in this group, with ages ranging from 65 to 84 years old (mean age, 72.6 years). The participants in this group had an average of 5.6 years of schooling. Two participants were from Iporã do Oeste, four were from Mondaí, and eight from Porto Alegre. These participants’ information was gathered in the general background questionnaire.

3.3.1.4 Younger monolinguals from UFSC

This group consisted of 14 young monolinguals, 7 males and 7 females, their ages ranging from 18 to 26 years (mean age, 20.7 years). Participants had 12.6 years of formal education. Participants’ answers to the general background questionnaire showed that the participants in this group were undergraduate students from different programs at UFSC, including 3 participants from Pedagogy, 3 participants from Design, 3 from Journalism, one from Administration, one from Mathematics, one from Letras (Portuguese), one from Physical Education, and one participant from Gastronomy.

3.3.2 Bilingual participants

Fifty-two (52) bilingual participants took part in the present study. Thirty-eight were early bilinguals (Portuguese/ Hunsrückisch speakers) and 14 consisted of late bilinguals (Portuguese/English speakers). They will be described below.

3.3.2.1 Early bilinguals

Thirty-eight early Hunsruckisch/Portuguese bilinguals volunteered for this research. Hunsrückisch is a German dialect which was brought to Brazil about 180 years ago with the German immigrants, from a region called Hunsrück (Braun, 2010, p. 11). Throughout the years, this immigration language changed and has gone through a natural process of linguistic variation (Spinassé, 2008). Hunsrückisch was created from different types of German and suffered influences of Portuguese and other languages such as Italian and French. According to Spinassé (2008), Hunsrückisch, which is recognized as a Brazilian immaterial cultural patrimony, is spoken in the west of Santa Catarina and Paraná, and in northwestern Rio Grande do Sul. Most people who live in these regions have been bilinguals since their childhood and have used two languages regularly for most of their lives (Altenhofen & Frey, 2006).

As explained by Spinassé (2008), in 1937, Getúlio Vargas, who was then the president of Brazil, signed a law prohibiting schools to administer classes in any other language, but Portuguese. By prohibiting German language in schools, German decedents, who were taught in German, were deprived of learning how to read and write in their first language and were educated in Portuguese. In order to guarantee effective communication with Hunsrückisch speakers, and since I am not a speaker of this dialect, I decided to recruit participants with the help of two speakers of Hunsrückisch in the two cities in the west of Santa Catarina (Iporã do Oeste and Mondaí). These two people helped to recruit participants who were fluent Hunsrückisch speakers.

Data from the language background questionnaire indicated that Hunsrückisch was the first language these participants learned, followed by Portuguese. Only one participant reported having his first contact with Portuguese at the age of 8. All others reported having started learning Portuguese when they first arrived at school by the age of 5 or 6. These participants were divided into the 3 groups described below:

3.3.2.1.1 Younger bilinguals (Hunsrückisch/Portuguese)

Ten young Portuguese/ Hunsrückisch bilinguals (5 males and 5 females), with ages ranging from 18 to 26 years old (mean age, 22.6 years) took part in this study. Three participants reported, in the general background questionnaire, having just finished high school, two participants were college students and five had already completed an undergraduate degree. The average of years of formal education in this group was of 13.4. All participants in this group were from Iporã do Oeste, Santa Catarina.

3.3.2.1.2 Adult bilinguals (Hunsrückisch/Portuguese)

This group consisted of 14 adult Portuguese/ Hunsrückisch bilinguals, 7 males and 7 females. Their age ranged from 30 to 54 years old (mean age, 43.5 years). Participants' answers to the general questionnaire showed that only five participants had completed an undergraduate degree. All others reported having completed high school. In this group, 12.8 years was the average of formal educational. Thirteen participants were from Iporã do Oeste and one from Mondaí.

3.3.2.1.3 Older bilinguals (Hunsrückisch/Portuguese)

In this group, there were 14 older adult Portuguese/ Hunsrückisch bilinguals (7 males and 7 females), with ages ranging from 65 to 84 years (mean age, 72 years). These participants reported having an average of 5.3 years of formal education. Eleven participants were from Iporã do Oeste and 4 were from Mondaí.

3.3.2.2 Late bilinguals

This group consisted of 14 young Portuguese/English bilinguals (7 males and 7 females). Their ages ranged from 18 to 26 years old (mean age, 22.6 years). Participants had 14.4 years of formal education. These participants reported being college students attending distinct courses at UFSC, including 7 participants from Letras (English), 3 participants from Engineering, one from International Relations, one from Physical Education, and one from the Secretarial Program. Data from the language background questionnaire indicated that they had lived in an English speaking country for at least 2 months in the past 2 years. They were recruited by e-mail, in the English Letras Program, and personally in the Extracurricular Language Program at UFSC where, at the time of the data collection, they were attending English classes in advanced groups.

3.4 Materials

3.4.1 Questionnaires

Two questionnaires were applied to the participants: a language background questionnaire and a general background questionnaire. As mentioned in section 3.2, these questionnaires were applied in Portuguese, to all participants, by this researcher.

There were three language background questionnaires: one for early bilinguals, one for late bilinguals, and another one for monolinguals. The language background questionnaire consisted of questions aimed at obtaining information about language use, that is, information about which language participants use in different contexts, such as at home or at work. The language background questionnaire designed for the early bilinguals (Appendix A) consisted of two parts. In the first part, participants were asked some general information (name, age, gender, occupation, place of birth, and schooling). In the second part, there were 14 questions related to the use of both languages - Hunsrückisch and Portuguese - and to the frequency with which the participants were in contact with both languages in their daily lives. The early bilingual questionnaire also included questions about the age the Hunsrückisch/Portuguese participants started acquiring Portuguese, which is their second language, and in which contexts. Furthermore, in this questionnaire, early bilingual participants had to self-evaluate Hunsrückisch and Portuguese proficiency in speaking, comprehension, reading, and writing.

The questionnaire for the late bilinguals - Portuguese and English - also consisted of two parts (Appendix B), a general information section, followed by the second part, which consisted of 14 questions related to the use of the English language in their routines. The late bilingual questionnaire consisted of questions related to the age participants started studying English, their second language (L2), and the age participants first felt they had acquired proficiency and could communicate effectively in that language. In addition, participants were asked about the frequency of exposure to the L2 and contexts with which the L2 was spoken and used. In addition, as in the early bilingual questionnaire, late bilingual participants self-evaluated their L1 and L2 proficiency in speaking, comprehension, reading, and writing. In this bilingual questionnaire, late bilingual participants were also asked about whether they had lived in an English speaking country.

The language questionnaire for the monolinguals (Appendix C) was shorter than the questionnaires answered by the bilinguals. This questionnaire is also divided into two parts. The first part of the questionnaire is identical to the first part of the bilingual questionnaires. The second part of the questionnaire for the monolinguals consisted of 4 questions. In the first question, the participant was asked whether s/he knew how to speak any other language besides Portuguese. If the answer was 'no' the questionnaire ended here. But if the answer was 'yes' the 3 following questions were related to this second language the participant had contact with. The bilingual questionnaires were designed by this researcher based mainly on questionnaires developed by Scherer (2007) and Peters (2010). The monolingual questionnaire was based on Scherer's (2007) questionnaire. These two researchers have also carried out research comparing populations of bilinguals and monolinguals.

All participants, monolinguals and bilinguals, completed a general background questionnaire, which was designed to collect general information about the participants, including information about participants' health and handedness. The general questionnaire, which was designed based on Queen and Hess (2010), McManus (2009), and Tolonen Kuuslasmaa and Laatikainen (2002), was divided into 4 parts. The first part comprised participants' general information followed by part 2 which was about handedness information. In the third part, participants were asked about clinical information. Finally, in part 4, pharmacological information was asked to participants (see Appendix D). All questionnaires applied in the present study were in Portuguese.

3.4.2 Screening tests

Two screening tests were applied to all participants. The first test was the Mini-Mental State Examination (Folstein et al., 1975), which contained simple questions related to various areas such as arithmetic, repetition of words, and motor skills. The exam aims at detecting whether individuals have some sort of cognitive impairment. This test was first validated by Bertolucci and colleagues (1994) to be applied to the Brazilian population. The test consists of 6 categories: orientation to time, orientation to place, registration, calculation, recall, and language.

The Mini-Mental State Examination (MMSE) has recently been revised by Brucki, Nitrini, Caramelli, Bertolucci, and Okamoto (2003). In order to verify the adaptations of the MMSE used in Brazil, Brucki et al. (2003) conducted a study with 433 subjects using the screening test and concluded that educational level influences the subjects' performance. As a result, these researchers suggested a different score taking into consideration the participants' years of schooling. The MMSE is a 30 point test and the minimum scores proposed by these researchers was: 20, for illiterates; 25, for 1 to 4 years of schooling; 26.5, for 5 to 8 years of schooling; 28, for 9 to 11 years; and 29, for 11 or more years of formal educational. This scoring procedure was adopted in the present study (see Appendix E).

The other screening test was the Beck Depression Inventory (Beck et al., 1993), which consisted of questions to determine symptoms of depression. This screening test was translated and adapted to the Brazilian population by Gorestein and Andrade (1996). The Beck Depression Inventory (BDI) consists of 21 questions about how the participant has been feeling in the past week. The first 13 questions are related to psychological symptoms and the other 8 questions assess physical symptoms (see Appendix F). Each question contains four possible answers and each answer is assigned a score from 0 to 3. The participant's total score is compared to a key which indicates whether or not the participant is under depression. The cut-offs of the BDI are: 0 to 9 points (the participant is not depressed); 10 to 18 points (mild-moderate depression); 19 to 29 points (moderate-severe depression); and 30 to 63 (severe depression).

Mendonça (2006) explains that, although the MMSE and the Beck Depression inventory are clinical tests, both tests have frequently been used in cognitive research conducted with adults and older adults. For this reason, both tests/instruments were selected to be applied to the participants of the present study because any symptoms of cognitive impartment or depression would influence the results of the tasks.

3.4.3 The Proficiency Test

An English proficiency test was administered to all Portuguese/English bilinguals. A short version of the TOEFL paper-based format was developed to measure the ability of these participants in English (see Appendix H). The design and questions were taken from the website English Test Store – ETS - (http://www.ets.org/toefl). The

ETS is responsible for creating the TOEFL test. The test was divided into 4 sections: listening comprehension, structure and written expression, reading comprehension, and writing. The ability to understand spoken language was assessed in the listening comprehension section. Participants had to listen to a conversation between two students, for approximately one minute, and answer to 4 questions. The second section, named structure and written expression, consisted of 20 questions divided into 2 parts: 15 questions in which the sentences have to be completed correctly and 5 questions in which the participants have to identify the incorrect expression in the sentence presented. The reading comprehension, the third section of the test, consisted of a 4 passage text with approximately 360 words followed by 10 comprehension questions related to the passages. Finally, the last section consisted of a writing test. As late bilingual participants selected for this study had lived in an English speaking country, these participants had to write an essay reporting their experience abroad.

The test was completed in about an hour and fifteen minutes by the participants. As regards level of proficiency, participants who took part in the present study were fluent in English, that is, even though they had deficiencies in some domain of the L2, they could successfully function in the language. Participants, who scored 70% or more in the three first sections and scored 5 or 6 in the written part were considered proficient in English and were invited to participate in the present study. The written section was evaluated by this researcher and submitted to another rater: an English professor who is responsible for applying the English proficiency tests in the institution where she works. The raters followed the TOEFL PBT writing scoring guideline (Appendix I) to evaluate the participants' writing test and determine whether the participants were proficient in English. The scoring guide was taken from the ETS website (http://www.ets.org/toefl/pbt/scores/writing_score_guide/). The score ranged from 0 to 6, according to the scale recommend for the paper-format test. In the written section, participants who scored 5 or 6 were considered proficient in English, that is, in an advanced level. Raters should pay attention to use of grammatical features, support of the idea and development, appropriate use and choice of vocabulary, and coherence.

3.4.4 Tasks

In the present study, three cognitive tasks aimed at assessing inhibitory control and working memory. The Simon task (in two versions) aimed at assessing inhibitory control. The Alpha Span task aimed at assessing verbal working memory. The two versions of the Simon task and the Alpha Span task were run on a laptop Dell, 14 inches, connected to a 15-inch Dell monitor for stimulus display. The Alpha Span task was presented in Power Point, while the two versions of the Simon task were designed and run using the software E-Prime 2.0. A response box (SRBOX) was also used for obtaining more accurate response times from the performance of participants on the Simon tasks[20]. The three tasks were presented to participants in a random order and will be described below.

3.4.4.1 The Simon task 2 Colors

The Simon task[21] is widely used in research comparing bilinguals and monolinguals' attentional control across the lifespan (e.g., Bialystok et al., 2004; Bialystok et al., 2005a; Bialystok et al., 2005b; Bialystok et al., 2006). As the Simon task does not involve linguistic material, it is considered a content free task. Based on stimulus-response, the Simon task assesses participants' executive control. This task depends on inhibitory control function because in order to provide the correct response to a stimulus, participants are required to focus on the color of the stimulus, not on the position where the stimulus appears. Inhibitory control is assessed in trials in which the response side and the position where the stimulus appears do not correspond (incongruent trials). A delay in reaction time is expected for incongruent trials as compared to congruent trials, in which the response side and the position of the stimulus correspond. This difference in reaction time between incongruent and congruent trials, which is the Simon effect, is taken as a measure of inhibitory control.

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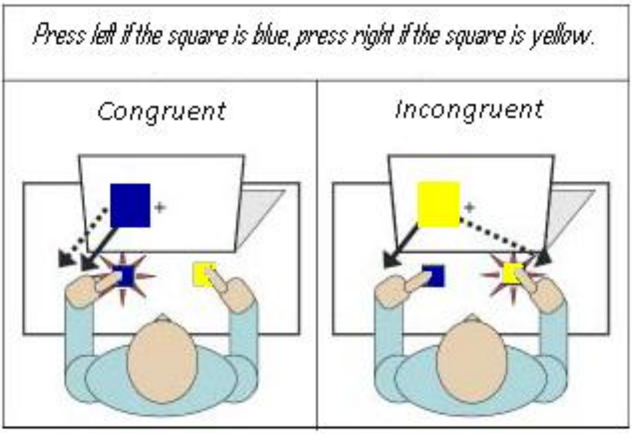
[20] I thank Cíntia Blank (UCPeL) for providing me with a version of these tasks.

[21] The Simon task was created by J. R. Simon in the late 1960s. The original Simon task could use visual stimuli (e.g. colors) or auditory stimuli (tone pitches). In the original version, the stimuli were provided in the left or right position, requiring participants to focus attention to the relevant information (color or tone pitch) and ignore irrelevant information (the side where the color or tone pitch was displayed) (Proctor, 2011).

In the Simon task designed for the present study, participants had to press the left or right shift key of the SRBOX according to the color that appeared on the screen. For example, when they saw a blue square, they were supposed to press the button on their left (key 1), and when they saw a yellow square, the button on their right (key 5). There were congruent trials - the correct key to be pressed was on the same side where the stimulus appeared - and incongruent trials - the correct key was on the opposite where the stimulus appeared, as illustrated in Figure 1[22]. After the blue or yellow square appeared, the square remained on the screen until a response to the stimulus was given, following the same pattern used in studies (Bialystok et al., 2004; Bialystok, 2006) which applied the Simon task. Participants' reaction time (RT) and accuracy (ACC) for each stimulus was recorded.

Figure 1



All participants received the instructions about the task in Portuguese, both orally and written on the screen. After that, each participant performed eight practice trials. In order to proceed to the experimental trials, participants had to provide correct answers to all the eight trials. Participants were provided with an additional practice trial if a mistake was made during the practice trials. After successfully

[22] Adapted from http://www.google.com.br/imgres?imgurl=http://media.wiley.com/wires/WCS/WCS99/nfig005.jpg&imgrefurl=http://wires.wiley.com/WileyCDA/WiresArticle/wisId-WCS99.html&usg=__wnw3hj_h6rmoXVEqWDD6QaVFJyM=&h=252&w=314&sz=39&hl=pt-BR&start=4&zoom=1&itbs=1&tbnid=D3G8wsrifqAG8M:&tbnh=94&tbnw=117&prev=/search%3Fq%3Dsimon%2Btask%26hl%3Dpt-BR%26sa%3DX%26biw%3D1280%26bih%3D675%26tbm%3Disch%26prmd%3Dimvns&ei=71iMTraVDMSysALbwvjFBA

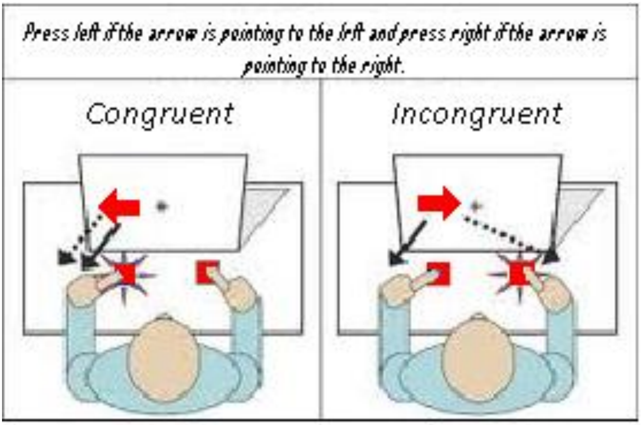
completing the eight practice trials, participants could perform the experimental trials, which consisted of 32 experimental trials, half of which being congruent trials, and half incongruent trials, presented in a random order.

3.4.4.2 The Simon Arrow task

This task is also based on stimulus-response and is used by researchers to assess the effects of bilingualism on executive control (e.g., Bialystok et al., 2004; Bialystok, 2005a; Bialystok et al., 2006). The Simon Arrow task is similar to the Simon task 2 Colors presented above. In this task, participants saw red arrows appearing on either the left or the right side of the computer screen. Hence, in order to provide the correct response to the stimuli, participants are required to ignore the position where the arrow appears and focus on the side the arrow is pointing to. Participants were instructed to press the response button according to the direction indicated by the arrow, as illustrated in Figure 2[23]. That is, if the arrow was pointing to the left, participants were supposed to press the left key, but if the arrow pointed right, the key on the right was the correct choice (corresponding to keys 1 and 5 of the SRBOX, respectively). If no answer was provided to the stimulus, the arrow remained on the screen. As regards the limit of time participants were given to respond to a stimulus, the present study adopted the same pattern used in studies (Bialystok et al., 2004; Bialystok, 2006) which applied the Simon task.

[23] Adapted from http://www.google.com.br/imgres?imgurl=http://media.wiley.com/wires/WCS/WCS99/nfig005.jpg&imgrefurl=http://wires.wiley.com/WileyCDA/WiresArticle/wisId-WCS99.html&usg=__wnw3hj_h6rmoXVEqWDD6QaVFJyM=&h=252&w=314&sz=39&hl=pt-BR&start=4&zoom=1&itbs=1&tbnid=D3G8wsrifqAG8M:&tbnh=94&tbnw=117&prev=/search%3Fq%3Dsimon%2Btask%26hl%3Dpt-BR%26sa%3DX%26biw%3D1280%26bih%3D675%26tbm%3Disch%26prmd%3Dimvns&ei=71iMTraVDMSysALbwvjFBA

Figure 2



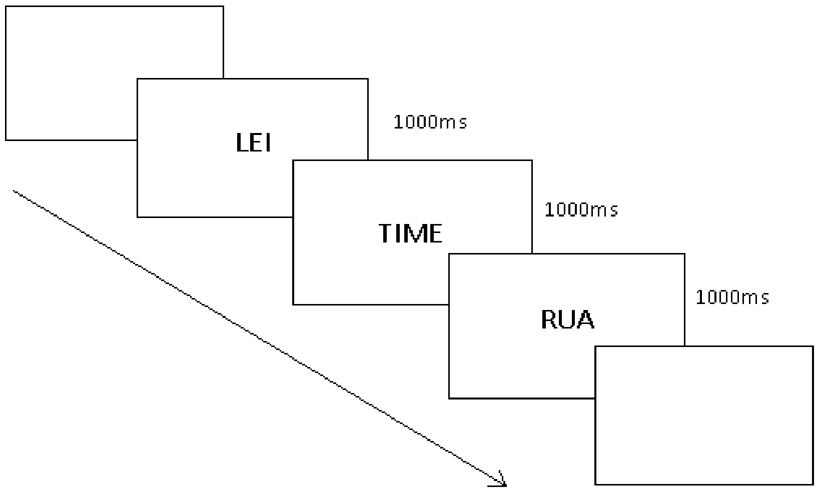
The experiment included a total of 32 trials with 16 congruent and 16 incongruent trials presented in random order. Participants received instructions, in Portuguese, about how to perform the Simon Arrow task. The instructions were read aloud to the participants while the written instructions were displayed on the screen. Additional explanation about the task was provided if necessary. Participants had a practice trial prior to the experiment. They were allowed to begin the experiment just after they had scored 100% in the practice trial.

3.4.4.3 The Alpha Span Task

The Alpha Span task measures verbal working memory. This task shows whether participants have the ability to store and use the received information properly. The original task developed by Fergun Craik in 1986 is in English. A version of the task was created by this researcher in Portuguese, based on the original sent by Craik (personal communication, in March, 2010). In order to design this task in Portuguese, a detailed search for the selection of the most frequent words used in Brazilian Portuguese was carried out in the online corpus of Linguateca (http://www.linguateca.pt/). Following the description of the Alpha Span task provided by Craik, only words composed of one and two syllables were chosen for the task. The words selected for the Alpha Span task in Portuguese were taken from the 2,135 most frequent words in Brazilian Portuguese, as indicated by the search run on Linguateca.

In the Alpha Span task designed for this study, 70 words were arranged into 14 lists. The experiment started with 2 lists consisting of 2 words each, then, 2 lists of 3 words each, followed by 2 lists of 4 words each. The number of words in the lists increased gradually up to 8 words on a list (Appendix J). The words on each list were presented to participants, one word at a time, in a randomized order (e.g., lei, time, rua) both orally and written on the screen. The participants were required to recall the words and repeat them back in alphabetical order (e.g., lei, rua, time). Each word remained on the screen for approximately 1000ms, as illustrated in Figure 3.

Figure 3



Upon seeing a blank screen, participants were required to recall the words in alphabetic order. Prior to the experiment, instructions of how to perform the task were provided to the participants both written on computer the screen and read aloud. Participants were provided with a practice trial containing 4 lists of words – 2 lists of 2 words and 2 lists of 3 words. Each list was presented once both orally and visually on the computer screen. The task was presented to the participants in PowerPoint and each word appeared in the center of the screen in black with font *Colibri* size 96.

After presenting each list of words, the experimenter took note of the words the participants could repeat in the alphabetical sequence in an answer sheet (Appendix K). The score (Appendix L) was determined as follows: (a) if the participant remembered all the words and repeated them in the correct alphabetical order, s/he was given 1 point for each word. For example, in the list "*voto, pai, loja, meia*" if the recall was correct (*loja, meia, pai, voto*), the score was 4 (1 point for each word); (b) For a partially correct sequence (e.g., loja, meia, ?, voto), the participant would score 1 point for *loja,* 1 point for *meia,* and 0 for *voto.* The total score here would be 2 because the participant only scores for correct adjacent runs. However, if the sequence remembered was "*loja, meia, pai, ?* ", the score would be 3 points, since the 3 words are adjacent. The presentation of the lists stopped two levels beyond the participant's last span. For example, if the participant recalled all the words in the alphabetical sequence at level 5, but not at level 6, the experiment proceeded until level 7 and would stop at this level if the participant failed both trials/lists.

3.5 Procedures

Data started to be collected on May 17th and finished on November 27th 2010. As explained in section 3.3, participants were introduced to me personally (early bilinguals and their monolingual peers) or recruited during their coffee-break at the university (monolinguals), by e-mail, in the English Letras Program, and personally in the Extracurricular Language Program at UFSC (late bilinguals). At that time, I would briefly explain what the study was about and would invite participants to join. Prior to engaging in the research, each participant received further information on the nature of the present study and signed a consent form (see Appendix G), which was also read aloud to the participants. At this point, participants had the chance to solve any doubts about the research. After that, the general background questionnaire was applied to the participants, followed by the language background questionnaire (Appendixes A, B, C and D). Next, the participants were assessed with the two screening tests (Appendixes E and F), and the proficiency test, if the participant were a late bilinguals (Appendix H).

After an analysis of the questionnaires and of the scores on the Mini-Mental State Examination and the Beck Depression Inventory, the participants who had similar background and scored well in the screening tests and the proficiency test (for late bilinguals) were invited to come back and perform the tasks. Participants sat comfortably in front of a screen and received instructions on each task, which were both written on the screen and given orally, simultaneously. All tasks had practice trials and the participants could clarify doubts about the tasks before the experiment. The Simon 2 colors and the Alpha Span task were applied to all 104 participants. The Simon Arrow Task was applied only to the 28 participants from UFSC (late bilinguals and monolinguals). Early bilinguals and monolinguals completed the questionnaires, the screening tests and the tasks in approximately an hour, while the late bilinguals completed all the procedures in approximately 2 hours and 15 minutes due to the proficiency test.

3.6 Data analysis

Data from all the tasks (Simon 2 colors, Simon arrow, and Alpha Span) were entered on a spread sheet of the Excel program and submitted to statistical treatment. First, a descriptive analysis of the data was conducted; it provided an overview of the groups' performance on the measures of variables of the three tasks mentioned above. The minimum, maximum, the mean values of general results for each of the measures, and the standard deviation for each group were provided by the descriptive analysis.

Second, an analysis of variance (ANOVA) procedure was used in order to determine whether there were significant differences between the 8 groups. For the Simon task 2 Colors, the one-way ANOVA was adopted to examine differences in the performance of the eight groups (104 participants). The variables considered in this task were the groups as independent variable and reaction time (RT), RT congruent, RT incongruent, and the Simon effect as dependent variables, analyzed separately. Then, the performance of early and late bilinguals was analyzed separately. The early bilingual groups and their monolingual counterparts were compared with a two-way ANOVA. The variables here were age group (younger, adult, and older) X language group (bilinguals and monolinguals) as independent variables. The dependent variables were RT, RT congruent, RT incongruent, and the Simon effect, also analyzed separately. A *t*-test was run to examine late bilinguals and their monolingual peers' performance on the Simon task 2 Colors. The dependent variables were RT, RT congruent, RT incongruent, and the Simon effect; however the independent variable was the two language groups. The same *t*-test was conducted for the Simon Arrow task, which was applied only to late bilinguals and their monolinguals. For the Alpha Span task, the dependent variable was always the score obtained by the participants. One-way ANOVA was conducted with the eight groups first, followed by a two-way ANOVA for early bilinguals and monolinguals in which the independent variables were age group X language group. Finally, a *t*-test was applied to verify late bilinguals' performance compared to monolinguals. Whenever a significant difference was detected by the ANOVA, a post-hoc test was run to determine where this difference was. For all analyses, the alpha was set at the < .05 level.

As regards accuracy (ACC), for the Simon tasks 2 Colors, the accuracy scores from the eight groups were submitted to a non parametric ANOVA, the Krushal-Wallis Test, for the following dependent variables: ACC, ACC congruent and ACC incongruent. For the Simon Arrow task, the Mann-Whitney test was used to analyze the ACCs from the late bilinguals and their monolinguals peers. A non parametric test was used because both tasks – the Simon task 2 Colors and the Simon Arrow task – consisted of only 32 experimental trials each. As a result, data was submitted to a non parametric test because the values of the ACCs within the 8 groups were similar.

The next step was to examine whether there were gender differences. The groups, then, were divided into male and female monolinguals and male and female bilinguals. The dependent variables were the same already mentioned above in each task. The same pattern described above was adopted, a one –way ANOVA followed by a two-way ANOVA. The independent variables, thus, were age group and gender group.

Finally, in order to check whether there were correlations between the results obtained by the participants in Simon task 2 Colors and the Simon Arrow task, Pearson Product Moment correlations were used to examine the RTs of late bilinguals and their monolinguals' peers on both Simon tasks.

The next section reports the pilot study carried out in order to test the materials and procedures of the research.

3.7 The pilot study

The pilot study was divided into two phases. The first phase consisted of a pilot conducted in order to check whether the questionnaires would fulfill their objectives, and if changes would be required. Twelve participants joined the first phase: eight early bilinguals and four monolinguals from the west of Santa Catarina, in the cities of Itapiranga, Mondaí, and Iporã do Oeste from February 15th to February 19th 2010. All of them answered two questionnaires (the language background questionnaire and the general background questionnaire) and were assessed on a screening test (Mini-Mental State examination). There was a specific language background questionnaire for bilinguals and another for monolinguals. The bilingual questionnaire was applied to eight bilinguals: four older Portuguese/ Hunsrückisch bilinguals, two adult Portuguese/ Hunsrückisch bilinguals, and two younger Portuguese/ Hunsrückisch bilinguals. This questionnaire consisted of questions aimed at obtaining information about language use of Portuguese/ Hunsrückisch speakers. The monolingual questionnaire was applied to four Portuguese speakers: one older monolingual, one adult monolingual and two younger monolinguals. By the end of the first phase, it was noticed that some changes related to the order of the questions, would be necessary in the bilingual questionnaire. No modifications were necessary in the general background questionnaire and the monolingual questionnaire. The Mini-Mental State Examination was applied in this pilot in order to provide this researcher with familiarity with the test.

The second phase consisted of another pilot conducted with the tasks (from May 1st to May 12th 2010). For this pilot the researcher invited 7 volunteers in Florianópolis, Santa Catarina. They were all English students at UFSC: three young, one adult, and three older adults. The objective of this pilot was to check if the tasks were running properly and to verify whether the instructions were clear. By the end of this phase, it was observed that in order to make instructions easier to be understood, some minor modifications related to vocabulary were needed in the instructions.

The next chapter presents the results and discussion of the data analysis.

CHAPTER IV

RESULTS AND DISCUSSION

This chapter aims at presenting and discussing the results obtained in order to answer the research questions presented in the previous chapter. Section 4.1 presents the descriptive statistically for the language, age, and gender groups' performance on each task. Section 4.2 is devoted to the inferential statistical analyses and discussion of the results obtained in the performance of the tasks (Simon task 2 Colors, Simon Arrow task, and Alpha Span task). In section 4.3 the correlation between the Simon task 2 Colors and the Simon Arrow task performed by late bilinguals will be presented. The last section, section 4.4, presents the answers for each research question.

4.1 Descriptive Analyses

The present section is divided into two subsections: Tables 1 to 5 bring the raw scores for age and language group in the two versions of the Simon tasks and the Alpha Span task; Tables 6 to 12 present the gender groups' performance on the three tasks.

Tables 1, 2, 3, 4, and 5 show the descriptive analyses for the Simon task 2 Colors, Simon Arrow task, and Alpha Span task. Table 1 reports the early bilinguals' performance on the Simon task 2 Colors while Table 2 presents late bilinguals' descriptive results. The mean Reaction Time (RT), accuracy (ACC), and standard deviation (SD) for the variables age and language group are presented in Tables 1 and 2. Table 3 refers to the performance of late bilinguals and their monolingual peers on the Simon Arrow task. The performances of early and late bilinguals on the Alpha Span task are presented in Tables 4 and 5, respectively.

As explained in the Review of Literature, section 2.1.1, the Simon task is a nonverbal task which assesses inhibitory control processes. Participants are required to focus attention on relevant information and ignore irrelevant information. In the Simon task 2 Colors, the relevant information is the color of the square - blue or yellow - and not the position where the square appears – right or left. Table 1 brings the descriptive analyses for the Simon task 2 Colors for early bilinguals and monolinguals.

Table 1

Descriptive Statistics for Simon Task 2 Colors - Mean Reaction Time and Accuracy by age and language group (Early bilinguals and monolinguals)

				Congruent		Incongruent		
Age and language groups	**N**	**RT (in ms)**	**Accuracy (%)**	**RT (in ms)**	**Accuracy (%)**	**RT (in ms)**	**Accuracy (%)**	**Simon effect**
Younger								
Monolinguals	10	452.66 (72.32)	96.56 (3.1)	435.11 (77.91)	98.75 (2.6)	470.21 (75.72)	94.37 (5.4)	51.85 (28.87)
Bilinguals BP/H	10	450.07 (40.02)	96.56 (3.7)	435.12 (49.91)	97.5 (4.3)	464.99 (49.66)	95.62 (6.6)	29.87 (59.15)
Adult								
Monolinguals	14	525.64 (78.59)	96.87 (3.6)	511.2 (87.14)	97.77 (3.9)	540.08 (79.45)	95.98 (4.6)	28.87 (55.74)
Bilinguals BP/H	14	524.35 (74.15)	98.21 (2.3)	507.75 (69.58)	98.66 (3.6)	540.95 (87.37)	97.76 (3.9)	33.19 (54.37)
Older								
Monolinguals	14	650.56 (123.72)	94.64 (4.4)	600.3 (124.63)	96.88 (5.8)	700.79 (134.18)	92.41 (5.5)	100.49 (76.61)
Bilinguals BP/H	14	726.69 (233.56)	97.31 (2)	697.68 (194.07)	98.66 (2.6)	755.71 (286.38)	95.98 (4.6)	58.03 (145.46)

Note. Standard deviations (SD) are in parentheses; N = number of participants; RT = Reaction Time; BP/H = Brazilian Português/Hunsrückisch; ms= milliseconds

As can be seen in Table 1, the mean reaction time of early bilinguals and their monolingual counterparts was very similar in their age groups. The Table shows that younger bilinguals' and monolinguals' performance does not differ much in overall reaction time (450.07ms and 452.66ms, respectively). The main reaction time of adult monolinguals and bilinguals are almost the same as well, (525. 64ms and 524.35ms, respectively). A small difference in means can only be observed for older participants in which older monolinguals' response time (650.56ms) was lower than older bilinguals reaction time in the Simon task 2 Colors (726.69ms). It is possible that older bilinguals were more concerned with providing correct responses than with the speed of the response, since their accuracy was superior to older monolinguals' accuracy. Taken together, these results may be an indication that monolinguals are as great as early bilinguals in inhibitory control tasks.

Table 2 shows the descriptive analyses for late bilinguals and their monolingual peers in the Simon task 2 Colors.

Table 2

Descriptive Statistics for Simon Task 2 Colors - Mean RT and Accuracy by language group (Late bilinguals and monolinguals)

				Congruent		Incongruent		
Language groups	**N**	**RT (in ms)**	**Accuracy (%)**	**RT (in ms)**	**Accuracy (%)**	**RT (in ms)**	**Accuracy (%)**	**Simon effect**
Monolinguals	14	486.8 (103.1)	98.6 (2.6)	471.8 (130.5)	99.1 (2.2)	512 (93.7)	98.2 (3.8)	40.18 (81.64)
Bilinguals BP/E	14	433.1 (83.7)	97.1 (3.3)	435.2 (3.2)	97.7 (4.6)	431 (80.7)	96.4 (5.3)	-4.18 (48.88)

Note. Standard deviations (SD) are in parentheses; N = number of participants; RT = Reaction Time; BP/E = Brazilian Portuguese/English; ms= milliseconds

As seen in Table 2, late bilinguals were faster than their monolingual counterparts (433.1ms and 486.8ms, respectively) in overall reaction time. Comparing the 4 groups of younger participants: early bilinguals and monolinguals from Table 1 (450.07ms and 452.66ms, respectively) and late bilinguals from Table 2, it can be noticed that the mean scores in overall reaction time (RT) is very similar among the younger participants. However, late bilinguals were a little faster (433.1ms) than the other three groups of younger participants. These results may be an indication that late bilinguals are faster and maybe more efficient in tasks that involve inhibitory control than early bilinguals and monolinguals.

Considering age-related differences, as can be seen in Table 1, older participants, both monolinguals and early bilinguals, took longer to respond to the stimuli (650.56ms and 726.69ms, respectively). Adult monolinguals and bilinguals (525.64ms and 524.35ms, respectively) were not as fast as younger monolingual and bilingual participants (452.66ms and 450.07ms, respectively), but their reaction times do not differ much. The cognitive decline associated with normal aging can clearly be observed in Table 1. Furthermore, Table 1 indicates that older early bilinguals and older monolinguals have higher standard deviation (*SD* = 123.72 and *SD* = 233.56, respectively) than the younger and adult bilingual and monolingual groups, which indicates that there was more variance in speed for the older participants. Resnick and colleagues (2003) explain that seniors have 0.5% of loss of brain volume per year; therefore, this variance for older groups is expected considering that participants in these two groups range from 65 to 84 years old.

Table 1 also shows that the 6 groups - younger, adult and older bilinguals and monolinguals - reacted faster to congruent items than to incongruent ones. Table 1 also presents the RT data for the Simon effect. As explained in Chapter II, section 2.1.1, the Simon effect measures the efficiency of inhibitory control. It consists of the difference between the reaction times to incongruent and congruent items. The inhibition costs are smaller for younger and older bilinguals (29.87ms and 58.03ms, respectively) than for younger and older monolinguals (51.85ms and 100.49ms, respectively). Adult groups have very similar inhibition costs. However, the Simon effect for monolinguals (28.87ms) was a little smaller than for bilinguals (33.19ms). Table 2 shows that late bilinguals had better performance for incongruent trials (431ms) than their monolingual peers (512ms), and the smallest Simon effect cost among all groups, (- 4.18ms). Taken together, late bilinguals and early bilinguals – younger and older – showed a smaller Simon effect, which can be indicating that these bilinguals were less disrupted by irrelevant items presented in the Simon task 2 Colors.

In addition to the reaction time data, the descriptive statistics in Table 1 shows the mean accuracy (ACC) for each group (early bilinguals and monolinguals) in the Simon task 2 Colors. It can be seen that early bilinguals are more accurate than monolinguals, except for younger participants in congruent trials, in which the performance accuracy was 97.5% for younger early bilinguals and 98.75% for younger monolinguals. As seen in Table 1, for incongruent trials, for instance, early bilinguals - younger, adult and older participants - were more accurate than their monolingual counterparts. However, the opposite can be seen in Table 2: the performance of late bilinguals on congruent and incongruent items (97.7% and 96.4%, respectively) was less accurate than their monolingual peers in congruent and incongruent trials (99.1% and 98.2%, respectively). As seen in Table 2, when the performance of late bilinguals and their monolingual peers is compared, late bilinguals performed faster, but less accurately than monolinguals. It is possible that late bilinguals emphasized speed over accuracy, while monolinguals emphasized accuracy over speed.

Table 3 presents the descriptive statistics for the Simon Arrow task which was performed only by late bilinguals (BP/English) and their monolingual peers. The Simon Arrow task is also a nonverbal task which involves inhibitory control processes. In this task, participants have to focus on the direction to where the arrow is pointing to – right or left – and ignore the position where the arrow appears on the screen – right or left.

Table 3

Descriptive Statistics for Simon Arrow Task - Mean Reaction Time and Accuracy by language group (Late bilinguals and monolinguals)

				Congruent		Incongruent		
Language groups	N	RT (in ms)	Accuracy (%)	RT (in ms)	Accuracy (%)	RT (in ms)	Accuracy (%)	Simon effect
Monolinguals	14	548.31 (127.2)	94.6 (2.6)	546.7 (141.5)	95.5 (2.2)	549.8 (119.6)	93.7 (3.8)	3.11 (62.9)
Bilinguals PB/E	14	453.5 (86.7)	96.6 (3.3)	453.7 (93.9)	97.3 (4.6)	453.4 (83.9)	95.9 (5.3)	-.3 (39.8)

Note. Standard deviations (SD) are in parentheses; N = number of participants; RT = Reaction Time; BP/E = Brazilian Portuguese/English; ms= milliseconds

As can be seen in Table 3, late bilinguals reacted faster to stimuli (453.5ms) than monolinguals (548.31ms). Furthermore, late bilinguals were more accurate (96.6%) than monolinguals (94.6%) in all trials. Contrasting the means from Tables 2, which presents late bilinguals and their monolingual counterparts' reaction time and accuracy for the Simon task 2 Colors, and the means from Table 3, in which late bilinguals and their monolingual counterparts' reaction time and accuracy for the Simon Arrow task are presented, some differences in the performance of these two groups – late bilinguals and monolinguals – in the two versions of the Simon task can be highlighted. First, the reaction time means increased for both language groups in the Simon Arrow task, that is, they took longer to respond to stimuli in the Simon Arrow task. However, it can be noticed that in the Simon task 2 Colors and the Simon Arrow task late bilinguals' overall reaction times (433.1ms and 453.5ms, respectively) were shorter than monolinguals' (486.8ms and 548.31ms, respectively). Second, the Simon effect for the monolingual group decreased from 40,18ms in the Simon task 2 Colors to 3,11ms in the Simon Arrow task. As can be seen in Table 3, the Simon effect difference between late bilinguals and monolinguals in the Simon Arrow task was almost the same (-0.3ms and 3.11ms, respectively. Last, although both groups scored lower for accuracy in the Simon Arrow than in the Simon task 2 Colors, late bilinguals were more accurate than monolinguals for all trials on the Simon Arrow task. Together, these results may be an indication that late bilingualism may bring benefits to inhibitory control.

Table 4 presents the descriptive analyses for early bilinguals and monolinguals in the Alpha Span task, which is a verbal working memory task. As explained in the Method chapter, section 3.4.4, in the Alpha Span task lists of words are presented to the participants, who are required to recall these strings of words in the correct alphabetical order.

Table 4

Descriptive Statistics for Alpha Span Task - Mean measures by age and language group (Early bilinguals and monolinguals)

Age and language groups	N	Mean	SD
Younger			
Monolinguals	10	25.8	10.3
Bilinguals BP/H	10	28.7	5.6
Adult			
Monolinguals	14	18.9	9.6
Bilinguals BP/H	14	22.4	5
Older			
Monolinguals	14	8.5	7
Bilinguals BP/H	14	11	8.3

Note. N = number of participants; BP/H = Brazilian Portuguese/Hunsrückisch; SD = Standard Deviations

In Table 4, it can be seen that monolinguals scored lower in the Alpha Span task than early bilinguals. As shown in Table 4, younger, adult, and older bilinguals' mean scores were M = 28.7, M = 22.4, and M = 11, respectively, whereas younger, adult, and older monolinguals' mean scores were M = 25.8, M = 18.9, and M = 8.5, respectively. Although the difference between the 2 language groups is not great, this difference, which is observed for younger and adult bilinguals, is observed for older bilinguals as well. Taken together, early bilinguals can better manipulate and recall items held in memory than monolinguals. These results may indicate that early bilingualism can bring benefits to verbal working memory.

Table 5 presents the descriptive analyses for late bilinguals and their monolingual peers in the Alpha Span task. Late bilinguals mean score in the Alpha Span task is also higher than monolinguals' scores (M = 32.14 and M = 27.93, respectively).

Table 5

Descriptive Statistics for Alpha Span Task - Mean measures by language group (Late bilinguals and monolinguals)

Language groups	N	Mean	SD
Monolinguals	14	27.93	8.9
Bilinguals PB/E	14	32.14	8.8

Note. N = number of participants; BP/E = Brazilian Portuguese/English; SD = Standard Deviations

Comparing younger late and early bilinguals, in Tables 4 and 5, it can be noticed that these two groups performed better than their younger monolingual peers, whose mean scores were M = 27.93 for late bilingual's peers and M = 25.8 for early bilinguals' peers. The results of descriptive statistical analyses for the Alpha Span task, from Tables 4 and 5, indicate that both early and late bilinguals seem to recall words more easily and accurately than monolinguals.

In Table 4, the standard deviation for the Alpha Span task is also presented. Comparing the standard deviation for monolinguals and bilinguals, the variation was bigger for younger and adult monolinguals (*SD* = 10.3 and *SD* = 9.6, respectively) than for younger and adult bilinguals (*SD* = 5.6 and *SD* = 5, respectively). The variance was a little higher for older bilinguals than for older monolinguals (*SD* = 8.3) and (*SD* = 7), respectively. Table 5 provides the variations for monolinguals (*SD* = 8.9) and late bilinguals (*SD* = 8.8), which shows no significant differences among them. Although, the standard deviation of the 8 groups was similar, the analyses involve a high variance in the scores and are based in a relatively small sample size, which may influence the results in the Alpha Span task.

In Tables 4 and 5, great age-related differences can be noticed. Once again, younger participants performed better and obtained the highest scores, followed by adult participants. Older monolinguals and bilinguals scored very low compared to the other age groups (M = 8.5 and M = 11, respectively). These results can be an indication that, regardless of the language background, performance in verbal working memory declines with aging.

Having reported the descriptive analyses comparing monolinguals and bilinguals on the three tasks – the Simon task 2 Colors, the Simon Arrow task, and the Alpha Span task, I turn now to the descriptive statistical analyses contrasting males and females' performance on the same three tasks.

Tables 6 to 12 show the descriptive analyses for gender group and for both bilinguals and monolinguals, in each task. Tables 6 presents the descriptive statistics for monolingual males and females (N = 38) in the Simon task 2 Colors. Table 7 presents the descriptive statistics for early bilingual males and females (N = 38) in the Simon task 2 Colors. In Table 8, the descriptive statistics for late bilingual females and males and their monolingual counterparts (N = 28) in the Simon task 2 Colors are presented. Table 9 presents the descriptive statistics for late bilingual and monolingual males and females (N = 28) in the Simon Arrow task. Table 10 presents the descriptive statistics for monolingual males and females (N = 38) in the Alpha Span task. In table 11, the descriptive statistics for early bilingual males and females (N = 38) in the Alpha Span task are presented. Finally, Table 12 presents the descriptive statistics for late bilingual and monolingual males and females (N = 28) in the Alpha Span task.

Table 6

Descriptive Statistics for Simon Task 2 Colors - Mean Reaction Time and Accuracy by age and gender (monolinguals)

				Congruent		Incongruent		
Age and gender	N	RT (in ms)	Accuracy (%)	RT (in ms)	Accuracy (%)	RT (in ms)	Accuracy (%)	Simon effect
Younger								
Male	5	447.37 (83.09)	96.25	424.05 (93.97)	98.75	470.68 (84.55)	93.75	40.64 (65.85)
Female	5	457.96 (49.52)	96.87	446.18 (43.04)	98.75	469.75 (56.34)	95	23.57 (15.46)
Adult								
Male	7	550.53 (92.29)	95.98	548.93 (96.6)	97.32	552.12 (94.62)	94.64	3.19 (49.93)
Female	7	500.76 (41.38)	97.77	473.48 (43.87)	98.21	528.04 (49.81)	97.32	54.45 (44.26)
Older								
Male	7	685.56 (110.95)	93.75	630.44 (116.07)	94.64	740.67 (122.9)	92.86	110.23 (88.96)
Female	7	615.57 (116.91)	95.53	570.17 (116.4)	99.11	660.92 (123.1)	91.96	90.75 (52.87)

Note. Standard deviations (SD) are in parentheses; N = number of participants; RT = Reaction Time; ms= milliseconds

Table 7

Descriptive Statistics for Simon Task 2 Colors - Mean Reaction Time by age and gender (Early bilinguals)

				Congruent		Incongruent		
Age and gender	N	RT (in ms)	Accuracy (%)	RT (in ms)	Accuracy (%)	RT (in ms)	Accuracy (%)	Simon effect
Younger								
Male	5	455.32 (46.46)	98.12	459.12 (55)	97.5	451.52 (49.51)	98.75	-7.6 (48.13)
Female	5	444.83 (25.88)	95	411.12 (17.52)	97.5	478.46 (56.34)	92.5	67.34 (34.27)
Adult								
Male	7	528.23 (73.49)	96.87	510.76 (66.09)	97.32	545.69 (94.62)	96.43	34.94 (48.12)
Female	7	520.49 (69.14)	99.55	504.76 (67.87)	100	536.21 (80.83)	99.1	31.45 (56.21)
Older								
Male	7	635.03 (81.14)	96.87	627.94 (98.29)	97.32	642.11 (84.86)	96.43	14.17 (85.97)
Female	7	818.37 (279.13)	98.75	767.42 (224.85)	100	869.32 (345.40)	97.5	101.89 (167.50)

Note. Standard deviations (SD) are in parentheses; N = number of participants; RT = Reaction Time; ms= milliseconds

Table 8

Descriptive Statistics for Simon Task 2 Colors - Mean Reaction Time and Accuracy by language and gender (Late bilinguals and monolinguals)

				Congruent		Incongruent		
Language and gender	N	RT (in ms)	Accuracy (%)	RT (in ms)	Accuracy (%)	RT (in ms)	Accuracy (%)	Simon effect
Monolinguals								
Male	7	459.91 (102.05)	98.21	427.55 (121.35)	99.11	492.35 (91.31)	97.32	64.8 (66.74)
Female	7	513.69 (88.92)	99.1	516.2 (114.07)	99.11	531.77 (84.89)	99.11	15.57 (81.92)
Bilinguals								
Male	7	442.31 (107.34)	96.87	459.48 (113.75)	96.43	425.15 (105.59)	97.32	-34.32 (45.6)
Female	7	423.96 (36.34)	97.31	410.99 (45.03)	99.11	436.94 (29.76)	95.54	25.94 (23.29)

Note. Standard deviations (SD) are in parentheses; N = number of participants; RT = Reaction Time; ms= milliseconds

As can be seen in Table 6, adult and older monolingual women were faster (500.76ms and 615.57 ms, respectively) and more accurate (97.77% and 95.53%, respectively) than their adult and older male counterparts in overall reaction time (550.53ms and 685.56ms, respectively) and accuracy (95.98% and 93.75%, respectively) in the Simon task 2 Colors, except in accuracy for incongruent trials, in which older men were more accurate than older women (92.86% and 91.96 %, respectively). Younger monolingual females were a little slower than younger males (447.37ms and 457.96ms, respectively). However, younger women were a little more accurate than their male peers, especially in incongruent trials (95% and 93.75%, respectively). Besides, the Simon effect was smaller for younger and older women (23.57ms and 90.75ms, respectively) than for younger and older men (40.64ms and 110.23ms, respectively). It seems that monolingual women can give faster and more accurate responses than monolingual men in the Simon task 2 Colors. These results may indicate not only a more efficient inhibitory control, but that this type of task may produce a women advantage.

Table 7 shows that, early bilingual women also performed more accurately than early bilingual men on the Simon task 2 colors. Adult and older bilingual women's performance accuracy was 99.55% and

97.77%, respectively, whereas the performance accuracy for the Simon task 2 Colors was 96.87% for both adult and older males. As regards reaction times to congruent trials, younger and adult bilingual women were faster (411.12ms and 504.76ms, respectively) than younger and adult men (459.12ms and 510.76ms, respectively). In addition to that, adult bilingual women also performed better than their male counterparts on incongruent trials (536.21ms and 545.69ms, respectively). However, younger and older bilingual men were faster (451.52ms and 642.22ms, respectively) than their younger and older female counterparts (478.46ms and 869.32ms, respectively) on incongruent trials. In addition, younger and older bilingual men presented smaller Simon effects than women of the same age, indicating that early bilingual men, in general, show less disruption in misleading trials than bilingual women. On the other hand, the results presented in Tables 6 and 7 show that adult monolingual and bilingual women performed the Simon task faster and more accurately than men for both congruent and incongruent trials. Taken together, the results presented in Tables 6 and 7 show that, in general, monolingual and early bilingual women were faster and more accurate than their male counterparts in the Simon task 2 Colors. These results may be an indication that women can make decisions faster and more accurately than males in the Simon task 2 Colors. In addition, these results may also indicate that the nature of the stimuli presented in this task, perhaps, favors women.

The results also show that reaction time increases gradually with age for both sexes. Due to the small number of subjects in each gender group, a large variation was expected. This variation was also expected to strongly influence the results. Older bilingual women’s mean reaction time is the highest among all groups because of two participants (9 and 24), whose RT means were higher than the rest of the group. These two participants increased the groups’ RT means from 668.01ms to 818.37ms. However, as the sample is already small (N = 7), I decided not to exclude these two participants from the analysis. As a result, women’s mean reaction time is higher than their male counterparts’ mean reaction time in the Simon task 2 Colors (818.37ms and 635.03ms, respectively). As such gender difference is not seen among other groups, one possible explanation is that participants 9 and 24 were probably more concerned with the accuracy than the speed to perform the Simon task 2 Colors.

The means for late bilinguals and their monolingual peers’ performance on the Simon task 2 Colors are presented in Table 8. Table 8 shows that monolingual males were faster that monolingual females

(459.91ms vs. 513.69ms, respectively) in overall RTs. On the other hand, Table 8 shows that bilingual males were slower than bilingual females (442.31ms vs. 423.96ms, respectively) in reaction time in the Simon task 2 Colors. Contrasting the results of younger monolingual males, in Tables 6 and 8, it can be seen that, like monolinguals from Table 8, younger monolingual males from Table 6 were faster than their female peers (447.37ms vs. 457.96ms) in the Simon task 2 Colors in overall RTs. In contrast, when younger early bilinguals from Table 7 and younger late bilinguals from Table 8 are compared, an advantage is observed for younger early and late bilingual women (444.83ms and 423.96ms, respectively) over younger early and late bilingual men (455.32ms and 442.31ms, respectively) in overall RTs in the Simon task 2 Colors. Although results from Tables 7 and 8 show that younger women, both early and late bilinguals, reacted faster to stimuli than their bilingual male peers in the Simon task 2 Colors, such advantage for younger bilingual women was noticed in overall reaction times and on congruent trials. Tables 7 and 8 show that younger bilingual males, both early and late bilinguals, were more efficient (451.52ms and 425.15ms, respectively) than younger early and late bilingual females (478.46ms and 436.94ms, respectively) on incongruent trials. Taken together, these results can be an indication that, although younger early and late bilingual men are better at ignoring misleading information and solving conflicts than their younger early and late bilingual female peers in tasks that involve inhibitory control, younger and late bilingual women excel in overall reaction time and congruent trials. That is, early and late bilingual women were faster than early and late males at answering the trials, suggesting that the Simon task 2 Colors may present stimuli that produce a women advantage.

The next Table, Table 9, presents the performance of late male and female bilinguals and their monolingual peers on the Simon Arrow task.

Table 9

Descriptive Statistics for Simon Arrow Task - Mean Reaction Time and Accuracy by language and gender (Late bilinguals and monolinguals)

				Congruent		Incongruent		
Language and gender	N	RT (in ms)	Accuracy (%)	RT (in ms)	Accuracy (%)	RT (in ms)	Accuracy (%)	Simon effect
Monolinguals								
Male	7	498.56 (119.99)	95.52	503.6 (140)	97.32	493.54 (108.36)	93.75	-10.06 (71.35)
Female	7	598.07 (103.47)	93.78	589.93 (117.85)	93.79	606.21 (92.11)	93.79	16.28 (43.85)
Bilinguals								
Male	7	444.4 (93.72)	97.31	439.34 (91.83)	97.32	449.46 (96.56)	97.32	10.12 (19.37)
Female	7	462.77 (70.97)	95.98	468.19 (86.81)	97.32	457.38 (60.98)	94.64	-10.78 (48.57)

Note. Standard deviations (SD) are in parentheses; N = number of participants; RT = Reaction Time; ms= milliseconds

As shown in Table 9, on the Simon Arrow task, male participants were faster and more accurate than female participants in both monolingual and late bilingual groups. The difference in overall RT means was smaller between bilingual females and males (462.77ms – 444.4ms = 18.33ms) than between monolingual females and males (598.07ms – 498.56ms = 99.51ms). As can be seen in Table 9, both late bilingual and monolingual men were superior to late bilingual and monolingual women on the Simon Arrow task. By comparing, then, the performance of younger males and females - late bilinguals and their monolinguals peers - on both Simon tasks (Tables 8 and 9), it can be noticed that regardless of the language group, that is, late bilinguals or monolinguals, males and females took longer to perform the Simon Arrow task than the Simon task 2 Colors. Such difference is noticed mainly for monolingual females, but in general, the difference between the mean reaction time in the Simon Arrow task is greater for women than for men. Taken together, these results seem to indicate that the design of the Simon Task can influence the performance of both males and females. While the Simon task 2 Colors seems to be easily performed by women, the Simon Arrow task appears to yield a female disadvantage for younger participants.

Table 10 reports the descriptive analyses for males and females difference - younger, adult, and older adult monolinguals (N = 38) - in the Alpha Span task.

Table 10

Descriptive Statistics for Alpha Span Task - Mean measures by age and gender (Monolinguals)

Age and gender	N	Mean	SD
Younger			
Male	5	24.4	11.45
Female	5	27.2	7.7
Adult			
Male	7	16.7	10.4
Female	7	21.14	7.4
Older			
Male	7	9.7	6.16
Female	7	7.2	7.17

Note. N = number of participants; SD = Standard deviations

As can be seen in Table 10, the performance of younger and adult females (M = 27.2 and M = 21.14, respectively) was better than younger and adult male peers (M = 24.4 and M = 16.7 , respectively) in the Alpha Span task. In contrast, older monolingual males' performance was superior to older monolingual women's performance (M = 9.7 and

M = 7.2, respectively). These results seem to indicate that younger and adult monolingual women perform better than men in tasks that require verbal working memory. In addition, results also indicate that the ability of maintaining and recalling information seem to become less efficient with normal aging. Moreover, these results can be an indication that verbal working memory abilities decline more in women than in men with aging.

Tables 11 reports early bilingual males and females' performance (N = 38) on the Alpha Span task. As can be seen in Table 11, the performance of younger and adult early bilingual females (M = 30.6 and M = 24.26, respectively) was superior to younger and adult early bilingual male peers' performance (M = 26.8 and M = 20.5, respectively) on the Alpha Span task. However, older early bilingual males' performance was better than older early bilingual women's performance (M = 12.7 and M = 9.4, respectively). The results found for early bilingual males and females in the Alpha Span task seem to indicate a female advantage for both younger and adult women in verbal working memory and a disadvantage for older women, suggesting that early bilingual and monolingual women become more impaired in verbal working memory abilities than men with aging.

Table 11

Descriptive Statistics for Alpha Span Task – Mean measures by age and gender (Early bilinguals)

Age and gender	N	Mean	SD
Younger			
Male	5	26.8	5.81
Female	5	30.6	4.03
Adult			
Male	7	20.5	5.83
Female	7	24.26	2.66
Older			
Male	7	12.7	8.61
Female	7	9.4	7.15

Note. N = number of participants; SD = Standard deviations

Comparing Tables 10 and 11, it can be noticed that younger and adult women, both monolinguals and early bilinguals, obtained better scores than their male peers in the Alpha Span task. However, older women – monolinguals and early bilinguals - were less able to maintain and recall the words in the correct order than older monolingual and early bilingual men. It is also possible to observe that the scores decrease gradually across the ages, both for monolingual and early bilinguals, which indicates cognitive changes associated with aging.

These results also indicate that verbal working memory decline can be more severe in women than in men. As regards the effects of bilingualism, the mean scores are higher for early bilinguals than for monolinguals across the ages for both sexes, which seems to indicate that bilingualism may promote an advantage in verbal working memory for both early bilingual males and females.

Table 12 presents the mean scores for late bilingual males and females and their monolingual counterparts in the Alpha Span task. Younger monolingual and late bilingual males performed better (M = 29.43 and M = 35.71, respectively) than younger monolingual and late bilingual females (M = 26.4 and M = 28.5, respectively). The descriptive statistics in Table 12 indicate that both monolingual and late bilingual males performed better than their female peers, contrasting with what was found for sex difference in Tables 11 and 12. However, the same bilingual advantage found for early bilinguals was found for late bilingual males and females. Late bilinguals, both males and females, scored higher on measures of verbal working memory than their monolingual counterparts. These results may indicate that late bilingualism improves verbal working memory for both males and females.

Table 12

Descriptive Statistics for Alpha Span Task - Mean measures by language and gender (Late bilinguals and monolinguals)

Language and gender	N	Mean	SD
Monolinguals			
Male	7	29.43	10.47
Female	7	26.4	5.9
Bilinguals			
Male	7	35.71	9.13
Female	7	28.5	6

Note. N = number of participants; SD = Standard deviations

To summarize, the results of the descriptive statistical analyses so far indicate that there are slight differences in performance among the language groups (monolinguals of Brazilian Portuguese, early bilinguals of Hunsrückisch and Brazilian Portuguese, and late bilinguals of Brazilian Portuguese and English). It can also be observed that performance on inhibitory control and verbal working memory tasks is influenced by age. That is, the descriptive results demonstrate that as we age our cognitive abilities, such as inhibition and working memory, decline gradually. Results also seem to indicate positive effects of early and late bilingualism on verbal working memory, but not much difference in performance can be observed on inhibitory control tasks. As regards gender differences, it seems that there is a female advantage in overall reaction times in the Simon task 2 Colors over males' overall reaction times. In contrast, a male advantage in reaction time can be observed in the Simon Arrow task.

Having reported the results of the descriptive analyses for executive control tasks (Simon tasks) and the verbal working memory task (Alpha Span task), I turn now to the results of the analysis of variance (ANOVA), the independent-sample *t*-test, the Mann-Whitney test, and the Kruskal-Wallis test which were used to verify whether the perceived differences described in this section were statistically significant.

4.2 Results and Discussion

Statistical tests were run in order to verify whether there were significant differences between the language groups (monolinguals, early bilinguals, and late bilinguals), the age groups (younger, adult, and older adults), and the gender groups (monolingual, early and late bilingual males and females) in the Simon task 2 Colors, the Simon Arrow tasks, and the Alpha Span task. In addition, correlations were run for the two versions of the Simon task (the Simon task 2 Colors and the Simon Arrow task). The following section will be divided into four main subsections: in subsection 4.2.1 the results for language and age groups for monolinguals and early and late bilinguals in Simon Task 2 Colors are presented. In subsection 4.2.2, results comparing late bilinguals and their monolingual peers' performance on the Simon Arrow task are reported. In the third subsection (4.2.3), the results for monolinguals, early and late bilinguals in the Alpha Span task are presented. Finally, subsection 4.2.4 is devoted to monolingual and early and late bilingual males and females' performance on the three tasks (the Simon 2 Colors task, the Simon Arrow task, and the Alpha Span task). In each subsection, a discussion of the results will be provided.

4.2.1 Performance on the Simon task 2 Colors

As explained in the Review of Literature, the Simon task is a nonverbal task of executive control. This task has been widely used by researchers who investigate the effects of bilingualism on inhibitory control ability (Bialystok et al., 2004; 2005a; 2005b; Bialystok, 2006). In the present study, for reaction time (RT) scores on the Simon task 2

Colors, one-way analysis of variance (ANOVA) was conducted with the 104 participants to compare the performance of the 8 groups[24]. As shown in Table 13, results indicate that there were significant RT main effects for group (*F*(7, 96) = 10.369, *p*: <0.0001). Results were also statistically significant for congruent (*F*(7, 96) = 8.804, *p*: <0.0001) and incongruent (*F*(2, 96) = 9.850, *p*: <0.0001) trials, but not for the Simon effect (*F*(7, 96) = 1.970, p: = 0.067). These results revealed that there are statistically significant differences for overall RT, RT congruent and RT incongruent trials among the means of all the groups being compared.

Table 13

Mean Reaction Time comparisons (performed by the 8 groups)

Variables	df	Error df	F	p
RT	7	96	10.369	.000
RT Congruent	7	96	8.804	.000
RT Incongruent	7	96	9.850	.000
Simon Effect	7	96	1.970	.067

N = 104

Once determined that differences exist among the means, the 8 groups were then divided into early bilinguals and late bilinguals for the following analyses: (1) a two-way ANOVA for early bilinguals (H/BP) and monolinguals from Western SC (in a total of 6 groups: younger, adults, and older adult bilinguals and their monolingual peers, N = 76) and (2) a *t*-test for late bilinguals (BP/E) and monolinguals from UFSC (2 groups, N = 28). For the Simon task 2 Colors, a two-way ANOVA was conducted to examine the overall RT data, the RT for congruent and incongruent trials, and the Simon effect, separately. The analyses involved two independent variables: (1) age group (younger, adult, and older participants from Western SC) and (2) language group (bilinguals and monolinguals from Western SC). RTs were entered as dependent variables. Table 14 presents the results of the two-way ANOVA.

[24] The groups were arranged as follows: three early bilingual groups (younger, adult, and older adult bilinguals), one late bilingual group (younger late bilinguals), two younger monolingual groups, one adult monolingual group, and one older adult monolingual group.

Table 14

Mean RT comparisons between age and language for Simon task 2 Colors (Early bilinguals and monolinguals)

Variables	df	Error df	F	p
RT				
Language	1	70	.671	.415
Age	2	70	22.813	.000
RT Congruent				
Language	1	70	1.367	.246
Age	2	70	21.768	.000
RT Incongruent				
Language	1	70	.237	.628
Age	2	70	20.327	.000
Simon Effect				
Language	1	70	.558	.458
Age	2	70	2.891	.62

N = 76

As can be seen in Table 14, a significant difference ($F(2, 70) = 22.813$, p: <0.0001) was found for age group, but not for language group as regards RT data ($F(1,70) = .671$, p: = .415). As expected, the analyses demonstrate that the reaction times of older participants, both early bilinguals and monolinguals, were higher than the younger and adult groups. The results presented in Table 13 show that the mean RT data for congruent and incongruent trials was also significant among the 8 groups: $F(7,96) = 8.804$, p: <0.0001 and $F(7, 96) = 9.85$, p: <0.0001, respectively. The results presented in Table 14 show that younger groups - early bilinguals and monolinguals - were faster than adult and older adult bilingual and monolingual participants for congruent trials ($F(2, 70) = 21.768$, p: <0.0001). As can be seen in Table 14, no language group difference was found between the groups for congruent trials ($F(1,70) = 1.367$, p: = .246). For incongruent trials, the younger and adult participants - early bilinguals and their monolingual peers - were faster than the two elderly groups: the older monolingual and older early bilingual groups, $F(2, 70) = 20.327$, p: <0.0001. However, no language group difference was found for congruent trials ($F(1,70) = .237$, p: = .628). Furthermore, as show in Table 13, late bilinguals and their monolingual peers were also significantly faster than the adult and older adult groups - monolinguals and early bilinguals for Western SC - for incongruent items ($F(7, 96) = 9.85$, p: <0.0001).

The results of the present study, so far, show that no significant language group differences between the performance of early bilinguals and their monolingual counterparts were found on the Simon task 2 Colors. In other words, monolinguals were as fast as early bilinguals in inhibitory control. In contrast to what Bialystok et al. (2004) have postulated, the present study has not found a statistically significant bilingual advantage related to reaction time in congruent and incongruent trials. The results found in the present study were similar to the results reported by Billig (2009) and Pinto (2009), who also investigated early bilingualism with a Hunsrückisch/Portuguese population. Billig (2009) concluded that, perhaps, other factors in addition to bilingualism, such as schooling, can contribute to cognitive advantages. According to Valenzuela (2008), formal education level is a predictor of cognitive maintenance. Bialystok and her colleagues have reported that their older participants had a bachelor degree (Bialystok et al., 2004) or even more years of education than younger participants (Bialystok et al., 2008b). The Brazilian level of formal education is considered low, especially in the case of the older population. In Brazil, according to IBGE, 46.2% of the population over 60 years old is illiterate[25]. In the present study, older participants – monolinguals and early bilinguals – reported having 5.6 and 5.3 years of formal education, respectively. In Bialystok`s studies (Bialystok, et al., 2004; Bialystok, et al., 2008b), older participants reported having higher education, which corresponds to about 15 years of formal education. Speculatively, it can be argued that a bilingual advantage may be greater in populations which have a higher level of formal education.

Some tasks require more selective attention and ability to inhibit misleading information than others. The Simon tasks applied in the present study randomly presented congruent and incongruent trials to participants. Random presentation of trials demands much attention. As already explained in the Review of Literature, according to Bialystok et al. (2005a), misleading information is more demanding than relevant information because participants depend heavily on inhibitory mechanisms to choose the correct response. The difference between the time taken to react to these two types of information - incongruent and congruent items - is named the Simon effect, which indicates the efficiency of inhibitory control. In the Simon task 2 Colors, the stimuli consist of two features: color and position. Participants are required to focus attention on the color while the side (left-hand or right-hand side) where the stimuli appear must be ignored.

As can be seen in Table 13 the result for the Simon effect was not statistically significant among the 8 groups ($F(7, 96) = 1.970$, p: =

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[25](http://www.ibge.gov.br/home/presidencia/noticias_visualiza.php?id_noticia=1717&id_pagina=1)

0.067). Although the Simon effect difference was not statistically significant in the present study, results show that older bilinguals produced a smaller Simon effect (58.03ms) than older monolinguals (100.49ms) showing less interruption from the incongruent items, which indicates greatest level of inhibitory control in the old bilingual group. A similar result was reported by Bialystok, Craik, and Luk (2008b). In their study, the magnitude of the Simon effect increased with normal aging more for older monolinguals than for older bilinguals. This result was interpreted as an indication that early bilingualism attenuates age-related decline in inhibitory control. In the present study, even though there was not a statistically significant difference in the Simon effect, the pattern found in the magnitude of the Simon effect can be taken as evidence that the level of inhibitory control is greater in older bilinguals than in older monolinguals.

As mentioned above, level of formal education is a predictor of cognitive maintenance. Another possibility for not having found a statistically significant bilingual advantage, also speculative but worth exploring, is the level of language dominance. That is, the dominance of the four abilities (speaking, writing, auditory, and reading comprehension) in both languages. The bilinguals investigated by Bialystok et al. (2004) were formally educated in their two languages. In the present study, the early bilinguals did not have formal access to Hunsrückisch, that is, the early bilinguals of the present study do not read and write in Hunsrückisch. Therefore, this difference in degree of dominance makes me believe that early bilingualism effects on inhibitory control might be influenced not only by the context of use of the language, which includes the frequency of use and social context (Paradis, 2004), but abilities such as speaking, writing, auditory, and reading comprehension. Speculatively, it can be argued that the positive effects of early bilingualism on inhibitory control may also depend on the level of dominance developed in both languages. In this case the level of dominance in the language is also related to the level of formal education.

The present study shows a statistically significant difference for age groups in the means of RTs for the Simon task 2 Colors. Results demonstrated a disadvantage for the older adults, both monolinguals and early bilinguals, who performed significantly slowlier on congruent and incongruent trials compared to younger adults. This difference in performance shows that the ability to control attention and inhibit irrelevant information decreases as age increases. This finding is supported by a number of researchers who have reported that inhibitory control becomes less efficient with aging (Salthouse and Meinz, 1995; Alain and Woods, 1999; Zellner and Bäuml, 2006; Butler and Zacks, 2006). The results of the present study corroborate Bialystok and colleagues' (2004, 2008b) who reported that, regardless of language (monolinguals or bilinguals), there is significant disadvantage in the performance of older adult monolinguals and bilinguals when compared to their younger peers'. In these two studies, older participants were slower on tasks that required speed and inhibition. This is consistent with the notion that reaction time increases with aging (Van der Lubbe & Verleger, 2002). Furthermore, in the present study, the magnitude of the Simon effect increases with aging, a result that was interpreted as evidence that older adults' ability to inhibit misleading cues reduces with aging (Bialystok et al., 2004).

Table 15 presents the results of late bilinguals and their monolingual counterparts in the Simon task 2 Colors.

Table 15

Mean RT comparisons for the Simon task 2 Colors (Late bilinguals and monolinguals)

Variables	M	SD	MD	p
RT				
Monolinguals	486.8	103.1	53.66	.143
Bilinguals BP/E	433.1	83.7		
RT Congruent				
Monolinguals	471.8	130.5	36.63	.401
Bilinguals BP/E	435.2	3.2		
RT Incongruent				
Monolinguals	512	93.7	81.01	.021
Bilinguals BP/E	431	80.7		
Simon Effect				
Monolinguals	40.18	81.64	25.43	.093
Bilinguals BP/E	-4.18	48.88		

Note: N = 28; MD = Mean difference between the 2 groups; M = Mean; SD = Standard deviations; RT = Reaction Time; BP/E = Brazilian Portuguese/English

As can be seen in Table 15, a *t*-test conducted with late bilinguals and their monolingual peers show no significant differences between their overall RTs: t (26) = 1.511, p = .143. However, Table 15 shows that a significant difference for language group in the means RTs for late bilinguals and their monolingual peers was found for incongruent data. A *t*-test confirmed that late bilinguals were significantly faster than their monolingual counterparts on incongruent trials, t (26) =2.45, p = .021. Furthermore, late bilinguals (who were also in the younger age group) significantly outperformed the adult and older early bilingual and monolingual groups, but not the younger early bilinguals and younger monolinguals (younger early bilingual peers).

To the best of my knowledge, no studies have been conducted investigating the relationship between late bilingualism and its effects on inhibitory control. In the present study, for late bilinguals, significant differences were found for reaction time on incongruent trials. As stated in the Review of Literature, incongruent items elicit slower responses than congruent items (Bialystok et al., 2005). It is believed, then, that the reaction time for incongruent items should be higher than that for congruent items. Surprisingly, in the present study, late bilinguals were faster on incongruent trials than on congruent trials, showing that late bilinguals could efficiently inhibit the influence of incongruent information. This suggests less inhibition cost and more efficiency in cognitive tasks that demand high inhibitory processing. This result can be interpreted as an indication that the beneficial effects of bilingualism on executive control and inhibitory processing may also be present in those who have learned a second language in the classroom context.

In the present study, once late bilinguals use Portuguese for schooling and social life, English is not their dominant language. It is possible that greater inhibitory control is required when late bilinguals perform their second and less dominant language. Speculatively, it could be posited that inhibitory processes are involved to inhibit the dominant language (in this case Portuguese). That is, in order to perform in their second language, late bilinguals need to focus on the relevant linguistic representations and ignore the linguistic representations from their more dominant language. In the present study, the results indicate that late bilingualism may promote a boost in inhibitory control. In the case of early bilinguals, who did not have the problem of language dominance in BP, they exercised this ability less.

Table 16 presents the results of accuracy (ACC) for monolinguals, early bilinguals, and late bilinguals. The accuracy scores were submitted to a nonparametric test, the kruskal-test, in order to determine whether there were group differences for accuracy in the Simon task 2 Colors.

Table 16

Mean Accuracy comparisons for Simon task 2 Colors (performed by the 8 groups)

	ACC		ACC Congruent		ACC Incongruent	
Age and Language group	**MR**	**p**	**MR**	**p**	**MR**	**p**
Younger						
Monolinguals	46.65	.130	54.30	.941	43.8	.084
Bilinguals BP/H	49.35		48.35		53.85	
Monolinguals	67.86		57.07		65.64	
Bilinguals BP/E	52		52.04		55.82	
Adult						
Monolinguals	52.39		49.36		51.71	
Bilinguals BP/H	62.29		56.29		61.46	
Older						
Monolinguals	35.75		48.32		33.89	
Bilinguals BP/H	51.14		53.61		51.71	

Note: N = 104; MR = Mean rank; ACC = accuracy; BP/E = Brazilian Portuguese/English; BP/H = Brazilian Portuguese/Hunsrückisch

As can be seen in Table 16, there is no statistically significant difference among the groups in terms of accuracy. Although the Portuguese/Hunsrückisch bilinguals were, in general, more accurate than their monolingual peers on both congruent and incongruent trials, statistically, the accuracy was as great for bilinguals as it was for monolinguals. For instance, early bilinguals scored higher than their monolingual peers on incongruent trials, indicating that in order to make correct responses, much attention was devoted to misleading cues. This result shows evidence that the level of attention to relevant information is greater in bilinguals than in monolinguals.

In summary, the results revealed a statistically significant age-related decrease in inhibitory control functions, that is, older monolinguals and bilinguals showed increased reaction time and higher Simon effect compared to the younger participants, showing that the ability to inhibit irrelevant information reduces with aging. As regards language groups, the results did not show statistically significant differences between monolinguals and early bilinguals. However, a tendency for a bilingual advantage can be seen in the magnitude of the Simon effect, which was smaller for older bilinguals than for older monolinguals. Furthermore, early bilinguals were more accurate than monolinguals on incongruent trials. These results can be interpreted as evidence for the positive benefits that early bilingualism can bring to inhibitory control. Finally, late bilinguals were statistically faster than their monolingual peers on incongruent trials, a result which can be interpreted as evidence that bilingualism enhances inhibitory control in those who have acquired a second language in a formal context.

4.2.2 Performance on the Simon Arrow task

The Simon Arrow task was applied only to late bilinguals and their monolinguals peers in order to verify whether the performance of the late bilingual and monolingual participants on the two versions of Simon task - the Simon task 2 Colors and the Simon Arrow task – differs from each other. Using a *t*-test, the variables language group and RT, RT congruent, RT incongruent, and the Simon effect were examined. Table 17 displays the results of the *t*-test for RT scores, bilinguals were significantly faster than monolinguals (t (26) = 2.302, *p* = 0.030). Furthermore, results revealed that bilinguals were faster than their monolingual counterparts for incongruent trials (t (26) = 2.470, *p* = 0.020). Results also indicate that the Simon effect was not statistically significant for late bilinguals and their monolingual counterparts (t (26) = 0,173, *p* = 0.864).

Table 17

Mean comparisons between Late bilinguals and their monolinguals peers for RT on the Simon Arrow Task

Variables	M	SD	MD	p
RT				
Monolinguals	548.31	127.2	94.73	0.030
Bilinguals	453.5	86.7		
RT Congruent				
Monolinguals	546.7	141.5	93.01	0.051
Bilinguals	453.7	93.9		
RT Incongruent				
Monolinguals	549.8	119.6	96.45	0.020
Bilinguals	453.4	83.9		
Simon Effect				
Monolinguals	3.11	62.9	3.43	.864
Bilinguals	-0.3	39.8		

Note: N = 28; MD = Mean difference between the 2 groups; RT = Reaction Time; SD = Standard deviations

Table 18 presents the mean accuracy for late bilinguals and monolinguals on the Simon Arrow task. Although late bilinguals scored higher than monolinguals for accuracy, it can be observed that the difference between mean accuracy was not statistically significant.

Table 18

Comparing ranks for ACC - Late bilinguals and their monolinguals peers on the Simon Arrow Task

Variables	MR	p
ACC		
Monolinguals	14.21	.874
Bilinguals	14.79	
ACC Congruent		
Monolinguals	14.57	.982
Bilinguals	14.43	
ACC Incongruent		
Monolinguals	13.89	.701
Bilinguals	15.11	

Note; N = 28; MR = Mean rank; ACC = Accuracy

As already said in previous chapters, the present study is built on Bialystok and colleagues studies (Bialystok et al., 2004, Bialystok et al., 2005a, Bialystok et al., 2008a; Bialystok et al., 2008b) who have observed that early bilingualism can attenuate age-related losses of inhibitory control. These researchers conduct studies with bilinguals across the lifespan, that is, people who have spoken two languages daily for almost all their lives. To the best of my knowledge, no other study has investigated the effects of late bilingualism on inhibitory control and verbal working memory. The present study not only presents results considering the effects of early bilingualism across the lifespan, but investigates the possibility of similar effects for late bilinguals. Although a Simon effect for the Simon Arrow task was not found, it seems clear that late bilinguals outperformed monolinguals on this task, since the mean RTs were lower for late bilinguals than for their monolingual peers. These findings may be taken as an indication that becoming fluent in a second language late in life can also bring positive cognitive benefits.

As already said, the Simon Arrow task was also included in the present study to verify whether the performance on Simon Arrow would be similar to the Simon task 2 Colors presented above. As mentioned in section 4.1, this chapter, some differences in the performance of these two groups – late bilinguals and monolinguals – in the two versions of the Simon task can be highlighted. First, both language groups took longer to respond to stimuli in the Simon Arrow task. However, it can be noticed that in the Simon task 2 Colors and the Simon Arrow task late bilinguals' overall reaction times (433.1ms and 453.5ms, respectively) were shorter than monolinguals' (486.8ms and 548.31ms, respectively), showing that the Simon Arrow task was more complex to be solved than the Simon task 2 Colors both groups.. The second difference is that the Simon effect for the monolingual group decreased from 40,18ms in the Simon task 2 Colors to 3,11ms in the Simon Arrow task. The Simon effect difference between late bilinguals and monolinguals in the Simon Arrow task was almost the same (-0.3ms and 3.11ms, respectively), indicating that inhibitory control processes were as efficient for late bilinguals as for their monolingual peers. Furthermore, the Simon effect was close to zero for both groups in the Simon Arrow task, showing an absence of Simon effect. According to Bialystok et al. (2008b), such finding for the Simon effect is not usual, which can be taken as an indication that both late bilinguals and monolinguals responded to both congruent and incongruent stimuli at similar rate, that is, participants performed all the trials carefully.

Although the size of the Simon effect was not statistically significant in the two versions of the Simon task, the comparison of late bilinguals and monolinguals' performance on the two Simon tasks shows that late bilinguals outperform monolinguals on incongruent trials in the Simon task 2 Colors (t (26) = 2.45, $p = 0.021$) and in the Simon Arrow (t (26) = 2.470, $p = 0.020$), which indicates that late bilinguals are less disrupted by interference on irrelevant trials than monolinguals. According to Costa et al. (2009), who investigated the relationship between early bilingualism and executive control functions, dealing with two linguistic representations requires control. In other words, bilinguals need to focus on the relevant language and ignore the other. For this reason, it is expected that bilinguals should perform better only on non corresponding trials. In the present study, however, late bilinguals were also superior to monolinguals in the congruent trials in the Simon Arrow (t (26) = 2.302, $p = 0.030$), a result that can be interpreted, following Costa et al. (2009) as showing that bilingualism can also aid monitoring processes. That is, as bilinguals are constantly monitoring their two languages while interacting, they could be better at dealing with tasks involving mixed set of trials, monitoring for trials which can or not imply conflict (Costa et al., 2009).

In sum, late bilinguals in the present study were better able to inhibit irrelevant items than monolinguals. Late bilingualism seems to contribute to the enhancement of executive control functions in nonverbal cognitive tasks which involve inhibitory control.

4.2.3 Performance on the Alpha Span Task

The Alpha Span task is considered a complex span task and was included in the present study as a measure of working memory capacity. First, a one-way ANOVA was conducted to determine whether there were group differences. Results showed that there were significant differences between the groups ($F(7, 96) = 14.658$, p: <0.000). A follow-up two-way ANOVA was run on the results of early bilinguals and their monolingual counterparts which revealed that there were significant age group differences. Table 19 presents the statistical results of early bilinguals and their monolingual peers in the Alpha Span task.

Table 19

Mean Alpha Span task Scores for Early Bilinguals measured by Age and Language Group

Variables	df	Error df	F	p
Language	1	70	2.659	.107
Age	2	70	30.404	.000

N = 76

As can seen in Table 19, the younger groups - early bilinguals and monolinguals - performed better than the adult and older groups on the Alpha Span task ($F(2, 70) = 30.404$, p: <0.0001). As seen in section 4.1, this chapter, monolinguals scored lower in the Alpha Span task than early bilinguals. Younger, adult, and older monolinguals' mean scores were M = 25.8, M = 18.9, and M = 8.5, respectively, while younger, adult, and older bilinguals' mean scores were M = 28.7, M = 22.4, and M = 11, respectively. Although bilinguals have higher scores than their monolingual peers, statistically the scores were as great for bilinguals as they were for monolinguals. This finding is consistent with Bialystok et al. (2004) who reported that a bilingual advantage was not found for verbal working memory.

Table 20 displays the statistical results of late bilinguals and monolinguals' performance on the Alpha Span task.

Table 20

Mean Alpha Span task Scores for Late Bilinguals measured by Language Group

Variables	M	SD	MD	p
Monolinguals	27.93	8.9	-4.214	.221
Bilinguals	32.14	8.8		

Note. MD = Mean difference between the 2 groups; N = 28

As shown in Table 20, late bilinguals also scored higher than monolinguals (M = 32.14 and M = 27.93, respectively). However, the difference was not statistically significant (t (26) = -1.254, p = 0.221). Furthermore, late bilinguals and their monolingual peers outperformed the two older adult groups ($F(7, 96) = 14.658$, p: <0.000) on the Alpha Span task.

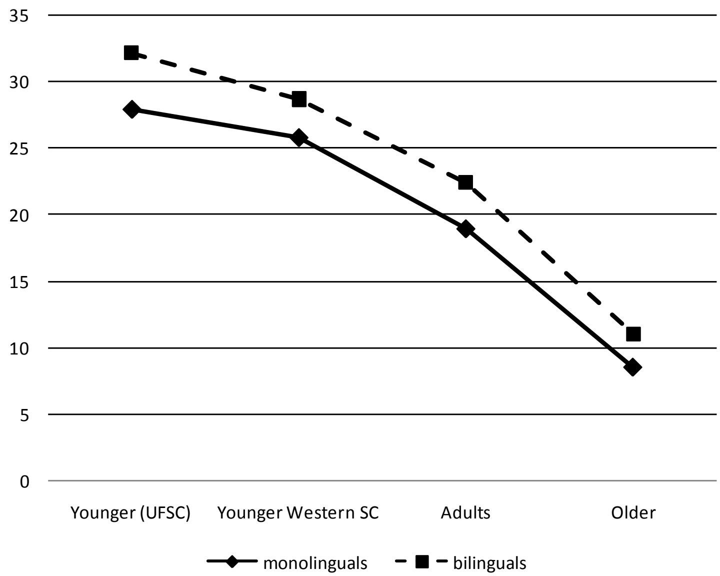
Taking into account that working memory system stores and manipulates a limited amount of information and that processing speed slows down with age, it was expected that older adults would score lower than adults and younger adults. The present study reveals statistically significant age-related differences, in that the older bilinguals and monolinguals recalled fewer words than their younger and adult counterparts. As Salthouse (1996) explains, working memory performance is influenced by speed of processing, that is, slow processing results in loss of information. In the present study, the Alpha Span task becomes more complex as the number of words in the strings increases. In this sense, due to the gradual increase of the number of words in the strings in the Alpha Span task, it was observed that for the more complex stages, that is, after stage 5, in which there are 5 words in the string to be recalled, younger and adult subjects recalled the first half of the words in the correct alphabetical order, the second half was usually forgotten. For the older bilingual and older monolingual participants, this difficulty was observed by stages 3 and 4. Considering that older adults are slow to process items, the expectation was that they would rarely reach the more complex stages of the task (Park, 2000).

Moreover, Reuter-Lorenz et al. (2008) point out that older adults assess executive control when performing even simple working memory tasks. Thus, when older adults have to perform more complex working memory tasks, they perform poorly because a great part of their attentional control is devoted to the first stage of the process, which includes storage and retrieval (Reuter-Lorenz et al., 2008). Thereby, the second stage, which consists of manipulating information, would be affected by the first stage. As explained by Reuter-Lorenz et al. (2008), despite the level of complexity of the working memory task, every working memory task recruits some degree of attentional control. Speculating, in the present study, the strings of words, presented in the Alpha Span task, would not be active for so long in participants' working memory. Consequently, by the time participants had to speak the words aloud, the last words in the order would be lost, especially for the older adult participants (bilinguals and monolinguals). As a result, older participants recalled fewer items than their younger peers in the Alpha Span task.

Another explanation for the older participants' poor performance is that, as already explained in section 2.1.1, the ability to inhibit irrelevant information becomes impaired with aging, that is, inhibitory processes cannot efficiently remove information no longer relevant (Hasher, Zacks & May, 1999). As regards working memory, due to the inability to inhibit and remove misleading information, working memory becomes overloaded with misleading information (Oberauer, 2001). In the present study, the Alpha Span task requires that participants manage words already presented in previous trials not to interfere in the current trial. Speculating, it is possible that each time older participants were presented with a new string of words, the words presented in past trials were still in working memory, reflecting in low span scores for older participants.

Considering that working memory (WM) tasks involve high cognitive processing demands and executive control functions, it was expected to find language group differences in the Alpha Span task. Performing this particular span task not only requires storage and manipulation of items, but the ability to inhibit the words presented in previous lists and focus on the current one. According to Bialystok (2007), the daily use of two languages "may modify the development or operation of executive functions for bilinguals" (p. 212). As explained by Engle (2002) attentional control influences WM capacity. He states that performing WM tasks requires attention in order to store information while ignoring irrelevant items. As a result it would be expected that bilinguals would perform better than monolinguals on this task. Figure 4 shows that this prediction was somehow confirmed in the sense that all bilinguals - early and late - obtained better scores than their monolingual counterparts.

Figure 4 - Early and late bilinguals' and their monolingual peers' performance on the Alpha Span task.



Although this advantage was not statistically significant, it may be taken as an indication that early and late bilingualism would attenuate age-related losses of verbal working memory since bilinguals obtained better results.

4.2.4 Comparing males and females

Females and males have been compared on a variety of cognitive tasks. As discussed in section 2.2, chapter II, the influence of sex on cognitive performance seems to be well established, with women performing better tasks involving verbal abilities (Weiss et al., 2006; Lejbak et al., 2011) and men excelling in spatial abilities (Lejbak et al., 2011; Kimura, 1999a).

As demonstrated in section 4.1, this chapter, males and females' performance differs on inhibitory control and verbal working memory tasks. An ANOVA was run comparing gender (males and females) and age (younger, adult, and older) for each language group (monolingual and bilingual) in the three tasks (the two Simon tasks and the Alpha

Span task). The independent variables considered, then, were gender and language group.

For the Simon task 2 Colors, data was compared for the following dependent variables: Reaction Time (RT), Reaction Time (RT) for congruent and incongruent trials, and the Simon effect. Table 21 shows the means for monolingual males and females (early bilingual's peers) in the Simon task 2 Colors.

Table 21

Mean RT comparisons between gender and age for Simon task 2 Colors (monolinguals)

Variables	df	Error df	F	p
RT				
Gender	1	70	3.023	.086
Age	2	70	22.752	.000
RT Congruent				
Gender	1	32	1.872	.180
Age	2	32	8.219	.000
RT Incongruent				
Gender	1	32	16.683	.252
Age	2	32	1.353	.000
Simon Effect				
Gender	1	32	0.074	.787
Age	2	32	5.120	.010

N = 38

As can be seen in Table 21, there were no statistically significant differences between gender groups. However, significant differences were found for age, that is, reaction time was higher for both older males and females. While there was no difference for gender, $F(1,70) = 3.023$, p = 0.86, younger and adult males and females were faster than older males and females, $F(2,70) = 22.752$, p:<0.000.

Table 22 reports the mean reaction time of early bilingual males and females in the Simon task 2 Colors. Like their male and female monolingual peers, early bilingual males and females' performance on the Simon task 2 Colors was not statistically significant, $F(1,70) = 3.040$, p = 0.85.

Table 22

Mean RT comparisons between gender and age for Simon task 2 Colors (early bilinguals)

Variables	df	Error df	F	p
RT				
Gender	1	70	3.040	.085
Age	2	70	21.425	0.000
RT Congruent				
Gender	1	32	0.767	.387
Age	2	32	13.891	0.000
RT Incongruent				
Gender	1	32	2.207	.146
Age	2	32	8.696	0.000
Simon Effect				
Gender	1	32	2.595	.116
Age	2	32	0.325	.724

N = 38

As can be seen in Table 22, there was a significant difference across the age groups, $F(2,70) = 21.425$, p:<0,000. Taken together, Tables 21 and 22 reveal that although women showed better performance for the Simon task 2 Colors, males were as great as females on the task. In addition to that, for both monolingual and bilingual groups there was a statistically significant difference for age group ($F(2,70) = 22.752$, p:<0.000 and $F(2,70) = 21.425$, p:<0,000, respectively). Results of the present study indicate that, regardless of language background, inhibitory control declines in a similar pattern for both males and females who were significantly slower than younger and adult groups.

As mentioned in section 4.1, this chapter, although it was observed that, in general, women can attribute faster and more accurate responses than men in the Simon task 2 Colors, especially adult women, no statistically significant differences were found between males and females from the same age group. Speculating, this slight advantage for women may be also related to explicit memory and women's ability to deal with lists of words (Hartshorne and Ullman, 2006) and verbal fluency (Kimura, 1999a). As Duff and Hampson (2001) explain, the female advantage seems to depend on the type of the stimuli presented in the task. For example, in the Simon task 2 Colors, two distinct colors are presented as the stimuli. According to Duff and Hampson (2001), colors are easy to be verbalized. In this sense, the verbal contribution provided by the colors in the Simon task 2 Colors may produce a female advantage.

As regards late bilinguals and their monolingual peers, an ANOVA procedure was run considering the variables gender (male and female) and language (monolingual and bilingual) for the Simon task 2 Colors. Table 23 presents the results of gender differences in the Simon task 2 Colors for late bilinguals and their monolingual counterparts.

Table 23

Mean RT comparisons of gender for Simon task 2 Colors (late bilinguals and monolinguals)

Variables	df	Error df	F	p
RT				
Gender	1	52	.719	.4
Language	2	52	4.774	.03
RT Congruent				
Gender	1	24	.226	.638
Language	2	24	0.707	.408
RT Incongruent				
Gender	1	24	.570	.457
Language	2	24	5.908	.02
Simon Effect				
Gender	1	24	2.932	.833
Language	2	24	2.932	.09

N = 28

As can be seen in Table 23, there was no significant difference between males and females. However, there were significant findings for language group. Monolingual women were slower than late bilingual women for overall reaction time ($F(2,52) = 4.774$, p = 0.030) and for reaction time for incongruent trials ($F(2,24) = 5.908$, p = 0.02) in the Simon task 2 Colors.

The same variables considered for the analysis of the results of males and females on the Simon task 2 Colors were considered for the Simon Arrow task: gender (male and female) and language (monolingual and bilingual). Table 24 reports similar results found for the Simon task 2 Colors as regards language group.

Table 24

Mean RT comparisons of gender for Simon Arrow task (late bilinguals and monolinguals)

Variables	df	Error df	F	p
RT				
Gender	1	52	4.35	.04
Language	2	52	11.240	.03
RT Congruent				
Gender	1	24	1.608	.216
Language	2	24	4.198	.051
RT Incongruent				
Gender	1	24	2.622	.118
Language	2	24	6.711	.016
Simon Effect				
Gender	1	24	2.932	.833
Language	2	24	0.053	.07

N = 28

As seen in Table 24, late bilingual women were faster than monolingual women for overall reaction time ($F(2,52) = 11.240$, p = .04) and for reaction time for incongruent items, $F(2,24) = 6.711$, p = .016 in the Simon Arrow task. Taken together, results show a significant difference between monolingual and bilingual females in the two versions of the Simon task, which may indicate that late bilingualism enhances inhibitory control of attention in women.

In addition, a gender difference was found for different language groups, late bilingual men were also faster than monolingual women, F(1,52) = 4.35, p = .04 in the Simon Arrow task. As mentioned in section 4.1, this chapter, in the Simon Arrow task, male participants were faster and more accurate than female participants in both monolingual and late bilingual groups. The difference in overall RT means was smaller between bilingual females and males (462.77ms – 444.4ms = 18.33ms) than between monolingual females and males (598.07ms – 498.56ms = 99.51ms) in the Simon Arrow task. Both late bilingual and monolingual men were superior to late bilingual and monolingual women on the Simon Arrow task. Although both males and females, regardless of language group, took longer to perform the Simon Arrow task than the Simon task 2 Colors. Such difference is noticed mainly for monolingual females, but in general, the difference between the mean reaction time in the Simon Arrow task is greater for women than for men. As mentioned above, Duff and colleague (2001) state that tasks that present stimuli, which are easy to be verbalized can facilitate women’s performance on cognitive tasks. For example, the two colors presented in the Simon task 2 Colors may produce a female advantage. In contrast, although males and females performed faster on the Simon task 2 Colors than the Simon Arrow task, monolingual and late bilingual women took longer to reach the stimuli in the Simon Arrow task than men. Since the Simon Arrow task presents arrows pointing either to the left or the right. This task seems to depend on spatial abilities, in which men is known to excel (Lejbak et al., 2011). Speculating, the stimuli presented in the Simon Arrow task may be difficult to be quickly processed and verbalized by women, producing a female disadvantage in the Simon Arrow task.

Gender differences were also examined in the Alpha Span task. The scores were examined with ANOVA for gender and age group. Table 25 presents the results for monolinguals and early bilinguals across the lifespan in the Alpha Span task, which, as already mentioned, is a verbal working memory task.

Table 25

Score comparisons between gender and age for Alpha Span task (early bilinguals and monolinguals)

Variables	df	Error df	F	p
Monolinguals				
Gender	1	32	.250	.620
Age	2	32	11.135	.000
Bilinguals				
Gender	1	34	.284	.597
Age	2	34	21.813	.000

N = 76

As can be seen in Table 25, no significant gender differences were found. Nevertheless, differences were found for age group, older monolingual women scored lower than younger and adult monolingual women ($F(2,32) = 11.135$, $p:<0.0001$) and older bilingual men scored lower than younger bilingual men and younger and adult bilingual women scored higher than older bilingual women, $F(2,34) = 21.813$, $p:<0.0001$. In Table 26, the results of the comparison for gender among the four younger groups (monolinguals and bilinguals from Western SC and from UFSC) are provided.

Table 26

Score comparisons among the younger groups for the Alpha Span task (4 groups)

Variables	df	Error df	F	p
Monolinguals				
Gender	1	20	.0213	.885
UFSC/Western SC	1	20	.275	.605
Bilinguals				
Gender	1	20	.667	.423
UFSC/Western SC	1	20	1.152	.295

N = 48

As can be seen in Table 26, no significant differences were found for gender among younger groups in verbal working memory. However, early and late bilinguals, both males and females, scored higher than their monolingual male and female peers on the Alpha Span task. These results can be an indication that, although executive control is at its peak in the late teens and early twenties (Bialystok, 2006), early and late bilingualism brings benefits in verbal working memory for younger bilinguals compared to monolinguals.

Age-related declines are observed in a variety of cognitive functions. In the present study, the Alpha Span task revealed main effects for older monolinguals and bilinguals. According to Sherwin (2003), estrogen provides cognitive advantages in tasks which involve verbal ability and memory. Since females produce higher level of estrogen than men in adult life, females are known to excel in verbal abilities. Consistent with this claim, in the present study, younger and adult women, both monolinguals and early bilinguals, outperformed their younger and adult male counterparts on verbal working memory. However, in the present study, older women of both groups scored lower than older men in the Alpha Span task. One possibility is that increased age associated with the decreased levels of estrogen implies changes in verbal working memory for both men and women; however, it seems that older women are more affected than men. Speculating, as estrogen levels positively influence the performance on verbal tasks and gradually decrease with aging (Sherwin, 2003), the female advantage in verbal tasks, such as verbal working memory tasks, tend to be affected due to the low levels of estrogen which are, in turn, related to their increased age.

Though there were no statistical significant differences for gender, it was observed that late bilingual and monolingual men (UFSC participants) scored higher than their female peers in the Alpha Span task. This difference was not expected since studies (Weiss et al., 2006;

Kimura, 1999a) comparing sexes usually show a female advantage in verbal abilities. Speculating, it is possible that a male advantage in the Alpha Span task is modulated by other factors, such as the course they attend at the University.

It is also interesting to point out that all bilinguals, females and males, were superior to monolingual males and females in the Alpha Span task. These results can be interpreted as evidence that early and late bilinguals demonstrate more efficient working memory thus better storing, manipulating, and recalling items. This difference in performance between language groups (monolinguals vs. bilinguals) is shown in Figures 5 and 6.

Figure 5 - Monolingual and bilingual males' performance on the Alpha Span task

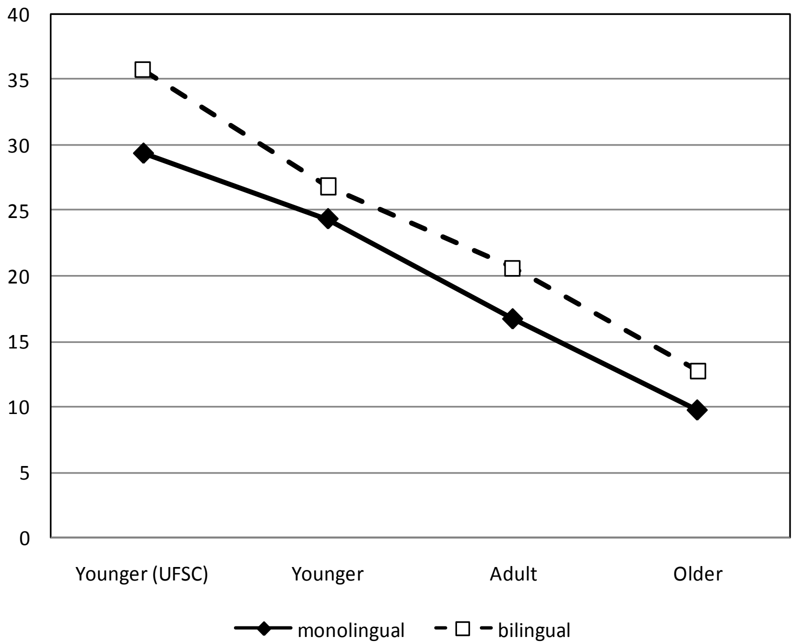
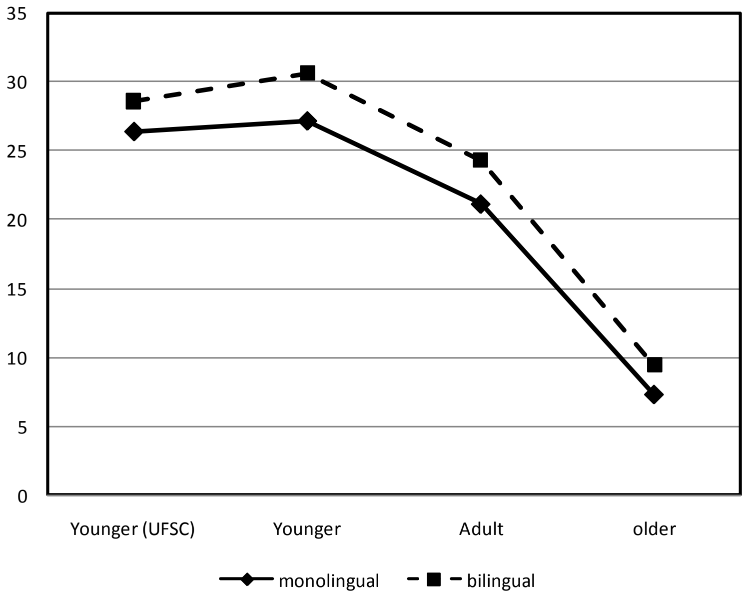


Figure 6 - Monolingual and bilingual females' performance on the Alpha Span task.



Summing up, as stated in the Review of Literature gender differences cannot be denied. Although statistically significant differences were not found between males and females, there is an interesting tendency towards sex-related differences, in which women tend to perform better on the Simon task 2 Colors than on the Simon Arrow task. Furthermore, late bilingual women outperformed their monolingual peers, suggesting that late bilingualism might bring an enhancement of inhibitory control processing. Another tendency that can be noticed is the bilingual males and females' advantage in verbal working memory. Though these interpretations should be treated with caution due to the small number of participants in each group, the findings also revealed that cognitive declines occur in a similar pattern for both males and females in tasks which involve verbal working memory and inhibitory control.

4.3 Correlations

In the present study, the correlations run provided insights on language and gender group performance on the two Simon tasks. In an attempt to verify which of the two Simon tasks would be more suitable to assess inhibitory control, Pearson Product Moment Correlation tests were run to investigate participant's performance on the two tasks. The correlations were run only on the results of late bilinguals and their monolingual peers. First, correlations were conducted with the language groups separately.

Table 27 shows that there were significant correlations for overall reaction time and reaction time for incongruent trials for both monolinguals and bilinguals.

Table 27

Pearson Correlations - Simon 2 Colors and Simon Arrow (Late bilinguals and monolinguals)

	RT	RT Congruent	RT Incongruent
Language Group			
Monolinguals	.613**	.427	.665*
Bilinguals	.579**	.424	.691*

*Correlation is significant at the .01 level (2-tailed)
**Correlation is significant at the .05 level (2-tailed)
N = 28

Despite the similarity in performance on the two tasks, reaction times in each task were closer in performance for monolinguals than for bilinguals (r = .613 and r = .579, respectively). On the other hand, bilinguals' reaction times were closer for incongruent items (r = .691) than monolinguals' reaction times (r = .665) at the .01 level.

At this point, it is not possible to state which task would be more appropriate to measure inhibitory control processing. It was observed that the correlation between language groups in the two versions of the Simon task was very similar. That is, the correlation demonstrates that the performance of monolinguals and bilinguals on these two tasks followed a pattern, showing that most participants in each group obtained higher reaction time for the Simon Arrow task than for the Simon task 2 Colors. In an attempt to determine whether the performance of the participants on these tasks differ in a way that we can predict which task would seem better to measure inhibitory control, a second correlation was, then, run for gender groups.

Table 28 presents the results of the correlation for males and females in the Simon task 2 Colors and the Simon Arrow task.

Table 28

Pearson Correlations - Simon 2 colors and Simon Arrow (males and females)

	RT	RT Congruent	RT Incongrueny
Gender			
Males	.511*	.306	.638*
Females	.818*	.611**	.868*

*Correlation is significant at the .01 level (2-tailed)
**Correlation is significant at the .05 level (2-tailed)
N = 28

As presented in Table 28, females and males performed differently on the Simon tasks. There were significant correlations for both males and females, however, stronger correlations were found for females on the two tasks. Results indicate that a great number of women were faster on the Simon task 2 Colors than on the Simon Arrow task (*r* = .818). There is also a correlation found for men (*r* = .511). However, half were faster on Simon task 2 Colors and the other half on the Simon Arrow task.

These findings suggest that although the Simon tasks are considered appropriate for all ages, as mentioned by Bialystok and colleagues (2005a), the results of the present study show that these two tasks differ and such difference interferes on the performance of males and females. In order to accomplish the Simon task 2 Colors, participants have to remember which button represents which color and such information is kept active in working memory and available to consciousness. Having this in mind, it is possible that the fact of remembering the colors could be related to linguistic processing, which involves explicit memory. As already mentioned, according to Ullman (2005), the explicit memory system is influenced by estrogen. As females have higher level of estrogen than men, women should show more ability on tasks that require verbal abilities (Sherwin, 2003), which is related to explicit memory. The Simon Arrow task presents red arrows pointing to the right or to the left. Despite the fact that men were faster and more accurate than women in the Simon Arrow task, half performed faster on the Simon Arrow and the other half were on the Simon task 2 Colors. As a result, we cannot suggest that the Simon Arrow task favors men, but, it seems to be more complex for women. Speculating, a female disadvantage in the Simon Arrow task may be due to the spatial ability required to solve this task, in which females show disadvantage compared to tasks in which stimuli can be verbalized.

In sum, due to sex differences already documented in research, it was expected that males and females would not perform in the same way on the Simon tasks: the Simon task 2 Colors and the Simon Arrow task. The results of the correlation between the performance of participants on the two Simon tasks show that women have advantages on the Simon task 2 Colors. According to Kimura (1999a) when two tasks are correlated and the results show a large correlation between them, that means that the same ability is being assessed by the tasks. In contrast, a weak correlation indicates that other abilities are probably also being assessed. In the present study there is a strong correlation between the Simon tasks, especially on incongruent trials (conflict), suggesting that they are two inhibitory control tasks. As a result, both tasks are appropriate to measure inhibitory control as far as they are applied to groups in which the number of men and women are matched.

Now I turn to the last section of this chapter, which will be devoted to answer each of the proposed research questions.

4.4 Readdressing the research questions

In this section I readdress the research questions and summarize the results obtained.

Research question 1: Did early and late bilinguals outperform their monolingual peers on measures of inhibitory control and verbal working memory?

The answer is no, at least in part. As already mentioned, Bialystok et al.'s (2004) study revealed that early bilinguals, especially older bilinguals, outperform monolinguals on tasks involving executive control. Moreover, such advantage is seen in tasks that requiring inhibitory control to ignore a misleading information. According to Bialystok and colleagues (2005a) the extensive practice of one kind, such as speaking two languages, demands attention which, in turn, enhances inhibitory control abilities. In the present study, no statistically significant differences were found between the performance of early bilinguals and their monolingual peers. The speculative conclusion is that other factors in addition to bilingualism, such as education (Billig, 2009), and language dominance, can contribute to cognitive advantages

However, late bilinguals significantly outperformed their monolingual counterparts on inhibitory control processing. Late bilinguals were statistically faster than their monolingual peers on incongruent trials, a result which can be interpreted as showing that bilingualism enhances inhibitory control in those who have acquired a second language in a formal context. As for verbal working memory, although there were no significant language group differences, it was observed that all bilingual groups scored higher than their monolingual peers. These results may be taken as evidence that early and late bilingualism demonstrate better verbal working memory related to storing, manipulating and recalling items.

Research question 2: From a cognitive perspective, does bilingualism across the lifespan help in offsetting age-related losses in inhibitory control and verbal working memory?

The answer is no, at least in part. There were no significant differences between early bilinguals and monolinguals. However, it was observed that younger and older early bilinguals were more able to inhibit irrelevant information than monolinguals. The magnitude of the Simon effect increased more for older monolinguals than for older bilinguals, which indicate that monolinguals were less able to ignore the conflict represented by the incongruent items. A result that was interpreted by Bialystok et al. (2004) as showing that bilingualism attenuates the age-related decline in inhibitory control. Furthermore, early bilinguals were more accurate than monolinguals in most trials, especially for incongruent trials. A statistically significant difference was found for late bilinguals' performance on inhibitory control. Speculatively, these results may indicate that late bilingualism can attenuate age-related decline in inhibitory control. In addition, since early and late bilinguals obtained better results than monolinguals in verbal working memory task, it can be taken as an indication that bilingualism can contribute to enhance and maintain verbal working memory.

Research question 3: Does a second language learned late in life (late bilingualism) through instruction in the classroom lead to the same pattern of enhancement of executive control, reported by Bialystok and colleagues (2004), obtained in natural learning environments (early bilingualism)?

The answer is yes. As regards inhibitory control tasks, statistically significant differences between late bilinguals and their monolinguals counterparts were found. The results show that late bilinguals were faster for incongruent items, which demand more effort from inhibitory control in order to ignore irrelevant information. Furthermore, late bilinguals scored higher than their monolingual peers in verbal working memory. Bilinguals are expected to excel in tasks involving executive control functions (Colzato et. al, 2008), such as inhibition and working memory. Once late bilinguals' dominant language is Portuguese, which is used at school and in social life, it is possible that greater inhibitory control is required when late bilinguals perform their second and less dominant language, which is English. Speculatively, in order to perform in their second language, late bilinguals need to focus on the relevant linguistic representations and ignore the linguistic representations from their more dominant language. In this sense, late bilingualism may promote a boost in inhibitory control. The present findings, thus, suggest that late bilingualism can bring benefits to inhibitory control and verbal working memory.

Research question 4: Do females and males perform differently on inhibitory control and verbal working memory tasks?

The answer is no, at least in part. Although there were no statistically significant differences between males and females, differences do exist and should be reported. It was observed that women generally performed faster and more accurate than men on the Simon task 2 Color. Speculating, such slight advantage for women may be related to women’s verbal abilities. As Duff and Hampson (2001) explain, the female advantage seems to depend on the type of the stimuli presented in the task. For example, in the Simon task 2 Colors, two distinct colors are presented as the stimuli. According to Duff and Hampson (2001), colors are easy to be verbalized. In this sense, the verbal contribution provided by the colors in the Simon task 2 Colors may produce a female advantage. In contrast, although males and females performed faster the Simon task 2 Colors than the Simon Arrow task, monolingual and late bilingual women took longer to react to the stimuli in the Simon Arrow task than men. Since the Simon Arrow task presents arrows pointing either to the left or the right, this task seems to depend on spatial abilities, in which men are known to excel (Lejbak et al., 2011). The speculative conclusion is that the stimuli presented in the Simon Arrow task may be difficult to be verbalized and quickly processed by women, producing a female disadvantage in the Simon Arrow task.

Regarding verbal working memory, statistically significant differences between males and females were not found. However, it was noted that in the younger and adult women groups, early bilinguals and their monolingual peers, scored higher than men. However, older women of both groups, early bilinguals and monolinguals, scored lower than older men in the Alpha Span task. Speculating, as estrogen levels positively influence the performance on verbal tasks and gradually decreases with aging (Sherwin, 2003), the female advantage in verbal tasks, such as verbal working memory tasks, tend to be affected due to the low levels of estrogen. However, the opposite was found for late bilingual and monolingual females and males. Younger late bilingual and monolingual women scored lower than their male counterparts in the Alpha Span task, which was not expected, since women tend to perform better on verbal ability tasks. Finally, an interesting tendency was observed for verbal working memory task, early and late bilingual males and females scored higher than their monolingual counterparts. Though these interpretations should be treated with caution due to the small number of participants in each group, these results can be interpreted as evidence that early and late bilingual females and males demonstrate more efficient working memory abilities, in general.

Research question 5: Considering that both Simon tasks (the Simon task 2 Colors and the Simon Arrow task) reflect the inhibitory processes, does the performance of the participants on these tasks differ in a way that we could predict which task would seem better to measure inhibitory control?

The answer is no. Correlating the results participants obtained in the Simon task 2 Colors and the Simon Arrow task suggest that both are considered inhibitory control tasks. Higher correlation was mainly found for incongruent trials, which suggests that both tasks present conflicting information, a characteristic required for inhibitory control tasks. Although language group differences were not found in late bilinguals and monolinguals' performance on the two versions of the Simon task, correlating the results of male and female participants (late monolinguals and monolinguals), it was found that women had performed better on the Simon task 2 Colors than on the Simon Arrow task. Taking the present result into consideration, though the Simon tasks are content free and simple for subjects of all ages, gender is an aspect to be considered when selecting cognitive tasks.

CHAPTER V

FINAL REMARKS

The main objective of the present study was to investigate the performance of both early and late bilinguals on inhibitory control and working memory tasks. Inhibitory control and verbal working memory were assessed through cognitive tasks applied to early bilinguals aged from 18 to 84 years old and young late bilinguals with ages ranging from 18 to 26 years. Another goal of this study was to verify whether males and females would differ on tasks, which assessed executive control and verbal working memory abilities. Furthermore, motivated by a methodological issue, the present study also investigated the performance of late bilingual and monolingual participants on two different versions of the Simon task (the Simon task 2 Colors and the Simon Arrow task) to analyze whether both tasks would assess inhibitory control in a similar way.

This research was organized as follows: Chapter I presented the introduction of this study. Chapter II was devoted to the review of theoretical issues related to age-related cognitive changes, bilingualism, and gender differences. Chapter III presented the method adopted in the present study in order to collect and analyze the data. The results and discussion was also presented in chapter IV. It also provided the answers for the research questions. The main purpose of this chapter, chapter V, is to summarize the results of the present research, acknowledge limitations of the study, and bring suggestions for further research. It will also present the methodological and pedagogical implications of the present findings.

5.1 Conclusions

The most important results obtained from data analyses were:

1. Early bilinguals and their monolingual peers' performance – the results of the present investigation revealed that there was no statistically significant difference between early bilinguals and monolinguals across the lifespan; however, a tendency could be noticed for bilinguals in both inhibitory control and working memory tasks. In the Simon task 2 Colors, younger and older bilinguals showed less interference caused by irrelevant information (incongruent trials) than monolinguals, which is an index of efficiency of inhibitory control mechanism. Besides, early bilinguals were more accurate than monolinguals in the Simon task 2 Colors. In the working memory task,

early bilinguals scored higher than monolinguals, that is, bilinguals could store, manipulate, and repeat words back more correctly than monolinguals. Considering age-related cognitive differences, the older adults, both monolinguals and bilinguals, were significantly slower than young participants in both cognitive abilities.

2. Late bilinguals and their monolingual counterparts' performance – results showed that late bilinguals significantly outperformed monolinguals on incongruent trials in both Simon tasks (2 Colors and Arrow). These results revealed that late bilinguals can more efficiently ignore misleading cues than monolinguals suggesting that despite being learned late in life, a second language can exert positive effects on inhibitory control. For the working memory task, late bilinguals were also superior to monolinguals; however, the difference was not statistically significant.

3. Males and females' performance - although no statistically significant differences were found between males and females of the same age and language group, a tendency was observed. An overview of gender performance for the eight groups revealed that women seemed to perform better than men on inhibitory control processing as assessed by the Simon task 2 Colors. However, for the Simon Arrow task, women were slower and less accurate than men. Another interesting tendency found was that bilingual males and females from the eight groups performed better on the verbal memory task than their monolingual peers. Furthermore, late bilingual females significantly outperform monolingual females on both inhibitory control tasks.

4. The two versions of the Simon task – results of Pearson Product Moment Correlations demonstrated that both tasks assess the same cognitive ability. There is a high correlation between them, especially for the results of the participants for incongruent trials, which reflect the irrelevant information to be inhibited, that is, the conflict to be solved. Correlating the results of the participants in the two Simon tasks also provided important insights on the design of these tasks, showing that women performed better on the Simon task 2 Colors than on the Simon Arrow task. In other words, maybe different colors (as stimuli) are easier for women to maintain in mind and retrieve when an appropriate response is required than to deal with arrows pointing to left or right. This phenomenon was not noticed for men, once half were faster in the Simon task 2 Colors and the other half in the Simon Arrow task. As a conclusion, the major aspect to be considered in this analysis is gender differences and not which task would be better as a measure of inhibitory control. In this sense, both tasks are appropriate to measure

inhibitory control as far as they are applied to groups in which the number of men and women are matched.

Although this study shows some interesting results, it is important to keep in mind that it is an exploratory study which presents a number of limitations. These limitations will be discussed in the following section.

5.2 Limitations and suggestions for further research

The present study represents an attempt to investigate the effect of bilingualism across the lifespan. Regardless of the fact that this investigation was carried out based on methodological and theoretical literature on bilingualism and aging, these data should be treated with some caution. This section presents some limitations of this investigation followed by some suggestions for further research.

First, the present study is limited in the number of participants in each group. Although all participants went through screening tests and were comparable in educational background within each group, no generalizations can be made since the data collected represents a small sample of bilinguals. A more representative sample would be also needed to allow the investigation of the difference between men and women' performance on verbal and nonverbal cognitive tasks, that is, a more representative sample would be necessary to allow generalizations. Future research should consider a larger number of subjects.

The present study, which investigated effects of early and late bilingualism on some cognitive functions, such as executive control and verbal working memory, has certainly brought evidence to the fact that mastering two languages somehow helps to maintain executive functioning. Nevertheless, taking into account the Brazilian context, this type of research is in its infancy and further empirical studies are required in order to fully understand the effects of bilingualism on cognitive functions. In the case of this study, in which lifelong bilinguals' performance did not show statically significant differences compared to monolinguals, the results made me wonder whether a delay of age-related decline depends on the context where bilinguals are inserted. As Paradis (2004) explains, despite the fact that bilinguals share the experience of using two or more languages, there are many types of bilinguals. Paradis (2004) suggests that as bilinguals differ in a number of aspects and cannot be considered a homogenous group, there is no a consensus about what a bilingual is. Early bilinguals investigated in this research, as already mentioned, were fluent in both languages

(Hunsrückisch / Portuguese). However, one of their languages (Hunsrückisch) was only used orally, that is, early bilinguals did not have access to printed material in this language and they have not learned how to read or write in Hunsrückisch. In contrast, Bialystok et al. (2004) have reported that the early bilinguals of their study, despite the fact that they also learned their languages early in life, were educated in both their languages. According to them, the use of two languages provided an enhancement of their participants' executive functions. The present study results have found an advantage only for late bilinguals, another type of bilinguals, who have acquired a second language in a formal context and have developed the four skills in both of their languages. Considering these aspects, I believe that the effects of bilingualism on executive functions might be influenced by the type of bilingualism being investigated. That is, the level of cognitive enhancement would depend not only on the age and context in which languages were acquired, but the degree of dominance. In this sense, another limitation of the present study may be the degree of dominance of early bilinguals. That is, the abilities developed in their languages, such as speaking, writing, auditory, and reading comprehension. For further research, it would be interesting to investigate an early bilingual population in Brazil which has mastered the four abilities in their two languages.

In the present study, the effects of early bilingualism on inhibitory control and working memory capacity were investigated with a population ranging from 18 to 84 years old. However, the effects of late bilingualism on executive control functions were carried out only with a younger population. Like for early bilinguals, it would have been very interesting if fluent second language speakers (late bilinguals) from different ages (adults and older adults) could be investigated. This can be taken as another limitation in the present study. Further studies could consider conducting cross-sectional research in order to verify whether the positive benefits on inhibitory control found for younger late bilinguals, in the present study, would be maintained in older late bilinguals.

Finally, in an attempt to analyze two types of tasks - the Simon task 2 Colors and the Simon Arrow task - developed and applied in cognitive research to assess inhibitory control. In the present study, the Simon Arrow task was applied to participants - late bilinguals and monolinguals - in order to verify whether both versions of the Simon task would assess inhibitory control in a similar way. In this sense, the Simon Arrow task was only performed by younger participants - late bilinguals and their monolingual peers. My third recommendation would be that the assessment of inhibitory control could be analyzed more in depth. An analysis could be carried out comparing the performance of older adults on these two inhibitory control tasks in order to verify the performance differs between tasks and whether age-relate decline is linear between younger adults and older adults on both tasks.

The next section will bring the possible methodological implications that can be drawn from the results obtained in the present study.

5.2 Methodological and pedagogical implications

In this section some methodological and pedagogical implications of the present study will be presented.

A possibly important methodological contribution brought by this study is related to the data collection. Tasks were applied in a quiet and well lighted room where participants were interviewed and took the tasks one at a time. I believe that these aspects have contributed to provide participants more confidence and comfort to perform the tasks. Furthermore, instead of using the computer keyboard to collect participants' responses to stimuli, participants used the SRBOX. This device not only contributed to facilitate the performance of participants, especially older adults who do not have the habit to use computers, but to collect the data, once the device is important to provide precise timing information and widely used in this kind of experiment.

Another important methodological contribution of this study is the difference between types of inhibitory control tasks. An important explanation offered by Kimura (1999a) is that tasks which assess the same cognitive function, may measure different aspects of such function. For example, the two versions of the Simon tasks assess inhibitory control; however, they may correspond to different levels of irrelevant information which promoted distinct males and females performance on these tasks. In this pursuit, I believe that it is important that the number of males and females should be considered when analyzing the results at group level, that is, in order to compare groups, they should be matched for sex in each group.

As regards pedagogical implication, an important contribution, based on the findings of the present study, is to encourage parents, who are early bilinguals in Brazil, to speak their native language with their children. Although some studies report that early bilingualism have some disadvantages (Verhallen & Schoolen, 1993; Umbel & Oller, 1994), such as a smaller vocabulary in each language compared to monolingual children, learning two languages early in life is associated with increased meta-linguistic skills and influences cognitive development (Bialystok, 2001, Bialystok et al., 2004). According to Bialystok (2008), “the possibility that early bilingualism affects children’s language and cognitive development has long been a concern for parents and educators (p. 01).” Bialystok states that the difficulties faced by early bilingual children at school can be easily overcome if schools and educators can provide these children a means to improve in their second language. Furthermore, by teaching the language of their home to their children, parents will provide their children the opportunity to manage two languages, which spoken regularly, brings an enhancement of executive control processes. This positive cognitive advantage endures into adulthood and contributes to attenuate normal decline that occurs with age (Bialystok et al., 2004; Bialystok et al., 2007).

Another possible pedagogical contribution provided by the present study is related to late bilingualism. Foreign language classrooms are full of people willing to learn a second language. The reasons for this are varied, such as employment prospects, travelling, leisure, and culture. However, learning a second language late in life is not an easy task, since it takes time and dedication. The findings of the present study bring one more reason to motivate second language learners to keep in their studies. Results show that late bilingualism may improve inhibitory control processes and verbal working memory. Furthermore, it is important for language teachers to know that learning a foreign language can bring their students benefits on some cognitive functions, mainly in executive control processes.

To conclude, factors that slow the rate of cognitive decline in older adults are not yet clear. Despite the biological factors, there is evidence that lifestyle factors can maintain cognitive functioning. Valenzuela (2008) suggests that complex mental activities would contribute to delay the onset of symptoms of cognitive decline. From this perspective, mastering two different languages regularly should be considered as one of a large number of complex activities that can play an important role to attenuate the effects of age-related losses in cognitive functioning.

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APPENDIX A

UNIVERSIDADE FEDERAL DE SANTA CATARINA
CENTRO DE COMUNICAÇÃO E EXPRESSÃO
DEPARTAMENTO DE LÍNGUA E LITERATURA ESTRANGEIRAS
Programa de Pós Graduação em Inglês e Literatura Correspondente

Pesquisa: Bilinguismo ao longo da vida: efeitos no controle executivo e memória de trabalho.

Questionário para bilíngues

Nome: ____

Idade:_____ Sexo: ( ) M ( ) F Profissão:___________________
Nacionalidade: ___________ Local de Nascimento: __________________
Grau de escolaridade
( ) Nenhuma escolaridade
( ) Ensino Fundamental: de 1º à 4º série
( ) Ensino Fundamental: de 5º à 8º série
( ) Ensino Médio
( ) Superior

1) Quantos idiomas você fala? ___________

2) Quais são?____

3) Qual idioma você aprendeu primeiro? __________________________

4) Na época em que você estava na escola, você teve a oportunidade de estudar e aprender a língua alemã? _________________________

5) Gostaria que marcasse ao lado de cada habilidade como você avalia o seu desempenho na língua alemã. Escreva (1) para **muito bom,** (2) para **bom,** (3) para **regular** e (4) para **ruim**:
   a) Fala (quando você fala alemão, as pessoas o/a entendem?)____
   b) Escrita (como é a sua escrita em alemão?) ___________
   c) Leitura (como é a sua leitura em alemão?) ___________

d) Compreensão (você entende o que está sendo dito quando as pessoas falam alemão?)___________

6) Com que idade você começou a aprender português? ____________

7) Como você aprendeu português? Você pode assinalar mais de uma alternativa:
   ( ) em casa, com os familiares;
   ( ) interagindo com as pessoa da comunidade;
   ( ) interagindo com os vizinhos;
   ( ) na escola;
   ( ) através dos meios de comunicação (rádio, TV, jornal, e outros).

Sinta-se à vontade para citar outros contextos em que você aprendeu o português:____

8) Depois que você aprendeu português, em que tipo de situação você continuou tendo contato com a língua alemã? Você pode assinalar mais uma opção.
   ( ) em casa com os familiares;
   ( ) interagindo com as pessoa da comunidade;
   ( ) interagindo com os vizinhos;
   ( ) na escola;
   ( ) através dos meios de comunicação (rádio, TV, jornal, e outros).

Sinta-se à vontade para citar outros contextos em que você mantem contato com sua primeira língua: __________________________________

9) No seu dia a dia, em que língua você geralmente pensa? __________

10) Na maioria das vezes, em qual língua você se sente mais à vontade para falar? ____

11) Em qual das duas línguas você se sente mais à vontade para comunicar-se:
a) Em casa com familiares ____________________
b) No mercado ____________________
c) Na igreja _________________

d) Com alguém que você não conhece direito, mas sabe que ele/ela fala os mesmos idiomas que você ______________
e) Numa comemoração, festa, baile ______________________
f) Numa roda de amigos que falam os mesmos idiomas que você ____________

12) Faça uma avaliação do seu desempenho na língua portuguesa. Marque (1) para **muito bom,** (2) para **bom,** (3) para **regular** e (4) para **ruim** ao lado de cada habilidade.

a) Fala (quando você fala português, as pessoas lhe entendem?)__
b) Escrita (como é sua escrita em português?) ___________
c) Leitura (como é a sua leitura em português?) ___________
d) Compreensão (você entende quando as pessoas falam português?) _________

13) Marque a alternativa que mais combina com você no momento:

a) Comunico-me somente em uma das línguas;
b) Comunico-me nos dois idiomas regularmente, mas em situações diferentes (ex.: falo um idioma em casa e outro no trabalho);
c) Comunico-me nos dois idiomas todos os dias em todas as situações (ex.: falo as duas línguas em casa, no trabalho...).

14) Com que frequência você se encontra num ambiente onde os dois idiomas que você fala podem ser utilizados alternadamente?

a) O tempo todo
b) Quase o tempo todo
c) Em certas ocasiões
d) Raramente
e) Nunca

APPENDIX B

UNIVERSIDADE FEDERAL DE SANTA CATARINA
CENTRO DE COMUNICAÇÃO E EXPRESSÃO
DEPARTAMENTO DE LÍNGUA E LITERATURA ESTRANGEIRAS
Programa de Pós Graduação em Inglês e Literatura Correspondente

Pesquisa: Bilinguismo ao longo da vida: efeitos no controle executivo e memória de trabalho.

Questionário para bilíngues (Português/Inglês)

Nome: ____
Idade:______ Sexo: ( ) M ( ) F Profissão:____________________
Nacionalidade: ________________ Local de Nascimento: ____________
Grau de escolaridade
( ) Nenhuma escolaridade
( ) Ensino Fundamental: de 1º à 4º série
( ) Ensino Fundamental: de 5º à 8º série
( ) Ensino Médio
( ) Superior

1) Quantos idiomas você fala? ___________

2) Quais são?____

3) Você se considera fluente em inglês? (É considerado fluente aquele que consegue se comunicar na segunda língua sem precisar traduzir na língua materna)
( ) Sim ( ) Não

4) Com que idade você começou a aprender inglês?
____

5) Com que idade você percebeu que já tinha o domínio do inglês?
____

6) Você se sente à vontade para conversar em inglês com alguém estranho?
( ) Sim ( )Não

7) Em que contexto (s) você aprendeu a língua inglesa? (Ex.: curso, morou no exterior)

____
____
____
____

8) Faça uma avaliação do seu desempenho na língua portuguesa e na língua inglesa. Abaixo de cada habilidade escreva (1) para **muito bom,** (2) para **bom,** (3) para **regular** e (4) para **ruim**:

Idiomas	Fala	Compreensão	Leitura	Escrita
Português	______	_______	_______	_______
Inglês	______	_______	_______	_______

9) Você já morou num país onde você ficou exposto à língua inglesa?

( ) Sim ( ) Não

Se 'sim', responda as perguntas abaixo:

Onde você morou e quanto tempo morou lá?

____

Durante o tempo em que você morou no exterior, em que contexto (s) você utilizou a língua inglesa? (Ex.: em casa, na escola)

____

10) Instrução em Língua inglesa:

Você frequentou aulas de inglês num curso de línguas?

( ) Sim ( ) Não

Se 'sim'quanto tempo você frequentou as aulas?

____

11) Você continua tento aula de inglês? ( ) Sim ( ) Não

Se 'sim', qual o seu nível? ____________________________________

12) Marque a alternativa que mais combina com você no momento.

a) Comunico-me somente em uma das línguas;
b) Comunico-me nos dois idiomas regularmente, mas em situações diferentes (ex.: falo um idioma em casa e outro no trabalho);
c) Comunico-me nos dois idiomas todos os dias em todas as situações (ex.: falo as duas línguas em casa, no trabalho...).

13) Com que frequência você se encontra num ambiente onde os dois idiomas que você fala podem ser utilizados alternadamente?

a) O tempo todo
b) Quase o tempo todo
c) Em certas ocasiões
d) Raramente
e) Nunca

14) Quantas horas por dia/semana você tem contato com a língua inglesa? (Ex.: assistir TV – 2 horas por dia)

____
____
____

APPENDIX C

UNIVERSIDADE FEDERAL DE SANTA CATARINA
CENTRO DE COMUNICAÇÃO E EXPRESSÃO
DEPARTAMENTO DE LÍNGUA E LITERATURA ESTRANGEIRAS
Programa de Pós Graduação em Inglês e Literatura Correspondente

Pesquisa: Bilinguismo ao longo da vida: efeitos no controle executivo e memória de trabalho.

Questionário para Monolíngues

Nome: ____

Idade:______________ Sexo: ( ) M ( ) F Profissão: _______________
Nacionalidade: __________________ Local de Nascimento: __________
Grau de escolaridade
( ) Nenhuma escolaridade
( ) Ensino Fundamental: de 1º à 4º série
( ) Ensino Fundamental: de 5º à 8º série
( ) Ensino Médio
( ) Superior

1) Além do português, você fala algum outro idioma?
   ( ) Sim ( ) Não

2) Se 'sim', escreva qual idioma ou quais idiomas você sabe:
   ____

3) Como você aprendeu esse(s) idioma(s)? Na escola, com os familiares, com outros?
   ____

4) Mencione com que frequência você faz uso desse(s) idioma(s) no seu dia a dia (todos os dias, quase todos os dias, ocasionalmente, raramente, nunca)
   ____
   ____

APPENDIX D

UNIVERSIDADE FEDERAL DE SANTA CATARINA
CENTRO DE COMUNICAÇÃO E EXPRESSÃO
DEPARTAMENTO DE LÍNGUA E LITERATURA ESTRANGEIRAS
Programa de Pós Graduação em Inglês e Literatura Correspondente

Pesquisa: Bilinguismo ao longo da vida: efeitos no controle executivo e memória de trabalho.

Informações Gerais

1. Data ___/____/________ 2. Hora _______________
2. Nome do Pesquisador: ____________________________________
3. Nome do participante: ____________________________________
4. Data de nascimento:_________ 6. País de nascimento: __________
5. Nacionalidade: _____________________
6. Sexo: ( ) M ( ) F
7. Nível de escolaridade: __________________________
8. Escreva abaixo a sua profissão atual e as profissões anteriores (caso haja) e a data aproximada de início e desligamento no cargo.

Profissão	Data de início	Data de desligamento	Observações

9. Informações para contato
   Telefones: Residencial _________________________
   Comercial __________________________
   Celular ____________________________
   Endereço: ____
   Cidade _______________________ Estado_______________
   Cep______________

Informações sobre o uso das mãos

1. Você teve algum ferimento ou problema na sua mão ou pé de preferência, fazendo com você fosse obrigado a utilizar a outra mão ou pé permanentemente? (   ) Sim   (   ) Não

Se 'sim', indique quando e a razão da mudança da preferência.
Data: ___________________
Razão:
____
____

Instruções: **antes** do ferimento ou do problema na sua mão ou pé de preferência, marque na tabela abaixo qual a mão você usaria para as ações. Se você não tem preferência, diga 'ambas'.

Se 'não', para cada ação abaixo, diga se você prefere utilizar sua mão direita ou esquerda para realizá-la, tente também fazer de conta que está realizado as tarefas (com mímica). Para as tarefas as quais você tem forte preferência por uma das mãos, diga 'somente a direita' ou 'somente a esquerda'. Se você não tem preferência, diga 'ambas'.

2. Como a preferência é indicada (verbalmente: dizendo a preferência; fisicamente: representando).

	Verbalmente		Fisicamente		Observações
	Direita	Esquerda	Direita	Esquerda	
1. Escrever					
2. Desenhar					
3. Atirar um objeto					
4. Cortar com tesoura					
5. Escovar os dentes					
6. Cortar legumes com uma faca					
7. Comer com a colher					

8. Varrer – do lado direito e esquerdo do corpo					
9. Ascender um fósforo – com que mão segura o fósforo?					
10. Abrir a tampa de uma caixa					
Com qual pé você prefere chutar?					
Qual olho você prefere quando precisa usa somente um deles? (ex.: usar um telescópio)					

Informações Clínicas

1. Você ou alguém da sua família já foi diagnosticado como portador de algum distúrbio ou situação médica grave?

____

____

2. Você ou alguém da sua família já passou por cirurgia no cérebro, terapia eletroconvulsiva ou qualquer tipo de procedimento cerebral invasivo?

____

____

____

3. Você está tomando algum medicamento, com ou sem prescrição?

____

____

____

APPENDIX E

UNIVERSIDADE FEDERAL DE SANTA CATARINA

Pesquisa: Bilinguismo ao longo da vida: efeitos no controle executivo e memória de trabalho.

MINI-EXAME DO ESTADO MENTAL (MEM)

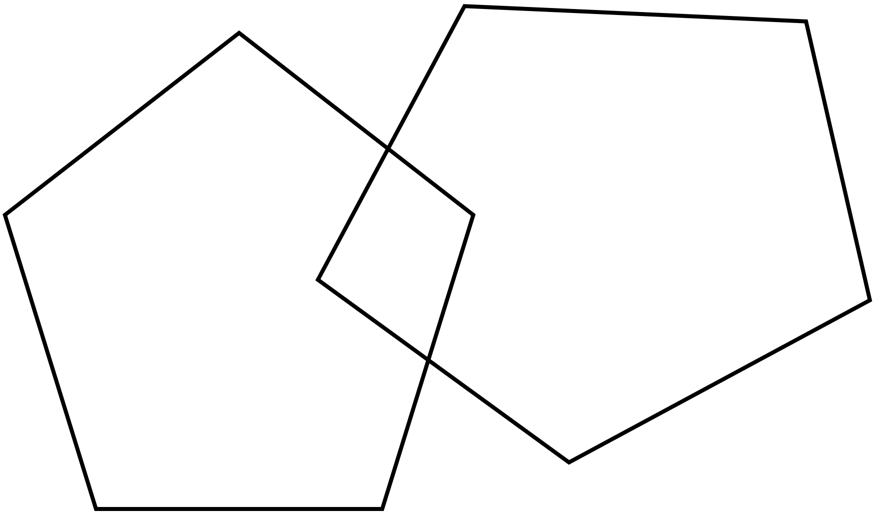
Nome: ____
Idade ______________ Data:________________

Anos de estudo:	***Pontos de Corte***
____ analfabeto	**20**
____ 1 a 4 anos	**25**
____ 5 a 8 anos	**26,5**
____ 9 a 11 anos	**28**
____ 11 + anos	**29**

Pontuação Máxima	**Pontuação do paciente**	
5		**Orientação temporal**: dia _______, mês _____, ano _____, dia da semana ____ , horas ______ (0 a 5)
5		**Orientação espacial**: Local (específico) _______, Local (geral), _______, bairro _______, cidade _________, estado _______ (0 a 5)
3		**Registro**: repetir: carro _____, vaso _____, tijolo _____
5		**Cálculo**: 100-7=93 ____; 93-7=86 _____, 86-7=79 ____; 79-7=72 ____; 72-7=65 _____ (0 a 5)
3		**Memória recente**: Quais foram as três palavras que te pedi para repetir? __________ (0 a 3)
9		**Linguagem:** ▪ Nomear dois objetos: caneta _____ e relógio_____ (0 a 2) ▪ Repetir a expressão "nem aqui, nem ali, nem lá" ______ (0 a 1) ▪ Comando de três estágios: pegue esta folha de papel com a mão direita, dobre-o ao meio e coloque-o no chão ________(0 a 3) ▪ Ler e executar (feche os olhos) _______ (0 a 1) ▪ Escrever uma frase completa _______ (0 a 1) ▪ Copiar o diagrama: _______ (0 a 1)
30		**Obs:**

BERTOLUCCI, P. *et al*, 1994; BUCKI et al., 2003.

Nome ____



APPENDIX F

UNIVERSIDADE FEDERAL DE SANTA CATARINA
CENTRO DE COMUNICAÇÃO E EXPRESSÃO
DEPARTAMENTO DE LÍNGUA E LITERATURA ESTRANGEIRAS
Programa de Pós Graduação em Inglês e Literatura Correspondente
Pesquisa: Bilinguismo ao longo da vida: efeitos no controle executivo e memória de trabalho.

Inventário de Depressão de Beck

Nome: _____________ Idade: ______ Estado Civil: _________

Profissão:_________Escolaridade: ______ Data de aplicação:_____

Pontuação: ____

Instruções

Neste questionário existem grupos de afirmações. Por favor leia cuidadosamente cada uma delas. A seguir selecione a afirmação, em cada grupo, que melhor descreve como se sentiu NA SEMANA QUE PASSOU, INCLUINDO O DIA DE HOJE. Desenhe um círculo em torno do número ao lado da afirmação selecionada. Se escolher dentro de cada grupo várias afirmações, faça um círculo em cada uma delas. Certifique-se que leu todas as afirmações de cada grupo antes de fazer a sua escolha.

1.

0 Não me sinto triste.
1 Eu me sinto triste.
2 Estou sempre triste e não consigo sair disto.
3 Estou tão triste ou infeliz que não consigo suportar.

2.

0 Não estou especialmente desanimado(a) quanto ao futuro.
1 Sinto-me desanimado(a) quanto ao futuro.
2 Acho que nada tenho a esperar.
3 Acho o futuro sem esperança e tenho a impressão que as coisas não podem

melhorar.

3.

0 Não me sinto um fracasso.
1 Acho que fracassei mais do que uma pessoa comum.
2 Quando olho para tras, na minha vida, tudo que posso ver é um monte de fracassos.
3 Acho que, como pessoa, sou um completo fracasso.

4.

0 Tenho tanto prazer em tudo como antes.
1 Não sinto mais prazer nas coisas como antes.
2 Não encontro um prazer real em mais nada.
3 Estou insatisfeito(a) ou entediado(a) com tudo.

5.

0 Não me sinto especialmente culpado(a).
1 Eu me sinto culpado(a) grande parte do tempo.
2 Eu me sinto culpado(a) a maior parte do tempo.
3 Eu me sinto sempre culpado(a).

6.

0 Não acho que esteja sendo punido(a).
1 Acho que posso ser punido(a).
2 Creio que serei punido(a).
3 Acho que estou sendo punido(a).

7.

0 Não me sinto decepcionado(a) comigo mesmo(a).
1 Estou decepcionado(a) comigo mesmo(a).
2 Estou enojado(a) de mim.
3 Eu me odeio.

8.

0 Não sinto, de qualquer modo, pior que os outros.
1 Sou crítico em relação a mim por minhas fraquezas ou erros.
2 Eu me culpo sempre por minhas faltas.
3 Eu me culpo por tudo de mau que acontece.

9.

0 Não tenho quaisquer ideias de me matar.
1 Tenho ideias de me matar, mas não as executaria.
2 Gostaria de me matar.
3 Eu me mataria se tivesse oportunidade.

10.

0 Não choro mais do que o habitual.
1 Choro mais agora do que costumava.
2 Agora, choro o tempo todo.
3 Costumava ser capaz de chorar, mas agora não consigo, mesmo que queira.

11.

0 Não sou mais irritado(a) agora do que já fui.
1 Fico aborrecido(a) ou irritado(a) mais facilmente do que costumava.
2 Atualmente, me sinto irritado(a) o tempo todo.
4 Não me irrito mais com as coisas que costumavam me irritar.

12.

0 Não perdi o interesse pelas outras pessoas.
1 Estou menos interessado pelas pessoas do que costumava estar.
2 Perdi a maior parte do meu interesse pelas outras pessoas.
3 Perdi todo o meu interesse pelas outras pessoas.

13.

0 Tomo decisões tão bem quanto antes.
1 Adio as tomadas de decisões mais do que costumava.
2 Tenho maior dificuldade em tomar decisões do que antes.
3 Não consigo mais tomar decisão.

14.

0 Não acho que a minha aparência esteja pior do que costumava ser.
1 Estou preocupado por estar parecendo velho(a) ou sem atrativos.
2 Acho que há mudanças permanentes na minha aparência que me fazem parecer sem atrativos.
4 Acredito que pareço feio(a).

15.

0 Posso trabalhar tão bem quanto antes.
1 Preciso de um esforço extra para fazer qualquer coisa.
2 Tenho que me forçar muito para fazer qualquer coisa.
3 Não consigo mais fazer trabalho algum.

16.

0 Consigo dormir tão bem como o habitual.
1 Não durmo tão bem quanto costumava.
2 Acordo 1 ou 2 horas mais cedo que o habitual e tenho dificuldade em voltar a dormir.
3 Acordo várias horas mais cedo do que costumava e não consigo voltar a dormir.

17.

0 Não fico mais cansado(a) do que o habitual.
1 Fico cansado(a) com mais facilidade do que costumava.
2 Sinto-me cansado ao fazer qualquer coisa.
3 Estou cansado(a) demais para fazer qualquer coisa.

18.

0 Meu apetite não está pior do que o habitual.
1 Meu apetite não é tão bom quanto costumava ser.
2 Meu apetite está muito pior agora.
3 Não tenho mais nenhum apetite.

19.

0 Não tenho perdido nenhum peso, se é que perdi algum recentemente.
1 Perdi mais de 2,5 kg.
2 Perdi mais de 5 kg.
3 Perdi mais de 7 kg.

Estou tentando perder peso de propósito, comendo menos:
Sim ____ Não ____

20.

0 Não estou mais preocupado(a) com minha saúde do que o habitual.
1 Estou preocupado(a) com problemas físicos, tais como dores, indisposição do

estômago ou prisão de ventre.
2 Estou muito preocupado(a) com problemas físicos e é difícil pensar em outra coisa.
3 Estou tão preocupado(a) com meus problemas físicos que não consigo pensar em qualquer outra coisa.

21.

0 Não notei qualquer mudança recente no meu interesse por sexo.
1 Estou menos interessado(a) por sexo do que costumava estar.
2 Estou muito menos interessado em sexo atualmente.
3 Perdi completamente o interesse por sexo.

Total: ______ **Classificação: _________________**

Traduzido, adaptado e validado para a população brasileira (GORESTEIN; ANDRADE, 1996).

APPENDIX G

UNIVERSIDADE FEDERAL DE SANTA CATARINA
CENTRO DE COMUNICAÇÃO E EXPRESSÃO
DEPARTAMENTO DE LÍNGUA E LITERATURA ESTRANGEIRAS
Programa de Pós Graduação em Inglês e Literatura Correspondente

Formulário de Consentimento Livre e Esclarecido

Título do Projeto: "Bilingualism across the lifespan: Effects on Executive Control and Verbal Working Memory" - Bilinguismo ao longo da vida: efeitos no controle executivo e memória de trabalho.

A função cognitiva é fundamental em nossa vida. A cognição nos permite interagir no mundo em que vivemos conservando a nossa identidade existencial. É um conjunto de processos mentais que envolvem a atenção, percepção, memória, raciocínio e linguagem. Essas habilidades cognitivas, com o passar dos anos, sofrem alterações. Assim, gostaria de lhe convidar a participar de um projeto de pesquisa que contribuirá com dados para os estudos sobre alterações na cognição em nosso país.

Objetivo do Estudo: O objetivo desse estudo é comparar os processos cognitivos de pessoas bilíngues e não bilíngues. Os dados coletados nesse estudo serão utilizados na minha dissertação de Mestrado que tem como orientadora a Prof. Dra. Mailce Borges Mota (UFSC/CCE/DLLE/PPGI - mailce@cce.ufsc.br). Os dados, também serão utilizados para publicação de artigo(s) cientifico(s).

Procedimentos: Se você aceitar participar desse estudo, primeiramente você preencherá alguns questionários, após você será solicitado a realizar as seguintes tarefas: a) uma tarefa de controle de atenção; b) duas tarefas de memória declarativa; c) duas tarefas de memória procedimental; d) uma tarefa de memória do trabalho. Essas tarefas serão realizadas em uma sala e as respostas serão armazenadas por um equipamento para posterior análise.

Riscos e Benefícios do Estudo: Não há riscos em participar deste estudo. Antes de realizar as tarefas, você terá tempo de se familiarizar com elas, receberá todas as instruções de como elas funcionam e como você deve realizá-las. Você não receberá nenhuma nota ou crítica pelo seu desempenho. Ao final da pesquisa, os resultados serão tornados públicos, mas sua identidade será totalmente preservada, ou seja, nenhuma informação que possa identificá-lo (a) será incluída. Somente a pesquisadora deste projeto e sua orientadora terão acesso aos dados coletados.

Natureza voluntária do estudo: Se você decidir participar e depois decidir desistir, não tem problema. Você poderá desistir a qualquer momento. Peço apenas que você me notifique, você não precisa se justificar.

Pesquisadora responsável: Rossana Kramer (rossanakramer@yahoo.com.br; (48)9621.6463)

Declaração de consentimento:

Declaro que li a informação acima. Quando necessário, fiz perguntas e recebi esclarecimentos. Eu concordo em participar deste estudo.

Nome:____Data:________

____________________ ______________________

Assinatura do participante Assinatura da pesquisadora responsável

APPENDIX H

UNIVERSIDADE FEDERAL DE SANTA CATARINA
CENTRO DE COMUNICAÇÃO E EXPRESSÃO
DEPARTAMENTO DE LÍNGUA E LITERATURA ESTRANGEIRAS
Programa de Pós Graduação em Inglês e Literatura Correspondente

Research: Bilingualism across the lifespan: Effects on Executive Control and Working Memory.

PLACEMENT TEST

Section 1 – Listening Comprehension

Directions: Listen to the conversation then answer the questions.

1) What is the relationship between the speakers?

   a) They're lab partners
   b) They're cousins
   c) They're classmates
   d) They're roommates

2) Why was the man worried at first?

   a) He couldn't decide on a topic for his paper
   b) He hadn't heard from his family in a while
   c) He thought his paper was late
   d) He thought the woman had been ill

3) According to the man, how do some bees use their sense of smell?

   a) To find their way back to the nest
   b) To identify relatives
   c) To identify kinds of honey
   d) To locate plant fibers

4) What will the man do over the weekend?

   a) Write a paper
   b) Plan a family reunion
   c) Observe how bees build nests
   d) Visit his parents

Section 2 – Structure and Written Expression

Part A - Structure

Directions: The questions here test your knowledge of English grammar. Choose the letter of the word or group of words that **best** completes the sentence.

5. According to the third law of thermodynamics, _______ possible is -273.16 degrees centigrade.

   a) that temperature is lowest
   b) the temperature is lower
   c) lowest temperature
   d) the lowest temperature

6. After the First World War, the author Anais Nin became interested in the art movement known as Surrealism and in psychoanalysis, both ________ her novels and short stories.

   a) in which the influence
   b) of which influenced
   c) to have influence
   d) its influence in

7. Muskrats generally _________close to the edge of a bog, where their favorite plant foods grow plentifully.

   a) staying
   b) they are staying
   c) stay
   d) to stay there

8. Oliver Ellsworth, ______of the United States Supreme Court, was the author of the bill that established the federal court system.

   a) he was the third chief justice
   b) the third chief justice was
   c) who the third chief justice
   d) the third chief justice

9. __________Colonial period the great majority of Connecticut's settlers came from England.

a) Since
b) The time
c) During the
d) It was

10. A politician can make a legislative proposal more _________ by giving specific examples of what its effect will be.

a) to understanding
b) understandably
c) understandable
d) when understood

11. A few animals sometimes fool their enemies ________ to be dead.

a) appear
b) to appear
c) by appearing
d) to be appearing

12. Before every presidential election in the United States, the statisticians try to guess the proportion of the population that ________ for each candidate.

a) are voted
b) voting
c) to be voted
d) will vote

13. ________ at a river ford on the Donner Pass route to California, the city of Reno grew as bridges and railroad were built.

a) Settle
b) To settle
c) It was settling
d) Having been settled

14. Mango trees, _______ densely covered with glossy leaves and bear small fragrant flowers, grow rapidly and can attain heights of up to 90 feet.

a) whose
b) which are
c) are when
d) which

15. The Chisos Mountains in Big Bend National Park in Texas were created by volcanic eruptions that occurred _______.

a) the area in which dinosaurs roamed
b) when dinosaurs roamed the area
c) did dinosaurs roam the area
d) dinosaurs roaming the area

16. Alaska found the first years of its statehood costly because it had to take over the expense of services _______ previously by the federal government.

a) to provide
b) be provided
c) providing
d) provided

17. With age, the mineral content of human bones decreases, _______ them more fragile.

a) make
b) and make
c) thereby making
d) which it makes

18. The first explorer_______ California by land was Jedediah Strong Smith, a trapper who crossed the southwestern deserts of the United States in 1826.

a) that he reached
b) reached
c) to reach
d) reaching it

19. _________ many copper mines in the state of Arizona, a fact which contributes significantly to the state's economy.

a) They are
b) There are
c) Of the
d) The

Part B – Written Expression

Directions: The questions here test your knowledge of English grammar. Choose the letter of the word or group of words that **is not correct**.

20. Before pioneers cleared the land for farms, cities, and road, forests
A B
covered about 40 percent of what is now the state of Illinois.
C D

21. The sea chantey, a type of folk music, not only described the pleasures of
A …. B
station's lives ashore, also but the harsh conditions of life aboard ship.
C . D

22. Mount Rushmore National Memorial in South Dakota has a heads of
A B
four presidents of the United States carved into its face.
C D

23. Nest building is much less commonly among mammals than among birds.
A B C D

24. The Awaking, a novel by Kate Chopin, shocked readers and cause a storm of
A B C
criticism.
D

Section 3 – Reading

Directions: Read the passage and answer the questions.

During the seventeenth and eighteenth centuries, almost nothing was written about the contribution of women during the colonial period and the early history of the newly formed United States. Lacking the right to vote and absent from the seats of power, women were not considered an important force in history. Anne Bradstreet wrote some significant poetry in the seventeenth century, Mercy Otis Warren produced the best contemporary history of the American Revolution, and Abgail Adams penned important letters showing she exercised great political influence over her husband, John, the second President of the United States. But little or no notice was taken of these contributions. During these centuries women remained invisible in history books.

Throughout the nineteenth century, this lack of visibility continued, despite the efforts of female authors writing about women. These writers, like most of their male counterparts, were amateur historians. Their writings were celebratory in nature, and they were uncritical in their selection and use of sources.

During the nineteenth century, however, certain feminists showed a keen sense of history by keeping records of activities in which women were engaged. National, regional, and local women's organizations compiled accounts of their doings. Personal correspondence, newspaper clippings, and souvenirs were saved and stored. These sources form the core of the two greatest collections of women's history in the United States – one at the Elizabeth and Arthur Schlesinger Library Radeliffe College, and the other the Sophia Smith Collection at Smith College. Such sources have provided valuable materials for later generations of historians.

Despite the gathering of more information about ordinary women during the nineteenth century, most of the writing about women conformed to the "great women" theory of history, just as much of mainstream American history concentrated on "great men". To demonstrate that women were making significant contributions to American life, female authors singled out women leaders and wrote biographies, or else important women produced their autobiographies. Most of these leaders were involved in public life as reformers, activists working for women's right to vote, or authors, and were not representative of all of the great mass of ordinary women. The lives of ordinary people continued, generally, to be unfold in the American histories being published.

Question 25: What does the passage mainly discuss?

a) The role of literature in early American histories.

b) The place of American women in written histories.

c) The "great women" approach to History used by American historians.

d) The keen sense of history shown by American women.

Question 26: The word "contemporary" in line 5 means that history was

a) thoughtful
b) informative

c) faultfinding

d) written at that time

Question 27: In the first paragraph, Bradstreet, Warren, and Adams are mentioned to show that

a) Even the contributions of outstanding women were ignored.
b) Poetry produced by women was more readily accepted than other writing by women.

c) A woman's status was changed by marriage.

d) Only three women were able to get their writing published.

Question 28: The word "celebratory" in line 11 means that the writings referred to were

a) serious
b) religious
c) related to parties
d) full of praise

Question 29: The word "they" in line 11 refers to

a) sources
b) authors
c) counterparts
d) efforts

Question 30: In the second paragraph, what weakness in nineteenth century does the author point out?

a) They were printed on poor quality paper.

b) They left out discussion of the influence on money on politics.
c) The sources of the information they were based on were not necessarily accurate.
d) They put too much emphasis on daily activities.

Question 31: On the basis of information in the third paragraph, which of the following would most likely have been collected by nineteenth-century feminist organizations?

a) Newspaper accounts of presidential election results.
b) Letters from a mother to a daughter advising her how to handle a family problem.
c) Biographies of John Adams.
d) Books about famous graduates of the country's first college.

Question 32: What use was made of the nineteenth-century women's history materials in the Schlesinger Library and the Sophia Smith Collection?

a) They provided valuable information for twentieth century historical researchers.
b) They formed the basis of college courses in the nineteenth-century.
c) They were combined and published in a multivolume encyclopedia about women.
d) They were shared among women's colleges throughout the United States.

Question 33: In the last paragraph, the author mentions all of the following as possible roles of nineteenth-century "great women" EXCEPT

a) authors
b) reformers
c) activists for women's rights
d) politicians

Question 34: The word "representative" in line 26 is closest in meaning to

a) satisfied
b) distinctive
c) typical
d) supportive

Section 4 - Writing

Think about relevant aspects you have experienced while living overseas. Write a text about how your experience abroad contributed to improve your English language skills and your intercultural competence.

APPENDIX I

Writing Scoring Guide

The following scoring guidelines relate to the TOEFL® PBT Test Writing & Structure section.

Score of Six
An essay at this level:
- shows effective writing skills
- is well organized and well developed
- uses details clearly and properly to support a thesis or illustrate ideas
- displays consistent ability in the use of language
- demonstrates variety in sentence structure and proper word choice

Score of Five
An essay at this level:
- may address some parts of the task more effectively than others
- is generally well organized and developed
- uses details to support a thesis or illustrate an idea
- displays ability in the use of the language
- shows some variety in sentence structure and range of vocabulary

Score of Four
An essay at this level:
- addresses the writing topic adequately but does not meet all of the goals of the task
- is adequately organized and developed
- uses some details to support a thesis or illustrate an idea
- shows adequate but possibly inconsistent ability with sentence structure
- may contain some usage errors that make the meaning unclear

Score of Three
An essay at this level may reveal one or more of the following weaknesses:
- inadequate organization or development
- poor choice of details or does not provide enough details to support or illustrate generalizations
- a noticeably improper choice of words or word forms

- numerous errors in sentence structure and/or usage

Score of Two

An essay at this level is seriously flawed by one or more of the following weaknesses:

- serious disorganization or underdevelopment
- little or no detail, or irrelevant specifics
- serious and frequent errors in sentence structure or usage
- serious problems with focus

Score of One

An essay at this level:

- may be incoherent
- may be undeveloped
- may contain severe and persistent writing errors

Score of 0

An essay will be rated 0 if it:

- contains no response
- merely copies the topic
- is off-topic, is written in a foreign language or consists only of keystroke characters

APPENDIX J

Alpha Span Test

Farei a leitura de uma lista de palavras, uma palavra por vez. Depois você as repetirá em ordem alfabética. Começarei com uma lista de duas palavras e irei aumentando gradativamente (repetir instruções).

Vamos praticar um pouco
Prática 1: vila, céu
(2) 2: urna, faca
Agora eu direi uma lista com 3 palavras
Prática 1: nota, cara, sopa
(3) 2: copo, lata, avó

Aqui começa o teste:
Lista 1: país, casa
(2) 2: jogo, ano
(agora eu direi 3 palavras)
Lista 1: rua, time, lei
(3) 2: nome, bola, vida
(agora eu direi 4 palavras)
Lista 1: povo, luz, sala, foto
(4) 2: voto, pai, loja, meia
(agora eu direi 5 palavras)
Lista 1: pé, vaca, rio, café, mãe
(5) 2: voz, aula, mesa, fogo, pele
(agora eu direi 6 palavras)
Lista 1: onda, tela, boca, mapa, gás, arma
(6) 2: mar, olho, fila, cama, dono, sopa
(agora eu direi 7 palavras)
Lista 1: moça, lixo, cão, sol, fita, irmã, ovo
(7) 2: fé, mão, alvo, pano, bebê, lã, soja
(agora eu direi 8 palavras)
Lista 1 : pó, sal, flor, roda, lua, doce, gelo, boi
(8) 2: rosa, bolo, lago, suco, chá, moto, vila, paz

APPENDIX K

Alpha Span Answer/Scoring

Prática 1: Céu, Vila
(2) 2: Faca, Urna
Prática 1: Cara, Nota, Sopa
(3) 2: Avó, Copo, Lata
Aqui começa o teste:
Lista 1: Casa, País

(2) 2: Ano, Jogo

Lista 1: Lei, Rua, Time

(3) 2: Bola, Nome, Vida

Lista 1: Foto, Luz, Povo, Sala

(4) 2: Loja, Meia, Pai, Voto

Lista 1: Café, Mãe, Pé, Rio, Vaca

(5) 2: Aula, Fogo, Mesa, Pele, Voz

Lista 1: Arma, Boca, Gás, Mapa, Onda, Tela

(6) 2: Cama, Dono, Fila, Mar, Olho, Sopa

Lista 1: Cão, Fita, Irmã, Lixo, Moça, Ovo, Sol

(7) 2: Alvo, Bebê, Fé, Lã, Mão, Pano, Soja

Lista 1 : Boi, Doce, Flor, Gelo, Lua, Pó, Roda, Sal

(8) 2: Bolo, Chá, Lago, Moto, Paz, Rosa, Suco, Vila

APPENDIX L

Alpha Span Scoring

1.One problem with alpha span is that traditional span measures (e.g. the longest list giving at least one completely correct trial) yield little variance--most people score 5 or 6. Therefore a method giving credit for partially correct item and order recall is preferable.

2.One way to accomplish this is first to continue testing TWO levels beyond the traditional span level (which equals ONE level beyond the first level at which the participant fails both trials). If the person fails both at level 4, but gets one correct at level 5, then consider 5 = span and proceed for a further two levels

e.g.l) (2V,2V) + (3V,3V) + (4V,4x) + (5x,5x) + (6x,6x)

2) (2V,2V) + (3V,3V) + (4x,4x) + (5V,5x) + (6x,6x) + (7x,7x),

where V = correct and x = fail

3. In all eases record actual responses; if correct, then simply check items

e.g. Presentation: log, gun, table, apple, queen

Recall: "apple, gun, queen, table"

4.Scoring: Give 1 point for each item in correct adjacent runs.

So completely correct sequences score sequence length, i.e. level 3 = 3, level 4 = 4 etc.

Partial scoring examples:

Presentation	= uncle, bedroom, guitar, flower, radio, sun.						
Recall	= "bedroom, guitar, radio, sun, unc1e"						
Score	=	0	1	1	1	1	= 4

i.e. bedroom = 0 because it is not a member of a run of at least 2
(even tho' in correct position).

Presentation:	rabbit, moon, boy, father, tide, picture, kite						
Recall:	boy, father, picture, kite, rabbit, tide						
Score:	1	1	0	0	1	1	= 4

i.e. only boy-father and rabbit-tide are correctly adjacent.

5. Examples of complete procedure + score

1. Length	Points	Total
2	2+2	4
3	3+3	6
4	4+4	8 span
5	3+0	3
6	2+3	5
7	-	-
8	-	-
Score =		26

2. Length	Points	Total
2	2+2	4
3	3+3	6
4	4+3	7
5	5+2	7 span
6	4+2	6
7	0+0	0
8	-	-
Score =		30

APPENDIX M

Participants

Participants	Schooling	Age	Gender	Language	MMSE	Beck Depression	City
8	PS	75	M	H/BP	26	2	Mondaí/SC
9	PS	69	F	H/BP	26	3	Mondaí/SC
10	FS	66	M	H/BP	28	1	Mondaí/SC
11	FS	73	F	H/BP	30	5	Mondaí/SC
12	PS	70	F	Monolingual	25	3	Mondaí/SC
13	PS	68	F	H/BP	27	2	Mondaí/SC
14	HE	38	F	H/BP	30	4	Mondaí/SC
15	PS	81	F	H/BP	25	4	Iporã do Oeste/SC
16	HE	23	F	Monolingual	29	1	Iporã do Oeste/SC
17	HE	19	M	Monolingual	29	2	Iporã do Oeste/SC
18	HS	41	M	H/BP	28	6	Iporã do Oeste/SC
19	PS	72	M	H/BP	28	5	Iporã do Oeste/SC
20	PS	73	M	H/BP	26	4	Iporã do Oeste/SC
21	PS	70	F	H/BP	25	8	Iporã do Oeste/SC
22	HE	24	F	H/BP	29	6	Iporã do Oeste/SC
23	FS	71	M	H/BP	28	5	Iporã do Oeste/SC
24	PS	84	F	H/BP	28	3	Iporã do Oeste/SC
25	FS	66	M	H/BP	27	6	Iporã do Oeste/SC
26	HS	22	M	Monolingual	28	0	Iporã do Oeste/SC
27	HE	18	M	Monolingual	29	0	Iporã do Oeste/SC
28	HE	46	F	H/BP	29	4	Iporã do Oeste/SC
29	HE	20	M	Monolingual	29	1	Iporã do Oeste/SC
30	HE	70	M	H/BP	27	3	Iporã do Oeste/SC
31	HE	30	F	Monolingual	29	2	Iporã do Oeste/SC
32	HS	54	M	H/BP	28	7	Iporã do Oeste/SC
33	HE	23	F	Monolingual	29	4	Iporã do Oeste/SC
34	FS	71	F	H/BP	28	2	Iporã do Oeste/SC
35	HS	39	F	H/BP	30	3	Iporã do Oeste/SC
36	HS	44	F	H/BP	29	5	Iporã do Oeste/SC
37	HS	51	F	Monolingual	29	5	Iporã do Oeste/SC
38	HS	66	M	Monolingual	29	4	Iporã do Oeste/SC
39	HE	22	F	H/BP	30	2	Iporã do Oeste/SC
40	HE	23	F	H/BP	30	3	Iporã do Oeste/SC
41	HS	37	M	Monolingual	29	2	Iporã do Oeste/SC
42	FS	65	F	Monolingual	27	2	Iporã do Oeste/SC
43	HE	24	M	H/BP	30	2	Iporã do Oeste/SC
44	FS	48	F	Monolingual	29	1	Iporã do Oeste/SC
45	HE	25	F	H/BP	30	0	Iporã do Oeste/SC
46	HE	50	F	Monolingual	29	5	Iporã do Oeste/SC
47	FS	54	M	Monolingual	28	5	Iporã do Oeste/SC
48	HE	40	M	H/BP	30	2	Iporã do Oeste/SC
49	HE	40	F	H/BP	30	3	Iporã do Oeste/SC
50	HE	47	M	H/BP	30	5	Iporã do Oeste/SC
51	HE	22	M	Monolingual	30	0	Iporã do Oeste/SC
52	FS	47	M	Monolingual	28	5	Iporã do Oeste/SC
53	HS	48	M	H/BP	29	1	Iporã do Oeste/SC
54	HS	24	M	H/BP	30	0	Iporã do Oeste/SC
55	HE	20	F	Monolingual	30	2	Iporã do Oeste/SC
56	HE	20	M	H/BP	29	0	Iporã do Oeste/SC
57	HS	18	F	H/BP	30	0	Iporã do Oeste/SC
58	HE	44	M	H/BP	29	3	Iporã do Oeste/SC
59	HS	21	M	H/BP	28	5	Iporã do Oeste/SC
60	HE	25	M	H/BP	30	1	Iporã do Oeste/SC

61	PS	46	F	Monolingual	27	4	Iporã do Oeste/SC
62	FS	42	F	Monolingual	28	3	Iporã do Oeste/SC
63	HS	45	M	H/BP	28	5	Iporã do Oeste/SC
64	HS	48	M	Monolingual	29	4	Iporã do Oeste/SC
65	HS	52	F	H/BP	28	4	Iporã do Oeste/SC
66	FS	80	M	Monolingual	28	6	Porto Alegre/RS
67	HS	43	M	Monolingual	28	4	Iporã do Oeste/SC
68	HE	19	F	Monolingual	29	1	Iporã do Oeste/SC
69	HE	32	F	H/BP	29	3	Iporã do Oeste/SC
70	PS	67	F	Monolingual	25	7	Mondaí/SC
71	HS	20	F	Monolingual	29	0	Mondaí/SC
72	PS	69	F	Monolingual	25	3	Mondaí/SC
73	PS	75	M	Monolingual	25	6	Mondaí/SC
74	HS	47	F	Monolingual	28	5	Mondaí/SC
75	HS	50	M	Monolingual	28	4	Mondaí/SC
76	HS	52	M	Monolingual	30	6	Mondaí/SC
77	FS	68	M	Monolingual	26	6	Porto Alegre/RS
78	FS	73	M	Monolingual	27	9	Porto Alegre/RS
79	FS	78	M	Monolingual	27	8	Porto Alegre/RS
80	PS	75	F	Monolingual	26	5	Porto Alegre/RS
81	HS	73	F	Monolingual	28	6	Porto Alegre/RS
82	HS	74	M	Monolingual	28	6	Porto Alegre/RS
83	PS	84	F	Monolingual	25	9	Porto Alegre/RS
84	HE	21	M	BP/English	30	4	UFSC
85	HE	21	M	BP/English	29	9	UFSC
86	HE	24	M	BP/English	30	7	UFSC
87	HE	21	F	BP/English	30	2	UFSC
88	HE	23	F	BP/English	30	1	UFSC
89	HE	18	F	BP/English	28	3	UFSC
90	HE	25	F	BP/English	30	3	UFSC
91	HE	24	M	BP/English	29	1	UFSC
92	HE	38	F	BP/English	29	1	UFSC
93	HE	24	M	BP/English	29	4	UFSC
94	HE	20	F	Monolingual	29	3	UFSC
95	HE	20	M	Monolingual	29	1	UFSC
96	HE	19	F	Monolingual	30	1	UFSC
97	HE	22	M	Monolingual	29	2	UFSC
98	HE	22	F	BP/English	30	3	UFSC
99	HE	21	F	Monolingual	29	3	UFSC
100	HE	18	M	Monolingual	29	1	UFSC
101	HE	21	M	Monolingual	29	2	UFSC
102	HE	18	M	Monolingual	30	2	UFSC
103	HE	23	F	Monolingual	30	2	UFSC
104	HE	23	F	Monolingual	30	1	UFSC
105	HE	22	M	Monolíngue	30	3	UFSC
106	HE	26	F	BP/English	30	7	UFSC
107	HE	24	F	Monolingual	30	4	UFSC
108	HE	19	M	Monolingual	30	7	UFSC
109	HE	21	F	Monolingual	29	5	UFSC
110	HE	21	M	BP/English	30	4	UFSC
111	HE	24	M	BP/English	30	1	UFSC
112	HE	23	F	BP/English	30	2	UFSC

Note. MMSE = Mini-Mental State examination; F = Female; M = Male; PS = Primary School (1 to 4 years of schooling); Fundamental School (5 to 8 years of schooling); HS = High School (9 to 11 years of schooling); HE = High Education (undergraduate and postgraduate education).

APPENDIX N

Charts - Performance of participants on the Simon tasks

Chart 1 – Performance of early bilinguals and their monolingual peers on the Simon task - 2 Colors.

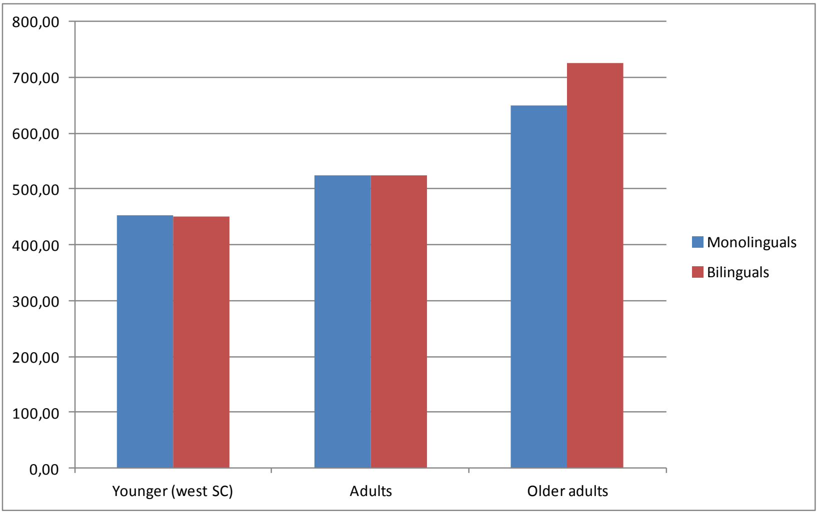


Chart 2 – Results of the Simon effect for early bilinguals and their monolingual peers' performance on the Simon task – 2 Colors.

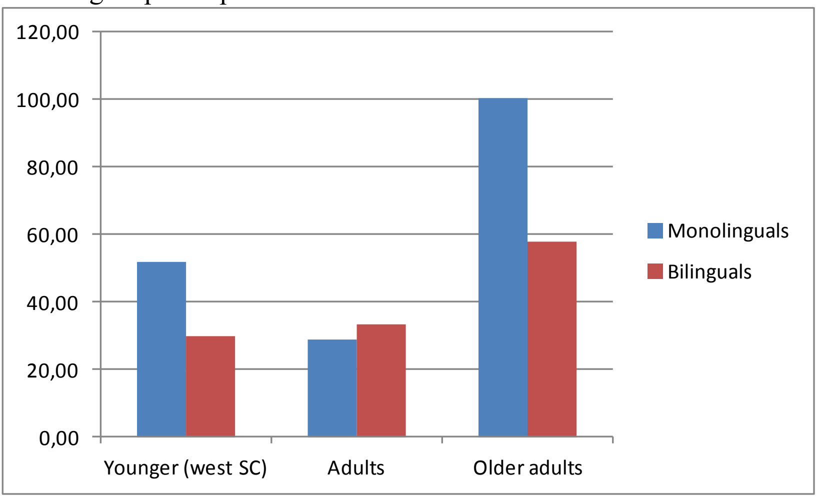


Chart 3 – Performance of late bilinguals and their monolingual peers on the Simon task - 2 Colors.

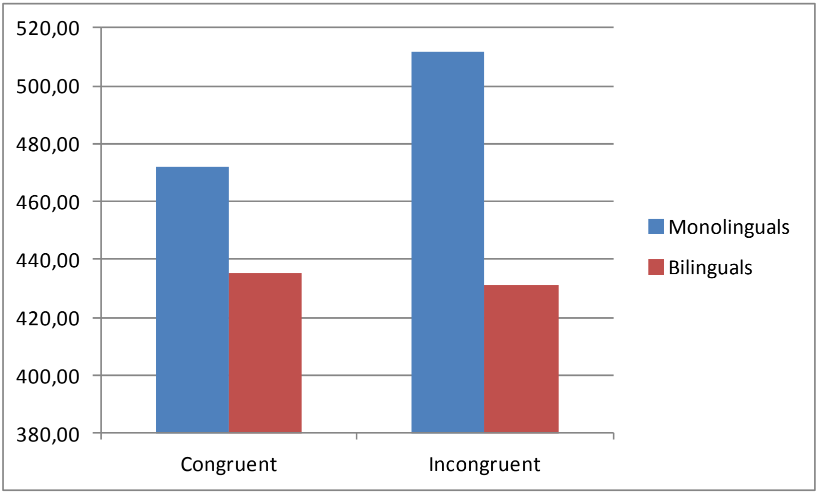
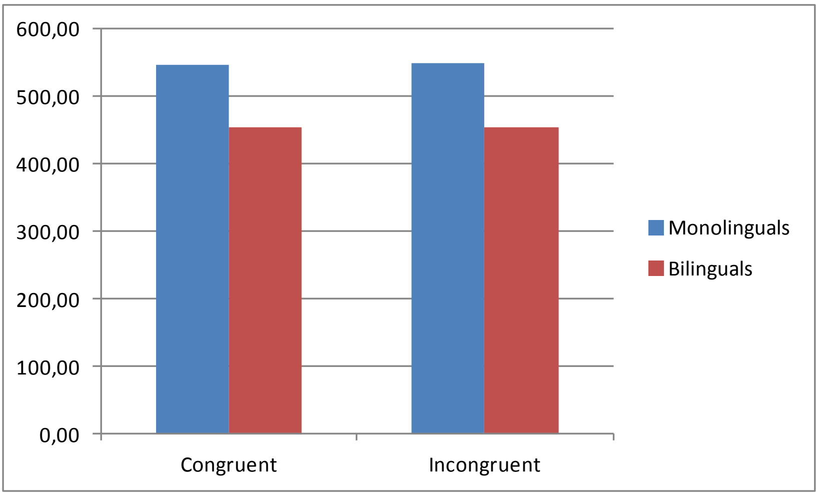


Chart 4 – Performance of late bilinguals and their monolingual peers on the Simon Arrow task.



APPENDIX O

The Simon task 2 Colors - Frequency Tables

Overall Reaction Time (RT) – Frequency Table

		Frequency	Percent	Valid Percent	Cumulative
Valid	304.59	1	1.0	1.0	1.0
	334.53	1	1.0	1.0	1.9
	348.09	1	1.0	1.0	2.9
	366.50	1	1.0	1.0	3.8
	368.50	1	1.0	1.0	4.8
	371.78	1	1.0	1.0	5.8
	376.59	1	1.0	1.0	6.7
	379.00	1	1.0	1.0	7.7
	382.25	1	1.0	1.0	8.7
	393.81	1	1.0	1.0	9.6
	397.84	1	1.0	1.0	10.6
	400.59	1	1.0	1.0	11.5
	402.18	1	1.0	1.0	12.5
	404.63	1	1.0	1.0	13.5
	406.78	1	1.0	1.0	14.4
	409.34	1	1.0	1.0	15.4
	413.31	1	1.0	1.0	16.3
	413.65	1	1.0	1.0	17.3
	414.15	1	1.0	1.0	18.3
	414.88	1	1.0	1.0	19.2
	415.88	1	1.0	1.0	20.2
	421.12	1	1.0	1.0	21.2
	425.88	1	1.0	1.0	22.1
	426.15	1	1.0	1.0	23.1
	436.72	1	1.0	1.0	24.0
	436.94	1	1.0	1.0	25.0
	440.68	1	1.0	1.0	26.0
	441.43	1	1.0	1.0	26.9
	444.03	1	1.0	1.0	27.9
	445.53	1	1.0	1.0	28.8
	446.46	1	1.0	1.0	29.8
	447.81	1	1.0	1.0	30.8
	451.78	1	1.0	1.0	31.7
	454.81	1	1.0	1.0	32.7
	461.28	1	1.0	1.0	33.7
	462.93	1	1.0	1.0	34.6
	465.96	1	1.0	1.0	35.6

471.81	1	1.0	1.0	36.5
472.91	1	1.0	1.0	37.5
476.96	1	1.0	1.0	38.5
478.12	1	1.0	1.0	39.4
479.40	1	1.0	1.0	40.4
479.71	1	1.0	1.0	41.3
485.63	1	1.0	1.0	42.3
485.72	1	1.0	1.0	43.3
487.06	1	1.0	1.0	44.2
489.25	1	1.0	1.0	45.2
489.71	1	1.0	1.0	46.2
491.88	1	1.0	1.0	47.1
494.28	1	1.0	1.0	48.1
498.09	1	1.0	1.0	49.0
500.87	1	1.0	1.0	50.0
503.56	1	1.0	1.0	51.0
504.50	1	1.0	1.0	51.9
508.31	1	1.0	1.0	52.9
508.75	1	1.0	1.0	53.8
509.78	1	1.0	1.0	54.8
515.34	1	1.0	1.0	55.8
517.96	1	1.0	1.0	56.7
524.92	1	1.0	1.0	57.7
525.62	1	1.0	1.0	58.7
527.50	1	1.0	1.0	59.6
528.93	1	1.0	1.0	60.6
531.00	1	1.0	1.0	61.5
538.27	1	1.0	1.0	62.5
540.25	1	1.0	1.0	63.5
544.46	1	1.0	1.0	64.4
554.16	1	1.0	1.0	65.4
556.03	1	1.0	1.0	66.3
564.96	1	1.0	1.0	67.3
567.31	1	1.0	1.0	68.3
594.28	1	1.0	1.0	69.2
595.84	1	1.0	1.0	70.2
602.03	1	1.0	1.0	71.2
609.13	1	1.0	1.0	72.1
610.00	1	1.0	1.0	73.1
610.75	1	1.0	1,0	74.0
617.50	1	1.0	1.0	75.0
631.09	1	1.0	1.0	76.0
631.21	1	1.0	1.0	76.9

	634.25	1	1.0	1.0	77.9
	637.50	1	1.0	1.0	78.8
	637.75	1	1.0	1.0	79.8
	640.84	1	1.0	1.0	80.8
	642.72	1	1.0	1.0	81.7
	647.59	1	1.0	1.0	82.7
	652.78	1	1.0	1.0	83.7
	659.22	1	1.0	1.0	84.6
	660.34	1	1.0	1.0	85.6
	662.81	1	1.0	1.0	86.5
	678.06	1	1.0	1.0	87.5
	683.56	1	1.0	1.0	88.5
	691.90	1	1.0	1.0	89.4
	705.59	1	1.0	1.0	90.4
	740.25	1	1.0	1.0	91.3
	741.00	1	1.0	1.0	92.3
	744.18	1	1.0	1.0	93.3
	757.48	1	1.0	1.0	94.2
	778.15	1	1.0	1.0	95.2
	800.53	1	1.0	1.0	96.2
	801.21	1	1.0	1.0	97.1
	818.85	1	1.0	1.0	98.1
	963.21	1	1.0	1.0	99.0
	1425.34	1	1.0	1.0	100.0
	Total	104	100.0	100.0	

Reaction Time Congruent Trials – Frequency Table

		Frequency	Percent	Valid Percent	Cumulative
Valid	295.69	1	1.0	1.0	1.0
	299.87	1	1.0	1.0	1.9
	328.75	1	1.0	1.0	2.9
	351.21	1	1.0	1.0	3.8
	354.31	1	1.0	1.0	4.8
	356.06	1	1.0	1.0	5.8
	359.50	1	1.0	1.0	6.7
	363.81	1	1.0	1.0	7.7
	365.25	1	1.0	1.0	8.7
	373.38	1	1.0	1.0	9.6
	375.50	1	1.0	1.0	10.6
	384.12	1	1.0	1.0	11.5
	384.44	1	1.0	1.0	12.5
	386.50	1	1.0	1.0	13.5

387.00	1	1.0	1.0	14.4
388.63	1	1.0	1.0	15.4
393.37	1	1.0	1.0	16.3
395.63	1	1.0	1.0	17.3
398.18	1	1.0	1.0	18.3
402.68	1	1.0	1.0	19.2
403.81	1	1.0	1.0	20.2
404.56	1	1.0	1.0	21.2
404.62	1	1.0	1.0	22.1
406.75	1	1.0	1.0	23.1
408.81	1	1.0	1.0	24.0
409.06	1	1.0	1.0	25.0
413.37	1	1.0	1.0	26.0
414.81	1	1.0	1.0	26.9
415.31	1	1.0	1.0	27.9
420.12	1	1.0	1.0	28.8
421.81	1	1.0	1.0	29.8
425.43	1	1.0	1.0	30.8
426.06	1	1.0	1.0	31.7
436.18	1	1.0	1.0	32.7
436.93	1	1.0	1.0	33.7
438.37	1	1.0	1.0	34.6
444.62	1	1.0	1.0	35.6
446.06	1	1.0	1.0	36.5
451.31	1	1.0	1.0	37.5
455.25	1	1.0	1.0	38.5
465.25	1	1.0	1.0	39.4
466.12	1	1.0	1.0	40.4
467.31	1	1.0	1.0	41.3
473.18	1	1.0	1.0	42.3
473.93	1	1.0	1.0	43.3
475.25	1	1.0	1.0	44.2
479.18	1	1.0	1.0	45.2
479.37	1	1.0	1.0	46.2
479.43	1	1.0	1.0	47.1
479.62	1	1.0	1.0	48.1
481.60	1	1.0	1.0	49.0
485.31	1	1.0	1.0	50.0
488.31	1	1.0	1.0	51.0
488.94	1	1.0	1.0	51.9
492.75	1	1.0	1.0	52.9
496.31	1	1.0	1.0	53.8
498.31	1	1.0	1.0	54.8

499.75	1	1.0	1.0	55.8
500.75	1	1.0	1.0	56.7
504.00	1	1.0	1.0	57.7
509.87	1	1.0	1.0	58.7
511.18	1	1.0	1.0	59.6
516.43	1	1.0	1.0	60.6
535.75	1	1.0	1.0	61.5
536.75	1	1.0	1.0	62.5
543.12	1	1.0	1.0	63.5
549.75	1	1.0	1.0	64.4
550.75	1	1.0	1.0	65.4
552.75	1	1.0	1.0	66.3
553.00	1	1.0	1.0	67.3
553.56	1	1.0	1.0	68.3
554.56	1	1.0	1.0	69.2
567.56	1	1.0	1.0	70.2
572.62	1	1.0	1.0	71.2
575.43	1	1.0	1.0	72.1
583.00	1	1.0	1.0	73.1
596.87	1	1.0	1.0	74.0
597.06	1	1.0	1.0	75.0
600.12	1	1.0	1.0	76.0
606.50	1	1.0	1.0	76.9
607.87	1	1.0	1.0	77.9
615.37	1	1.0	1.0	78.8
617.75	1	1.0	1.0	79.8
618.43	1	1.0	1.0	80.8
620.25	1	1.0	1.0	81.7
633.00	1	1.0	1.0	82.7
634.62	1	1.0	1.0	83.7
639.12	1	1.0	1.0	84.6
659.00	1	1.0	1.0	85.6
662.88	1	1.0	1.0	86.5
662.94	1	1.0	1.0	87.5
663.43	1	1.0	1.0	88.5
677.18	1	1.0	1.0	89.4
685.81	1	1.0	1.0	90.4
698.56	1	1.0	1.0	91.3
714.93	1	1.0	1.0	92.3
722.62	1	1.0	1.0	93.3
730.68	1	1.0	1.0	94.2
778.93	1	1.0	1.0	95.2
800.56	1	1.0	1.0	96.2

	808.37	1	1.0	1.0	97.1
	828.43	1	1.0	1.0	98.1
	845.25	1	1.0	1.0	99.0
	124.81	1	1.0	1.0	100.0
	Total	104	100.0	100.0	

Reaction Time Incongruent Trials – Frequency Table

		Frequency	Percent	Valid Percent	Cumulative
Valid	309.31	1	1.0	1.0	1.0
	317.81	1	1.0	1.0	1.9
	344.38	1	1.0	1.0	2.9
	373.87	1	1.0	1.0	3.8
	378.68	1	1.0	1.0	4.8
	379.75	1	1.0	1.0	5.8
	400.50	1	1.0	1.0	6.7
	401.68	1	1.0	1.0	7.7
	404.50	1	1.0	1.0	8.7
	408.25	1	1.0	1.0	9.6
	408.44	1	1.0	1.0	10.6
	411.81	1	1.0	1.0	11.5
	420.56	1	1.0	1.0	12.5
	420.62	1	1.0	1.0	13.5
	422.37	1	1.0	1.0	14.4
	423.68	1	1.0	1.0	15.4
	425.31	1	1.0	1.0	16.3
	427.81	1	1.0	1.0	17.3
	430.75	1	1.0	1.0	18.3
	434.13	1	1.0	1.0	19.2
	436.19	1	1.0	1.0	20.2
	437.68	1	1.0	1.0	21.2
	440.38	1	1.0	1.0	22.1
	443.43	1	1.0	1.0	23.1
	444.37	1	1.0	1.0	24.0
	447.81	1	1.0	1.0	25.0
	454.12	2	1.9	1.9	26.9
	455.93	1	1.0	1.0	27.9
	456.37	1	1.0	1.0	28.8
	462.75	1	1.0	1.0	29.8
	465.81	1	1.0	1.0	30.8
	467.31	1	1.0	1.0	31.7
	470.43	1	1.0	1.0	32.7
	476.43	1	1.0	1.0	33.7
	476.87	1	1.0	1.0	34.6

477.37	1	1.0	1.0	35.6
479.56	1	1.0	1.0	36.5
479.81	1	1.0	1.0	37.5
480.56	1	1.0	1.0	38.5
482.50	1	1.0	1.0	39.4
486.94	1	1.0	1.0	40.4
487.50	1	1.0	1.0	41.3
490.19	1	1.0	1.0	42.3
491.12	1	1.0	1.0	43.3
494.31	1	1.0	1.0	44.2
494.43	1	1.0	1.0	45.2
496.68	1	1.0	1.0	46.2
497.69	1	1.0	1.0	47.1
498.87	1	1.0	1.0	48.1
499.77	1	1.0	1.0	49.0
510.88	1	1.0	1.0	50.0
517.75	1	1.0	1.0	51.0
522.30	1	1.0	1.0	51.9
529.81	1	1.0	1.0	52.9
530.93	1	1.0	1.0	53.8
532.43	1	1.0	1.0	54.8
537.00	1	1.0	1.0	55.8
539.62	1	1.0	1.0	56.7
547.06	1	1.0	1.0	57.7
550.18	1	1.0	1.0	58.7
551.00	1	1.0	1.0	59.6
555.56	1	1.0	1.0	60.6
557.12	2	1.9	1.9	62.5
562.31	1	1.0	1.0	63.5
564.06	1	1.0	1.0	64.4
582.37	1	1.0	1.0	65.4
585.18	1	1.0	1.0	66.3
610.37	1	1.0	1.0	67.3
613.12	1	1.0	1.0	68.3
615.00	1	1.0	1.0	69.2
619.62	1	1.0	1.0	70.2
619.87	1	1.0	1.0	71.2
620.06	1	1.0	1.0	72.1
622.56	1	1.0	1.0	73.1
625.19	1	1.0	1.0	74.0
631.43	1	1.0	1.0	75.0
632.25	1	1.0	1.0	76.0
632.62	1	1.0	1.0	76.9

636.31	1	1.0	1.0	77.9
642.00	1	1.0	1.0	78.8
643.50	1	1.0	1.0	79.8
652.06	1	1.0	1.0	80.8
665.12	1	1.0	1.0	81.7
678.62	1	1.0	1.0	82.7
687.81	1	1.0	1.0	83.7
703.68	1	1.0	1.0	84.6
705.37	1	1.0	1.0	85.6
708.87	1	1.0	1.0	86.5
712.18	1	1.0	1.0	87.5
724.81	1	1.0	1.0	88.5
731.75	1	1.0	1.0	89.4
737.68	1	1.0	1.0	90.4
745.93	1	1.0	1.0	91.3
757.68	1	1.0	1.0	92.3
759.37	1	1.0	1.0	93.3
792.68	1	1.0	1.0	94.2
836.75	1	1.0	1.0	95.2
857.75	1	1.0	1.0	96.2
880.31	1	1.0	1.0	97.1
887.50	1	1.0	1.0	98.1
1081.18	1	1.0	1.0	99.0
1605.87	1	1.0	1.0	100.0
Total	104	100.0	100.0	

Accuracy (ACC) for the Simon task 2 Colors – Frequency Tables

Overall Accuracy

		Frequency	Percent	Valid Percent	Cumulative
Valid	84.37	1	1.0	1.0	1.0
	90.62	11	10.6	10.6	11.5
	93.75	13	12.5	12.5	24.0
	96.85	1	1.0	1.0	25.0
	96.87	34	32.7	32.7	57.7
	100.00	44	42.3	42.3	100.0
	Total	104	100.0	100.0	

ACC - Congruent Trials

		Frequency	Percent	Valid Percent	Cumulative
Valid	84.37	1	1.0	1.0	1.0

	90.62	11	10.6	10.6	11.5
	93.75	13	12.5	12.5	24.0
	96.85	1	1.0	1.0	25.0
	96.87	34	32.7	32.7	57.7
	100.00	44	42.3	42.3	100.0
	Total	104	100.0	100.0	

ACC - Incongruent Trials

		Frequency	Percent	Valid Percent	Cumulative
Valid	81	1	1.0	1.0	1.0
	88	6	5.8	5.8	6.7
	94	16	15.4	15.4	22.1
	100	81	77.9	77.9	100.0
	Total	104	100.0	100.0	

APPENDIX P

The Simon Arrow task - Frequency Tables

Overall ReactionTime (RT) – Frequency Table

		Frequency	Percent	Valid Percent	Cumulative
Valid	340.09	1	3.6	3.6	3.6
	354.53	1	3.6	3.6	7.1
	373.31	1	3.6	3.6	10.7
	379.06	1	3.6	3.6	14.3
	380.00	1	3.6	3.6	17.9
	381.78	1	3.6	3.6	21.4
	402.22	1	3.6	3.6	25.0
	414.50	1	3.6	3.6	28.6
	414.69	1	3.6	3.6	32.1
	415.00	1	3.6	3.6	35.7
	429.09	1	3.6	3.6	39.3
	444.75	1	3.6	3.6	42.9
	471.59	1	3.6	3.6	46.4
	480.94	1	3.6	3.6	50.0
	494.06	1	3.6	3.6	53.6
	519.13	1	3.6	3.6	57.1
	522.84	1	3.6	3.6	60.7
	538.75	1	3.6	3.6	64.3
	539.50	1	3.6	3.6	67.9
	540.53	1	3.6	3.6	71.4
	556.09	1	3.6	3.6	75.0
	570.41	1	3.6	3.6	78.6
	601.06	1	3.6	3.6	82.1
	607.81	1	3.6	3.6	85.7
	651.91	1	3.6	3.6	89.3
	711.34	1	3.6	3.6	92.9
	728.94	1	3.6	3.6	96.4
	762.75	1	3.6	3.6	100.0
	Total	28	100.0	100.0	

Reaction Time Congruent Trials – Frequency Table

		Frequency	Percent	Valid Percent	Cumulative
Valid	331.4	1	3.6	3.6	3.6
	349.9	1	3.6	3.6	7.1
	372.4	1	3.6	3.6	10.7
	373.9	1	3.6	3.6	14.3

384.1	1	3.6	3.6	17.9
390.1	1	3.6	3.6	21.4
393.1	1	3.6	3.6	25.0
404.1	1	3.6	3.6	28.6
413.3	1	3.6	3.6	32.1
419.5	1	3.6	3.6	35.7
424.1	1	3.6	3.6	39.3
470.2	1	3.6	3.6	42.9
476.5	1	3.6	3.6	46.4
478.6	1	3.6	3.6	50.0
481.6	1	3.6	3.6	53.6
487.9	1	3.6	3.6	57.1
499.9	1	3.6	3.6	60.7
513.2	1	3.6	3.6	64.3
513.4	1	3.6	3.6	67.9
518.5	1	3.6	3.6	71.4
541.8	1	3.6	3.6	75.0
566.9	1	3.6	3.6	78.6
595.6	1	3.6	3.6	82.1
630.6	1	3.6	3.6	85.7
660.8	1	3.6	3.6	89.3
723.4	1	3.6	3.6	92.9
791.8	1	3.6	3.6	96.4
800.6	1	3.6	3.6	100.0
Total	28	100.0	100.0	

Reaction Time Incongruent Trials – Frequency Table

		Frequency	Percent	Valid Percent	Cumulative
Valid	348.81	1	3.6	3.6	3.6
	359.12	1	3.6	3.6	7.1
	369.94	1	3.6	3.6	10.7
	372.75	1	3.6	3.6	14.3
	379.44	1	3.6	3.6	17.9
	385.69	1	3.6	3.6	21.4
	391.12	1	3.6	3.6	25.0
	405.31	1	3.6	3.6	28.6
	413.00	1	3.6	3.6	32.1
	424.87	1	3.6	3.6	35.7
	436.94	1	3.6	3.6	39.3
	438.69	1	3.6	3.6	42.9
	473.00	1	3.6	3.6	46.4
	483.25	1	3.6	3.6	50.0
	506.50	1	3.6	3.6	53.6

532.50	1	3.6	3.6	57.1
537.19	1	3.6	3.6	60.7
538.31	1	3.6	3.6	64.3
541.31	1	3.6	3.6	67.9
559.00	1	3.6	3.6	71.4
573.94	1	3.6	3.6	75.0
593.19	1	3.6	3.6	78.6
598.75	1	3.6	3.6	82.1
620.00	1	3.6	3.6	85.7
657.31	1	3.6	3.6	89.3
673.25	1	3.6	3.6	92.9
699.25	1	3.6	3.6	96.4
733.75	1	3.6	3.6	100.0
Total	28	100.0	100.0	

Accuracy (ACC) for the Simon Arrow task – Frequency Tables

Overall ACC

		Frequency	Percent	Valid Percent	Cumulative
Valid	69	1	3.6	3.6	3.6
	88	1	3.6	3.6	7.1
	91	3	10.7	10.7	17.9
	94	3	10.7	10.7	28.6
	97	10	35.7	35.7	64.3
	100	10	35.7	35.7	100.0
	Total	28	100.0	100.0	

ACC – Congruent Trials

		Frequency	Percent	Valid Percent	Cumulative
Valid	69	1	3.6	3.6	3.6
	88	1	3.6	3.6	7.1
	94	9	32.1	32.1	39.3
	100	17	60.7	60.7	100.0
	Total	28	100.0	100.0	

ACC – Incongruent Trials

		Frequency	Percent	Valid Percent	Cumulative
Valid	69	1	3.6	3.6	3.6
	81	1	3.6	3.6	7.1
	88	4	14.3	14.3	21.4
	94	7	25.0	25.0	46.4
	100	15	53.6	53.6	100.0
	Total	28	100.0	100.0	

APPENDIX Q

The Alpha Span task – Frequency Table

		Frequency	Percent	Valid Percent	Cumulative
Valid	0	5	4.8	4.8	4.8
	2	1	1.0	1.0	5.8
	4	3	2.9	2.9	8.7
	6	6	5.8	5.8	14.4
	7	1	1.0	1.0	15.4
	8	1	1.0	1.0	16.3
	9	2	1.9	1.9	18.3
	11	2	1.9	1.9	20.2
	12	7	6.7	6.7	26.9
	13	1	1.0	1.0	27.9
	14	1	1.0	1.0	28.8
	15	3	2.9	2.9	31.7
	16	1	1.0	1.0	32.7
	17	1	1.0	1.0	33.7
	18	4	3.8	3.8	37.5
	19	3	2.9	2.9	40.4
	20	3	2.9	2.9	43.3
	21	1	1.0	1.0	44.2
	22	4	3.8	3.8	48.1
	23	2	1.9	1.9	50.0
	24	5	4.8	4.8	54.8
	25	2	1.9	1.9	56.7
	26	4	3.8	3.8	60.6
	27	4	3.8	3.8	64.4
	28	4	3.8	3.8	68.3
	29	8	7.7	7.7	76.0
	30	4	3.8	3.8	79.8
	31	4	3.8	3.8	83.7
	32	3	2.9	2.9	86.5
	33	3	2.9	2.9	89.4
	34	3	2.9	2.9	92.3
	36	1	1.0	1.0	93.3
	37	3	2.9	2.9	96.2
	43	2	1.9	1.9	98.1
	47	1	1.0	1.0	99.0
	54	1	1.0	1.0	100.0
	Total	104	100.0	100.0	