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THE EFFECT OF L2 PROFICIENCY ON THE DECLARATIVE AND PROCEDURAL MEMORY SYSTEMS OF BILINGUALS: A PSYCHOLINGUISTIC STUDY

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Orientadora: Profa. Dra. Mailce Borges Mota

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To my parents
Daniel (in memoriam) and Maria Miralva
with much love and gratitude

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ABSTRACT

THE EFFECT OF L2 PROFICIENCY ON THE DECLARATIVE AND PROCEDURAL MEMORY SYSTEMS OF BILINGUALS: A PSYCHOLINGUISTIC STUDY
Daniela Brito de Jesus
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Memory is one of the mental processes that compose human cognition. It is one of the fundamental parts of cognitive processing, which also includes attention, perception, reasoning, and language. It is through these functions that humans are capable of interacting with other human beings and with the world. For bilinguals, this interaction takes place through the knowledge and use of at least two languages, which involves cognitive and linguistic processes that are systematically different from those engaged in monolingual language use (Bialystok, 2010). In this sense, being bilingual entails the management and appropriate development of at least two language systems, in which skills of mental management should apply to aspects of cognition such as attention, conflict resolution, and executive control (Bialystok, Craig, Green & Gollan, 2009). Previous research has demonstrated that bilingualism seems to bring advantages to certain cognitive abilities, including executive functioning and working memory (Bialystok, Craik & Luk, 2008). Based on the assumptions presented above, the current study goes a step further to investigate whether bilingualism affects declarative and procedural memory systems positively. Forty young adult participants were divided into 3 groups: two experimental and one control group. The first experimental group consisted of 16 high L2 proficiency Portuguese-English bilinguals. The second experimental group consisted of 16 low L2 proficiency Portuguese-English bilinguals. The third group was the control group and consisted of 8 Brazilian Portuguese monolinguals. All participants were tested in four psycholinguistic tasks, designed in Brazilian Portuguese (L1), which aimed at assessing declarative and procedural memory. Prior to testing sessions, all participants were submitted to one of three types of proficiency test.

Bilinguals at a low level of proficiency performed the Cambridge ESOL 'Key English Test', whereas those at a high proficiency performed the Cambridge ESOL 'Preliminary English Test' (PET). The control group of monolinguals performed the Mini Language English Test, designed for the purposes of the present study to control for their knowledge of English. In the psycholinguistic tasks, the dependent variables were reaction time (RT) and accuracy (ACC), and multiple comparisons were run for data from the three groups. Overall results showed that most of the comparisons between bilinguals and monolinguals favored bilinguals in the performance of memory tasks, especially those aimed at assessing declarative memory. For the comparisons between the high proficiency group, the low proficiency group, and monolinguals, in the linguistic tasks, there was a very significant difference in performance favoring the high proficiency group in relation to their low proficiency and monolingual counterparts, suggesting a positive effect of L2 proficiency on these tasks. For the comparisons between the same groups in the nonlinguistic tasks, there were also statistically significant differences for the high proficiency group overall performance. Taken together, the results of the present study indicate that a higher level of proficiency in an L2 seems to contribute to more accurate performance on declarative and procedural memory tasks. These results are discussed in light of the theoretical and empirical literature on human memory, bilingualism and language proficiency.

Keywords: Long-term memory systems. L2 proficiency. Performance. Bilingualism.

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RESUMO

O EFEITO DA PROFICIÊNCIA EM L2 NOS SISTEMAS DE MEMÓRIA DECLARATIVA E PROCEDURAL EM BILÍNGUES: UM ESTUDO PSICOLINGUÍSTICO

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A memória é um dos processos mentais que compõe a cognição humana. Ela é uma das partes fundamentais do processamento cognitivo, juntamente com a atenção, a percepção, o raciocínio e a linguagem. É através destas funções que os humanos são capazes de interagir com outros seres humanos e com o ambiente em que vivem. Para os bilíngues, esta interação ocorre através do conhecimento e do uso de, pelo menos, duas línguas, o que por sua vez envolve processos cognitivos e linguísticos que são sistematicamente diferentes daqueles empregados por monolíngues (Bialystok, 2010). Nesse sentido, ser bilíngue requer o gerenciamento e o desenvolvimento apropriado de dois sistemas linguísticos, nos quais as habilidades mentais de gerenciamento devem se estender a aspectos da cognição tais como a atenção, a resolução de conflitos e o controle executivo (Bialystok, Craig, Green & Gollan, 2009). Estudos recentes demonstraram que o bilinguismo parece trazer vantagens e contribuições a certas habilidades cognitivas, que incluem as funções executivas e a memória de trabalho (Bialystok, Craik & Luk, 2008). Com base na pesquisa sobre os efeitos do bilinguismo nas funções cognitivas, o presente estudo investiga se o bilinguismo afeta os sistemas de memória declarativa e procedural positivamente. Quarenta participantes jovens adultos foram divididos em três grupos: dois grupos experimentais e um grupo controle. Dezesseis participantes bilíngues do par linguístico português-inglês de alta proficiência em L2 compuseram o primeiro grupo experimental. O segundo grupo experimental foi composto por dezesseis participantes bilíngues do par linguístico português-inglês de baixa proficiência em L2. O terceiro grupo foi o grupo controle, composto por oito participantes monolíngues de Português brasileiro. Todos os participantes foram testados em quatro tarefas psicolinguísticas desenvolvidas em português brasileiro (L1) com o objetivo de avaliar os sistemas de memória declarativa e procedural dessa população. Antes de serem submetidos às tarefas, os participantes foram submetidos a um de três tipos de testes de proficiência. Os bilíngues com baixa proficiência desempenharam o Cambridge ESOL ‘Key English Test’, enquanto os de alta proficiência desempenharam o Cambridge ESOL ‘Preliminary English Test’ (PET). O grupo controle de monolíngues desempenhou o Mini Teste de Linguagem em Inglês, desenvolvido para os fins do presente estudo com o objetivo específico de controlar o conhecimento em inglês desses participantes. Nas tarefas psicolinguísticas, as variáveis dependentes foram tempo de reação (RT) e acurácia (ACC). Comparações múltiplas foram realizadas nos dados obtidos dos três grupos. De maneira geral, os resultados mostraram que a maioria das comparações feitas entre bilíngues e monolíngues (considerando o tempo de resposta, o desvio padrão e a acurácia dos participantes em todas as tarefas) favoreceu os bilíngues no desempenho em tarefas de memória, especialmente naquelas destinadas à avaliação da memória declarativa. Para as comparações entre o grupo de alta proficiência, o de baixa proficiência e os monolíngues, nas tarefas linguísticas, houve uma diferença significativa no desempenho do grupo de alta proficiência, em relação aos grupos de baixa proficiência e os monolíngues, sugerindo um efeito positivo da proficiência em L2 nessas tarefas. Para as comparações entre os mesmos grupos nas tarefas não-linguísticas, diferenças significativas também foram encontradas no desempenho do grupo de alta proficiência. Todos esses resultados, de forma geral, indicam que a proficiência em L2 parece contribuir de forma positiva para um desempenho mais acurado em tarefas de memória declarativa e procedural. Esses resultados são discutidos à luz de estudos teóricos e empíricos sobre memória humana, bilinguismo e proficiência.

Palavras-chave: Sistemas de memória de longo prazo. Proficiência em L2. Desempenho. Bilinguismo.

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LIST OF ABBREVIATIONS AND SYMBOLS

PPGI – Programa de Pós-Graduação em Inglês/UFSC
L1 – first language
L2 – second language
AL – Applied Linguistics
SLA – Second Language Acquisition
PN – Picture Naming Task
PR – Picture Recognition Task
AGL – Artificial Grammar Learning Task
ASRT – Alternating Serial Reaction Time Task
Bil – bilingual(s)
Mono – monolingual(s)
High – high (L2) proficiency bilinguals
Low – low (L2) proficiency bilinguals
N – number of participants
DP Model – Declarative Procedural Model of language
LabLing – Language and Cognitive Processes Laboratory/UFSC
KET – Cambridge ESOL Examination ‘Key English Test’
PET – Cambridge ESOL Examination ‘Preliminary English Test’
CEFR – Common European Framework of Reference for Language
ms - milliseconds
SRBOX – Serial Response Box
RT – reaction time
ACC – accuracy
SD - standard deviation
SPSS – Statistical Package for Social Science software
M – mean
SD – standard deviation
p level – probability level (α)

CHAPTER I

INTRODUCTION

1.1 Preliminaries

Memory is central to most aspects of human experience. We are who we are mostly because of what we learn and remember (Squire & Kandel, 2009). However, memory is much more than a record of personal experience: it allows us to become educated and to share what we have learned with other humans, through communication and, therefore, language (Squire & Kandel, 2009, p. 2). Within the several domains of cognitive psychology[1] (e.g. attention and consciousness), memory and language are two particularly challenging aspects of human cognition (Eysenck & Keane, 2005).

During the past twenty years, many attempts to better understand the relationship between memory and language emerged in research (e.g. Gazzaniga, 2009; Paradis, 1994; 1995a; 1998; Ullman, 2001a; 2001b; 2001c; 2004). In 2009, I had the chance to read two book chapters published by Michael Ullman (2005; 2006) that referred to aspects of the neural bases of the mental lexicon (some sort of mental dictionary) and the mental grammar in first and second language (L1 and L2). In his 2005 chapter, he discusses a neurocognitive model of language, in an attempt to provide the knowledge base and empirical approaches of cognitive neuroscience to bear on the study of Second Language Acquisition (SLA) (Ullman, 2005). In the 2006 chapter, the author explores the biology of the brain and issues related to the study of the biology of language (Ullman, 2006). These chapters would provoke me to pursue further the literature in one of the theoretical frameworks adopted in Applied Linguistics (AL) research in Brazil: Cognitivism. This framework can be associated to some recent research which is in contact with neuroscience, specifically the neuroscience of language, and also to recent trends in cognitive science and psychology.

[1] Cognitive Psychology is a psychological science which is interested in various mind and brain related subfields such as cognition, the mental processes that underlie behavior, reasoning, and decision making (Eysenck & Keane, 2005).

Integrating issues of the cognitive science and SLA literature with psycholinguistics[2] and cognitive psychology, the present study was designed to investigate the effect(s) of L2 proficiency on long-term memory systems from a psycholinguistic – behavioral – perspective. More specifically, the present investigation aims at exploring the declarative and procedural memory performance of bilinguals at two levels of L2 proficiency – low and high proficiency - on cognitive tasks in their first language (L1) – Brazilian Portuguese.

According to Gander and Gardiner (1981), the term *cognition* can be thought of as the act or process of obtaining knowledge, including perceiving, recognizing, reasoning and judging. Cognition involves thinking, knowing, remembering, categorizing and problem solving (Gander & Gardiner, 1981). It is the human capacity to acquire knowledge, since it deals with how our brain acquires, processes, interprets, memorizes and projects the information from the world we live in (Gander & Gardiner, 1981). In this sense, memory is one of the essential elements for human cognition.

Human cognition and mental processes are explored by cognitive psychology, which is a subdiscipline of psychology concerned with the acquisition, processing and storing of information. According to Ashcraft (1994), one possible approach towards the understanding of memory is cognitive psychology and the three assumptions that inform the field are (1) that mental processes exist, (2) that people are active information-processors, and (3) that mental processes and structures can be revealed by time and accuracy measures. The assumptions from cognitive psychology state that, by observing patterns of behavior, it will be possible to infer the "mental" events causing such behavior (Gregg, 1986 in Xhafaj 2006). Thus, considering that mental processes take time, one way to make inferences on the workings of the mind is by observing how long a given process takes to be completed (Ashcraft, 1994). Much mental effort is required to make use of central cognitive abilities such as attention, perception, thinking, reasoning, memory and language (Reed, 2007 in Kramer, 2011). Hence, from a cognitive perspective, the present study will address issues in SLA and bilingualism, and in the study of memory in first (L1) language, in a sample of Portuguese-English bilinguals at low and high L2 proficiency and of Brazilian Portuguese monolingual

[2] According to Gleason and Ratner (1998), the field of psycholinguistics, or the psychology of language, is concerned with discovering the psychological processes by which humans acquire and use language.

participants when performing memory tasks. One important issue in SLA, addressed in the current study concerns internal factors - that is, cognitive mechanisms which enable learners to extract information about the L2 from the input they receive (Ellis, 2008), and whether this amount of input (knowledge) possessed by learners in the L2 causes any effect on their long-term memory.

In the past decades, according to Mota (2011), SLA has been an active field of research. Studies in the area have dealt with the main issues discussed in the national and international scenario and have done so from a variety of conceptual approaches and research methodologies (p. 9). Given that SLA is a well-established area of research and is growing as a field of inquiry in Brazil, it is important to consider studies that cover themes in the contemporary research of the mechanisms and processes involved in the acquisition of a non-primary language (Mota, 2011). Thus, studies that address issues related to cognition and neurocognition of SLA bring solid contributions to recent trends in the field.

Recent studies in cognition in SLA and bilingualism have focused on the linguistic and cognitive benefits of bilingualism (e.g. Bialystok, 2001; Bialystok, 2004); this research has attempted to establish the nature of these benefits and the point at which they emerge (Babcock, Krawczyk & Scialabba, 2011). Results on the advantages of bilingualism vary greatly, indicating positive cognitive effects, especially in the areas of control processes and conflict resolution (e.g. Bialystok, 2007; Costa, Hernández, Costa-Faidella & Sebastian-Gallés, 2009; Luk, Sa & Bialystok, 2011). Over the past years, several studies (e.g. Bialystok, 2001; Bialystok, 2010; Bialystok & Craik, 2010; Bialystok, Craik & Luk, 2008a; Bialystok, Craik & Luk, 2008b; Bialystok, Craik, Klein & Viswanathan, 2004; Bialystok & Shapero, 2005;) have investigated the performance of bilinguals and monolinguals across the lifespan – children, young adults, middle-aged and older adults - on a diversity of tasks which involve cognitive constructs such as attention. These studies have shown that bilinguals outperformed monolinguals on a variety of cognitive tasks. These findings suggest that the regular use of two different languages can bring positive effects to cognitive functioning.

Many different tasks are used to assess cognitive processing, especially long-term memory systems' performance of bilingual and monolingual participants. Measures of declarative and procedural memory provide the assessment of participants' abilities to learn via these memory systems (Carpenter, 2008). There are tasks that investigate both verbal and non-verbal learning domains both in declarative and procedural memory (e.g. California Verbal Learning Test, Continuous Visual Memory Task, Object/ Picture Naming Task, Artificial Grammar Learning Task, Weather Prediction Task, (Alternating) Serial Reaction Time Task, to mention a few) and these tasks are largely employed in language studies that investigate memory performance both in L1 and in L2 (e.g. Bowden, Gelfand, Sanz & Ullman, 2010; Carpenter, 2008; Chang & Knowlton, 2004; Nemeth, Janacsek, Londe, Ullman, Howard and Howard, Jr., 2010).

To the best of this researcher's knowledge, no studies have been conducted investigating the relationship (if any) between (1) long-term memory systems performance on behavioral (declarative and procedural memory) tasks developed and performed in participants' L1 (Brazilian Portuguese) and (2) language proficiency in the L2 (American English).

1.2 The present study

The present study aims at investigating the performance of Portuguese-English bilinguals at two distinct levels of L2 proficiency (low and high proficiency – experimental groups) and of Brazilian Portuguese monolinguals (control group) in four experimental memory tasks designed in Brazilian Portuguese (L1) to assess participants' declarative and procedural memory. More specifically, the present study attempts at exploring the effect of L2 proficiency on the long-term memory systems of a sample of 40 young adults. The present investigation pursued two research questions:

1. Do young adults, native speakers of Brazilian Portuguese at high proficiency in English as an L2, outperform those at low proficiency and the Brazilian Portuguese monolinguals in the 'Picture Naming' and the 'Artificial Grammar Learning' linguistic tasks?

2. Do young adults, native speakers of Brazilian Portuguese at high proficiency in English as an L2, outperform those at low proficiency and the Brazilian Portuguese monolinguals in the 'Picture Recognition' and the 'Alternating Serial Reaction Time' nonlinguistic tasks?

1.3 Significance of the Research

The present study adds to research on the relationship between cognitive processing in L1 and language proficiency in an L2, considering that existing research in Brazil and abroad have explored the construct of proficiency as an important factor in the acquisition and processing of an L2 (e.g. Basso, 2010; Bowden, Gelfand, Sanz & Ullman, 2010; Carpenter, 2008; Luo, Luk & Bialystok, 2009; Morgan-Short; Sanz, Steinhauer & Ullman, 2010; Prebianca, 2009;).

Also, the present study aims at contributing to the research program on SLA and bilingual cognitive processing in two major ways. First, as previously stated, no studies to date, to the best of my knowledge, have been conducted to investigate the relationship between long-term memory systems and L2 proficiency in the language pairing Portuguese-English, more specifically in relation to monolinguals and bilinguals performance in linguistic and nonlinguistic memory tasks. Second, this study uses memory tasks designed in Portuguese and adapted to our Brazilian context, focusing on the investigation of mental processes and memory performance of Brazilian learners of English as an L2.

Lastly, the present study might contribute to the field of psycholinguistics by adding empirical data concerning the nature of language(s) processing and their relationship with the cognitive construct of memory.

1.4 Organization of the thesis

This thesis is organized into five major chapters. Chapter I is the present introductory chapter. Chapter II reviews theoretical and empirical literature found relevant to this investigation. Initially, human memory is explored into its three existing distinctions: episodic and semantic memory, explicit and implicit memory and declarative and procedural memory. Then, the field of Bilingualism is addressed, taking into consideration studies of memory systems in bilinguals; furthermore, the Declarative/Procedural neurocognitive model of language (e.g. Ullman, 2001b) is described. In addition to that, the chapter presents a review on the proficiency factor, focusing on the role of L2 proficiency in cognitive performance.

In chapter III, the objectives, research questions and hypothesis that guide the present study are portrayed. Additionally, it describes the methodology and general procedures adopted for the study as well as presenting a detailed description of the participants, design, instruments of data collection and analysis.

Chapter IV reports and discusses the results obtained in this study. The descriptive analysis of the performance of low and highly proficient bilinguals and monolinguals on the four memory tasks are presented first, followed by statistical analysis and discussion. Lastly, this chapter readdresses the research questions for the present study.

Chapter V presents and comments the findings and conclusions drawn from this study. Firstly, it portrays a summary of the main findings of the study. In addition, it reports some limitations and mentions suggestions and recommendations for further research. Finally, the chapter includes some pedagogical implications.

CHAPTER II

REVIEW OF LITERATURE

In this chapter, a review of literature related to human memory, bilingualism and language proficiency is presented. It is divided as follows: section 2.1 provides an overview of human memory and its distinctions into episodic/semantic, explicit/ implicit and declarative/ procedural memory (sections 2.1.1, 2.1.2 and 2.1.3, respectively). Section 2.2 is dedicated to general issues of bilingualism, such as memory systems in bilinguals in 2.2.1. Also, this subsection presents the Declarative/ Procedural (DP) Model (e.g. Ullman, 2005), which provides explanation on this neurocognitive model of language (section 2.2.1.1). Finally, section 2.3 is dedicated to language proficiency, followed by studies addressing the role of L2 proficiency in cognitive performance.

2.1 Human Memory

According to Squire and Kandel (2009), "memory is the process by which what is learned persists across time" (p. 2). In the Oxford Handbook of Memory, Tulving (2000) explains that the term *memory* can designate a number of concepts. Among the more frequently occurring meanings of memory are: (1) memory as neurocognitive capacity to encode, store, and retrieve information; (2) memory as a hypothetical store in which information is held; (3) memory as the information in that store; (4) memory as some property of that information; (5) memory as a componential process of retrieval of that information; (6) memory as an individual' phenomenal awareness of remembering something (Tulving, 2000, p. 36). To give an account of more concrete illustrations of the various concepts of memory, Tulving (2000) advocates that when one speaks about 'testing a patient's memory' or about 'profound losses of memory', one usually has in mind *memory* in the broad sense of neurocognitive capability of a particular kind, one that is related to but separable at the same time from other cognitive capabilities such as thought and perception. This is the central concept of memory for the purpose of the present study, that is, memory as a neurocognitive capacity to encode, store and retrieve information (Tulving, 2000).

Learning[1] and memory are fundamental to human experience (Squire & Kandel, 2009). The study of memory and learning arose from philosophical questions regarding how people come to know things about their world (Bower, 2000). Thus, learning is defined as the primary way we acquire knowledge, and remembering is a primary means by which people support knowledge claims, when, for instance, a witness in court asserts that remembers seeing someone in a given situation with a revolver (Bower, 2000). In this sense, psychology as a discipline developed out of philosophical discussions regarding the nature of the mind and mental life (Bower, 2000).

Until late in the nineteen century, the study of memory was restricted to the domain of philosophy; however, during the twentieth century, the focus of inquiry gradually moved to more experimental studies, initially in psychology, and now biology (Squire & Kandel, 2009). In this millenium, as the authors explain, the questions posed by psychology and biology have begun to converge on common ground (Squire & Kandel, 2009). The combined strength of both disciplines is providing an exciting picture of how the brain learns and remembers; consequently, this scenario has led to a new synthesis of knowledge about learning and memory (Squire & Kandel, 2009).

The study of human memory is one of the most fascinating areas of cognitive science, with research accumulating in various topics as a result of different approaches to this aspect of human cognition (Mota, 1995). Aristotle was perhaps the first to propose a theory of memory, in 384 B.C. and, since then, philosophers have brought forward their insights on the nature of thought and memory (Ashcraft, 1994). Systematic research on memory began with Hermann Ebbinghaus, in a pioneering work on memory for nonsense syllables which took place in the years 1879 and 1880 (Toth, 2000; Xhafaj, 2006). Ebbinghaus initiated the experimental investigation of human memory and the results of this investigation were published firstly in 1885, in a monograph entitled “Memory” and then published again in 1964 (Toth, 2000; Ashcraft, 1994). Ideas such as Ebbinghaus’ (1885/1964) set the stage for modern cognitive conceptions of memory whereby prior experiences are viewed as mental representations, encoded, stored and retrieved in human information-processing system (Toth, 2000).

[1] Learning, in the present study, is defined as the process in which new information is acquired by the nervous system and can be observed through changes in behavior (Purves, Augustine, Fitzpatrick, Hall, LaMantia, MacNamara & White, 2010).

As already mentioned in chapter I (section 1.1) one possible approach towards the understanding of memory is cognitive psychology. In this field of research it is believed that, by observing patterns of behavior, together with private subjective experiences, it will be possible to infer the "mental" events causing such behavior (Gregg, 1986 in Xhafaj, 2006). Considering that mental events take time, one way to infer the workings of the mind is by observing how long a given mental process takes to be completed (Ashcraft, 1994). Following this perspective, Baddeley, in one of his studies (1990), observes that the use of a single term for memory when studying mental processes might suggest that memory is a unitary system, a view that has long been disputed by scholars. Despite Waugh and Norman (e.g. Gregg, 1986) having coined the terms Primary and Secondary memory, William James was the first to use them, in 1890, to define that Primary memory is the memory immediately available, the one we are aware of, and Secondary memory is a larger one, usually hidden or passive, which holds past experiences (Gregg, 1986). An interesting fact is that later, in the 1950s and 1960s, when the first serious models of information-processing were put forward, these same two kinds of memory were included (Ashcraft, 1994).

Much later, in the 1990s, Baddeley claimed that there was strong empirical evidence against a unitary view of memory. In 2002, he stated again that the concept of human memory as a unitary faculty began to be seriously eroded in the 1960s, with a proposal of the fractionation of memory into long-term memory (LTM) and short-term memory (STM) (Baddeley, 2002)[2]. Researchers (e.g. Purves et al.,2010; Baddeley, 2002) explain that human memory can be categorized according to the time in which it is effective in our minds. Details concerning this division are still part of a hot debate among psychologists and neurobiologists; however, three categories are largely accepted (Purves et al., 2010).

The first is *immediate memory*, which is our daily capacity to maintain in conscience, from fractions of seconds to a few seconds, our ongoing experiences (e.g. what you just read in this paragraph) (Purves et al., 2010). The second category of memory is *working memory,* which is the capacity of maintain and manipulate information in conscience from

[2] The most influential two-component memory model was that of Atkinson and Shiffrin (1968), who proposed that information came in from the environment into a temporary short-term storage system which served as an antechamber to the more durable long-term memory (Baddeley, 2003). In their model, "the temporary system also served as a working memory, a workspace necessary not only for long-term learning, but also for many other complex activities such as reasoning and comprehension" (Atkinson and Shiffrin, 1968 in Baddeley, 2003).

seconds to a few minutes, while it is used to achieve a given behavioral goal (e.g. when you lose your car keys at your home; because of your working memory, you do not search for it in repeated places) (Purves et al., 2010). Finally, the third category of memory is *long-term memory*, which concerns the retention of information in a more permanent manner, for days, weeks, years or even a lifetime (Purves et al., 2010). The authors also advocate that part of the information held in the immediate memory and in the working memory is stored as long-term memory, although most of this registration is forgotten, as a natural process of non-oppression of our encephalon with huge amounts of information (Purves et al., 2010). The different types of memory have their own particular mode of operation, but they will certainly cooperate in the process of memorization.

As explained by Baddeley (1992a), researchers have tended to conceptualize this system along two main lines of study (Mota, 1995). In the first one, long-term memory is divided into *episodic and semantic memory*, a distinction first proposed by Tulving (e.g. 1985). In the second one, the system is divided into *declarative and procedural memory*, terms adopted after the study by Anderson (1983 in Mota, 1995). There is a third line of research referring to long-term memory. In this line, long-term memory is subdivided into *implicit and explicit memory*, terms employed by neuropsychologists such as Schacter, in a study from the late 1980s (1987).[3]

From the types of memory mentioned above, long-term memory is the category explored in the current study. In general terms, it is through this category that our knowledge about the world is acquired from our experiences and maintained in our minds (e.g. Squire & Kandel, 2009). Therefore, memory holds our record of personal experience, and it is a powerful force to our unique ability to communicate (Squire & Kandel, 2009). Hence, memory is central to many aspects of human experience, such as psychological and emotional issues, as a result of experiences that have been coded in it (Squire & Kandel, 2009). The localization of memory storage is part of a tradition that attempts to address the following issue: Can any mental processes be localized to a specific region or a combination of regions in the human brain? (Squire & Kandel, 2009).

Recent findings in the cognitive neuroscience of memory (e.g. Eichenbaum, 2002) refer to memory as encoded within the cerebral

[3] Further explanations on the long-term memory distinctions will be fully detailed in sections 2.1.1, 2.1.2 and 2.1.3 in this chapter.

cortex in two general ways, each of which involving a modification of the normal sensory processing function of the cells in these specific areas (Eichenbaum, 2002). Firstly, Eichenbaum (2002) states, memory is reflected in the capacity of cortical cells to shift or modulate the responses evoked by the stimuli that drive them. Second, the author stresses, "memory is encoded in the capacity of cells to sustain or reactivate their normal sensory responses in the absence of the stimulus ordinarily required to evoke the representation" (Eichenbaum, 2002, p. 192). These observations emphasize the fundamental theme that memory should be conceived as intimately intertwined with information processing in the cortex, in which "memory" and "information processing" are indistinguishable (Eichenbaum, 2002). One interpretation of this view is that memory is related to the plastic properties of specific cortical information processing; in this sense, the mechanisms of the cerebral cortex – divided into four major regions or lobes[4] - involve a combination of information processing and memory to constitute neural networks that contain the structure of our knowledge about the world (Eichenbaum, 2002; Squire & Kandel, 2009).

To account for such findings, biological approaches have recently joined with those of systems neuroscience and with cognitive psychology; this perspective forms a unified science that has proven to be fascinating from a molecular and also behavioral point of view (Squire & Kandel, 2009). The partnership between these once independent areas of study is leading to a new synthesis of knowledge about memory and the brain; these fields together are explaining issues on how nerve cells work together in neural circuits, how learning processes and memory systems are organized, and how they operate (Squire & Kandel, 2009). Squire & Kandel (2009) also point out that investigations of brain systems and behavior are providing a road map that identifies components of memory, areas of the brain where these components can be studied in detail, and also nerve cells in a particular neural circuit related to a particular form of memory in mind.

As previously explained, long-term memory is the one of the focus of the present investigation. It can be explored into three distinctions: episodic/semantic, explicit and implicit and declarative and procedural memory. In the next section, the distinction episodic-semantic memory will be explored.

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[4] The cerebral cortex is divided into frontal, temporal, parietal and occipital lobes, in which the temporal lobe is concerned with memory (Eichenbaum, 2002).

2.1.1 Episodic/Semantic memory distinction

According to Tulving (1972), episodic and semantic memory are two information processing systems that (a) selectively receive information from perceptual systems (Gibson, 1966 in Tulving, 1972) or other cognitive systems, (b) retain various aspects of that information, and (c) upon instructions transmit specific retained information to other systems, including those responsible for translating this into behavior and conscious awareness. Tulving (1972) explains that these two systems differ from one another in terms of (a) the nature of stored information, (b) autobiographical versus cognitive reference, and (c) conditions and consequences of retrieval, and probably in terms of (d) their vulnerability to interference resulting in transformation and erasure of stored information. Besides, the author complements with another difference: their dependence upon each other (Tulving, 1972).

Episodic memory receives and stores information about temporally dated episodes or events, and temporal-spatial relations among these events (Tulving, 1972). Tulving (1972) observes that a perceptual event can be stored in the episodic system uniquely in terms of its perceptible properties or attributes, and it is always stored in terms of autobiographical reference to the already existing content of the episodic memory store. In contrast, semantic memory is the memory necessary for the use of language (Tulving, 1972). Is it a mental thesaurus, that is, an organized knowledge a person possesses about words and other verbal symbols, their meaning and referents and about relations among them; semantic memory does not register perceptible properties of inputs, but rather cognitive referents of input signals (Tulving, 1972). The semantic system, according to Tulving (1972) is probably much less susceptible to involuntary transformation and loss of information than the episodic system.

Both episodic and semantic memories are part of declarative memory. As explained by Squire (2004), declarative memory is the kind of memory that is meant when the term "memory" is used in everyday language. It is related to the capacity for conscious recollection about facts and events (e.g. Cohen & Squire, 1980; Ullman, 2001a; 2005), and is the kind of memory that is impaired in amnesia (e.g. Baddeley, 2002; Cohen & Squire, 1980; Schacter, 1992; Squire, 1992) and dependent on structures in the medial temporal lobe and midline diencephalon (Squire, 2004). As previously stated, declarative memory can be divided into semantic memory (facts about the world) and episodic memory (the capacity to reexperience an event in the context in which it originally occurred (Cohen & Squire, 1980; Tulving, 1983 in Squire, 2004). Moreover, episodic memory requires the participation of brain systems in addition to those that support semantic memory, for example, the frontal lobes (Shimamura & Squire, 1987 in Squire, 2004).

As pointed out by Tulving (1983 in Bower, 2000) the episodic and semantic memory systems were contrasted in terms of their conditions and consequences of retrieval, nature of stored information, vulnerability to interference, and interdependence. Bower (2000) explains that this hypothesis has led to much discussion in the literature; critics argue that although the two classes of memories clearly differ in their contents, strengths, and specific time-place contextual references, the two classes are otherwise similar in their properties (Bower, 2000). The discussion has continued over the years. Recent developments have proposed use of brain neuroimaging data gathered during episodic versus semantic retrieval tasks, in an attempt to obtain discriminating evidence for the brain-basis for the distinction (e.g. Bower, 2000; Buckner, 1996).

2.1.2 Explicit/Implicit memory distinction

One important issue that has emerged from recent studies of learning and memory concerns the possibility that information can be learned implicitly and independently of awareness (Knowlton & Squire, 1996). Considering this assumption, different aspects of memory - explicit and implicit memory[5] – will be reviewed in this section. According to Schacter (1987), “implicit memory is revealed when previous experiences facilitate performance on a task that does not require conscious or intentional recollection of those experiences; explicit memory is revealed when performance on a task requires conscious recollection of previous experiences” (p. 501). Dornyei (2009) states that these conceptual areas (first explicit-implicit memory, and then the closely related declarative-procedural paradigm) dominate contemporary memory research, each having its own substantial body of literature. These paradigms appear to cover very similar ground and the corresponding terms are often used

[5] The explicit-implicit dichotomy appears in many forms in research on language acquisition, and it has been applied to SLA as well. The gist of the contrast, according to Dornyei (2009) is clear: ‘explicit’ has something to do with consciousness, while ‘implicit’ is associated with unconscious, automatic, or indirect processes. The explicit-implicit dichotomy is applied to three different concepts in the literature – learning, knowledge and memory, and it is only very rarely explained how these are interconnected (Dornyei, 2009).

interchangeably (Dornyei, 2009). Empirical research on implicit learning falls largely into three categories: artificial grammars, sequence learning, and control of complex systems (DeKeyser, 2003). The oldest paradigm, and the one that continues to generate most research, is artificial grammar learning (AGL). In this paradigm, participants are typically able to discriminate the grammatical strings with above-chance accuracy despite believing they are guessing or using intuition and despite being unable to verbalise the rules of grammar (e.g. Scott & Dienes, 2010). From the first experiment originally proposed by Reber (1967), (in which the author states that the ability to discriminate grammatical strings resulted from the implicit acquisition of regularities encountered during learning) to subsequent experiments (e.g. Reber, 1976), the controversy they generated led to an industry of artificial grammar studies of increasing complexity and sophistication (e.g. Chang & Knowlton, 2004; Dienes, Broadbent & Berry, 1991; Knowlton & Squire, 1994; 1996; Scott & Dienes, 2010).

Researchers (e.g. Butler & Berry, 2001 Dornyei, 2009; Paradis, 2004; Perrig, 2001) have explored explicit and implicit dichotomy by observing memory as a psychological term, conceptualized in terms of retrieval rather than internal representations or structure. Because of that, it becomes clear why 'memory tasks' assume a special importance; after all, retrieval can be operationalized only through these tasks (e.g. Perrig, 2001). Perrig (2001) observes that 'implicit memory' refers to memory effects that can be shown by implicit tasks that, in contrast to explicit tasks, do not instruct the subjects to remember what happened in the past. In this, the author explains, the terms 'implicit' and explicit' refer to different tasks, distinguished operationally by the instructions given to subjects at test (Perrig, 2001).

In a study carried out by Dienes, Broadbent and Berry (1991), the authors examined the claim for distinct implicit and explicit learning modes in the artificial grammar learning task (Reber, 1967; 1989[6]). Artificial grammar learning is a paradigm that has been extensively used to investigate the acquisition of implicit knowledge (e.g. Carpenter, 2008; Chang & Knowlton, 2004; Knowlton & Squire, 1996; Reber, 1967, 1989; Reber & Allen, 1978). In this paradigm, subjects typically memorize strings of letters that appear arbitrary but are actually generated by a set of

[6] Arthur Reber, the pioneer of implicit learning research, defined implicit learning as "a primitive process of apprehending structure by attending to frequency cues" as opposed to "a more explicit process whereby various mnemonics, heuristics, and strategies are engaged to induce a representational system (1976, p.93).

rules in the form of a finite-state grammar (e.g. DeKeyser, 2003; Dienes et al., 1991). Subjects never get to see the rules, and are generally not aware of the rules after being exposed to a set of exemplar strings; yet, they perform above chance when they are unexpectedly asked to classify new strings into those that conform to the structure of the exemplars and those that do not (DeKeyser, 2003).

In Dienes et al's study (1991), 40 healthy young adults initially attempted to memorize strings of letters and then classified new grammatical or nongrammatical strings. According to these researchers, results have shown that subjects' assessment of isolated parts of strings was sufficient to account for their classification performance. Subjects' typical classification performance – about 65% - indicated that these participants have acquired substantial knowledge about the artificial grammar (Dienes et al., 1991).

Knowlton and Squire (1996) found evidence of implicit learning in unhealthy subjects. In this investigation, the contributions of exemplar-specific and abstract knowledge to artificial grammar learning were examined in amnesic patients and controls (Knowlton & Squire, 1996). In Experiment 1, grammatical rule adherence and chunk strength exerted separate effects on grammaticality judgments (consider 'chunk strength' as the number of times the chunks – bigrams or trigrams of letters – appeared in the training items). Results demonstrated that amnesic patients exhibited intact classification performance, showing the same pattern of results as controls (Knowlton & Squire, 1996). In Experiment 2, amnesic patients showed impaired declarative memory for chunks; for Experiment 3, the results indicated that both amnesic patients and controls exhibited transfer when tested with a letter set different than the one used for training, although performance was better when the same letters were used at training and test (Knowlton & Squire, 1996). Overall results suggest that individuals learn both abstract information about training items and exemplar-specific information about chunk strength and that both types of learning occur independently of participants' declarative memory (Knowlton & Squire, 1996).

More recent work conducted by Chang & Knowlton (2004) investigated whether exemplar-specific knowledge acquired in the artificial grammar learning task is based on the visual features of the exemplars, that is, when a change in the font and case occurred between study and test. Sixty undergraduate students (44 women and 16 men) took part in the experiments. Results have shown that there was no effect on sensitivity to grammatical rules in classification judgments (Chang & Knowlton, 2004). Nevertheless, such a change in font and case virtually eliminated sensitivity to training frequencies of letter bigrams and trigrams (chunk strength) in classification judgments (Chang & Knowlton, 2004). Also, performance on a secondary task during study eliminated this font sensitivity and generally reduced the contribution of chunk strength knowledge (Chang & Knowlton, 2004). The findings are consistent with the notion that perceptual fluency makes a contribution to artificial grammar learning judgments (Chang & Knowlton, 2004).

It is commonly held that implicit knowledge expresses itself as fluency (Scott & Dienes, 2010). Also, there is substantial evidence in literature that the knowledge acquired in implicit learning – especially of artificial grammars – is expressed largely as familiarity, defined as the subjective feeling of oldness elicited by a stimulus (e.g. Scott & Dienes, 2008). A question that arises is related to the basis of that familiarity. In a 2010 study, Scott and Dienes used a perceptual clarification task to examine the relationship between perceptual processing fluency, subjective familiarity, and grammaticality judgments through artificial grammar learning. Four experiments with young adults explored the effects of naturally occurring differences and manipulated differences in perceptual fluency, in which decisions were based on a brief exposure to test-strings or normal exposure. According to Scott and Dienes (2010), when perceptual fluency was not manipulated, it was weakly related to familiarity and grammaticality judgments, but unrelated to grammatical status and hence not a source of accuracy. Counterbalanced grammatical and ungrammatical strings did not differ in perceptual fluency but differed in subjective familiarity (Scott & Dienes, 2010). On the other hand, when fluency was manipulated, faster clarifying strings were rated as more familiar and were more often endorsed as grammatical but only when exposure was brief. Results suggest that subjective familiarity derived from a source other than perceptual fluency, is the primary basis for accuracy in artificial grammar learning.

The next section will address the declarative-procedural memory dichotomy.

2.1.3 The Declarative/Procedural memory distinction

Humans possess at least two different systems for storing information. These systems are usually designated as *declarative* and *nondeclarative* memory systems (Purves et al., 2010). Stimulated by neuropsychological studies showing that brain- damaged patients sometimes display normal performance on certain types of memory tasks despite exhibiting severe impairments on others, and by experimental demonstrations in healthy populations that performance on different types of memory tasks can be dissociated from one another, contemporary researchers have postulated distinctions among a number of forms of memory or memory systems (Schacter, Wagner & Buckner, 2000). These distinctions include, but are not limited to, episodic and semantic memory (e.g. Tulving, 1972, 1983), implicit and explicit memory (e.g. Dornyei, 2009; Schacter, 1987) and also *declarative and nondeclarative* (e.g. Squire, 1992; Squire & Kandel, 2009) *or procedural memory*[7] (e.g. Cohen & Eichenbaum, 1993; Eichenbaum, 2002; Ullman, 2005).

According to Dornyei (2009), the declarative-procedural distinction is used with regard to knowledge and the memory that stores that knowledge. Declarative knowledge is frequently taken as a synonym for explicit knowledge and procedural knowledge for implicit knowledge. As observed by Carlson (2003, p. 38), "declarative knowledge is knowledge that can be explicitly expressed ("declared") or consulted, whereas procedural knowledge ('knowing how') can only be performed". One difference in emphasis between the terms 'implicit' and 'procedural' is that procedural knowledge/ memory is usually used in the context of skill learning and skill performance rather than rule learning (Dornyei, 2009).

Bear, Connors & Paradiso (2008) explain that throughout our lives, we learn many facts (e.g., Bangkok is the capital of Thailand); we also store information about events in our daily lives, such as "I ate cereal for breakfast this morning" or "I had an annoying Chemistry class yesterday". This memory system for facts and events is the declarative memory, that is, what we usually refer to when mentioning the word *memory* in its daily use (Bear et al., 2008). In a general sense, declarative memories are available to conscience, as opposed to nondeclarative memory. Another difference observed by the authors is that declarative memories are frequently easy to compose and also easy to forget. In contrast, the formation of nondeclarative memories tends to require repetition and practice during a longer period, but these memories have a lower probability of being forgotten (Bear et al., 2008). Nondeclarative memories can be focused

[7] The terms *nondeclarative* and *procedural* memory are brought together in this section to illustrate that sometimes the terms are used interchangeably.

on procedural memory, or a memory for procedures. This is the memory system for abilities, habits and behavior, and it is related to information such as learning how to play the piano, to play soccer or to drive a car, because somehow this information is stored in our encephalon as a direct result from experience (Bear et al., 2008).

One important aspect of both declarative and procedural memory is that neuroanatomical studies have been successful in identifying the brain areas where each type of memory resides (Dornyei, 2009). Declarative memory appears to be primarily located in the medial temporal lobe, including the hippocampus, whereas procedural memory is usually associated with a network of more diffuse brain structures rooted in the frontal/basal ganglia circuits (e.g. Ullman, 2004). An important contribution from these studies is that they clearly dissociate the two systems from each other.

According to Paradis (2004), the implicit competence which underlies the performance of motor and cognitive skills is said to be procedural because it relates to internalized procedures, genuine behavior programs, which eventually contribute to the automatic performance of the task. Thus procedural memory contrasts with declarative memory, which subserves everything that can be represented at the conscious level, i.e., memory of specific, consciously experienced events (e.g., the recollection of what happened on a particular occasion, and what psychologists call semantic memory, i.e., the individual's general encyclopedic knowledge (i.e., the knowledge that an event too place, whether or not one was present), including the knowledge of the meaning of words (Paradis, 2004). Paradis (2004) yet states that the procedural/declarative memory dimension is a crucial element that determines the performance in the appropriation, use and loss of languages.

The declarative-procedural dichotomy is closely associated with the work of cognitive psychologist John Anderson. This dichotomy comprises an integral part of Anderson's 'ACT-R' theory. This acronym stands for Adaptive Control of Thought-Rational, and is an evolving conceptualization of the overall architecture of human cognition by John Anderson and his colleagues (Anderson et al., 2004). ACT-R has grown out of Anderson's earlier ACT theory, which represented a cognitive psychological approach based on the distinction between declarative and procedural memory since its inception in the mid-1970s (Dornyei, 2009).

Following Anderson' distinction of declarative and procedural memory, Michael Ullman and his collaborators have been pursuing a unique, focused agenda to investigate the neurocognition of both L1 and L2, using neuroimaging techniques. Over the past years, Ullman has proposed a theory that applies the declarative-procedural distinction to L2 knowledge (e.g. Ullman, 2001a; 2004; 2005). According to Ullman (2005), few studies were conducted in order to address the specific neural substrates of second language and the relations between its neural, cognitive, and computational underpinnings. In this line, the author proposes a neurocognitive model - declarative/ procedural (DP) model - (Ullman, 2001a; 2001b; 2001c; 2004; 2005) that is meant to complete these theoretical gaps concerning the context of both first and second languages and to promote a broader understanding of the mind and the brain (e.g. Ullman, 2005).

In the perspective addressed by this model, both first and second languages are acquired and processed by two well-studied brain systems (declarative and procedural memory) that underlie the use of language (Ullman, 2001b). In the L1, the model poses that the mental lexicon and the mental grammar are posited to rely on one of the two memory systems. On the one hand, the memorization, storage and processing of the sound-meaning pairings of lexical memory are subserved by declarative memory, a brain memory system that is rooted in medial temporal lobe regions (e.g. the hippocampus), which are connected extensively with temporal and parietal neocortical regions (Suzuki and Amaral, 1994 in Ullman, 2005); this system may be peculiarly important for learning arbitrary relations (such as the fact that Paris is the capital of France) and it is implicated in the learning, representation and use about facts (semantic knowledge) and events (episodic knowledge) (Ullman (2001b; 2005).[8]

The knowledge learned in declarative memory is partly explicit, that is, available to conscious awareness (Ullman, 2005). On the other hand, Ullman (2001b, 2005) states that the learning, representation, and processing of aspects and rules of grammar depend upon procedural memory, a brain memory system that is rooted in left frontal/basal-ganglia structures, and is implicated in the learning and use of motor and cognitive skills and habits, especially involving sequences. Neither the learning nor the remembering of these procedures seems to be accessible to conscious memory; thus, this system is frequently referred to as an implicit memory system (Ullman, 2005). These rules of grammar processed by this system constrain how lexical forms combine to make complex representations,

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[8] The Declarative Procedural Model of language and its predictions are further discussed in section 2.2.1.1.

and allow us to interpret the meanings of morphologically simple and complex forms (Ullman, 2005).

In the next section, bilingualism will be addressed, followed by aspects of memory systems in bilinguals in section 2.2.1 and the declarative-procedural model (section 2.2.1.1).

2.2 Bilingualism

There are a number of experiences that effectively influence cognitive performance. One of these experiences is that of being bilingual. Paradis (2004) suggests that there is no consensus about what a bilingual individual is. In other words, a monolithic concept does not exist because defining bilinguals can involve a wide category of concepts; because of that, defining a bilingual is a difficult task. In any study of bilingualism, one needs to be aware that bilinguals do not form a homogeneous group. As a matter of fact, a consensus does not even exist as to what constitutes a bilingual (Paradis, 2004). The dictionary definition of a bilingual is usually of a “person who knows or uses two languages”. However, this definition leaves open for interpretation what it means to know a language and also to what extent it must be used to define one as bilingual (Paradis, 2004). Consequently, some authors consider their subjects to be bilingual as long as they have some reading knowledge of a language other than their native language (e.g., Macnamara, 1969), while others insist that a bilingual must understand and speak each language like a native in all modalities of use, all domains of discourse, and all sociolinguistic registers; in sum, in all levels of formality and informality (e.g. Thiery, 1976).

According to Bialystok (2010), “the cognitive and linguistic processes involved in the acquisition and use of two languages are systematically different from those processes engaged in monolingual language use, leading to detectable changes in language and cognitive outcomes for bilinguals” (p. 1). Another evidence for the influence of bilingualism was found by Mechelli et al. (2004), in which early bilinguals and people who have greater proficiency in the L2 have increased density in the brain, shown in the left inferior parietal cortex, a region that is responsible for vocabulary acquisition in monolinguals and bilinguals. In this line, Bialystok (2009) explains that the crucial aspect for fluent bilinguals’ experience, which often use both languages, is the fact that when one is in use, both are active and available (e.g. Kaushanskaya & Marian, 2007). Because of this, bilinguals need to control attention to the target system in the context of an activated and competing system. (Bialystok, 2009). All in all, it seems that bilingualism is an experience with such potential to modify cognitive performance and brain structure.

In a recent study, Bialystok (2010) complements the effect of bilingualism on cognitive performance stating that bilinguals seem to show enhanced functioning of the executive control in relation to monolinguals (Bialystok, 2010). This effect that follow from the experience of bilingualism emerge from an interaction of factors related to constructs in cognitive psychology, social experience, and linguistic theory (Bialystok, 2010). Thus, bilingual language use stands at the interface of the individual, the social context, and the communicative interaction, bringing effects on cognitive and brain systems (Bialystok, 2010).

The intuitive response to the question of the nature of impact of bilingualism on linguistic processing is that it would be beneficial, that is, people who regularly use two languages should be in some real sense more linguistically sophisticated (Bialystok, 2010). The idea that bilingualism can alter cognitive functioning positively is very new in research. It has become more balanced in that it has been open to both positive and negative outcomes, more broad in that it has explored its effects across a variety of domains, and more methodologically diverse in that it has incorporated evidence from behavioral, neuroimaging, and modeling traditions (Bialystok, 2010). Especially in adulthood, differences in language competence between monolinguals and bilinguals shift from representational aspects of how much language is known to processing differences in how efficiently language is accessed (Bialystok, 2010; Bialystok et al., 2009). These differences in accessing, retrieving, and remembering verbal material – usually tested at the level of individual words - are found equally in bilingual's two languages (Michael & Gollan, 2005 in Bialystok, 2010).

From a cognitive perspective, research on bilingualism indicates both benefits and costs (Bialystok & Craik, 2010). Some recent studies have reported that bilinguals experience more tip-of-the-tongue states than monolinguals, take longer to name pictures, make more naming errors than monolinguals, and produce fewer responses in verbal fluency tests (e.g., Bialystok, 2010; Gollan & Silverberg, 2001; Gollan et al, 2005; Roberts et al, 2002). Nevertheless, in a series of studies, researchers have proposed that lifelong bilingualism enhances attentional control (e.g., Bialystok, Craik, Klein & Viswanathan, 2004; Bialystok, Martin & Viswasnathan, 2005; Bialystok, 2007). According to these authors, managing two languages through the lifespan accelerates the development of executive control functions in children, increases cognitive functioning in adults, and delays decline in older adults. Also, bilinguals in general exhibit enhanced executive control in nonverbal cognitive tasks requiring conflict resolution, such as the Stroop and Simon task (Bialystok & Craik, 2010).

Both positive and negative outcomes in research in bilingualism intrigue researchers. Much remains to be explored. Bialystok, Craik, Green and Gollan (2009) state that "whether one speaks just one or more than one language, everyday use of language involves cognitive control" (p.105). Instead of developing a separate control system, the use of two languages imposes additional demands on a single control system, which are beyond those experienced by speakers of just one language (Bialystok, Craik, Green & Gollan, 2009). For these authors, this control system is used by both monolinguals and bilinguals but additional role in bilingual language processing modifies it, changing its performance for all tasks and thus bringing cognitive consequences of such enhanced control. Bialystok and her colleagues also explore the components of the network involved in language control, by demonstrating how they also mediate the cognitive advantages shown by bilinguals, and by exploring the neural basis of control using various cognitive tasks. Next, issues on memory systems in bilinguals will be discussed.

2.2.1 Memory systems in bilinguals

The regular use of two languages by bilingual individuals has been shown to have a great impact on language and cognitive functioning, which is composed by mental processes such as attention, reasoning, thought and memory (e.g. Bialystok, Craik, Green & Gollan, 2009). As a fundamental part of our cognitive functioning, and already mentioned, Squire and Kandel (2009) define memory as "the process by which what is learned persists across time. In this sense, learning and memory are inextricably connected."

It is due to the cognitive functions that humans are capable of interacting with others and with the environment. This interaction is possible because of language use, which is represented by two distinct linguistic systems (e.g. Bialystok, 2010). The presence of two languages in mind changes fundamental aspects of language processing, which presents the bilingual mind as an intriguing set of puzzles (Bialystok, Craik, Green & Gollan, 2009). Since being bilingual obligatorily entails the management and appropriate development of two language systems, it makes sense that these special skills of mental management should also apply to aspects of attention, conflict resolution and cognitive control (Bialystok, Craik, Green & Gollan, 2009). However, should bilingualism provide benefits to other cognitive functions, such as memory? The answer will depend on the type of memory investigated (Bialystok et al., 2009).

Recent studies (e.g. van Heuven, et al., 2008) have distinguished the executive functions performed well in bilinguals in three: (1) updating of working memory, (2) inhibition of responses and (3) shifting between mental sets. Prior and MacWhinney (2010), after carrying out an important investigation to observe whether bilinguals would have any advantage in shifting between mental sets by using a non-linguistic task-paradigm, have discovered that bilinguals had a significant better performance, considering their speed to correctly respond a task on switch trials. Besides, they displayed a huge facility at activating a task set in response to a cue and were faster to overcome to any interference from the task performed on the previous trial (Meiran et al., Philipp et al., 2008). So, one can conclude that lifelong contact and practice with language switching can conduct to specific bilingual advantages, and that bilingual advantages are clearly linked to inhibitory functions, i.e., those related to preventing a process or an action.

Studies on the performance on semantic memory tasks (accessing stores of acquired knowledge) are likely to reflect experience with the type of information tested (Bialystok et al., 2009). Considering that bilingual vocabulary levels are typically lower than those of comparable monolinguals, one must expect that retrieval of verbal information tends to be poorer in bilingual participants (Bialystok et al., 2009) In this manner, Bialystok and collaborators state that "the knowledge base from which all language processing proceeds is less rich or less interconnected for a bilingual in each language than it is for a monolingual speaker of one of those languages" (Bialystok et al., 2009, p. 93). In addition, performance on naming tasks and other tasks of lexical retrieval in fact show this pattern more clearly (Bialystok et al., 2009). Thus, performance on episodic memory tasks may depend on the material in question (Bialystok et al., 2009). The authors also observe that a bilingual advantage should be found in working memory, given the evidence suggesting that bilinguals have an advantage in set maintenance (e.g. Colzato et al., 2008), and in related abilities of monitoring (Costa el al., 2009) and updating (Hernandéz et al., 2010). The evidence at present, to the best of this researcher's knowledge, shows that speaking more than one language indeed appear to have a beneficial effect on aspects of cognitive control (e.g. Bialystok & Craik, 2010), but new investigations on the relationship between memory as a mental process and performance in cognitive tasks are necessary.

In the next section, the Declarative Procedural Model will be presented.

2.2.1.1 The Declarative/Procedural Model

According to Ullman (2001c, 2004), language depends on two mental capacities that interact in a number of ways: a memorized 'mental lexicon' and a computational "mental grammar'. The "mental lexicon" contains memorized words (i.e. pairings of sound and meaning) and the "mental grammar" contains rules, including operations and constraints, complex abstract representations and linguistic structures, words, phrases, sentences and idiomatic expressions (Ullman, 2001b; 2001c). Much regularity can be found in language, and these can be captured by rules of grammar, as Ullman (2004) pointed out: "the rules constrain how lexical forms and abstract symbols or features *(e.g. walk, -ed, Verb, Past Tense)* can combine to make complex representations" (p. 234).

From a theoretical perspective - the Declarative Procedural (DP) model (e.g. Ullman, 2001a; 2001c; Ullman, 2004; Ullman et al., 1997) comprises the perspective that both first and second languages are acquired and processed by two brain systems (declarative and procedural memory) that are known to subserve particular nonlanguage functions and are largely independent from each other, though they interact in many ways (e.g. Ullman, 2004). The basic premise of the DP model (Ullman, 2005) is that aspects of the lexicon-grammar distinction are related to the distinction between declarative and procedural brain memory systems, which have been implicated in nonlanguage functions in humans and other animals (e.g. Squire & Knowlton, 2000 in Ullman, 2005). Besides, the DP model brings the knowledge base and empirical approaches of cognitive neuroscience to account for the study of second language acquisition (SLA) (Ullman, 2001b, 2005).

Ullman (2001a, 2004, 2005) presents an amount of varied evidence to support these correspondences, including neurophysiological data from lesion studies and neuroimaging data (e.g., ERP and fMRI). The DP model gives support to the existence of a dual language system, consisting of broadly conceived vocabulary and grammar (Dorneyi, 2009). In the L1, the DP Model posits that the declarative memory system underlies the mental lexicon, whereas the procedural memory system subserves aspects of mental grammar. They interact in a dynamic network that both cooperate and compete in the learning and processing of information (Ullman, 2005). Moreover, the DP model predicts two dissociations: one set of links is expected among neurocognitive markers (e.g. neuroimaging activation patterns) of stored linguistic representations, conceptual-semantic knowledge and declarative memory brain structures (Ullman, 2005), and a distinct set of links among neurocognitive markers of grammar (across subdomains, such as morphology and syntax), motor and cognitive skills, and procedural memory brain structures (Ullman, 2005).

However, in the L2, the DP model makes different predictions. At least, during early adulthood the acquisition of grammatical-procedural knowledge is expected to be more problematic than the acquisition of lexical-declarative knowledge, as compared to language learning in young children (Ullman, 2005). This may be a result of one or two factors that affect one or both brain systems, including decreased rule-abstraction abilities due to augmented working memory capacity, and the enhancement of declarative memory with aging (Ullman, 2001c; 2005). The changes in both procedural and declarative memory through lifespan may be at least partly explained by the increasing levels of estrogen that occur during childhood/ adolescence (in boys and in girls as well, though estrogen levels are higher in girls), considering that estrogen may somehow inhibit the procedural memory system and enhance declarative memory (e.g., Ullman, 2004; 2005). Due to their facility at declarative as compared to procedural learning, young adults L2 learners should tend to rely on declarative memory, even for functions that depend upon the procedural system in the L1 (Ullman, 2005). Particularly, L2 learners should tend to memorize complex linguistic forms (e.g., *walked*) that can be computed compositionally by L1 speakers (e.g., *walk* + *-ed*) (Ullman, 2005).

Thus, memorizing complex forms and rules in declarative memory may be expected to lead to a fairly high level of proficiency, the level of which should vary due to a number of factors; these include the amount and type of L2 exposure and individual differences concerning declarative memory abilities (Ullman, 2005). Hence, women's advantage at declarative memory should provide them with advantages at L2 learning, Ullman affirms (2005). All in all, at lower levels of L2 experience, declarative memory is posited to subserve the learning and use not only of idiosyncratic lexical knowledge but also of complex linguistic representations (Ullman, 2005). The author explains that, during early adulthood, women show an advantage at L2 acquisition as compared to men; at higher levels of L2 proficiency, the procedural system should be capable to acquire grammatical knowledge, resulting in a neurocognitive pattern similar to that of L1, in which the idiosyncratic lexical knowledge is stored in declarative memory while rule-governed complex forms are composed by the procedural system (Ullman, 2005).

Although the DP model is primarily representational rather than acquisitional, it allows for the comparison of different learner groups, such as novice and expert L2 learners, and thus it can inform SLA research (Dornyei, 2009). So far, the available evidence indicated that novice L2 learners tend to rely on their declarative learning systems more than native speakers, which is explained by the short-term effectiveness of associative declarative memory (Dornyei, 2009). As stated by Ullman (e.g. 2005), memorizing complex forms and even rules may be expected to lead to a fairly high degree of proficiency, but constructions that cannot be easily memorized pose problems. A sustained experience – practice, proficiency – with the L2, however, leads to increased procedural learning, making the co-operation (see-saw effect) of the two memory systems more balanced.

Next, issues related to a relevant topic to bilingualism - language proficiency - will be portrayed, in an attempt to better understand this construct and its relation to long-term memory systems.

2.3 Language proficiency

Researchers have attempted to define language proficiency from distinct points of view. Thomas (1994) defines proficiency as a broadly term to represent a person's overall competence and ability to perform in L2. A complementary consideration as regards proficiency is that the notion of *L2 proficiency* plays several roles in research in second language acquisition (Thomas, 1994). According to this researcher, proficiency is itself a central focus of attention, and the presence or absence of other characteristics of learners is correlated against it; conversely, in some studies, proficiency is only one of various factors measured or described (Thomas, 1994). In such scenarios, it is worthwhile considering how proficiency was assessed and whether the measures were satisfactorily reported (Thomas, 1994). Also, due to factors such as first language "transfer" and overgeneralization (that may play different roles in language learning at different stages of acquisition), the performance of a particular group of learners in a certain context or on a certain experimental task needs to be understood in the light of their present state of knowledge of the L2, i.e., their current L2 language experience.

From a different perspective, language proficiency is a term that describes how well a person can use a language to communicate in reading, writing, listening and speaking (Hargett, 1998). This term has also been called 'linguistic proficiency', 'degree of bilingualism', and 'balance of bilinguality' (Hoffman, 1991). All of these terms concern the ability of bilingual speakers in one or both of their languages. Bialystok (2001) defines it as "the ability to function in a situation that is defined by specific cognitive and linguistic demands, to a level of performance indicated by either objective criteria or normative standards" (p.18)

According to Barrett (2011), language proficiency, which is how well a person is able to communicate in each language; this is only one factor in language dominance[9] (Barrett, 2011). A bilingual speaker's dominant language is the language that he or she is more proficient in as well as uses more often, which may be different in certain settings (Baker, 2001). For instance, consider a child who speaks Chinese more when speaking with friends and family, but actually be able to complete school work better in English. Thus, as pointed out by other researchers (Abutalebi, Cappa & Perani, 2001 in Hulstjin, 2012), language proficiency seems to be the most important factor, more important than age of acquisition, affecting the bilingual language system (p. 422). Such factors would play a role in both language processing and production (Foote, 2010).

There are four major techniques of assessing the proficiency of L2 learners (Thomas, 1994). These techniques are named as (i) impressionistic judgment, consisting of an assertion that a learner has a given level of control over L2; (ii) institutional status, consisting of defining learners to levels of proficiency on the basis of institutional status, according to their positions in some hierarchically-organized social structure; (iii)

9 Language dominance is concerned with how often a language is used, the degree of comfort a speaker feels when using each language in different settings, and the individual's language history (Barrett, 2011). This information can be assessed through self-evaluation questionnaires, in which the bilingual person is asked to describe the age they began learning and using each language, the frequency of use, and in what situations each language is most used; this information is used to understand the environmental and educational situations that produce a particular bilingual profile (Barrett, 2011).

in-house assessment and research-internal measurement of proficiency, which relies on locally developed and administered tests, and finally (iv) standardized test scores, which employ standardized and internationally valid tests to assess L2 proficiency (Thomas, 1994). When choosing one of these techniques, the researcher may carefully observe which one is more adequate to the design and methodology to be employed.

Studies that have investigated the bilinguals' benefits versus costs have applied language proficiency as an important variable (e.g., Bialystok, 2001; Bialystok, 2010; Bialystok et al, 2008a). In this latter study by Bialystok and collaborators, four groups of participants were investigated – younger, 20 to 30 years of age - or older – 60 to 80 years – bilinguals or monolinguals. They completed tasks that assessed either language proficiency and lexical access or nonverbal executive functioning (Bialystok et al, 2008a in Bialystok & Craik, 2010). The main findings reported that monolinguals performed better on the former set of tasks, whereas bilinguals performed better on the latter; younger participants showed higher levels of performance on most tasks, although the older adults had a better performance on tasks tapping vocabulary knowledge.

Next section, 2.3.1, will present the role of L2 proficiency in cognitive performance.

2.3.1 The role of L2 proficiency in cognitive performance

Language has been shown to greatly affect the way in which cognitive functions develop (Barrett, 2011). Researchers who examine cognitive development in bilingual speakers are often interested in language proficiency in an attempt to identify its effects on particular abilities (Barrett, 2011). Especially concerning the role of L2 proficiency in cognitive processes (such as declarative and procedural memory systems), dissociations between simple and complex forms of grammatical knowledge are expected in high-experience L2 and in L1 but less so or not at all in low-experience L2 (Ullman, 2005). In direct comparisons between L1 and L2 within participants, the use of complex forms should depend more on declarative memory brain structures in low-experience L2 than in L1 or high-experience L2, in which complex forms should show a greater dependence on procedural memory brain structures (Ullman, 2005). The author also observes that, in contrast, idiosyncratic lexical knowledge should be stored in declarative memory in all individuals, and therefore no lexical dissociations between L1 and either low or high-experience L2 are expected. In this sense, researchers have begun to answer questions about bilingual language proficiency and its role in cognitive development and performance.

The effects of language proficiency on bilingual cognitive development have been analyzed from various perspectives. Hakuta and Diaz (1985) tested 123 Spanish- English bilingual children, aged from four through eight years-old, on the Raven's Progressive Matrices in order to identify a correlation between non-verbal cognitive abilities and the bilingual speaker's proficiency level. The participants were measured at two times during a six month longitudinal study. The results of the Raven's scores and the level of bilingualism at Time 1 were not significantly correlated; however, there was a significant correlation found between these measures at Time 2. These results indicate a link between the degree of bilingualism and general cognitive abilities within the same group of students. More importantly, these results suggest that link only becomes significant after the children become more proficient in their second language. The advantages that bilingual children have demonstrated in certain cognitive tasks' performance are only apparent once the child reaches a certain threshold of second language proficiency.

A study of language proficiency in bilingual adults demonstrates that proficiency not only affects general intelligence, but also specific language functions, such as inhibitory control (Zied, Phillipe, Karine, Valerie, Ghislaine & Arnaud, 2004). This study assessed inhibitory control using French and Arabic Stroop word tests on younger and older adults. The participants spoke both French and Arabic; nevertheless, some participants were balanced bilinguals and others were dominant in one of the languages. The participant's degree of bilingualism was assessed using the Boston Naming Test administered in both languages. The results that are of interest show that the balanced bilinguals, those participants who have relatively equal second language proficiency as their first language, have significantly better inhibitory control skills than bilingual participants who are more proficient in their first language. This study also indicates that the best time to examine bilingual speakers is when they are 'balanced bilinguals' speakers (Barrett, 2011).

In sum, the issues discussed in the present chapter are relevant to this research because they present a view of memory systems studies and its relation to language and SLA. Besides that, this chapter portrays that language dominance and proficiency are two factors that may determine whether bilingual speakers show advantages in cognitive abilities and performance. Language proficiency is of particular interest in bilingualism research, since it can be objectively measured. There are a number of tests commonly used to assess language proficiency in one or both languages in bilingual speakers. Another important issue raised in this chapter is that the development of language proficiency may be linked to the development of other cognitive abilities.

In the next chapter, the design employed in the current study will be described.

CHAPTER III

METHOD

The present chapter outlines in detail the methodological procedures designed for the present investigation. The chapter is organized into 9 sections. Section 3.1 presents the objectives of the research; section 3.2 provides the research questions, followed by section 3.3, which poses the hypothesis. In section 3.4, the general design is portrayed. Section 3.5 is devoted to the information regarding the participants who volunteered in the study. The instruments of data collection can be found in section 3.6. Section 3.7 describes the general procedures for data collection and section 3.8 provides the data analysis. The pilot study carried out prior to the current study will be described in section 3.9.

3.1 Objectives

The present study aims at investigating the effect of L2 proficiency in two long-term memory systems – declarative and procedural. More specifically, this study aims at exploring the performance of 40 young adults (Portuguese-English bilinguals at two distinct levels of proficiency in their L2 – low proficiency and high proficiency - and Brazilian Portuguese monolinguals) in declarative and procedural memory tasks in L1.

3.2 Research questions

Based on the objectives previously mentioned, the present study will pursue answers to the following questions:

1. Do young adults, native speakers of Brazilian Portuguese at high proficiency in English as an L2, outperform those at low proficiency and the Brazilian Portuguese monolinguals in the ‘Picture Naming’ and the ‘Artificial Grammar Learning’ linguistic tasks?

2. Do young adults, native speakers of Brazilian Portuguese at high proficiency in English as an L2, outperform those at low proficiency and the Brazilian Portuguese monolinguals in the ‘Picture Recognition’ and the ‘Alternating Serial Reaction Time’ nonlinguistic tasks?

In order to answer to these questions, declarative and procedural memory tasks were applied to high proficiency bilinguals and low proficiency bilinguals (composing the first and the second experimental group, respectively) and to Brazilian Portuguese monolinguals (the control group). They were all recruited in Florianópolis, in the state of Santa Catarina, Brazil. Table 3.1 summarizes the memory tasks divided into memory systems, task type and task name[1]. The tasks are also labeled in table 1 in numbers from 1 to 4.

Table 3.1 *The tasks*

Memory System	Task Type	Task Name	Stimuli
Declarative	Linguistic	Picture Naming (1)	197
	Non-Linguistic	Picture Recognition (2)	120
Procedural	Linguistic	Artificial Grammar Learning (3)	32
	Non-Linguistic	Alternating Serial Reaction Time (4)	170

As can be seen in table 3.1, the methodology for the present study was designed so as to investigate participants' performance on two long-term memory systems – declarative and procedural, into two types of memory tasks: linguistic and non-linguistic (two tasks per memory system). There were 197 stimuli for task 1, 120 stimuli for task 2, 32 stimuli for task 3 and 170 stimuli for task 4. Next, table 3.2 presents the proficiency/ language groups for the present study.

Table 3.2 *The proficiency/ language groups*

Proficiency /Language Groups	Sex		
	Male	Female	Total
High (%)	5 (12,5)	11 (27,5)	16 (40)
Low (%)	2 (5)	14 (35)	16 (40)
Mono (%)	2 (5)	6 (15)	8 (20)
Total(%)	n = 9 (22,5)	n = 31 (77,5)	**N= 40(100)**

Note. High = high proficiency bilinguals; Low = low proficiency bilinguals; Mono = Brazilian Portuguese Monolinguals; n = number of participants per group; N= total number of participants

[1] The memory tasks will be further explored in detail in section 3.6.3 in this chapter.

As shown in table 3.2, the three proficiency/ language groups were divided into sex and number of participants per group (High, Low and Mono). As presented in table 2, mostly women took part in the present investigation (n = 31; 77,5%).

3.3 Hypotheses

The performance of monolinguals and bilinguals at different levels of L2 proficiency is expected to be distinct. Thus, the research questions outlined generated two hypotheses:

1. The Portuguese-English bilinguals at high L2 proficiency will perform significantly better, that is, faster and more accurately than the low proficiency ones and the monolinguals in the 'Picture Naming' and the 'Artificial Grammar Learning' linguistic tasks.

2. The Portuguese-English bilinguals at high L2 proficiency will perform significantly better, that is, faster and more accurately than the low proficiency ones and the monolinguals in the 'Picture Recognition' and the 'Alternating Serial Reaction Time' nonlinguistic tasks.

3.4 General research design

In order to test the hypotheses aforementioned, the present study employed a design in which all participants could choose between a single data collection session or a two-session data collection[2]. They were informed before-hand that, according to their schedule preferences, they could join one or two testing sessions. For the bilinguals that underwent a *single data-collection session*, they were required to sign a consent form (see Appendix A) and to answer to two questionnaires: a general background questionnaire and a language background questionnaire (Appendix B). Also, these participants were tested on a language proficiency examination according to their expected level in English as an L2 (low or high proficiency) and were required to perform four memory tasks individually on a standard personal computer.

[2] At their own decision - due to schedule preferences - some participants have decided to undergo the two sessions in a row. In such cases, a pause of 3 to 5 minutes between both sessions was considered to avoid mental exhaustion.

Bilingual participants that underwent a *two-session data collection* followed the same procedures outlined above, except for the memory tasks which were performed on the second session. For the monolinguals, the single data-collection session consisted of signing the consent form, answering to a general background questionnaire and to a Mini-language Test for monolinguals. Besides, they were also required to perform four memory tasks individually on a standard personal computer; the monolinguals who preferred to participate in two sessions, followed the same procedures described above, except for the memory tasks, which were performed on the second session.

All participants were tested on the memory tasks and either on the proficiency test or the Mini-language Test by the same experimenter (the researcher herself) using the same equipment and materials, according to their group condition(s) and under the same instructional protocols. The data collection was carried out in the Language Studies and Cognitive Processes Laboratory (LabLing henceforth) at Universidade Federal de Santa Catarina (UFSC henceforth). Participants were mostly enrolled either in the Extracurricular Language Courses at UFSC or undergraduate students at the same University. The total number of participants for this study is of 40 volunteers, young adults, mostly women (31 women, 9 men). The research design is summarized next in Tables 3.3 and 3.4 for the experimental groups.

Table 3.3 *Data Collection Procedures for the Experimental Groups in a Single Session (Low and High)*

SINGLE DATA COLLECTION SESSION	SETTING
1. Consent form	Individually with the researcher/ LabLing-UFSC
2. General background questionnaire	
3. Language background questionnaire	
4. KET or PET	
5. Memory tasks	

Note. Low = low proficient bilinguals; High = highly proficient bilinguals; KET = Cambridge ESOL Examination 'Key English Test'; PET = Cambridge ESOL Examination 'Preliminary English Test'

Table 3.4 *Data Collection Procedures for the Experimental Groups in Two Sessions (Low and High)*

TWO-SESSION DATA COLLECTION		SETTING
Session 1	Session 2	Individually with the researcher/ LabLing-UFSC
1. Consent form	1. Memory tasks	
2. General background questionnaire		
3. Language background questionnaire		
4. KET or PET		

Note. Low = low proficient bilinguals; High = high proficient bilinguals; KET = Cambridge ESOL Examination 'Key English Test'; PET = Cambridge ESOL Examination 'Preliminary English Test'

Next, in Tables 3.5 and 3.6, the research design is summarized for the control group.

Table 3.5 *Data Collection Procedures for the Control Group in a Single Session (Mono)*

SINGLE DATA COLLECTION SESSION	SETTING
1. Consent form	Individually with the researcher/ LabLing-UFSC
2. General background questionnaire	
3. Mini-language test	
4. Memory tasks	

Note. Mono = Brazilian Portuguese monolinguals

Table 3.6 *Data Collection Procedures for the Control Group in Two Sessions (Mono)*

TWO-SESSION DATA COLLECTION		SETTING
Session 1	Session 2	Individually with the researcher/ LabLing-UFSC
1. Consent form	1. Memory tasks	
2. General background questionnaire		
3. Mini-language test		

Note. Mono = Brazilian Portuguese monolinguals

3.5 Participants

Forty Brazilians comprised the total group of participants of the present study. From this number, sixteen participants were native speakers of Brazilian Portuguese at high proficiency in English as an L2. These participants formed the first experimental group of this study. Sixteen participants were native speakers of Brazilian Portuguese at low proficiency in English as an L2. These participants took part in the second experimental group for the present investigation. The remaining 8 participants were Brazilian Portuguese monolinguals and formed the control group of the present study. All participants were in their early adulthood (ages ranging from 17 to 31 years, with a mean age of 24), and agreed to participate voluntarily.

To be part of the low proficient experimental group, the participant should have studied English up to 2 following semesters only, with maximum of 3 schooling hours per week, and/or should have studied English only in regular school. The participants should not have spent more than 2 weeks in an English-speaking country. They also should not have scored more than 40% on the Cambridge ESOL Examination Key English Test (KET)[3].

To be included in the high proficient experimental group, the participant should reach a very high level of performance in the four linguistic skills in English (namely listening, speaking, reading and writing) scoring at least 90% on the Cambridge ESOL Examination Preliminary English Test (PET). These bilinguals should also have studied English formally for at least 6 semesters or should have lived at least 2 semesters in an English-speaking country. In the latter case, they should have returned to Brazil within the last 4 semesters. The bilingual population for the present study should not have studied another foreign language formally for more than 2 semesters over the last 3 years.

The Brazilian-Portuguese monolinguals should preferably have studied English only in regular school or should not have studied English for more than one semester for at least the past 3 years. Like the bilinguals, they should not have studied another foreign language formally for more

[3] In the present study, three instruments were used to control for participants' proficiency in English as an L2: (1) the Cambridge ESOL Examination Key English Test (KET) for low proficient bilingual participants; (2) the Cambridge ESOL Examination Preliminary English Test (PET) for highly proficient bilingual participants, and (3) a Mini-language test devised for the purpose of controlling for Brazilian Portuguese monolinguals' knowledge of English. Section 3.6.2 brings the information about the control of proficiency.

than 2 semesters over the last 3 years. In addition, they should not have stayed in a foreign country for more than 2 weeks over the last 5 years. Besides, these participants should not score more than 3 items on the Mini-language test for monolinguals, especially designed for the present investigation.

All participants selected for this study should have at least 12 years of schooling, be right-handed, and have no neurological or language disorder.

3.6 Instruments of data collection

The instruments of data collection used in the present study comprise (i) two linguistic tasks: one designed to assess declarative memory performance and another to assess procedural memory performance (the Picture Naming and the Artificial Grammar Learning Tasks, respectively); (ii) two nonlinguistic tasks: one designed to assess declarative memory performance and another designed to assess procedural memory performance (the Picture Recognition and the Alternating Serial Reaction Time Tasks, respectively). The four tasks were applied to all participants of the experimental and control groups and all four were designed in their L1 - Brazilian Portuguese. Additionally, the following proficiency tests were adopted as instruments to control for participants' proficiency: (a) the Cambridge ESOL Examination Key English Test (KET) and (b) the Cambridge ESOL Preliminary English Test (PET)[4], and (c) the Mini-Language Test for Monolinguals of Brazilian Portuguese, designed by the experimenter (myself) to control for their knowledge of English. A brief explanation of the tasks and the tests will be provided in Section 3.6.2.

3.6.1 Consent form and questionnaires

When participants came to the LabLing for the unique session or the first session (out of two), they were required to sign a consent form (Appendix A) and to answer orally to a general background questionnaire (both materials in the case of monolinguals) and to answer to a language background questionnaire (Appendix B) (the three materials in the case

4 Section 3.6.2 in this chapter will provide further information concerning the control of proficiency in the present study, by describing the proficiency tests and the mini-language test applied.

of low and high proficient bilinguals). These questionnaires were filled out by the experimenter while interviewing each participant individually.

The general background questionnaire, both for bilinguals and monolinguals, consisted of questions concerning participants' age and gender, contact information, years of education, occupation and handedness information. The language background questionnaire consisted of questions regarding the participant's knowledge of English, language(s) information, communicative skills and formal instruction.[5] Monolinguals were required to sign the consent form and were interviewed about the items in the questionnaires in the first session of data collection. They were tested on their knowledge of English through the Mini Language Test for Monolinguals. The monolingual participants informed, either by e-mail or in personal communication, that they had no previous knowledge of English or of any other language but Portuguese.

3.6.2 Proficiency tests and Mini Language Test

The proficiency tests chosen for the bilingual population of the present study were the Key English Test (KET) and the Preliminary English Test (PET) both from Cambridge ESOL Examination Tests. For the monolinguals, a Mini Language Test was developed by the experimenter (myself) so as to guarantee the monolingual condition of the participant. The three exams will be explained next.

The Key English Test is an elementary level exam that tests the participants' ability to deal with basic written and spoken communications. KET is at Level A2 of the Common European Framework of Reference for Languages (CEFR) – an internationally recognized benchmark of language ability[6]. At the A2 level, the participants/ users of the test are expected to: (i) understand and use everyday expressions and basic phrases, (ii) introduce themselves and answer basic questions about personal details, and (iii) interact with English speakers who talk slowly and clearly. The framework uses six levels to describe language ability from A1 to C2.

The test has three papers: Reading and Writing (about 1h duration), Listening (30min) and Speaking (10min). For the purpose of the present

[5] The questionnaires and the memory tasks were designed and administered in Brazilian Portuguese to all participants.

[6] Further information available at <http://www.cambridgeesol.org/exams/general-english/ket.html>

study, the total amount of time recommended for the exam remained, which is of 1 hour and 40 minutes.

The other exam chosen for this study was the Preliminary English Test. It is an exam for people who can use everyday written and spoken English at an intermediate level. [7]Taking into consideration the different learning contexts of second language learning in Brazil, in which the intermediate learner has not been communicating in English since childhood (late learner) and has not been exposed to real life language situations in English very often, this *intermediate* level of the examination would correspond to the *ideal advanced level* of participants required in the present study and more frequently found in the Brazilian context.

Considering the specific characteristics of the exam, PET reflects the use of language in real life, such as understanding signs and announcements; it is accepted for use in jobs where spoken English is necessary, such as tourism, construction and engineering. PET is at Level B1 of the Common European Framework of Reference for Languages (CEFR). At the B1 level, participants/ users are expected to: (i) understand the main points of straightforward instructions or public announcements, (ii) deal with most situations you might meet when traveling as a tourist in an English-speaking country, (iii) ask simple questions and take part in factual conversations in a work environment, and (iv) write letters, e-mails or make notes on familiar matters. PET has three papers: Reading and Writing (about 1h30), Listening (about 30min) and Speaking (10-12min). For the purpose of the present study, PET has been adapted and lasted about 1 hour and 50 minutes.

Finally, the Mini Language Test designed for the monolingual population of the present investigation consists of questions to evaluate participants' comprehension, grammatical judgment and vocabulary recognition in English. It is organized in a question and answer, multiple-choice and true-or-false format in two pages. Questions were all in English and participants had up to 30 minutes to complete the test. If the participant scored more than 3 questions, s/he was excluded from the monolinguals' group. Next subsection will provide information concerning the assessment of memory in the present study.

[7] Further information available at <http://www.cambridgeesol.org/exams/general-english/pet.html>

3.6.3 Memory Tasks

In the present investigation, four experimental tasks aimed at assessing participant's declarative and procedural memory. The Picture Naming Task and the Picture Recognition Task aimed at assessing participant's declarative memory. The Artificial Grammar Learning Task and the Alternating Serial Reaction Time aimed at assessing participants' procedural memory (see appendices for general task instructions). These four tasks were run on a Dell standard personal computer, connected to a 14-inch Dell monitor for stimulus display. All tasks were designed and run using the software E-Prime v.2.0.

For the Picture Naming Task, a microphone was placed in front of each participant to record every oral response they provided when performing the task. For the Picture Recognition, the Artificial Grammar Learning and the Alternating Serial Reaction Time Tasks, a PST Serial Response Box (SRBOX) Model 200A was used for obtaining more accurate response times from the performance of participants on the tasks. The four tasks were presented to participants in a random order and will be described next.

3.6.3.1 Assessment of Declarative Memory

3.6.3.1.1 The Picture Naming Task

Based on the study carried out by Szekely, D'Amico, Devescovi, Federmeier, Herron, Iyer, Jacobsen, Arévalo, Vargha and Bates (2005), a timed picture-naming paradigm was designed so as to assess participants' declarative memory linguistically, by checking each participant's reaction time and accuracy in relation to the oral production of the name of the picture(s) they have seen. In the Picture Naming Task, the participant was required to sit in front of a computer screen in which black-and-white line drawings series of pictures were presented, one picture at a time. The participant's task was to name each picture in one single word, out and loud; these pictures were all representing concrete nouns (See Figure 3.1).

Figure 3.1. Sample of a correct and an incorrect oral response on the Picture Naming Task

The task was composed by a learning phase, a practice phase and a testing phase. All participants received the instructions for each phase in Portuguese, both orally and written on the screen (see Appendix C). Each picture stimulus was programmed to appear on the screen for a total time of 4000 milliseconds (3000 milliseconds as a time-window for the participant's response + 1000 milliseconds for the interval between each stimulus); if the participant did not verbalize anything, the task would produce an error sound and skip to the next picture; each picture stimulus was preceded by a fixation cross that remained on the screen for 1000 milliseconds.

Each participant's responses were voice recorded for posterior checking and also checked during the task by the experimenter, using a list with the expected responses. The software registered the time between the stimulus' appearance on the screen and the beginning of the oral production by the participant(s). The primary database from which the stimuli were taken consisted originally of 795 picture stimuli; for the purpose of the present study, 197 picture stimuli were selected[8]. To prevent from participants' mental exhaustion, after the series of 100 picture stimuli presentation, a 1-minute was pre-programmed before the beginning of the next series.

[8] In the past few years, Szekely et al. (2004; 2005) have obtained object-naming norms (including indices of name agreement) in many languages, such American English, Spanish and Italian. The version of the task in Brazilian Portuguese and the translation for the names of the selected picture stimuli was done based on their translation from American English and Spanish.

3.6.3.1.2 The Picture Recognition Task

Adapted from Manns, Hopkins, Reed, Kitchener, and Squire's study (2003), a picture recognition task was the second assessment of declarative memory designed for the present investigation, by checking each participant's reaction time and accuracy in relation to pictures they have recognized as *real,* or in other words, recognized as familiar material. In the Picture Recognition Task designed for the present study, the participant was required to sit in front of a computer screen in which black-and-white line drawings series of pictures were presented, one by one, for a very short amount of time each (500 milliseconds). As each picture disappeared from the screen, the participant's task was to indicate the picture as real or unreal, by pressing an specific button on the serial response box (SRBOX), which sensitivity is higher by means of measuring accuracy and reaction time patterns, in relation to a computer keyboard. The picture stimuli consisted of abstract line drawings and line drawing pictures; the latter represented real concrete nouns. (See Figure 3.2).

Figure 3.2. Sample of a correct (real) and an incorrect (unreal) response on the Picture Recognition Task.

As for the Picture-Naming Task, the task was composed by a learning phase, a practice phase and a testing phase. All participants received the instructions for each phase in Portuguese, both orally and written on the screen (see Appendix D). Each picture stimulus was programmed to appear on the screen for a total time of 500 milliseconds, followed by a screen ‘mask’ (response screen) of 4500 milliseconds; if the participant did not provide any response, the task would produce an error sound and skip to the next picture; each picture stimulus was preceded by a fixation cross that remained on the screen for 1000 milliseconds. Each participant had a total time of 5000 milliseconds to provide a response; if there was no answer, the task was programmed to skip to the next stimulus. The Picture Recognition Task consisted of 120 picture stimuli. In the following subsection, information regarding the assessment of procedural memory will be portrayed.

3.6.3.2 Assessment of Procedural Memory

3.6.3.2.1 The Artificial Grammar Learning Task

To assess participant’s procedural memory linguistically, the Artificial Grammar Learning Task (e.g. Chang & Knowlton, 2004; Carpenter, 2008) was applied. This task consisted of a learning phase, a training phase and a testing phase. Before each phase started, all participants received the instructions in Portuguese, both orally and written on the screen (Appendix E). During its learning phase, participants were instructed to memorize a series of 13 letter strings exemplars generated by a finite-state grammar[9] (e.g. Reber, 1967). Strings would vary from 2 to 6 letters, namely N, W, Y and F, in Font Times New Roman, size 24. Each letter string was presented individually on the computer screen and remained there for 3 seconds. The participant was required to take notes on each string just seen, which would form a list of strings to facilitate his/her memorization of the letter string and to ensure that they were really processing the series of strings presented. After a free interval (showing a blank screen) which allowed the participant to have some time to take notes on the string just seen, the experimenter pressed the space bar which would show the next string on the screen. (See Figure 3.3, in which part of the items used for the learning phase is illustrated).

[9] Finite-state grammars consist of letter strings and by means of grammaticality judgment, it can be checked the participant’s competence about the rule formation of the ‘language’ (Bailer, 2011). VanPatten (1994) explains that these grammars lack the properties and functions of natural languages, since they have serial structure while natural languages present hierarchical structure.

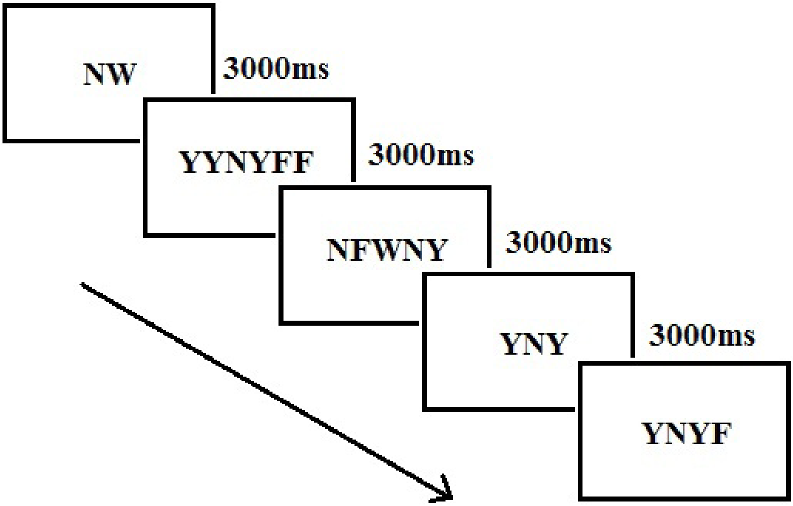

Figure 3.3. Illustration on some items used for the learning phase in the Artificial Grammar Learning Task.

During the training phase, the same series repeated 3 times, now with different letter strings – V, T, X and J. Participants received oral and written instructions (Appendix E) and were required to take notes on the strings again (not only look at them on the screen). Learning and training here were both determined by the number of letter strings that were correctly classified as following the rules of string formation. In the end of both learning and training phases, a screen of new instructions appeared in Portuguese and the experimenter read it with the participant, before beginning the following phase. This final phase would be the testing phase.

For the testing phase, the note-taking procedure remained: the same letter strings were again presented on the computer screen one at a time (V, T, X and J). After this first part, a 5 minute-interval previously programmed took place, not to facilitate participants' recall of the strings they had seen. Then, for the second part of the testing phase, participants received new instructions, both orally and written on the computer screen (Appendix E); after that, participants saw new letter strings (formed by the same letters) which they judged one by one as 'following a pattern' or 'not following a pattern' (of similarity or repetition of micro sets of letters within the different letter strings presented individually). The testing stimuli consisted of 32 grammatical letter strings, which were formed by introducing one or more violations into otherwise grammatical letter strings. So, in other words, the participant's task was to decide whether the string was grammatical (based on implicit rules/ patterns acquired by the participant on the previous phases) or ungrammatical (having no implicit rules/patterns 'behind' the letter strings) (e.g. Pretz et. al, 2010; Carpenter, 2008).

The participants were not informed that the protocols of instructions and procedures for this task were related to an artificial grammar learning experiment. For this task, the critical dependent measure was accuracy; reaction times were also measured to check participants' concern about their response time when performing the task. This type of information (e.g. their time concern) could be mentioned by participants on a post-task questionnaire (See Appendix F) applied to each participant as they finished the task, to verify their impressions and procedures adopted to complete the experiment as accurately as possible.

3.6.3.2.2 The Alternating Serial Reaction Time Task

The task applied to measure participants' nonlinguistic procedural memory performance in the present study was the Alternating Serial Reaction Time task (e.g. Nemeth, Janacsek, Londe, Ullman, Howard & Howard, Jr., 2010). In this task, repeating events alternate with random elements. This means that the location of every second stimulus on the screen is determined randomly. If, for instance, the sequence is 1-2-3-4, where the numbers represent locations on the screen, in the ASRT task, the sequence for the stimuli will be 1-R-2-R-3-R-4-R, with R representing a random element.

In a modified version of the original task from Howard and Howard (1997), a dog head (the stimulus) appears in one of four empty circles on the screen, and the participant had to press the corresponding key when it occurred. Because of this, the computer must be equipped with a special keyboard with four heightened keys, each corresponding to the circles. In our adapted version of Nemeth and colleagues' task (2010), the stimulus has been changed to a 'smile' figure. Each participant was trained to press four heightened keys (1, 2, 4 and 5), one at a time, each corresponding to the direction the 'smile' figure appeared in circles on the computer screen; besides, the keyboard used in Nemeth et al.'s study (2010) was replaced by the Serial Response Box (SRBOX), due to its preciseness and sensitiveness to capture time responses. The same parameters for both task versions remained valid. Before the beginning of the testing phase, participants had the instructions in Portuguese, both orally and written on the computer screen. The aim was to press key(s) 1, 2, 4 or 5 in sequence as quickly and as accurately as possible, according to the circle the smile appeared; if the participant pressed a key which did not correspond to the correct position of the 'smile' on the screen, the 'smile' would not move forward to the next position (Nemeth et. al, 2010) (See Figure 3.4).

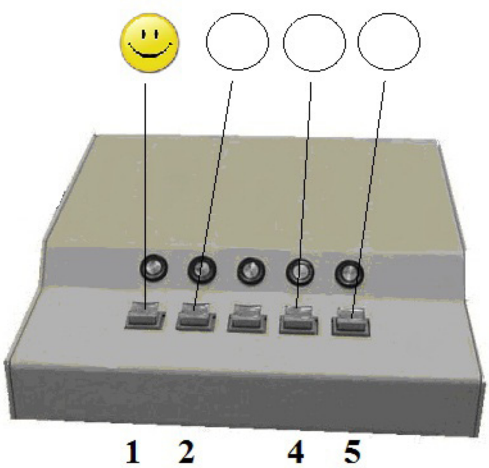

Figure 3.4. Illustration on the Serial Response Box used and the key(s) to press according to the position of each stimulus on the computer screen.

3.7 General procedures for data collection

The procedures for data collection followed in the present research aimed at investigating the effect of distinct levels of L2 proficiency (low and high) on two long-term memory systems (declarative and procedural memory). The two experimental groups (low L2 proficiency and high L2 proficiency) and the control group (monolinguals) performed two linguistic and two nonlinguistic memory tasks as well as one of the proficiency tests (either KET or PET, for bilinguals) or the Mini Language Test for monolinguals. Each participant came individually to LabLing to take part in this study. They were all contacted via email before-hand to schedule the sessions according to their availability. In the case of bilinguals, one session was organized for signing the consent form, answering the questionnaires and performing the memory tasks on the computer and another one for the proficiency test; in the case of monolinguals, one for signing the consent form, answering the questionnaires and the Mini Language Test and another session for the memory tasks on the computer. According to participant's preferences, this protocol would be changed to a single session. All data were collected in the same language laboratory (LabLing/ UFSC), which offered the infrastructure needed.

3.7.1 First session - bilinguals

After signing the consent form and answering the questionnaires in an interview-like procedure, the participant was invited to sit in front of a VGA Dell monitor in which the E-Prime v.2.0 software was installed and programmed with all memory tasks. Then, the experimenter ran the tasks in a randomized order of presentation, so as to avoid task effects, i.e. for each participant, the tasks were presented in a different numbered order, having each task represented by a number from 1 to 4 (See Appendix P). For instance, for participant #1 the order was 1-2-3-4; for participant #2, on the other hand, the order chosen was 3-1-4-2, and so on. The participant could ask for a pause of 1 or 2 minutes between tasks' performance.

3.7.2 Second session – bilinguals

When the bilingual participant arrived at LabLing for the proficiency testing session, the experimenter (myself) provided all explanations, all general procedures and also provided the steps for test completion, in relation to each paper that composed the proficiency test. Then, the participant was firstly invited to complete the paper for the Listening part of the test chosen according to the participant's level of proficiency expected (KET for low L2 proficiency or PET for high L2 proficiency). The experimenter would conduct this Listening part from a Dell standard personal computer, inviting the participant to use a headphone to do this part of the test on a desk next to the computer. After that, the participant should complete the Reading and Writing Paper of the test. Lastly, the participant should perform his/her oral skills on the Speaking part of the test, conducted by the experimenter (myself). Each participant had the maximum of 2 hours to finish the proficiency test session.

3.7.3 First session – monolinguals

In relation to monolinguals' first data collection session, after signing the consent form and answering the questionnaires in an interview-like procedure, the participant, as in the bilinguals' session, was welcomed and then the experimenter provided all explanations as regards the Mini-Language Test and the general procedures for its completion. The experimenter did not provide either explanations or translation of any parts of the test. Each participant had 30min to finish this testing session.

3.7.4 Second session - monolinguals

Following the bilinguals' first session procedures, after signing the consent form and answering the questionnaires in an interview-like procedure, the monolingual participant was invited to sit in front of a VGA Dell monitor where the E-Prime v.2.0 software was installed and programmed with all memory tasks. Then, the experimenter presented the tasks in a randomized order of presentation, so as to avoid task effects. For instance, for each participant, the tasks were presented in a different numbered order, having each task represented by a number from 1 to 4 (See table 3.1). Also, the monolingual participant could ask for a pause of 1 or 2 minutes between tasks' performance.

3.8 Data analysis

Data collected from the four tasks (Picture Naming, Picture Recognition, Artificial Grammar Learning and Alternating Serial Reaction Time) were entered on a spread sheet of the Microsoft Excel program and submitted to statistical treatment. First of all, a descriptive analysis of all data was conducted; it provided an overview of the two language groups' performance (bilinguals and monolinguals) and of the two proficiency groups' performance (high proficiency and low proficiency) on the measures of variables of the four tasks previously mentioned. The mean values of general results for each of the measures, and the standard deviation for each group were provided by the descriptive analysis.

Then, multiple tests comparing groups' performance were run between the linguistic tasks' data (Picture Naming and Artificial Grammar Learning) and the nonlinguistic tasks' data (Picture Recognition and

Alternating Serial Reaction Time), with twelve group comparisons among the three groups in the dependent variable reaction time (RT) and twelve group comparisons among the three groups in the dependent variable accuracy (ACC), that is, number of correct responses provided by participants. A total of 24 multiple tests comparison was run to examine differences in the performance of the three groups (in a total of 40 participants).

Regarding reaction time (RT), the statistical tests firstly chosen to analyze this dependent variable were the *t*-test and ANOVA (Analyses of Variance), in case the variable followed a normal distribution, or Mann-Whitney and Kruskal-Wallis, in case the variable did not follow a normal distribution. Since the results indicated that the variable did not follow a normal distribution, Mann-Whitney was the test used to run the RT comparisons between groups for the present investigation.

Concerning accuracy (ACC), the accuracy scores from the three groups were submitted to the nonparametric statistical test Chi-square, to verify whether the number of correct responses between groups was significantly different.

The Statistical Package for Social Science (SPSS), version 2.0, installed on a Mac 10.7.2 was the statistical software chosen to run the statistics for the data analysis. The significance level of the multiple comparison tests was adjusted to .0002 since all 24 tests were done in a .05 significance level.

3.9 Pilot study

Two pilot studies were conducted for the current study. The first was carried out through late June, first week of July and two first weeks of August 2011. In the first pilot study, the proficiency examinations were tested to check for participants level of acceptance, difficulty, time length and understanding of instructions; also, to test the first version of the memory tasks, which were eight at the time (the current four tasks previously mentioned plus two working memory tasks and two executive control tasks). Nine participants joined this first pilot study. From this sample, six were enrolled in graduate programs at UFSC.

The second pilot study took place in mid August 2011. It was necessary so as to retest the memory tasks modified according to the first pilot observations and weaknesses. Six participants took part in this second piloting phase.

Carrying out two pilot studies was of crucial importance for this study, since the final design of the experiments and procedures resulted from several attempts made during these two phases. The contributions resulted from these two piloting experiences stand as follows:

1. Adequacy of the place for data collection: since it was one of the first studies conducted at LabLing, there was this concern regarding aspects such as the room, the lights, the equipment and everything involved in a pleasant and comfortable place for a data collection session.

2. Programming the tasks: all memory tasks had to be studied in their peculiarities, parameters and design previously to be programmed in the software. Then, the experimenter was trained and had the opportunity to learn how to deal with computer programming in psycholinguistic experiments.

3. Clarifying the task instructions: instructions were clarified and improved so as to avoid misunderstandings in the memory tasks; moreover, to avoid further explanations of the tasks, and then keep the uniformity of instructions and sessions to all participants.

Data collection for the current study followed the same design, protocols and procedures from the two pilot studies, except for the total number of participants (40 participants) and the number of memory tasks (4, instead of 8). The number of tasks was decreased due to a methodological decision to focus this investigation on long-term memory systems tasks performance.

CHAPTER IV

RESULTS AND DISCUSSION

The present chapter aims at presenting and discussing the results obtained in order to answer the research questions presented previously in Chapter III. Section 4.1 is devoted to the descriptive statistics for language and proficiency groups' performance on each task (Picture Naming, Artificial Grammar Learning, Picture Recognition and Alternating Serial Reaction Time, respectively). Section 4.2 presents the inferential statistical analyses and discussion of the results obtained in the performance of the Picture Naming and Picture Recognition (declarative memory) tasks and Artificial Grammar Learning and the Alternating Serial Reaction Time (procedural memory) tasks. Finally, in section 4.3, the answers for each research question will be posed.

4.1 Descriptive Analyses

This section is divided into three subsections: tables 4.1 to 4.4 present the descriptive analyses for the linguistic memory tasks of the current study (Picture Naming and Artificial Grammar Learning tasks), divided into language groups (bilinguals and monolinguals) and proficiency groups (high and low proficiency), respectively. Tables 4.5 to 4.8 show the descriptive analyses for the nonlinguistic memory tasks (Picture Recognition and Alternating Serial Reaction Time tasks) of the present study, also divided into language groups and proficiency groups. Tables 4.1 to 4.8 report the mean reaction time (RT), accuracy (ACC) and standard deviation (SD) for the language and L2 proficiency group comparisons. The results for normality tests applied for the data analyses will be presented in table 4.9; tables 4.10 and 4.11 present the reaction time (RT) and accuracy (ACC) comparisons for language and proficiency groups in the Picture Naming and Artificial Grammar Learning tasks (linguistic) and Picture Recognition and Alternating Serial Reaction Time (non-linguistic) tasks, respectively. The statistical software SPSS v.2.0 was the program chosen to run the statistical analyses described in this section.

As explained in the Review of Literature, section 3.6.3.1.1, the Picture Naming task is a verbal linguistic task which assesses declarative memory. In this task, participants were required to name as fast and as accurately as possible, black-and-white pictures (drawing representations of objects, animals, people, and occupations) that appeared one by one at the center of a computer screen. Table 4.1 presents participants' mean reaction time and accuracy on the Picture Naming Task:

Table 4.1 *Descriptive statistics for the Picture Naming Task – Mean reaction time and accuracy by language groups (Bil and Mono)*

Language Groups	N	RT(in ms)	ACC(%)
Bil	32	1027.4(458.15)	83.1
Mono	8	1043.7 (507.0)	79.2

Note. Standard deviations (SD) are in parentheses; Bil = Portuguese-English bilinguals; Mono = Brazilian Portuguese monolinguals; N = total number of participants per group; RT = reaction time; ACC = accuracy (% of correct responses); ms = milliseconds

As shown in table 4.1, the mean reaction time of bilinguals (experimental groups) was lower than monolinguals (control group) (1027.4ms and 1043.7ms, respectively). That is, learners of English as an L2, at high and low proficiency, were faster at naming pictures in Portuguese than their monolingual counterparts. Table 4.1 also shows that monolinguals have higher standard deviation than the bilinguals (*SD* = 507 and *SD* = 458.15, respectively), which indicates that there was more variance in speed for the monolingual participants than for bilinguals in this task.

In addition to the reaction time data, table 4.1 shows that the mean accuracy of the bilingual participants was higher (83.1%) than that of monolinguals (79.2%). This shows that bilinguals' performance was more accurate than that of monolinguals. As reported in table 4.1, when the overall performance of bilinguals and monolinguals is compared, bilinguals performed faster and more accurately than monolinguals. Taken together, these results may be an indication that bilingualism brings benefits in declarative memory performance in a linguistic task. Table 4.2 presents the mean reaction time and accuracy of participants' performance on the Picture Naming task.

Table 4.2 *Descriptive statistics for the Picture Naming Task – Mean reaction time and accuracy by proficiency groups (High and Low)*

Proficiency/Language Groups	N	RT(in ms)	ACC(%)
High	16	974.36 (420.9)	87
Low	16	1080.44 (495.4)	79.2

Note. Standard deviations (SD) are in parentheses; High = high proficiency bilinguals; Low = low proficiency bilinguals; Mono = Brazilian Portuguese monolinguals; N= total number of participants per group; RT = reaction time; ACC = accuracy (% of correct responses); ms = milliseconds

As can be seen in table 4.2, the mean reaction times of high proficiency and low proficiency participants differ somewhat in the Picture Naming task (974.36ms and 1080.44ms, respectively). Table 4.2 shows that the mean reaction time of the high proficiency group is lower (974.36ms) than the low proficiency group (1080.44ms); also, comparing the standard deviation for high proficiency and low proficiency bilinguals, the variance in speed was smaller for the high proficiency group (*SD* = 420.9) than the low proficiency group (*SD* = 495.4). These results can be an indication that a higher L2 proficiency level may enhance the speed of performance on a linguistic task.

Regarding mean accuracy, high proficiency bilinguals were more accurate than their low proficiency peers (87% and 79.2%, respectively), that is, the high proficiency group provided a higher number of correct responses in the Picture Naming task than the low proficiency group.

It is possible that bilinguals groups were favored by their knowledge of a second language when performing a linguistic declarative memory task, in comparison to their monolinguals counterparts. Taken together, these results suggest that high proficiency bilinguals are faster and more efficient in a linguistic declarative memory task than low proficiency bilinguals; also, the results indicate that high proficiency bilinguals' overall performance was faster and more accurate in relation to the low proficiency group.

Moving on to the linguistic procedural memory task, table 4.3 presents the descriptive statistics (mean reaction time and accuracy) for the Artificial Grammar Learning Task for the experimental and control groups. In this task, participants should judge 26 letter strings as "following a (linguistic) pattern" or "not following a (linguistic) pattern".

Table 4.3 *Descriptive statistics for the Artificial Grammar Learning Task – Mean reaction time and accuracy by language groups (Bil and Mono)*

Language Groups	N	RT(in ms)	ACC(%)
Bil	32	2824.9 (1571.9)	59.45
Mono	8	3218.64 (2356.6)	61.3

Note. Standard deviations (SD) are in parentheses; Bil = Portuguese-English bilinguals; Mono = Brazilian Portuguese monolinguals; N = total number of participants per group; RT = reaction time; ACC = accuracy (% of correct responses); ms = milliseconds

As can be seen in table 4.3, the mean reaction time to judge whether a string followed a pattern, for both experimental and control groups, is high (approximately 3000ms). This is so possibly due to the instructions provided for participants on this task. These instructions emphasized accuracy as a central measure for this task (as instructions in experiments investigating the artificial grammar paradigm do) and reaction time, in this case, stands as a secondary variable of performance. Comparing bilinguals and monolinguals in table 4.3, it can be noticed that bilinguals had faster reaction times than monolinguals (2824.9ms and 3218.64ms, respectively). Also, bilinguals have a lower standard deviation (*SD* = 1571.9) in comparison to their monolingual peers (*SD* = 2356.6), which indicates that there was more variance in speed for monolinguals than for bilingual participants. Together, these results for reaction time show that bilinguals' overall performance in speed was lower than that of monolinguals'.

Considering the mean accuracy of performance on the Artificial Grammar Learning Task, as reported in table 4.3, contrary to expectations, monolinguals were more accurate than the bilingual groups (61.3% and 59.45%, respectively). When the performance of bilinguals and monolinguals is compared in this task, bilinguals performed faster, but less accurately than the monolinguals group. It is possible that bilinguals emphasized speed over accuracy, while monolinguals emphasized accuracy over speed.

Also, the monolingual participants learned their L1 in natural acquisition contexts, in which the learner is exposed to the language in social interaction with native speakers and this processing of learning is implicit, that is, turns into procedural knowledge through time and exposure. In this sense, monolinguals would be better conditioned to learn implicitly than bilinguals, especially because the bilinguals who took part in the present study are all L2 learners from traditional instructional settings, in which the learning process is explicit through formal instruction in a classroom context.

Next, table 4.4 presents the mean reaction time and accuracy for the proficiency groups (high and low) in the Artificial Grammar Learning task.

Table 4.4 *Descriptive statistics for the Artificial Grammar Learning Task – Mean reaction time and accuracy by proficiency groups (High and Low)*

Proficiency/Language Groups	N	RT(in ms)	ACC(%)
High	16	2840.69 (1605.2)	61,3
Low	16	2809.12 (1538.6)	57,6

Note. Standard deviations (SD) are in parentheses; High = high proficiency bilinguals; Low = low proficiency bilinguals; N = total number of participants per group; RT = reaction time; ACC = accuracy (% of correct responses); ms = milliseconds

Table 4.4 shows that, in this procedural memory linguistic task, the low proficiency bilinguals were faster (2809.12ms) at judging the grammaticality of strings than their high proficiency counterparts (2840.69ms). As regards the standard deviation, the low proficiency bilinguals have the lowest variance in speed (*SD* = 1538.6) in comparison to the high proficiency and monolingual groups (*SD* = 1605.2).

The mean accuracy for the Artificial Grammar Learning task in table 4.4 shows that the high proficiency bilinguals were more accurate in all trials (61.3% of accuracy) than the low proficiency group (57.6% of accuracy). It is possible to argue, thus, that the high proficiency group emphasized accuracy over speed of performance in this task. Taken together, these results suggest that a higher level of L2 proficiency may lead to more accurate, but not faster, performance on procedural memory linguistic tasks.

Having presented the descriptive analyses contrasting bilinguals and monolinguals and also high and low proficiency bilinguals in the linguistic tasks, I turn now to the descriptive analyses comparing the language groups and the proficiency groups in the nonlinguistic tasks chosen for the current study.

In the Picture Recognition task (nonlinguistic declarative memory task), as explained in the Method Chapter (section 3.6.3.1.2), participants were presented with a series of real and unreal black-and-white pictures for a very short amount of time each (500 milliseconds); after this time, each picture disappeared from the screen, and the participant's task was to decide whether the picture was "real" or "unreal", by pressing a specific button on a serial response box. Table 4.5 provides the descriptive analyses in the Picture Recognition task for the bilinguals and the monolinguals' groups.

Table 4.5 *Descriptive statistics for the Picture Recognition Task Mean reaction time and accuracy by language groups (Bil and Mono)*

Language Groups	N	RT(in ms)	ACC(%)
Bil	32	693.73 (217.55)	82.25
Mono	8	642.81 (283.4)	81.7

Note. Standard deviations (SD) are in parentheses; Bil = Portuguese-English bilinguals; Mono = Brazilian Portuguese monolinguals; N= total number of participants per group; RT = reaction time; ACC = accuracy (% of correct responses); ms = milliseconds

As can be seen in table 4.5, the monolingual participants reacted faster to stimuli than the bilinguals (642.81ms and 693.73ms, respectively). However, monolinguals have a much higher standard deviation (*SD* = 283.4) in relation to their bilingual peers (*SD* = 217.55). This may suggest that even though the monolinguals were faster than bilinguals, there was also more variance in their speed of performance.

Table 4.5 also presents the mean accuracy for the experimental and control group. Bilinguals provided more accurate responses than monolinguals in all trials (82.25% and 81.7%, respectively). Table 4.6 presents the mean reaction time and accuracy measures for the high and low proficiency groups on the Picture Recognition Task.

Table 4.6 *Descriptive statistics for the Picture Recognition Task – Mean reaction time and accuracy by proficiency groups (High and Low)*

Proficiency Groups	N	RT(in ms)	ACC(%)
High	16	707.16 (209.9)	87
Low	16	680.30 (225.2)	77.5

Note. Standard deviations (SD) are in parentheses; High = high proficiency bilinguals; Low = low proficiency bilinguals; N= total number of participants per group; RT = reaction time; ACC = accuracy (% of correct responses); ms = milliseconds

As can be seen in table 4.6, the mean reaction time of the low proficiency group is lower (680.30ms) than the high proficiency group (707.16ms). Besides, the low proficiency bilinguals have a higher variance in speed (*SD* = 225.2) in relation to their high proficiency counterparts (*SD* = 209.9), which indicates that the high proficient bilinguals had a lower variance in speed of performance in this task.

Considering bilinguals' and monolinguals' performance in accuracy, the high proficiency group was more accurate (87%) than their low proficiency group (77.5%). These results may suggest that high proficiency in an L2 favored these participants' performance in accuracy in comparison to their low proficiency counterparts.

Taken together, the results from this task and from the linguistic declarative memory task (Picture Naming) suggest that L2 proficiency favors performance in declarative memory tasks, especially in mean accuracy. The variance in speed of responses was lower for the high proficiency group in both declarative memory tasks; however, the mean reaction time was faster only in the linguistic declarative memory task (see table 2). Speculatively, it is possible to argue that the higher the proficiency, the greater the advantage in tasks that assess declarative memory linguistically. Furthermore, bilingualism seems to play a role in declarative memory tasks' performance as well, since bilinguals outperformed monolinguals in mean accuracy and had a lower variance in speed of responses in these tasks. This will be discussed in further detail in section 4.2, when the results will be reported from the inferential analyses.

In the Alternating Serial Reaction Time, which is a nonlinguistic procedural memory task, participants were instructed to press one of four keys on an SRBOX, each corresponding to the position in which the stimulus (a smiley-faced cartoon) appeared inside circles on the screen. Table 4.7 presents the mean reaction time and accuracy of the high and low proficiency bilinguals and the control group of Brazilian Portuguese monolinguals in the Alternating Serial Reaction Time task.

Table 4.7 *Descriptive statistics for the Alternating Serial Reaction Time Task – Mean reaction time and accuracy by language groups (Bil and Mono)*

Language Groups	N	RT(in ms)	ACC(%)
Bil	32	417.69 (119.9)	92.6
Mono	8	452.1 (120)	95.8

Note. Standard deviations (SD) are in parentheses; Bil = Portuguese-English bilinguals; Mono = Brazilian Portuguese monolinguals; N = total number of participants per group; RT = reaction time; ACC = accuracy (% of correct responses); ms = milliseconds

As seen in table 4.7, the experimental groups were faster (417.69ms) in responding to nonlinguistic stimuli in a procedural memory task than the control group of monolinguals. Regarding accuracy, monolinguals outperformed bilinguals in the number of correct responses in this task (95.8% and 92.6%, respectively). In this task, the performance of bilinguals was less accurate than that of monolinguals, which may be an indication that bilinguals emphasized speed over accuracy in the Alternating Serial Reaction Time task.

Table 4.8 *Descriptive statistics for the Alternating Serial Reaction Time Task – Mean reaction time and accuracy by proficiency groups (High and Low)*

Proficiency Groups	N	RT(in ms)	ACC(%)
High	16	416.91 (116.6)	95.2
Low	16	418.47 (123.2)	90

Note. Standard deviations (SD) are in parentheses; High = high proficiency bilinguals; Low = low proficiency bilinguals; N= total number of participants per group; RT = reaction time; ACC = accuracy (% of correct responses); ms = milliseconds

As shown in table 4.8, the high proficiency bilinguals were faster than their low proficiency counterparts in overall reaction time. Comparing the high proficiency group and the low proficiency group, it can be noticed that the mean scores in overall reaction time (RT) is very close (416.91ms and 418.47ms, respectively), but the high proficiency group shows lower variance in speed of responses in comparison to the low proficiency one (*SD* = 116.6 and *SD* = 123.2, respectively), which favors the high proficiency bilinguals in reaction time results.

As regards mean accuracy, the high proficiency bilinguals performed better than their low proficiency peers (95.2% and 90%, respectively).

High proficiency bilinguals overall performance in the Alternating Serial Reaction Time was faster and more accurate than their low proficiency counterparts, which may be an indication that L2 proficiency level plays a role in the performance of a nonlinguistic implicit memory task.

In sum, the results of the descriptive statistical analyses for the linguistic tasks (Picture Naming and Picture Recognition tasks) so far indicate that bilingualism, especially at a higher level of L2 proficiency seems to contribute positively to performance on declarative and procedural memory linguistic tasks, mostly in the dependent variable reaction time. It can also be observed that, although to a lesser extent, learning a second language influences positively participants' performance on nonlinguistic declarative and procedural memory tasks, since most comparisons favored the bilinguals in relation to their monolingual peers. In such tasks, the bilingual participants outperformed the monolinguals in overall reaction time results.

The results so far also show that bilingualism, especially at a high L2 proficiency level, contributes positively to accurate performance on tasks of declarative memory, mostly when these are linguistic tasks. In procedural memory tasks, L2 proficiency seems to contribute not only to faster but also to more accurate performance, especially on nonlinguistic tasks. Having reported the results of the descriptive statistics for the four tasks applied in the present study, I turn now to the results of the statistical tests used to verify whether the perceived differences in all group comparisons described previously in this section were statistically significant.

4.2 Inferential analyses

For the present investigation, statistical tests were run in order to verify whether there were significant differences between the proficiency/language group comparisons (high proficiency, low proficiency and monolinguals) in the Picture Naming, Picture Recognition, Artificial Grammar Learning and Alternating Serial Reaction Time tasks for the dependent variables reaction time (RT) and accuracy (ACC). Next, the results will be presented, followed by a discussion.

On the first attempt to analyze the data, the outcomes resulted in many outliers and the median of performance for the *t*-test and ANOVA[1] was not at the center of the distribution – this indicates these data were *not* normally distributed. In order to test for the normality of the data, the Shapiro-Wilk

[1] One-way analysis of variance.

normality test was run. Table 7 presents the results for the Shapiro-Wilk normality tests applied in the data analyses for reaction times (RT).

Table 4.9 *Shapiro-Wilk normality tests' results for the different proficiency/ language groups*

Memory Task	Proficiency	Statistics	Df	*p*-value
Picture Naming	High	0.807	3110	0.000
	Low	0.844	3007	0.000
	Mono	0.844	1493	0.000
Artificial Grammar Learning	High	0.704	512	0.000
	Low	0.668	512	0.000
	Mono	0.670	256	0.000
Picture Recognition	High	0.820	1917	0.000
	Low	0.785	1920	0.000
	Mono	0.598	959	0.000
Alternating Serial Reaction Time	High	0.843	2720	0.000
	Low	0.828	2720	0.000
	Mono	0.858	1360	0.000

Note. High=high proficiency bilinguals; Low=low proficiency bilinguals; Mono=Brazilian Portuguese monolinguals; df= degrees of freedom *(that is, the quantity of values that are free to vary in an statistical calculus result)*; *p*-value= probability of significance

As can be seen in table 4.9, all variables analyzed report a *p* (probability) value of 0.000, which is below the significance level determined for the data analyses ($\alpha = .002$). This confirms that these variables are *not* normally distributed. In an attempt to decrease the number of outliers or at least induce the data to normal distribution, some statistical procedures were applied, with no satisfactory results. As a result, the analyses were run without any changes on the original data.

Given that the data is not normally distributed, it was not possible to run parametric statistics on the analyses. Thus nonparametric statistical tests were chosen in order to compare the medians, *not* the means, between the variables. To do so, Mann-Whitney was the test applied to run the RT comparisons for the proficiency/ language groups for this study.

To verify whether the number of correct responses (accuracy) between groups was different, another nonparametric technique, the Chi-square was used. This technique allows the researcher to determine whether what is observed in a distribution of frequencies would be what is expected to occur by chance (Salkind, 2008). Next, table 4.10 reports the results for the declarative memory tasks.

Table 4.10 *RT and ACC comparison for the proficiency/ language groups in the declarative memory tasks*

Memory System	Task Type	Task Name		RT	ACC	
			Comparison	*p*-value	*Statistics*	*p*-value
Declarative	Ling	PN Task (1)	*High/Low*	***0.000***	***66.866***	***0.000***
			High/Mono	***0.000***	***47.706***	***0.000***
			Low/Mono	***0.001***	0.000	0.990
	NonLing	PR Task (2)	High/Low	0.950	***62.781***	***0.000***
			High/Mono	0.251	***72.973***	***0.000***
			Low/Mono	0.146	0.038	0.845

Note. RT = reaction time; ACC = accuracy; Ling = Linguistic; NonLing = nonlinguistic; PN = Picture Naming; PR = Picture Recognition

As can be seen in table 4.10, there are statistically significant differences between the groups High/Low (p = 0.000), High/Mono (p = 0.000) and Low/Mono (p = 0.001) for reaction time in task 1, the Picture Naming Task, which is a linguistic declarative memory task. However, no statistically significant differences were found between the groups for reaction time (p > 0.0002) in task 2, the Picture Recognition Task, a nonlinguistic declarative memory task. These results show evidence that, for the Picture Naming task, bilinguals responded faster to linguistic verbal stimuli than monolinguals, especially the high proficiency group, which outperformed the low proficiency group in the comparison for mean reaction time in this task. Also, results show that for the Picture Recognition Task, in which the group comparisons showed no statistically significant difference, the three proficiency groups performed similarly in time responses.

As shown in table 4.10, for the accuracy results in the declarative memory tasks, significant differences were found in the comparisons between the High/Low (*p* = 0.000) and High/Mono (*p* = 0.000) for task 1 – the Picture Naming Task (a linguistic task), showing that the high proficient bilinguals performed more accurately than their low proficient and monolingual counterparts. Moreover, there are also statistically significant differences between the High/Low (*p* = 0.000) and High/Mono (*p* = 0.000) for task 2 – the Picture Recognition Task (a nonlinguistic task), which also favors the high proficient bilinguals' group in number of correct responses given for this task. Table 4.11 reports the results for the procedural memory tasks.

Table 4.11 *RT and ACC comparison for the proficiency/ language groups in the procedural memory tasks*

Memory System	Task Type	Task Name	Comparison	RT *p*-value	ACC Statistics	*p-value*
Procedural	Ling	AGL Task (3)	High/Low	0.000	1.313	0.252
			High/Mono	0.000	0.006	0.937
			Low/Mono	0.183	0.823	0.364
	NonLing	ASRT Task (4)	High/Low	0.159	***52.767***	***0.000***
			High/Mono	*0.000*	0.589	0.443
			Low/Mono	*0.000*	***40.082***	***0.000***

Note. RT = reaction time; ACC = accuracy; Ling = Linguistic; NonLing = nonlinguistic; AGL = Artificial Grammar Learning; ASRT = Alternating Serial Reaction Time

As for the procedural memory tasks' RT comparisons seen in Table 4.11, the results show that there are no statistically significant differences between the groups for task 3 ($p > 0.0002$), the Artificial Grammar Learning Task. This result suggests that high and low proficiency bilinguals as well as monolingual participants had a similar performance for reaction time in this task.

The results presented in Table 4.11 show significant differences between the High/ Mono (*p* = 0.000) and the Low/ Mono (*p* = 0.000) groups' reaction times in the Alternating Serial Reaction Time Task (task 4), which means that bilinguals outperformed monolinguals in response times in these group comparisons.

Table 4.11 also shows that there were no statistically significant differences between the groups for accuracy ($p > 0.0002$) in the performance of the Artificial Grammar Learning Task (task 3). This suggests that accuracy was as successful for high and low proficient bilinguals as it was for monolinguals.

In contrast, for the Alternating Serial Reaction Time Task, statistically significant differences were found in accuracy measures for the comparisons between High/ Low ($p = 0.000$) and Low/Mono ($p = 0.000$) groups. This result shows evidence that high and low proficient bilinguals responded more accurately than their monolingual peers. Now, I turn to the discussion of the findings of the present investigation.

As explained in the Review of Literature, the Picture Naming Task (e.g., Szekely et al., 2004; 2005) is a linguistic task that aimed at assessing declarative memory. Szekely and colleagues (2004) point out that Picture Naming is a widely used technique for the investigation of lexical retrieval in normal children, adults and in various clinical populations. In the present study, for reaction time (RT) scores, results have shown a statistically significant difference for the three group comparisons, favoring the bilinguals in relation to monolinguals' performance, especially the highly proficient group.

Speculatively, it can be argued that bilinguals at high proficiency may be more efficient in performance in linguistic declarative memory tasks. In this case, high L2 proficiency seems to contribute to a better performance in this type of task. Also, some participants in the group were early bilinguals, which is a condition that may promote some advantage in verbal memory tasks, such as in the Picture Naming Task, for bilinguals (Kramer, 2011). In a recent study, Kaushanskaya (2012) argues that bilingualism may facilitate lexical learning in adults. The author first examined whether bilingual influences on word learning diverge for phonologically-familiar and phonologically-unfamiliar novel words. The author explored whether increased phonological memory capacity can account for bilingual effects on word learning. Two experiments were conducted and in each experiment bilingual adults were compared with two groups of monolingual adults: a high memory-span monolingual group (that matched bilinguals on phonological memory performance) and a low memory-span monolingual group. Results indicated that bilingual participants in both experiments outperformed monolinguals, both high span and low span, which suggests a positive influence of bilingualism in cognitive mechanisms involving lexical knowledge as well as a bilingual advantage in memory.

Another study (Runnqvist & Costa, 2012) shows that bilingualism seems to protect L1 memory. In Runnqvist and Costa (2012), three groups of Spanish-English bilingual participants were first shown drawings along with their labels in their non-dominant language. Afterwards, they named 75% of these drawings in their first language or in their non-dominant language. After that, participants' memory of all L1 words was tested through the presentation of a rhyme-cue. Results showed that the recall of L1 words was better after naming pictures in the non-dominant language, compared to when the picture was not named at all. This result suggests that speaking a second language seems to preserve the memory of our first language.

The results for the Picture Naming Task may be interpreted as an indication that being able to use a second language, regardless of the proficiency level, contributes to the fast performance of bilinguals on cognitive memory tasks. These findings add evidence to the claim that bilingualism brings verbal memory benefits (Bialystok, 2006).

Now, a considerable body of research shows that the development, efficiency and decline of crucial cognitive abilities are different for bilinguals than monolinguals (Bialystok, Craik & Luk, 2008). Studies conducted abroad with adult bilinguals report that the verbal skills of bilinguals in each language are generally weaker than those for monolingual speakers of each language (e.g. Bialystok, 2009; 2010; Bialystok, Craik & Luk, 2008). Regarding simply receptive vocabulary size, bilingual children (e.g. Bialystok et al., 2010) and adults (e.g. Bialystok & Luk, 2011) control a smaller vocabulary in the language of the community than do their monolingual counterparts (Bialystok, Craik & Luk, 2008). On picture-naming tasks, according to such studies, bilingual participants are usually slower (e.g. Bialystok et al., 2008) and less accurate (e.g. Gollan et al., 2007) than monolinguals. Performance on these tasks, according to these authors, reveal that the simple act of retrieving a common word is more effortful for bilinguals (e.g. Bialystok, Craik & Luk, 2008). In a review by Michael and Gollan (2005), the authors stress that such deficits "are quite limited, but they attribute the observed reduction in fluency to the bilingual's need to maintain a vocabulary base approximately twice as large as that of a monolinguals and to reduced frequency with which bilinguals access any particular word (p. 290). Thus, these conditions would result in weaker links between words and concepts for bilingual individuals (Michael & Gollan, 2005)

In this sense, results for the current study are at odds with these findings. In the case of the present study, in which bilingual participants outperformed monolinguals in most comparisons run in the four memory tasks, and notably in the linguistic declarative memory task, a possible explanation is that the bilinguals who took part in the studies carried out abroad (e.g., Bialystok, 2009; 2010; Bialystok & Craik, 2010; Bialystok et al., 2008; Bialystok et al., 2010; Bialystok, Craik & Luk, 2008; Gollan et al., 2007; Ivanova & Costa, 2008; Michael & Gollan, 2005)[2] speak both L1 and L2 on a daily basis, since they live in countries with a larger number of bilinguals[3], that is, their amount of exposure to the L2 is much higher in relation to the bilinguals of the present study. The bilingual population that took part in the present study has less practice and experiences fewer opportunities to enhance skills in the L2. For the most part, the bilingual participants of the present study have learned English as a foreign/additional language. Therefore, these findings for a bilingual advantage in memory tasks, especially in the linguistic (verbal) aspect of declarative memory, may be an indication that a further variable – formal L2 instruction – may contribute to declarative and procedural memory.

In contrast to the pattern of conflicting results in bilingual performance, research has shown that bilinguals at all ages demonstrate better executive control than monolinguals matched in age and other background factors (Bialystok, 2010; Bialystok, Craik & Luk, 2008). Executive control is the set of cognitive skills based on limited cognitive resources for such functions such as inhibition, switching attention, and working memory (Miyake et al., 2000). Executive control emerges late in development and declines early in aging; also, it supports activities such as high-level thought, multi-tasking, and sustained attention (Bialystok, Craik & Luk, 2008). This bilingual advantage has been shown to extend

[2] According to the 1996 Canadian Census, 11% of Canadians spoke English or French at home in addition to some other language; when only respondents over 65 years of age were considered, the figure was 13%. In the USA, 17.9% of Americans reported that they spoke a language other than English at home (USA Census Bureau, 2003). Given the prevalence of bilingualism in North American society, (and such prevalence is certainly greater in the European context as well) (Bialystok, Craik, Klein & Viswanathan, 2004), it is important to consider that the effects of bilingualism on cognitive processing for the population in those countries/contexts may provide different outcomes from Brazil/ the Brazilian context and, therefore, different results into practice.

[3] http://www.census.gov/compendia/statab/cats/population/ancestry_language_spoken_athome.html

into older age and protect against cognitive decline (Bialystok et al., 2004; Bialystok et al., 2008; Kramer, 2011). Results from the current study extrapolate from the body of research previously mentioned. They provide data results in which bilingualism seems to contribute to long-term memory systems, especially to the linguistic aspect of declarative memory. Experience with two language systems seems to conduct to a mental flexibility, some sort of superiority in concept formation, a more diversified set of mental abilities (Peal & Lambert, 1962) and therefore more efficient memory systems, notably in cognitive and linguistic performance of declarative memory. In this line, bilinguals do sometimes have an advantage in inhibition, but they also have an advantage in selection; bilinguals do sometimes have an advantage in switching, but they also have an advantage in sustaining attention (Bialystok, Craik & Luk, 2008). Additionally, bilinguals do sometimes have an advantage in working memory, but they also may have an advantage in representation in and retrieval from long-term memory.

As regards the results from the Picture Recognition Task, which is a nonlinguistic declarative memory task that required participants visual identification to stimuli in an attempt to recognize the picture stimuli as *real* or *unreal,* bilingual performance was not satisfactory in mean reaction time, which is in line with Bialystok findings (e.g. Bialystok, 2009; Bialystok, Craik & Luk, 2008), who claims for a low level of performance for bilinguals in mental processing in relation to monolinguals, or even equivalent scores in non-verbal tasks. In the present study there was no statistically significant difference among the groups for reaction time on the Picture Recognition Task. The findings also show that there was an advantage for bilinguals in accuracy Thus, again, bilingualism seems to contribute to cognitive processing, enhancing aspects of cognitive functioning, such as those related to memory systems (e.g. Bialystok, Craik & Luk, 2008; Salthouse & Mitchell, 1990).

The findings for the Artificial Grammar Learning Task, which is a linguistic task to measure participants' implicit learning and memory, show that bilinguals outperformed monolinguals in speed over accuracy, especially the low proficient group. This group, speculatively, might be more concerned with their speed responses over their number of correct responses.

There were no statistically significant differences, in relation to any of the group comparisons run, in mean reaction time and accuracy on this task. This is possibly due to strategies that participants applied to complete the task and to perform the task procedures, which were not related to participants' language proficiency or enhanced by their proficiency or linguistic level. The Artificial Grammar Learning Task has been extensively applied to investigate implicit and explicit processing (e.g., Chang & Knowlton, 1996; Knowlton & Squire, 2004). It is possible to argue, thus, that the proficiency level in an L2 is not crucial for accurate performance on procedural memory tasks, at least the linguistic type of task. Speculatively, it can be argued that individual factors, such as level of concentration on the letter strings formation, but not L2 proficiency, would explain these results.

The results from the Alternating Serial Reaction Time, a task that also assesses participants' procedural memory, show that bilinguals outperformed monolinguals. A tentative explanation for these findings is that, since it requires the participant to focus on the screen and to follow the stimulus shown in the circles, the task taps executive control processes which, as has been explained previously in this chapter, are positively affected by bilingualism.

4.3 Readdressing the Research Questions

In this section, the research questions for the present study are readdressed.

Research question 1: Do young adults, native speakers of Brazilian Portuguese at high proficiency in English as an L2, outperform those at low proficiency and the Brazilian Portuguese monolinguals in the 'Picture Naming' and the 'Artificial Grammar Learning' tasks?

The answer is yes, at least in part. From the eight comparisons between the high proficiency group and the low proficient and monolingual groups, six comparisons (which represent 75% out of eight comparisons run) showed a statistically significant difference between the groups, indicating that the high proficiency group outperformed the low proficiency group and the monolinguals and suggesting a positive effect of proficiency in L2 in linguistic memory tasks in the dependent variables reaction time and accuracy. The findings indicate that bilingualism, especially at a high L2 proficiency level, contributes to more accurate performance on tasks of declarative memory, mostly in the linguistic task. These results relate to the large body of research that has documented differences in linguistic ability between monolingual and bilingual adults on tests that require lexical access and fluency (e.g., Bialystok & Luk, 2012).

Research question 2: Do young adults, native speakers of Brazilian Portuguese at high proficiency in English as an L2, outperform those at low proficiency and the Brazilian Portuguese monolinguals in the 'Picture Recognition' and the 'Alternating Serial Reaction Time' tasks?

The answer is yes, at least in part. From the eight comparisons between the high proficiency group and the low proficiency and monolinguals' group, four of them (which represent 50% out of eight group comparisons) showed a statistically significant difference in the comparisons run, in which the high proficiency group outperformed the low proficiency and monolinguals' group. These results suggest a positive effect of proficiency in L2 on the Picture Recognition and Alternating Serial Reaction Time memory tasks, both in accuracy and reaction time. On such tasks, bilinguals outperformed monolinguals in overall results, especially in nonlinguistic/ implicit memory task.

In the next chapter, the final remarks of the present study will be reported.

CHAPTER V

FINAL REMARKS

The main objective of this study was to investigate the effect of L2 proficiency on two long-term memory systems – declarative and procedural memory. More specifically, the present study aimed at exploring the performance of 40 participants (32 Portuguese-English bilinguals at different levels of proficiency in their L2 – low proficiency and high proficiency, and 8 Brazilian Portuguese monolinguals) in their early adulthood, in declarative and procedural memory tasks in their L1.

This investigation was organized as follows: Chapter I presented the introduction of the study. Chapter II provided the review of literature, with theoretical issues related to human memory, bilingualism and language proficiency. Chapter III was devoted to the method adopted in the present study, in order to collect and analyze the data generated. The results and discussion are presented in Chapter IV. This chapter also provided the answers for the research questions pursued in this study. The main purpose of the present chapter, Chapter V, is to summarize the results, point out its limitations, and bring suggestions for further research. This final chapter will also present the pedagogical implications of the present findings.

5.1 Conclusions

The most relevant results obtained from data analysis in the current study were:

1. Comparing bilinguals and monolinguals' performance in declarative memory tasks, bilinguals outperformed monolinguals in accuracy and speed of performance, and were faster in the linguistic declarative memory task;

2. Comparing bilinguals and monolinguals' performance in procedural memory tasks, bilinguals outperformed monolinguals in overall speed of responses (reaction time and standard deviation measures). Thus, most comparisons between these two language groups favored bilinguals in memory tasks' performance, especially in declarative memory (75% of all comparisons run).

3. Comparing high proficiency and low proficiency bilinguals' performance in declarative memory tasks, the high proficiency group performed more accurately and had a better speed of performance than monolinguals; additionally, the high proficiency bilinguals were faster in their response to stimuli in the linguistic memory task.

4. Comparing high proficiency and low proficiency bilinguals' performance in procedural memory tasks, high proficiency bilinguals outperformed their monolingual counterparts in accuracy and in speed of performance (the latter only in the nonlinguistic task) and responded faster to stimuli in the nonlinguistic task. For the two proficiency groups of the present study, most comparisons between high and low proficiency bilinguals favored the high proficiency group in memory tasks' performance, especially in declarative memory (with 66,6% of all comparisons run).

Overall results suggest that bilinguals perform more accurately and have a faster speed of performance in linguistic declarative memory tasks; also, results indicated that a higher level of L2 proficiency seems to contribute to overall performance in linguistic memory tasks both in declarative and procedural memory, in the dependent variable accuracy, mostly in declarative memory tasks. It can also be observed that L2 proficiency does not seem to positively influence participants' performance in nonlinguistic declarative and procedural memory tasks. Results also seem to indicate that the proficiency factor in an L2 contributes to a better performance in tasks of declarative memory in the dependent variable accuracy, or number of correct responses. That is, bilingualism seems to play an important role in memory tasks' overall performance, and seems to contribute especially to a more accurate performance in this type of tasks. In addition, the descriptive statistics so far shows that L2 proficiency does not seem to contribute to a greater performance of bilinguals in procedural memory tasks in number of correct responses.

The proficiency level of an individual in a second language (L2) seems to affect positively performance of declarative and procedural memory linguistic tasks as regards reaction time; besides, L2 proficiency, regardless of the level, does not seem to contribute to overall performance of bilinguals in nonlinguistic declarative and procedural memory, in the variable reaction time. The results of this investigation speak in favor of a positive relationship between the construct of (long-term) memory and language proficiency in the L2.

5.2 Limitations and suggestions for further research

The current investigation was carried out to investigate whether L2 proficiency affects declarative and procedural memory systems. Due to the nature of the present study, the results gathered from this investigation are to be seen suggestive rather than conclusive. Despite the fact that it has been methodologically and theoretically driven by related literature, the present study suffered from limitations. In this section, some limitations of this study followed by some suggestions for further research will be presented.

First, the present study was limited in relation to the number of participants. Although all participants went through the same memory tasks and were comparable in educational and language background aspects within each group, no generalizations can be posed since the data collected represented just a small sample of bilinguals and monolinguals. Further research should consider a different approach to gather more participants and attempt to work with a larger and more expressive sample.

The present study explored the relationship between memory systems and language proficiency with a young population of learners. Further research should address the role of L2 proficiency with different populations (infants and older adults).

Finally, the present study included L2 learners at two broad levels of proficiency –high and low. Further research should consider designs with different proficiency levels and different types of bilinguals (e.g., early bilinguals). More specifically, further research should also attempt to assess proficiency in a more global manner and not only by means of standardized proficiency tests such as the ones used in the present investigation.

The next section will provide the implications that can be addressed from the results obtained in the present study.

5.3 Pedagogical implications

In this section, some pedagogical implications of the present investigation will be posed.

A possibly important pedagogical implication, based on the findings of the present study, is to encourage learners, especially from adolescence on, to learn and study a second (L2) language. As shown by this study and other related research, there are positive effects of bilingualism on cognitive functioning.

Another important pedagogical implication of this study is related to L2 classrooms. In this context, teachers encounter a great variety of students with different learning backgrounds, different learning aptitudes, distinct levels of proficiency of motivation, and also, different memory skills and abilities. Although memory experiments are not run or applied at schools, teachers must be aware of learners' individual differences in long-term memory, and how this may play a role in their learning and performance.

To conclude, the current study attempted to compare the performance of groups of bilinguals and to discuss the between-group findings in relation to their language proficiency. In the present study, this variable, probably along with other variables, "plays an important role in our understanding of language processing in bilinguals". (Grosjean, 1998, p.422). The findings of the present study also underscore the notion that language proficiency should be taken seriously because it is fundamental in the study of language acquisition and bilingualism from a cognitive perspective (Hulstjin, 2011). Despite conceptual and methodological issues, such as the definition and measurement of levels of language proficiency, the present study provokes us to further reflect on the interrelated nature of language and cognition and also on the constructive influence of bilingualism on cognitive processing.

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APPENDIX A

UNIVERSIDADE FEDERAL DE SANTA CATARINA
CENTRO DE COMUNICAÇÃO E EXPRESSÃO
PROGRAMA DE PÓS GRADUAÇÃO EM INGLÊS E LITERATURA CORRESPONDENTE

Formulário de Consentimento Livre e Esclarecido

Título do Projeto: *"Investigating the relationship between memory systems and L2 proficiency: a psycholinguistic study*". (Investigando a relação entre sistemas de memória e proficiência em L2: um estudo psicolinguístico.).

A memória é um dos processos mentais que compõem a cognição humana. Juntamente com a atenção, o raciocínio, o pensamento e a linguagem, a memória é parte fundamental de nossas funções cognitivas. É através dessas funções que o ser humano é capaz de interagir com outros seres humanos e com o ambiente em que vive. Esta interação ocorre em grande parte pelo uso da linguagem, que no caso dos indivíduos bilíngües é representada mentalmente por dois sistemas lingüísticos – línguas – distintos. Considerando as informações acima, este estudo visa explorar o desempenho em tarefas de memória declarativa, procedural e de trabalho em uma população bilíngüe de jovens adultos em diferentes níveis de proficiência na segunda língua (inglês).

Objetivo do Estudo: O objetivo desse estudo é investigar a relação entre diferentes sistemas de memória e diferentes níveis de proficiência (baixa proficiência e alta proficiência) na L2. 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), e também para publicação de artigo(s) científico(s).

Procedimentos: Se você aceitar participar desse estudo, primeiramente você deverá responder a dois questionários, em forma de entrevista. Você também será submetido(a) a um teste de proficiência e a oito tarefas cognitivas no computador, em português, em horário(s) acordado(s) com a pesquisadora. As tarefas cognitivas serão realizadas no

Laboratório da Linguagem e Processos Cognitivos (LabLing/UFSC) e as respostas serão armazenadas 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 resolver desistir, não há problema algum. Você poderá desistir a qualquer momento. Peço apenas que você me notifique, não é necessário se justificar.

Pesquisadora responsável: Daniela Brito de Jesus (danielabrito79@yahoo.com; (48) 9953-3436)

Declaração de consentimento:

Declaro que li as informações acima. Quando necessário, fiz perguntas e recebi os esclarecimentos necessários. Eu CONCORDO em participar deste estudo.

Nome:____

Data:____________

Outras informações: ____

Assinatura do participante responsável

Assinatura da pesquisadora

APPENDIX B

UNIVERSIDADE FEDERAL DE SANTA CATARINA
CENTRO DE COMUNICAÇÃO E EXPRESSÃO
PROGRAMA DE PÓS GRADUAÇÃO EM INGLÊS E LITERATURA CORRESPONDENTE

<u>Pesquisa</u>: Investigando a relação entre sistemas de memória e proficiência em L2: um estudo psicolinguístico.

<u>Orientadora</u>: Prof. Dr. Mailce Borges Mota (DLLE/ PPGI/ CNPq/ UFSC)

<u>Pesquisadora</u>: Daniela Brito de Jesus (Mestranda PPGI/ CAPES/ UFSC)

QUESTIONÁRIO LINGUÍSTICO - Bilíngues (Português/ Inglês)
Informações pessoais
A) Forneça as informações solicitadas abaixo:

1. Nome do participante: ____________________________________
2. Profissão/ Ocupação: ______________________________________
3. Nível de escolaridade:
   ( ) Ensino Médio completo
   ( ) Ensino Médio incompleto
   ( ) Superior completo
   ( ) Superior incompleto
   ( ) Pós-graduação – Especialização
   ( ) Pós-graduação – Mestrado
   ( ) Pós-graduação – Doutorado

B) Informações linguísticas
Preencha ou assinale as informações abaixo:

4. Quantos idiomas você fala? ( )1 ( ) 2 ( ) 3 ( ) 4 ou mais
Quais são?____
5. Quantos idiomas você entende? ( )1 ( ) 2 ( ) 3 ( ) 4 ou mais

Quais são? ____

6. Você se considera fluente em inglês? (É considerado fluente aquele que consegue se comunicar na segunda língua sem precisar recorrer à língua materna)
( ) sim ( ) não

7. Com que idade você começou a aprender inglês? ________________

8. Com que idade você percebeu que já tinha o domínio do inglês? _____

9. Você se sente à vontade para conversar em inglês com alguém estranho?
( ) sim ( ) não

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

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

Idioma	**Fala**	**Compreensão**	**Oral**	**Leitura**	**Escrita**
Inglês	_____	______	______	______	______

12. Você já morou num país no qual a língua inglesa seja o idioma oficial?
( ) sim ( ) não
Se 'sim', responda as perguntas abaixo:
Onde você morou? _____________________________________
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) ________________

C) Instrução em língua inglesa

Preencha ou assinale as informações abaixo:

Você frequentou aulas de inglês num curso de línguas?
(   ) sim (   ) não
Se 'sim', por quanto tempo você frequentou as aulas?
____
Você já teve algum outro tipo de instrução formal em inglês? (Ex.: professor particular)

____

Você continua tendo aula de inglês?   (   ) sim (   ) não

Se 'sim', qual seu nível? ____________________________________

D) Informações pertinentes ao uso da língua inglesa

Assinale a alternativa que mais combina com você atualmente:

a) Comunico-me somente em uma das línguas (por exemplo, português);
b) Comunico-me essencialmente em português, e em inglês raramente;
c) Comunico-me essencialmente em português, e em inglês ocasionalmente (Ex.: em sala de aula apenas).
d) Comunico-me tanto em português quanto em inglês, com a mesma regularidade nas duas línguas.

Informações pertinentes ao contexto e a exposição à língua inglesa

Com que frequência você se encontra num ambiente onde o português e o inglês possam ser utilizados alternadamente? Assinale abaixo.

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

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

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APPENDIX C

TASK INSTRUCTIONS – PICTURE NAMING TASK

Bem-vindo (a) à tarefa de NOMEAÇÃO DE FIGURAS.

Nesta tarefa você verá uma série de figuras, apresentadas uma de cada vez, representando um SUBSTANTIVO CONCRETO que você conhece.
Você deve nomear em APENAS UMA PALAVRA cada uma dessas figuras. Faça SILÊNCIO TOTAL antes da apresentação de cada uma das figuras.

Tente ser o mais rápido possível, pois vamos medir seu tempo de reação.

Pressione "ESPAÇO" para aprender como o experimento funciona.

APPENDIX D

TASK INSTRUCTIONS FOR THE PICTURE RECOGNITION TASK

Bem- vindo (a) à tarefa de RECONHECIMEN-TO DE FIGURAS.

Nesta tarefa você verá uma série de figuras REAIS e IRREAIS.

Pressione “1” para REAL e pressione “5” para IRREAIS.

Tente ser o mais rápido possível, pois estamos medindo o seu tempo de reação.

Pressione “ESPAÇO” para aprender como o experimento funciona.

APPENDIX E

TASK INSTRUCTIONS FOR THE ARTIFICIAL GRAMMAR LEARNING TASK
(LEARNING PHASE)

Bem-vindo (a) à tarefa GA.

Nas telas a seguir serão apresentados conjuntos de 2 a 6 letras, compostos pelas letras N, W, Y e F.

Você deverá ler e memorizar esses conjuntos e escrevê-los na folha de papel quando saírem da tela. Nessa fase, você vai se familiarizar com a tarefa.

Vamos começar?

Pressione "ESPAÇO" para começar.

(TRAINING PHASE)

Nas telas a seguir, serão apresentados novos conjuntos de 2 a 6 letras, agora compostos pelas letras V, T, X e J.

Você deverá ler e memorizar esses conjuntos e escrevê-los na folha de papel quando saírem da tela.

Vamos começar?

Pressione "ESPAÇO" para começar.

(TESTING PHASE)

A ordem das letras nos conjuntos apresentados anteriormente foi determinada por uma série de regras complexas. A seguir, serão apresentados conjuntos de letras por um tempo indeterminado. Sua tarefa será decidir se cada um dos itens foi ou não formado de acordo com as mesmas regras complexas da última sessão.

Se você achar que o conjunto de letras apresentado segue as mesmas regras dos conjuntos da sessão anterior, pressione “1” para SIM; caso contrário, pressione “5” para NÃO.

Como as regras são muito complexas, tome por base a sua intuição.

Pressione “ESPAÇO” para começar o experimento.

APPENDIX F

POST-TASK QUESTIONNAIRE – ARTIFICIAL GRAMMAR LEARNING TASK

UNIVERSIDADE FEDERAL DE SANTA CATARINA
CENTRO DE COMUNICAÇÃO E EXPRESSÃO
PROGRAMA DE PÓS-GRADUAÇÃO EM INGLÊS E LITERATURA CORRESPONDENTE

Pesquisa: Investigando a relação entre sistemas de memória e proficiência em L2: um estudo psicolinguístico.

Orientadora: Prof. Dr. Mailce Borges Mota (DLLE/ PPGI/ CNPq/ UFSC)

Pesquisadora: Daniela Brito de Jesus (Mestranda PPGI/ CAPES/ UFSC)

QUESTIONÁRIO COMPLEMENTAR PARA BILÍNGUES E MONOLÍNGUES

(acerca da tarefa de memória procedural linguística)

1.) Você utilizou alguma estratégia para extrair as regras das sequências apresentadas no experimento? Se sim, qual(is) estratégia(s)?

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2.) Você tentou buscar padrões explícitos nas sequências de letras? Se sim, qual(is)?

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3.) Você se preocupou mais em diferenciar as sequências corretas das incorretas ou em responder mais rapidamente? Justifique sua resposta.

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____
____
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____

4.) Indique o seu grau de certeza na avaliação que fez das sequências de letras:

(   ) 0 – 20%

(   ) 20% - 40%

(   ) 40% - 60%

(   ) 60% - 80%

(   ) 80% - 100%

APPENDIX G - PARTICIPANTS

Participant	Tasks' order	Number of sessions	Group
#1	1324	1	HP
#2	3241	2	HP
#3	3124	2	HP
#4	4312	1	HP
#5	2413	2	HP
#6	4123	1	HP
#7	1432	1	HP
#8	4321	1	HP
#9	2134	2	HP
#10	4213	2	HP
#11	1342	1	M
#12	1432	2	HP
#13	4231	2	HP
#14	4312	1	LP
#15	2431	2	HP
#16	1342	2	LP
#17	1243	1	M
#18	3124	2	HP
#19	2413	1	M
#20	4231	2	M
#21	1423	2	M
#22	3421	1	LP
#23	1243	2	LP

#24	2413	1	LP
#25	1324	1	LP
#26	2143	1	LP
#27	4132	1	LP
#28	1234	1	LP
#29	4231	1	LP
#30	2431	1	LP
#31	2143	1	LP
#32	1432	1	LP
#33	1243	1	M
#34	4213	1	HP
#35	2314	2	LP
#36	4123	2	HP
#37	1342	1	M
#38	3214	1	M
#39	4321	2	LP
#40	1234	2	LP
23 part., 1 session; 17 part., 2 sessions			

Note. HP = High proficiency bilinguals; LP = low proficiency bilinguals; M = monolinguals

HIGH PROFICIENCY BILINGUAL PARTICIPANTS	SEX	AGE
#1	F	23
#2	F	20
#3	M	26
#4	F	17
#5	M	28
#6	M	19

#7	F	29
#8	F	30
#9	F	28
#10	F	29
#12	F	26
#13	F	29
#15	F	24
#18	M	24
#34	F	27
TOTAL: 16 PARTICIPANTS	**12 women, 4 men**	**Mean age group: 23,69 years**

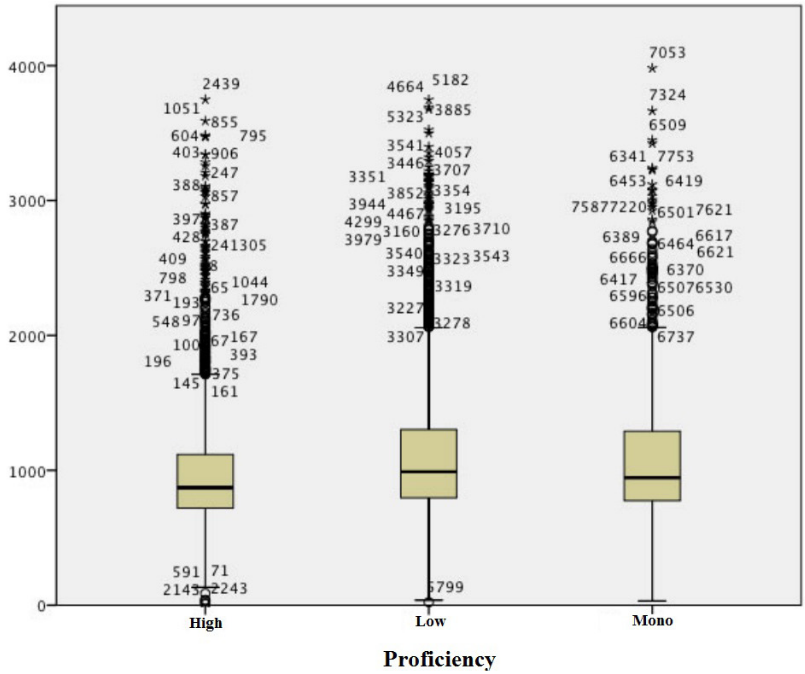
LOW PROFICIENCY BILINGUAL PARTICIPANTS	SEX	AGE
#14	F	20
#16	F	19
#22	F	20
#23	F	18
#24	F	24
#25	F	20
#26	F	20
#27	F	21
#28	F	27
#29	M	26
#30	F	31

#31	F	21
#32	F	18
#35	M	23
#40	F	18
TOTAL: **16 PARTICIPANTS**	**14 women, 2 men**	**Mean age group: 20, 38 years**

MONOLINGUAL PARTICI-PANTS	**SEX**	**AGE**
#11	F	26
#17	F	21
#19	M	24
#21	F	20
#33	M	28
#37	F	31
#38	F	26
#39	F	18
TOTAL: **8 PARTICIPANTS**	**6 women, 2 men**	**Mean age group: 24,25 years**

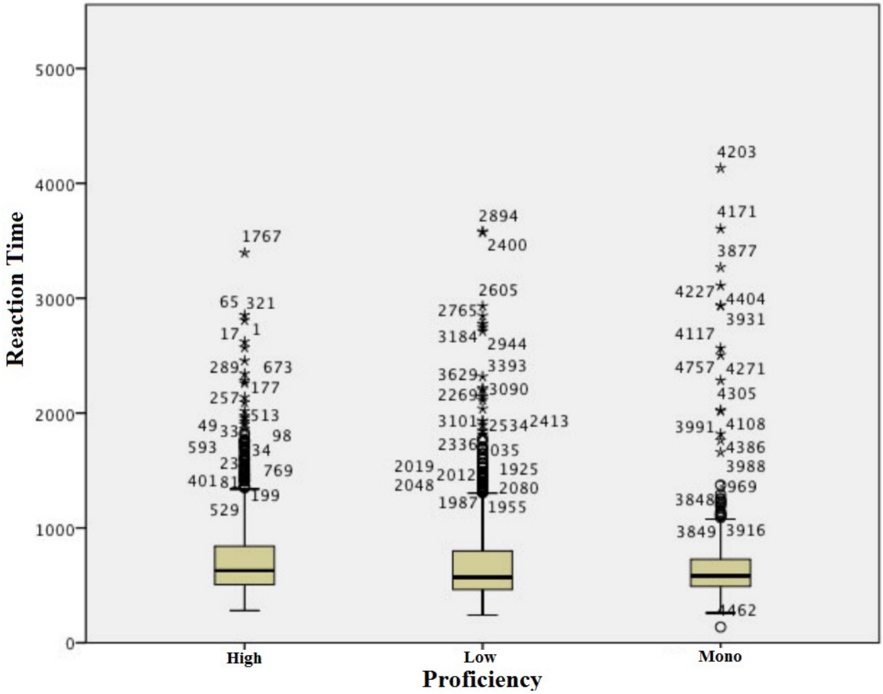
APPENDIX H

BOXPLOT COMPARING THE REACTION TIME BETWEEN HIGH, LOW AND MONO GROUPS FOR THE PN TASK



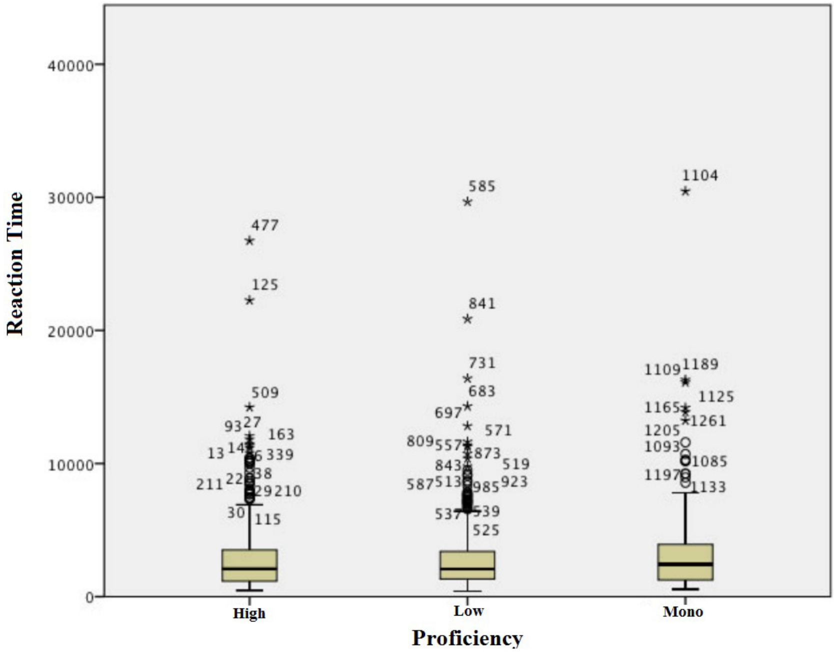
APPENDIX I

BOXPLOT COMPARING THE REACTION TIME BETWEEN HIGH, LOW AND MONO GROUPS FOR THE PR TASK



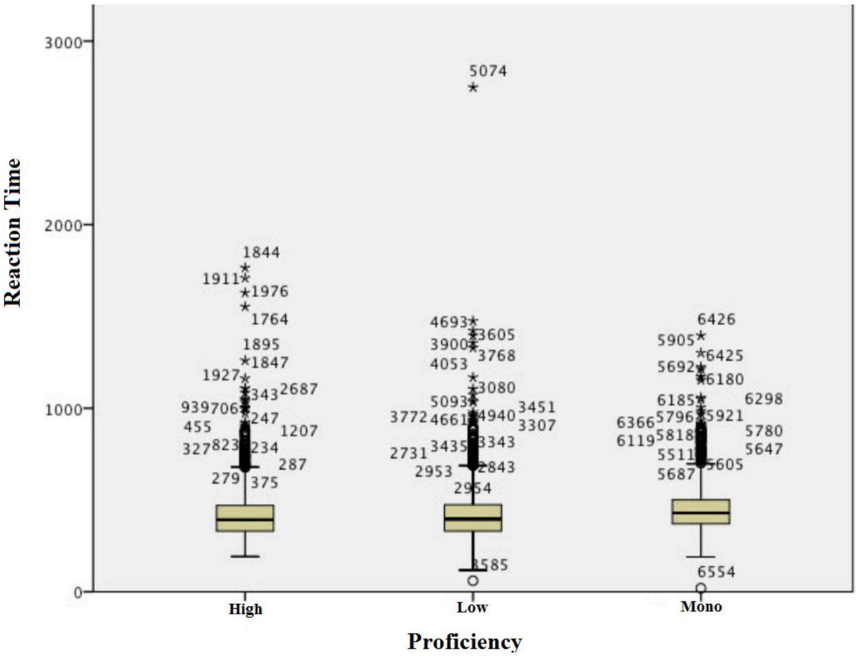
APPENDIX J

BOXPLOT COMPARING THE REACTION TIME BETWEEN HIGH, LOW AND MONO GROUPS FOR THE AGL TASK



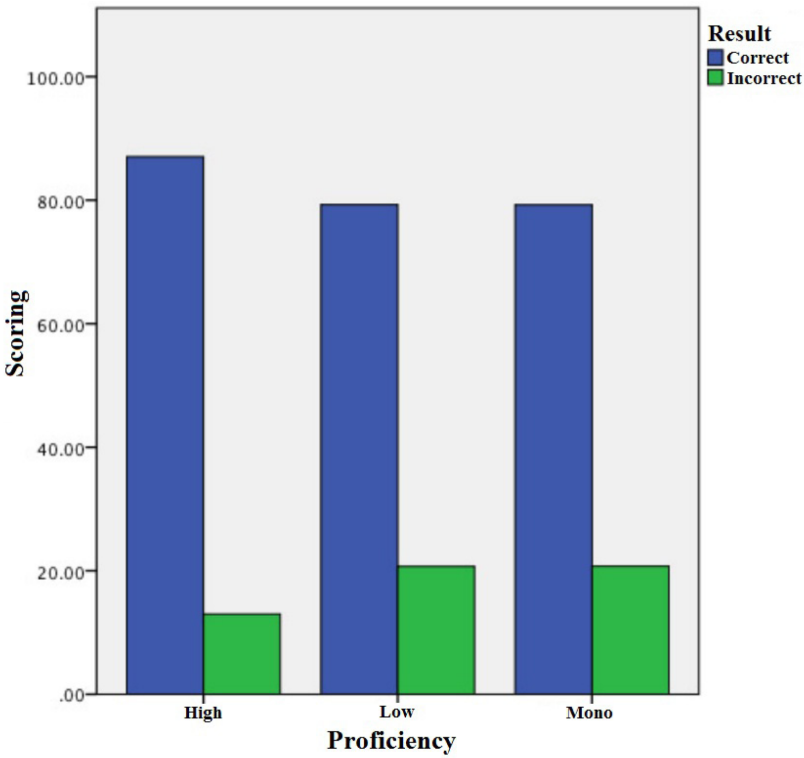
APPENDIX K

BOXPLOT COMPARING THE REACTION TIME BETWEEN HIGH, LOW AND MONO GROUPS FOR THE ASRT TASK



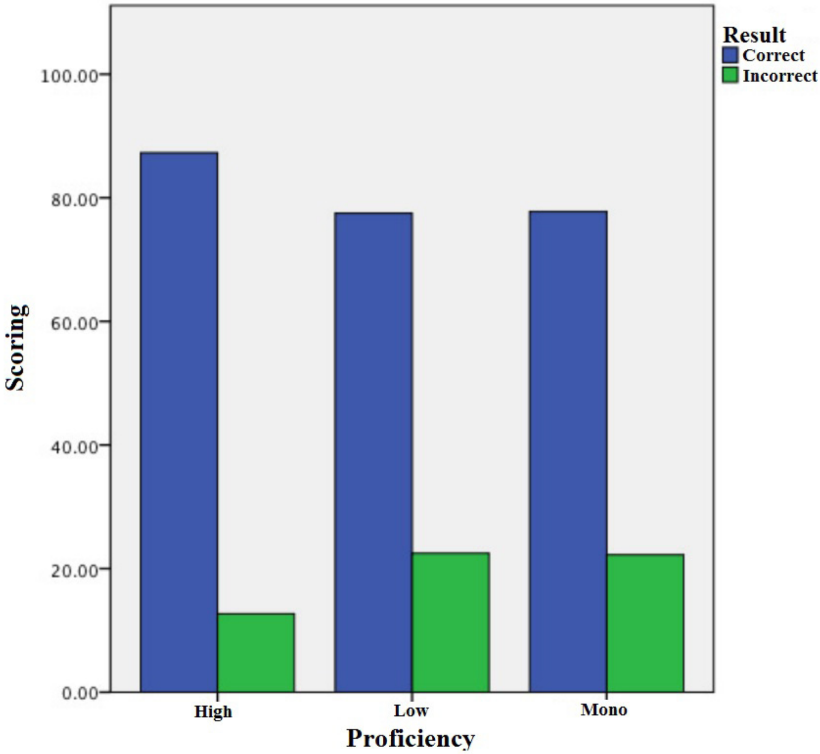
APPENDIX L

BAR GRAPH COMPARING THE SCORING FROM HIGH, LOW AND MONO GROUPS IN THE PN TASK



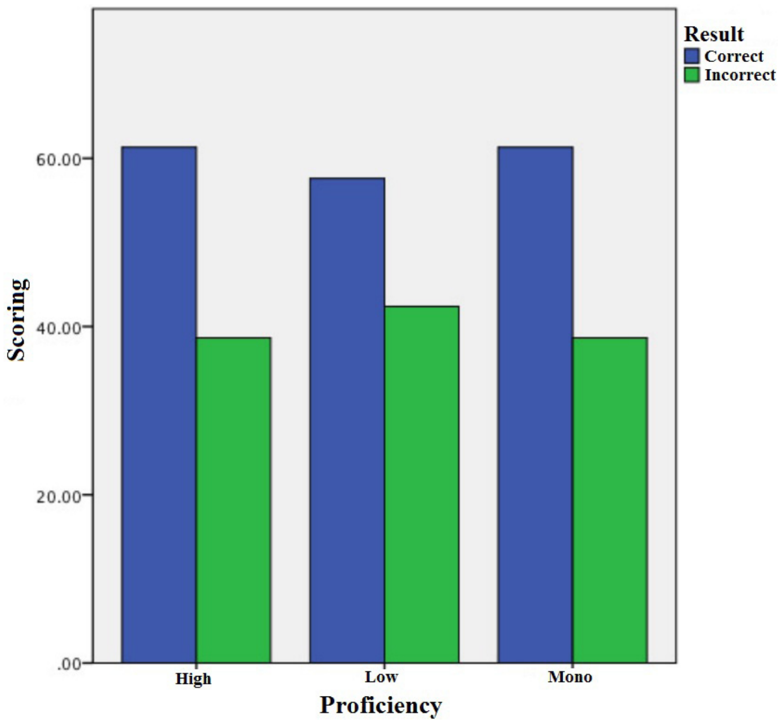
APPENDIX M

BAR GRAPH COMPARING THE SCORING FROM HIGH, LOW AND MONO GROUPS IN THE PR TASK



APPENDIX N

BAR GRAPH COMPARING THE SCORING FROM HIGH, LOW AND MONO GROUPS IN THE AGL TASK



APPENDIX O

BAR GRAPH COMPARING THE SCORING FROM HIGH, LOW AND MONO GROUPS IN THE ASRT TASK