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FREQUENCY EFFECTS AND THE PROCESSING OF VERBAL MORPHOLOGY BY L1 AND L2 SPEAKERS OF ENGLISH

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"Any intelligent fool can make things bigger, more complex, and more violent. It takes a touch of genius – and a lot of courage – to move in the opposite direction."

Albert Einstein

To my husband, my parents

and my brothers.

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The focus of this study is the processing of regular and irregular verbal morphology by L1 and L2 speakers of English. The theoretical and empirical literature on the processing of English verbal morphology presents different accounts for the processing and representation of regular and irregular English verbs. The dual-mechanism account argues that there are two distinct mental mechanisms for the representation and processing of verbal morphology. One is a rule-based computational system for the processing of regular verbs, and the other is a memory-based computational system for the storage of irregular verbs (Ullman, Corkin, Coppola, Hickok, Growdon, Koroshetz & Pinker, 1997; Pinker, 1999; Van der Lely & Ullman, 2001; Pinker & Ullman, 2002; Ullman, 2004; Ullman, 2005). In contrast, the connectionist single-mechanism account proposes that both rules and words are represented in a single computational system, and all forms (regular and irregular) are represented in a distributed associative memory (Rumelhart & McClelland, 1986; Plunket & Marchman, 1993; Joanisse & Seidenberg, 1999; McCelland & Patterson, 2002; Joanisse & Seidenberg, 2005; Woollams, Joanisse & Patterson, 2009). A third account for the processing of English verbal morphology is proposed by the full decomposition model of morphological complexity (Stockall and Marantz, 2006), which suggests that both regular and irregular inflectional forms are decomposed. This model also relies in a single system to process verbal morphology. However, the prediction that all verbal forms (regular and irregular) are decomposed by morphological rules challenges both the dual-mechanism and the connectionist single-mechanism views. In the context of verbal morphology processing, the objectives of the present study are: (a) to investigate the influence of frequency effects and proficiency on the processing of regular and irregular verbal morphology in English as L1 and L2, and (b) to investigate the role of inhibitory control and working memory capacity on the processing of English verbal morphology. In order to achieve these objectives, behavioral data were collected from a total of 72 participants, which were divided into three proficiency groups: (1) experimental group 1 consisted of 26 native speakers of Brazilian Portuguese with a high proficiency level in English as L2; (2) experimental group 2 consisted of 26 native speakers of Brazilian Portuguese with a low proficiency level in English as L2; (3) group 3 consisted of a control group of 20 native speakers of American English. The participants pre-selected for both experimental groups were required to take a proficiency test in English. All selected participants performed three tasks: (1) the Frequency Effects Task, which is a past tense production task designed to investigate English verbal morphology; (2) the Simon Arrow Task, which was used to assess participants' inhibitory control function; and (3) the Letter-Number Ordering Task, which was used to assess participants' working memory capacity. The results showed that participants' inhibitory control function and working memory capacity did not affect the processing of English verbal morphology. In addition, the results showed that the speakers of English as L1 and L2 behaved differently when processing regular verbs, most likely due to proficiency differences in the English language. However, all participants, regardless of their proficiency group, decomposed irregular verbs. Irregular forms decomposition is predicted only by the full decomposition model. Therefore, the full decomposition model of morphological complexity offers the strongest account for the results found in the present study.

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RESUMO

EFEITOS DE FREQUÊNCIA E O PROCESSAMENTO DA MORFOLOGIA VERBAL POR FALANTES DE INGLÊS COMO L1 E L2

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O foco desta pesquisa é o processamento da morfologia verbal por falantes de inglês como L1 e L2. A literatura teórica e empírica sobre o processamento da morfologia verbal do inglês apresenta diferentes propostas para o processamento e representação dos verbos regulares e irregulares em inglês. Os modelos de via dual argumentam que existem dois mecanismos mentais distintos para a representação e processamento da morfologia verbal. Um dos mecanismos é um sistema computacional baseado em regras e utilizado no processamento dos verbos regulares e, o outro mecanismo, é um sistema computacional baseado na memória e utilizado no armazenamento de verbos irregulares (Ullman, Corkin, Coppola, Hickok, Growdon, Koroshetz & Pinker, 1997; Pinker, 1999; Van der Lely & Ullman, 2001; Pinker & Ullman, 2002; Ullman, 2004; Ullman, 2005). Em contraste, o modelo conexionista de via simples propõe que ambas, as regras e as palavras, são representadas em um único sistema computacional, e que todas as formas (regulares ou irregulares) são representadas em uma memória associativa distribuída (Rumelhart & McClelland, 1986; Plunket & Marchman, 1993; Joanisse & Seidenberg, 1999; McCelland & Patterson, 2002; Joanisse & Seidenberg, 2005; Woollams, Joanisse & Patterson, 2009). Uma terceira explicação para o processamento da morfologia verbal do inglês é proposta pelo modelo de decomposição completa (Stockall e Marantz, 2006), o qual sugere que tanto os verbos regulares quanto os irregulares são decompostos. Este modelo também depende de um único sistema para processar a morfologia verbal, mas a explicação de que todas as formas verbais (regulares e irregulares) são decompostas por regras morfológicas se opõe aos modelos de via dupla e via simples. A partir do contexto de processamento da morfologia verbal, os objetivos que motivaram este estudo são: (a) investigar a influência dos efeitos de frequência e da proficiência no processamento da morfologia verbal do inglês como L1 e L2, e (b) investigar o papel do controle inibitório e da capacidade de memória de trabalho no processamento da morfologia verbal do inglês. Para alcançar esses objetivos, os dados comportamentais foram coletados de um total de 72 participantes, que foram divididos em três grupos de proficiência, que são: (1) O grupo experimental 1, formado por 26 falantes nativos de português brasileiro com alta proficiência em inglês como L2; (2) O grupo experimental 2, composto por 26 falantes nativos de português brasileiro com baixa proficiência em inglês como L2; e (3) o grupo controle, formado por 20 falantes nativos de inglês americano. Os participantes pré-selecionados para os grupos experimentais realizaram um teste de proficiência em inglês. Todos os participantes selecionados realizaram três tarefas: (1) a *Frequency Effects Task*, que é uma tarefa de produção do passado de verbos em inglês; (2) a *Simon Arrow Task*, que foi utilizada para avaliar o controle inibitório dos participantes; e (3) a *Letter-Number Ordering Task*, que foi utilizada para avaliar a capacidade de memória de trabalho dos participantes. Os resultados mostraram que o controle inibitório e a capacidade de memória de trabalho não afetaram o processamento do passado de verbos em inglês. Além disso, os resultados mostraram que os falantes de inglês como L1 e L2 se comportaram de maneira diferente ao processar os verbos regulares e que isto ocorreu provavelmente devido a diferenças de proficiência na língua inglesa. No entanto, todos os participantes, independentemente do seu grupo de proficiência, decompuseram os verbos irregulares, o que é previsto somente pelo modelo de decomposição completa. O modelo de decomposição completa oferece a explicação mais adequada para os resultados encontrados no presente estudo.

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CHAPTER 1
INTRODUCTION

1.1 Background

Over the past 25 years investigations on the English past tense have spawned a debate between researchers about the way the brain processes English verbal morphology (Stockall and Marantz, 2006). Rumelhart and McClelland (1986) proposed the first connectionist single-mechanism model with a potential explanation of how English regular and irregular verbal morphology is cognitively processed. Two years later, Pinker and Prince (1988) presented a critique on the single-mechanism model. This was the beginning of the past tense debate (Pinker & Ullman, 2002). Since then, the processing of the past tense has been studied focusing primarily on two views on verbal morphological processing, the dual-mechanism view and the connectionist single-mechanism view.

The dual-mechanism account for verbal morphological processing argues that there are two distinct mental mechanisms for the representation and processing of verbal morphology. One is a rule-based computational system for the processing of regular verbs, and the other is a memory-based computational system for the storage of irregular verbs (Ullman, Corkin, Coppola, Hickok, Growdon, Koroshetz & Pinker, 1997; Pinker, 1999; Van der Lely & Ullman, 2001; Pinker & Ullman, 2002; Ullman, 2004; Ullman, 2005). In contrast, the connectionist single-mechanism account for verbal morphological processing, started by Rumelhart and McClelland in 1986, proposes that there is no distinction between composed and non-composed forms. Instead, morphological rules and words are represented in a single computational system, and all forms (regular and irregular) are represented in a distributed associative memory (Rumelhart & McClelland, 1986; Plunket & Marchman, 1993; Joanisse & Seidenberg, 1999; McCelland & Patterson, 2002; Joanisse & Seidenberg, 2005; Woollams, Joanisse & Patterson, 2009).

More recently, Stockall and Marantz (2006) proposed the full decomposition model suggesting that both regular and irregular inflectional forms are decomposed. This model also relies in a single system to process verbal morphology. However, the prediction that all verbal forms (regular and irregular) are decomposed by morphological rules is in contrast with the dual-mechanism and the connectionist single-mechanism views.

Irregular and regular English past tense is often the primary focus of studies investigating inflectional morphological processing "because of the sharp contrast that it offers between a classically rule-like process […] and an idiosyncratic set of irregular forms" (Marslen-Wilson, 2007, p.177).

Before deciding to carry out the present study, I read an article published by Ullman et al. (1997) which offered an explanation for the processing of inflectional morphology from a dual-mechanism perspective. I thought the model was intriguing and I wanted to learn more about morphological processing. Reading more papers in this area, I found that there were conflicting accounts for regular and irregular morphological processing. I also noticed that more studies addressing the processing of English verbal morphology by Brazilian Portuguese speakers of English as L2 were missing from the body of studies carried out with this population in Brazil. Moreover, since individual differences are known to play an important role in the development of competence in the L2, I could not find studies investigating L2 morphological processing in which variables such as inhibitory control function and working memory capacity were controlled for. This inspired me to investigate the processing of English verbal morphology by Brazilians who were speakers of English as L2, taking into consideration the influence of frequency effects, proficiency and individual differences.

1.2 The present study

Two objectives motivated this study: (1) to investigate the influence of frequency effects and proficiency in the storage and composition of regular and irregular verbal morphology of English as L1 and L2, and (2) to investigate the role of inhibitory control and working memory capacity in the processing of English verbal morphology.

A frequency effects task eliciting the past tense production of regular and irregular verbs in English was used in order to achieve the first objective. Additionally, two proficiency tests were applied to select the potential participants according to the proficiency level required. To achieve the second objective, two other tasks were applied: (1) the Simon Arrow Task was used to assess inhibitory control function and (2) the Letter-Number Ordering Task was used to assess working memory capacity of selected participants.

In the present study, data was collected from a total of 72 participants, who were divided into three proficiency groups. The first experimental group consisted of 26 native speakers of Brazilian Portuguese with a high proficiency level in English as L2. The second experimental group consisted of 26 native speakers of Brazilian Portuguese with a low proficiency level in English as L2. Finally, the control group consisted of 20 native speakers of American English.

This study was carried out at the Laboratório da Linguagem e Processos Cognitivos (LabLing) situated in the room 511, in the Centro de Comunicação e Expressão (CCE) at Universidade Federal de Santa Catarina (UFSC).

1.3 Significance of the research

Our first language may influence the way we process verbal morphology, therefore it is important to include as many different first languages as possible when studying the processing of verbal morphology. Most work in the area of English verbal morphology has focused on the processing of native speakers (e.g. Ullman, Corkin, Coppola, Hickok, Growdon, Koroshetz & Pinker, 1997; Joanisse & Seidenberg, 1999, 2005; Stockall & Marantz, 2006; Newman, Ullman, Pancheva, Waligura & Neville, 2007), with some studies involving participants with other native languages (e.g. Birdsong & Flege, 2001; Babcock, Stowe, Maloof, Brovetto & Ullman, 2012). To the best of my knowledge, there are no published studies focusing on native speakers of Brazilian Portuguese processing English verbal morphology. Thus, the primary significance of this study is that it provides new data on the processing of English verbal morphology by this group of native speakers of Brazilian Portuguese.

Additionally, this study investigates two proficiency levels of English as L2, which gives a broader view of how Brazilian Portuguese speakers process English verbal morphology as they increase their proficiency. This study also investigates whether or not native speakers of English and native speakers of Brazilian Portuguese at these two proficiency levels process English verbal morphology in a similar manner.

Finally, the roles of inhibitory control function and working memory capacity have not been thoroughly investigated to determine whether or not they influence the processing of English verbal morphology. This study provides new data from speakers of Brazilian Portuguese at two different proficiency levels of English as L2. This can be used to help determine if these individual differences affect the processing of verbal morphology.

1.4 Organization of the thesis

This thesis is divided into 5 Chapters. Chapter 1 provides an overview of the present study, including the significance of the research and this organizational structure of the thesis.

Chapter 2 presents a review of the literature and is divided into 4 main sections. These sections present a review of English morphological processing, including the contrasting accounts for verbal morphological processing. These sections also present an overview of frequency effects on inflectional morphological processing and an overview of the Simon Arrow Task and the Letter-Number Ordering Task, which assess inhibitory control function and working memory capacity, respectively.

Chapter 3 describes in detail the method followed to carry out this study. First, it presents the objectives and the research questions of the study, followed by a description of the participants and a description of the materials used. Then, it describes the data collection procedures and the data analysis. Chapter 3 ends with a description of the pilot study carried out prior to the data collection phase.

Chapter 4 provides the results and the discussion for the results. It begins with descriptive statistical analysis followed by inferential statistical analysis. Then, it provides the Pearson correlations and the answers to the research questions.

Chapter 5 presents the final conclusions from this study. First, it presents the conclusions concerning the frequency effects and the processing of English verbal morphology as well as the conclusions concerning inhibitory control, working memory and the processing of English verbal morphology. Then, it describes the limitations of the study and proposes some suggestions for further research. It ends with the methodological and pedagogical implications of the present study.

CHAPTER 2
REVIEW OF THE LITERATURE

This chapter presents a review of the literature on verbal morphological processing of English as L1 and as L2, as well as the concepts of inhibitory control and working memory capacity. This chapter is divided into four main sections. Section 2.1 describes English regular and irregular morphological processing. Section 2.2 discusses frequency effects on regular and irregular verbal morphology. Section 2.3 defines the concept of inhibitory control. Finally, Section 2.4 defines the concept of working memory capacity.

2.1 Introduction to English regular and irregular morphological processing

This section begins with an overview of some morphological concepts which are central to this study. According to Carstairs-McCarthy (2002, p.16), "The area of grammar concerned with the structure of words and with relationships between words involving the morphemes that compose them is technically called morphology". In this context, English words are composed of one or more morphemes. In a classical definition, morpheme is the smallest meaningful unit in a language (Spencer, 1992; Chalker & Weiner, 1998; Carstairs-McCarthy, 2002; Rubba, 2004). Morphemes can be classified as free or bound. Free morphemes can function as an independent word, for instance the words *happy* and *smile*. Conversely, bound morphemes need to be attached to another morpheme, since they are part of a word, for instance the morpheme –*s*, representing the plural, as in the word *smiles* (Spencer, 1992; Chalker & Weiner, 1998; Carstairs-McCarthy, 2002; Rubba, 2004). Bound morphemes can be classified as derivational or inflectional. Derivational morphemes create new words, resulting from the combination of a stem and an affix, for example the word *happiness* is derived from the stem *happy* and the affix –*ness*, that is, the noun *happiness* was derived from the adjective *happy*, creating a new word. In contrast, inflectional morphemes create new forms of the words, and when combined with a stem they can indicate grammatical categories, e.g. plural of nouns and verbal tense. For example, the word *walked* is formed from the stem *walk* and the affix –*ed*, which forms the past tense of the verb *walk*, and not a new word (Spence, 1992; Carstairs-

McCarthy, 2002, Rubba, 2004; Marslen-Wilson, 2007). An affix is a bound morpheme and is always attached to a stem. The term affix is used to refer to prefix, suffix and infix (Rubba, 2004).

Another important morphological concept is allomorph. Allomorph is a variation of the pronunciation of a morpheme. Many morphemes of the English language present distinct pronunciations. Such variations can be seen in the morpheme spelling or only in the pronunciation of the morpheme and can affect roots and/or affixes (Rubba, 2004). In this context, the regular past tense of the English language presents three expected allomorphs (*/d/* as in the verb *dried*, */t/* as in the verb *looked* and */Id/* as in the verb *acted*) while the irregular past tense does not present a logical (expected) allomorph (Rubba, 2004).

Complex words are those which combine two or more morphemes, generally a stem and at least one bound morpheme (Chalker & Weiner, 1998; Carstairs-McCarthy, 2002; Rubba, 2004; Marslen-Wilson, 2007). According to Marslen-Wilson (2007), complex word formation in English is divided into three modes: compounding, derivational and inflectional morphology. Compounding words are formed by two different stems, e.g. *ceasefire* and *teapot*. Derivational morphology is represented by a stem combined with a derivational morpheme as in the word *happiness*, and inflectional morphology is represented by a stem combined with one (or more) inflectional morpheme as in the words *smiles* and *walked* (Marslen-Wilson, 2007).

According to Rubba (2004), there are three classes of words in the English language in which inflection can be applied: adjectives, nouns and verbs. Some inflectional categories of adjectives are the progressive aspect (e.g. *singing*), the comparative (e.g. *bigger*) and the superlative (e.g. *biggest*). Some inflectional categories of nouns are number (e.g. *cars*) and the possessive case (e.g. *the dog's fur*). Some inflectional categories of verbs are the third person singular present tense (e.g. *She walks*) and the past tense (e.g. *walked*).

The focus of this study is English verbal morphology. Specifically, the primary focus is the regular and irregular inflectional morphology of English verbs in the past tense. In this context, regular inflectional morphology refers to the past tense of regular verbs and irregular inflectional morphology refers to the past tense of irregular verbs. Regular past tense verbs are formed using a grammatical rule, verb + –*ed* (e.g. *agree/agreed*, *jump/jumped*). These forms present a predictable past tense (Marslen-Wilson, 2007). On the other hand, the past tense of irregular verbs is not formed by a grammatical rule (e.g. *give/gave*, *bring/brought*), so these verbs present an unpredictable past tense form (Marslen-Wilson, 2007).

The two distinct methods of forming the past tense (rule-based regular verbs versus idiosyncratic irregular verbs) have raised questions concerning the processing and the representation of the regular and irregular forms. The theories offered to explain the past tense phenomena generated what is known as the past-tense debate in English inflectional morphology.

The past-tense debate falls into two main accounts for English inflectional morphology processing and representation: the dual mechanism account and the connectionist single mechanism account (Marslen-Wilson, 2007; Stockall & Marantz, 2006). Both views argue that irregular verbs are not decomposable, that is, irregular verbs are represented in the memory as one entire word (Marslen-Wilson, 2007). However, they disagree about the processing of regular verbs. The dual mechanism view argues that regular verb past-tense forms are decomposed (computed by a mental process), not memorized as one entire word (Pinker, 1999). Conversely, the connectionist single mechanism view argues that all forms, regular and irregular, are represented in a single computational system (Joanisse & Seidenberg, 1999). Finally in addition to these two views, there is the full decomposition model of morphological complexity which argues that all complex words, regular and irregular, are decomposed (Stockall & Marantz, 2006). The following subsections provide detailed explanations of the dual-mechanism, the connectionist single-mechanism and the full decomposition model of morphological complexity.

2.1.1 The dual-mechanism account for English morphological processing

According to Pinker (1999), regular verbs are an open ended class, since there are thousands of regular verbs and new ones are continuously being created (e.g. *fax/faxed*). In contrast irregular verbs are a closed-end class. According to Pinker (1999) there are 165 irregular verbs and new forms have not been created recently. This fact, together with the predictability of the regular past tense and the unpredictability of the irregular past tense, leads to the dual-mechanism account for English morphological processing. This theory argues that there are two distinct mental mechanisms for representation and processing of inflectional morphology, one is a rule-based computation system for the processing of regular verbs, and the other is a memory-based computation system for the storage of irregular verbs (Pinker, 1999; Pinker & Ullman, 2002). The irregular forms (as a closed-end class with an unpredictable past tense) are memorized as an entire unit in a mental dictionary (Pinker, 1999). For instance, the verb *sing* and its past tense *sang* are linked, since the former is the present tense of the verb and the latter is the past tense of the same verb. However, they are two different words and are stored as two different units in memory (Pinker, 1999; Pinker & Ullman, 2002). In contrast, the regular forms (as an open-ended class with a predictable past tense) are computed online, since the past tense of these forms comes from a grammatical rule (verb+ *–ed*). For instance, the past tense of the verb *talk*, which is the word *talked*, does not need to be memorized because it is generated online by applying the regular verb past tense rule (Pinker, 1999; Pinker & Ullman, 2002). Summarizing, the dual-mechanism view proposes that regular verbs are computed and can be decomposed while irregular verbs are stored and cannot be decomposed.

Based on the dual-mechanism view, Ullman, Corkin, Coppola, Hickok, Growdon, Koroshets and Pinker (1997) proposed a model to explain L1 acquisition and processing, the Declarative and Procedural (DP) Model. This dual-mechanism model assumes that language is based on two mental abilities: the lexical and the grammatical, in which a mental lexicon contains arbitrary information about language, whereas a mental grammar is thought of as a rule-based system (Pinker, 1994; Chomsky, 1995). In the DP model, the mental grammar is tied to procedural memory while the mental lexicon is tied to declarative memory (Ullman et al., 1997; Ullman, 2001a, 2001b, 2001c, 2004, 2005). Declarative memory stores lexical knowledge of a language and information about events and facts, while procedural memory is responsible for the grammatical processing of a language and for cognitive and motor skills (Ullman et al., 1997; Pinker & Ullman, 2002; Ullman, 2005). It is important to highlight that only the language-related aspects of declarative and procedural memories will be discussed, since the objective of this study is to investigate the processing and representation of linguistic items (regular and irregular inflectional morphology).

The present study was designed to address the dual-mechanism theory, specifically the DP model for English as L1 and L2. In this model, speakers of English as L1 memorize irregular forms in declarative memory and process regular forms in procedural memory (Ullman et al., 1997; Van der Lely & Ullman, 2001; Newman, Ullman, Pancheva, Waligura & Neville, 2007; Ullman, 2012). The model predicts that advanced learners of English as L2 process regular and irregular forms in the same way that the native speakers of English do. However, when learners start to learn English as L2, the model states that they rely on declarative memory for both regular and irregular forms (Ullman, 2001b, 2004, 2005, and 2012). Thus, proficiency is a very important aspect on the processing and representation of inflectional morphology of English as L2. Ullman (2001b, 2004, 2005, and 2012) suggests that when proficiency increases, learners of the L2 will start to compute the regular forms on procedural memory like native speakers do.

According to Ullman (2004, 2005) the DP memories interact with each other in a competitive way. This means that enhancing one of the memory systems results in the inhibition of the other memory system. Ullman (2004) calls this the *see-saw effect*. This effect suggests that speakers of English as L1 enhance procedural memory when processing the past tense form of a regular verb, inhibiting declarative memory. Consequently, the effect suggests that speakers of English as L1 enhance declarative memory when retrieving the past tense form of an irregular verb, inhibiting procedural memory. The DP model predicts that the same happens with speakers of English as L2, but only at a high proficiency level.

This distinction between storage and composition as described in dual-mechanism theories has been scientifically addressed in a multidisciplinary way by studies from different areas, including the linguistic, computational, neural and behavioral areas (Marslen-Wilson, 2007). Various researchers have investigated regular and irregular inflectional morphology to study language processing and representation (e.g. Ullman et al., 1997; Birdsong & Flege, 2001; Hahne, 2001; Ullman 2001b; Brovetto & Ullman, 2001, 2005; Optiz & Friederici, 2003; Bowden, 2007; Newman et al., 2007; Bowden, Gelfand, Sanz & Ullman, 2010; Babcock, Stowe, Maloof, Brovetto & Ullman, 2012).

According to Bowden (2007, p. 63), “regular and irregular morphology can be well-matched on factors that might influence representation and processing.” This suggests that regular and irregular morphology can be used as a tool to study the processing and representation of a language. A selection of four of the studies cited above will be described in chronological order to show how the dual-mechanism view on regular and irregular inflectional morphology has evolved for L1 and L2.

The first selected study was carried out by Ullman et al. (1997). This was a behavioral study concerning English as L1 regular and irregular past tense production and it was carried out with patients that presented a developmental disorder. These patients were divided into 5 groups, according to their developmental disorder. They were 28 patients with Parkinson's disease (PD), 24 patients with Alzheimer's disease (AD), 17 patients with Huntington's disease (HD), 6 patients with Anterior Aphasia (AA) and 6 patients with Posterior Aphasia (PA). These patients were presented with a list of irregular, regular and novel (made up) verbs and should produce the past tense of each verbal form. Ullman et al. (1997) predicted that patients with AD and PA should be worse at producing the past tense of irregular verbs than the past tense of regular verbs, since these patients present impairments of the lexical memory, "the temporal-parietal/medial-temporal declarative system" (Ullman et al., 1997, p.267). Conversely, patients with PD and AA were predicted to be worse at producing the past tense of regular and novel verbs than the past tense of irregular verbs, since these patients present impairments in the processing of rules, "the frontal/basal-ganglia procedural system" (Ullman et al., 1997, p.267). Finally, overregularization errors (the application of the morpheme *–ed* in irregular verbs) were predicted for patients with AD, PA and HD. The predictions of Ullman et al.'s (1997) study were confirmed, supporting the dual-mechanism view and creating the DP model for L1.

The second selected study was carried out by Birdsong and Flege (2001). This was a behavioral study which investigated the regular/irregular dissociation in English as L2. The participants were divided into two different groups, according to their native language. One group consisted of 30 native speakers of Korean and the other group consisted of 30 native speakers of Spanish. The participants from both groups were proficient in English as L2 and had their Age of Arrival (AoA) controlled. The task presented 80 multiple-choice sentences, from which 40 sentences tested English regular and irregular past tense (with 20 high frequency verbs and 20 low frequency verbs) and the other 40 sentences tested English regular and irregular noun plurals (with 20 high frequency nouns and 20 low frequency nouns). The results from Birdsong and Flege's (2001) study showed that AoA had a larger effect on irregular verbs and nouns than on regular verbs and nouns. In addition, frequency effects were detected only in the processing of irregular verbs and nouns. Thus, the results from Birdsong and Flege's (2001) study support the dual-mechanism view concerning the processing of inflectional morphology of English as L2.

The third selected study was carried out by Newman et al. (2007). This was an electrophysiological study which investigated the regular and irregular inflectional dissociation in English as L1. The participants consisted of 26 male native English speakers. They read sentences in English (some sentences were correct and some sentences presented violations) while event related potentials (ERPs) were recorded. Overall, three ERP components were elicited in Newman et al.'s (2007) study, which were the LAN (Left Anterior Negativity), the P600 (Positivity at 600ms) and the N400 (Negativity at 400ms). The LAN is thought to be related to the brain electrical response to grammatical violations (Kaan, 2007). The P600 is considered to be related to the brain electrical response to syntactic/morpho-syntactic violations (Kaan, 2007), whereas the N400 is suggested to be related to the brain electrical response to words and their semantic meaning (Kaan, 2007). The results of Newman et al.'s (2007) study showed a LAN followed by a P600 for sentences which presented violations in the regular past tense while the violations in the irregular past tense elicited only a P600. This difference in the ERP components elicited by regular and irregular past tense violations suggest a distinction between regular and irregular processing of English as L1 (Newman et at., 2007). The same ERP components were elicited when the participants were reading sentences with a syntactic violation. However, when the violation in the sentence was semantic, a N400 was elicited. Semantic violation is predicted to relate to memory and syntactic violation is predicted to relate to computation. Thus, the results from Newman et al.'s (2007) study support the dual-mechanism view for English as L1.

The final selected study was carried out by Babcock et al. (2012). This was a behavioral study which investigated regular and irregular dissociation in English as L1 and L2. This study investigated frequency effects on English regular and irregular past tense production. Speakers of English as L2 had their length of residence (LoR) and age of arrival (AoA) controlled. Thirty participants were native speakers of Chinese with English as L2, 33 participants were native speakers of Spanish with English as L2 and 72 participants were native speakers of English. Participants were all adults and the L2 participants were late learners of English. Results showed that the past tense of irregular verbs was stored for all participants. However, the past tense of regular verbs was shown to be stored for all participants except for male native English speakers. The study also found that the longer the LoR, the less the female L2 participants presented reliance on storage, suggesting that over time they become more similar to the male native English speakers in their past tense production. According to Ullman (2001b, 2004, 2005), when the proficiency (here assessed in terms of LoR) increases, all learners of English as L2 should start to compute the regular forms. The results from Babcock et al.'s (2012) study also showed that participants with a higher AoA relied more on storage for regular past tense. Concerning the regular and irregular past tense computation in L1 and L2, this study suggested that "inflected forms can rely on either the same or different mechanisms in L2 as they do in L1, and that this varies as a function of multiple interacting factors" (Babcock et al., 2012, p.1). Concluding, this study proposes that external factors (such as AoA, LoR and sex) can have a significant effect on the processing of inflectional morphology in English as L1 and L2.

2.1.2 The connectionist single-mechanism account for English morphological processing

Rumelhart and McClelland (1986) presented a connectionist single-mechanism proposal for language learning and processing (Plunket & Marchman, 1993; McCelland & Patterson, 2002; Joanisse & Seidenberg, 2005). Rumelhart and McClelland's (1986) proposal suggested that language learning and processing occurs by association and is sensitive both to context and meaning.

There is a sound body of studies supporting the connectionist single-mechanism view (e.g. Rumelhart & McClelland, 1986; Plunket & Marchman, 1993; Joanisse & Seidenberg, 1999; McCelland & Patterson, 2002; Joanisse & Seidenberg, 2005; Woollams, Joanisse & Patterson, 2009; Nicoladis & Paradis, 2012). Based on the original proposal offered by Rumelhart and McClelland (1986), many connectionist single-mechanism models were proposed for inflectional morphology that focused on different aspects, such as cross-linguistic differences, language acquisition and brain impairments (Joanisse & Seidenberg, 2005).

In contrast with the dual-mechanism view, the connectionist single-mechanism account for inflectional morphology processing proposes that there is no distinction between composed and non-composed forms. Instead, morphological rules and words are represented in a single computational system, and all forms (regular and irregular) are represented in a distributed associative memory (Rumelhart & McClelland, 1986; Plunket & Marchman, 1993; Joanisse & Seidenberg, 1999; McCelland & Patterson, 2002; Joanisse & Seidenberg, 2005; Woollams, Joanisse & Patterson, 2009). According to Joanisse and

Seidenberg (1999), people's knowledge of words is used to generate the past tense forms. In this context, words are represented by their sounds (phonology), their spelling (orthography) and their meaning (semantics). Furthermore, "there is a single, distributed network that represents people's knowledge of words. The same network structure is used in processing all words" (Joanisse and Seidenberg, 1999, p.6).

Joanisse and Seidenberg (1999) proposed a simulation model focusing on brain impairments to validate the single-mechanism perspective. This simulation study offered a contrasting explanation for the results found in Ullman et al.'s (1997) study. As already discussed, Ullman et al. (1997) found that, depending on the patients' brain damage, they tend to be more impaired when producing the past tense of novel (made up) verbs or the past tense of irregular verbs. This dissociation was interpreted by Ullman et al. (1997) as empirical evidence for the dual-mechanism view, on the basis of the argument that these patients processed regular and novel verbs in different ways, by a rule-based system or by a memory-based system. However, Joanisse and Seidenberg (1999) claimed that these patients present damage in the processing of semantic or phonological information, and that Ullman et al.'s (1997) results showed differences in morphological processing due to these specific cognitive impairments and not due to dissociation.

According to Joanisse and Seidenberg (1999), damage in the processing of phonological information has a stronger effect on the past tense production of novel verbs than irregular verbs. This is due to the lack of meaning of the novel verbs, that is, since these verbs do not have a meaning, the past tense production will be formed by similarity to phonological forms which are known to the person. However, if there is damage in the processing of phonological information the patient will present greater difficulty in producing the past tense of novel verbs (Joanisse & Seidenberg, 1999). On the other hand, damage in the processing of semantic information leads to a stronger effect in the past tense production of irregular verbs. The irregular past tense is idiosyncratic (e.g. *Take/Took*). Thus, in order to produce the irregular past tense (e.g. *Took*), it is necessary to identify the semantic meaning of the verb in the present tense (e.g. *Take*). However, if there is a damage in semantic information, the present tense (e.g. *Take*) will not be identified (Joanisse & Seidenberg, 1999). Consequently, according to Joanisse and Seidenberg (1999), the past tense production will be formed according to similar phonological forms (e.g. *Fake and Tame*, which present a regular past tense), inducing the error (e.g. *Taked*).

The results from Joanisse and Seidenberg's (1999) simulation study supports the single-mechanism view as this study explains the patient's "deficits in terms of impairments to two types of lexical information, semantic and phonological, rather than memory systems organized around rules and exceptions" (Joanisse & Seidenberg, 1999, p.7593).

Many other studies support the connectionist single-mechanism view, such as Woollams et al. (2009), who investigated inflectional morphology from a behavioral and a simulation perspective. The task used was a past tense production task. In this task, the participants were expected to produce the past tense form based on the verb stem or on the meaning of the verb, represented by an action picture. Woollams et al. (2009) found that the presentation of the verbs, in a past tense production task, might promote the past tense regularity effect, that is, when the participants were expected to produce the past tense form based on the verb stem a regularity was found. However, when the participants were expected to produce the past tense form based on the meaning of the verb (represented by an action picture), there was no apparent difference between the past tense production of regular and irregular verbs. According to Woollams et al.'s (2009) results, the overall pattern of the participants' performance in the task supported the single-mechanism view.

2.1.3 Full decomposition model for English morphological processing

In contrast to the dual-mechanism and the connectionist single-mechanism views, Stockall and Marantz (2006) proposed the full decomposition model suggesting that both regular and irregular inflectional forms are decomposed. This model suggests that the regular and irregular past tense allomorphs (e.g. *walked* and *gave*, respectively) prime their stems (e.g. *walk; give*) allowing the application of a morphological rule (Stockall & Marantz, 2006). The general rule which is applied to all complex words relies under the combination of a root (stem) and its allomorph (Stockall & Marantz, 2006). Like all complex words, the specific morphological rules also have to be learned and memorized, so specific rules can be applied for specific complex words. In this context, regular and irregular forms are both decomposed, but the pattern involved in recognizing and generating regular and irregular allomorphs is different. Specifically, regular forms are generated by activating the default past tense allomorph (e.g. *–ed*), while irregular forms are generated by activating a non-default allomorph (Stockall & Marantz, 2006). In the specific case of irregular forms, the root from which the irregular past tense derives is shared with the word allomorph. For instance, when a person sees the irregular verb *give* (root) and s/he needs to produce its past tense, the morphological rule [Past] is activated and the irregular allomorph *gave* is produced, that is, the irregular past tense *gave* is derived from its root *give*. Similarly, in the processing of a morphologically complex word, such as *taught* (allomorph), the root of this irregular form (*teach*) is cognitively activated (Stockall & Marantz, 2006).

Like the connectionist single-mechanism view, the full decomposition model also relies on a single system to recognize and generate the past tense of regular and irregular forms. The difference is that in the full decomposition model all forms are decomposed, that is, the past tense of both regular and irregular forms are derived from a rule which combines stems (roots) and affixes.

In order to test the full decomposition model Stockall and Marantz (2006) carried out two experiments. Both experiments collected behavioral and neural data. The neural data was collected with a brain monitoring technology called magnetoencephalography[1] (MEG). Stockall and Marantz (2006) applied two lexical decision tasks in order to measure the activation of the root morphemes before lexical decision. One of the predictions (and the most relevant for the present study) was that the past tense of irregular forms (such as *taught*) primes its root (*teach*) in the same way that the past tense of regular forms (such as *walked*) primes its root (*walk*), since all complex words are decomposed (Stockall & Marantz, 2006). The stimuli used in both experiments were presented visually. The MEG component of interest in these experiments was the M350. According to Stockall and Marantz (2006, p.93) the M350 is "predicted to allow the dissociation of early effects of morphological priming from later effects of form or allomorph."

The first experiment presented the data collected from 17 English-speaking adults. MEG and behavioral data was collected from 9 participants and behavioral data alone was collected from 8 participants. The 400 pairs of stimulus were divided into four conditions: irregular low overlap (e.g. *ta**ug**ht/**te**a**c**h*), irregular high overlap (e.g. *g**a**ve/g**i**ve*), identity (e.g. *boil/boil*) and orthographic overlap (e.g. *c**u**rt/c**a**rt*). The past tense form was the prime stimulus while the stem was presented as the target stimulus. Each participant was presented first with the prime

[1] Magnetoencephalography (MEG) is "a functional imaging modality that enables a scientist or clinician to literally view the workings of the brain with a temporal resolution measured in milliseconds" (Zhong-Lin & Lloyd, 2011, p. ix).

word (e.g. *taught*) immediately followed by the target word (e.g. *teach*) on a computer screen. The participant should press a button to indicate his/her answer while neuromagnetic fields and reaction times were recorded. The results for the first experiment will be discussed together with the results from the second experiment.

The second experiment collected data from 13 English-speaking adults, and all participants had their reaction times and MEG data collected. In the second experiment, the order of the stimulus presentation was reversed. The stem was the prime stimulus while the past tense was presented as the target stimulus. In addition to the stimulus used in the first experiment, two other conditions were added to the stimulus: (a) the past tense of regular forms (e.g. *date-dated*) and (b) pairs of items with related meaning and orthography, but without a morphological relationship (e.g. *crinkle-wrinkle; flip-flop*). Two conditions from the first experiment were excluded: (a) the orthographic overlap and (b) identity. The primary focus of the second experiment was to investigate the processing of past tense of irregular and regular forms as well as their stems (Stockall & Marantz, 2006).

The results from the first and the second experiments showed a robust priming effect[2] for regular and irregular verbs and also for the identical pairs (e.g. *boil-boil*), being compatible with the full decomposition model, since both forms (regular and irregular) presented the same prime effects, meaning that both forms activated the morphological roots and their allomorphs (Stockall & Marantz, 2006). Concerning the stimulus direction, the order of presentation of the stimulus elicited different results. The first experiment (past tense prime/stem target) did not show a correlation between the neural priming (M350) and the reaction time measures. However, in the second experiment (stem prime/past tense target) the priming effect generated by the stem (e.g. *teach*) to the past tense allomorph (e.g. *taught*) presented a correlation between the reaction time measures and the neural priming (M350). Stockall and Marantz (2006) concluded that the processing of regular and irregular forms involve decomposition. This result contrasts with the dual-mechanism and connectionist single-mechanism views, since according to these two views irregular forms do not involve decomposition.

[2] Priming effect is “where unconscious exposure to a stimulus influences a response to a later stimulus” (Owen, 2012, p.76).

2.2 Frequency effects on inflectional morphological processing

Word frequency refers to the amount of times a word occurs in a determined language (Lehtonen, Niska, Wande, Niemi & Laine, 2006) and frequency effects refer to the effect that the frequency of usage of a word can have on its processing and representation. According to Duyck, Vanderelst, Desmet and Hartsuiker (2008, p.850) word frequency is "probably the most controlled variable in the literature on word recognition and production". Frequency effect studies are based on the assumption that words (such as verbs) with a high frequency of usage (input) are accessed in memory faster than words with a low frequency of usage (Bowden et al., 2010). In this context, when an inflected verb presents frequency effects it is assumed that this verb was retrieved from memory and when an inflected verb does not present frequency effects it is assumed that this verb was decomposed (Brovetto & Ullman, 2001, 2005; Woollams et al. 2009; Bowden et al. 2010; Babcock et al., 2012). Thus, the processing versus storage of regular and irregular forms can be tested by searching for frequency effects.

Frequency effects methods have been used in many studies to investigate inflectional morphological processing (e.g. Van der Lely & Ullman, 2001; Brovetto & Ullman, 2001, 2005; Pinker & Ullman, 2002; Lehtonen et al., 2006; Woollams et al. 2009; Bowden et al., 2010; Babcock et al., 2012, among others). In a frequency effects method, such as the lexical decision or past tense production task, if the participant's reaction times differ for high and low frequent words it is assumed that such words were memorized. On the other hand, if participants' reaction times do not differ according to the word frequency (high and low), then it is assumed that such words were decomposed (Brovetto & Ullman, 2001, 2005; Bowden et al. 2010; Babcock et al. 2012). Different theories for language learning and processing, such as the single and dual mechanisms, make different predictions based on the frequency effects method.

The dual-mechanism view predicts that frequency effects should be found only in the processing of irregular verbs, since the more often the verb is used, the faster the verb will be retrieved from memory. Thus, in behavioral studies using a frequency effects task, the past tense production of a high frequency irregular verb should be faster than the production of a low frequency irregular verb. Conversely, the processing of the regular past tense should not present frequency effects, since the same rule is applied for both high and low frequency regular verbs. In other words,

> "A set of forms that is stored in memory will show frequency effects […]. In contrast, composed forms (e.g., walk + *-ed*) will not show such "full-form" (or "surface") frequency effects (e.g. past tense frequency effects) because such forms are not accessed as full forms in memory. Thus, frequency effects can be taken as a diagnostic for storage, with their absence suggesting composition" (Babcock et al., 2012, p.3).

The connectionist single-mechanism view predicts that frequency effects should be found in all verbal forms, regular and irregular, since all verbs are represented and memorized in an associative memory (Plunket & Marchman, 1993; Joanisse & Seidenberg, 1999; McCelland & Patterson, 2002; Joanisse & Seidenberg, 2005; Woollams et al., 2009). Thus, the more frequent the verb is (regular or irregular), the faster the recognition and generation of the verb, since high-frequency forms are easier to remember.

Finally, in the full decomposition model, neither regular nor irregular verbs should present frequency effects, since in this model all verbal forms are decomposed (Stockall and Marantz, 2006). Thus, if frequency effects are not predicted for rule computation, frequency of use should not affect the recognition and generation of inflectional morphology.

2.3 Inhibitory control

Inhibitory control is an executive function which involves the ability to inhibit irrelevant information while focusing on relevant information (Bialystok, Craik, Klein & Viswanathan, 2004). Diamond (2006) explains inhibitory control as a cognitive ability to inhibit distractions to focus on the relevant information. The three principal functions of inhibitory control are: (1) the ability to suppress or delete from working memory the information that is irrelevant; (2) the ability to control and limit the access of relevant information in working memory while preventing the access of irrelevant information; and (3) the ability to restrain strong responses in order to estimate the appropriateness of them before being produced (Hasher, Zacks & May, 1999).

In order to assess inhibitory control, tasks must be carefully designed and present a conflicting situation to be solved (Bialystok, Martin & Viswanathan, 2005). The inhibitory control task chosen for this study was the Simon Arrow Task (explained in detail in Chapter 3). This task is based on a stimulus-response relationship and measures the participant's ability to inhibit the irrelevant information to focus on relevant information (Bialystok et al., 2004; Bialystok, 2006; Bialystok, Craik and Luk, 2008). According to Bialystok (2006, p.69) "performance in the Simon task engages processes involved with selective attention, inhibition, and response switching." In addition, since this task is non-linguistic and content-free, it is considered to be appropriate for all ages (Bialystok et al., 2005).

The Simon Arrow Task presents congruent and incongruent trials. The congruent trials match the stimulus direction with the stimulus location while in the incongruent trials the stimulus direction and location are mismatched. This stimulus mismatch generally causes a delay in the incongruent trials' reaction times when compared to the congruent trials' reaction times. This difference in the participants' reaction times between the congruent and the incongruent trials is called the Simon Effect (Bialystok et al., 2004). The Simon Effect is the measurement which indicates inhibitory control efficiency, that is, a reduced Simon Effect (difference between congruent and incongruent trials) indicates more efficient inhibitory control. Conversely, a greater Simon Effect indicates less efficient inhibitory control (Bialystok et al., 2004).

The inhibitory control task (Simon Arrow Task) was included in this study to investigate if the processing of inflectional morphology of English as L2 has a correlation with inhibitory control function, that is, if the participants with a more efficient inhibitory control were able to respond with higher accuracy and faster response times in the past tense production task. In this context, a correlation would suggest that inhibitory control function affects the processing of inflectional morphology of English as L2.

2.4 Working memory

Working memory is an executive function which involves the ability to maintain and recall information for a short period of time while processing information. Juffs and Harrington (2011, p.138) describe it as "the mental processes responsible for the temporary storage and manipulation of information in the course of on-going processing." According to Engle (2007), it is easier to understand working memory as part of cognition than part of memory, since it does not involve only storage (memorization) of information but it also involves processing of information. Briefly, working memory is a cognitive system responsible for the storage and processing of information for a short period of time (Juffs & Harrington, 2011).

The first working memory model and also the best known model is the one proposed by Baddeley and Hitch (1974). In this model, working memory presents three elements: a central executive and two subsystems, the Phonological Loop and the Visuo-spatial Sketchpad. The Phonological Loop is responsible for the temporary storage of verbal and phonological information, the Visuo-spatial Sketchpad is responsible for the processing of spatial and visual information, and a central executive is responsible for monitoring the information flow between these two subsystems. Later, Baddeley (2000) added a new element to the model, the Episodic Buffer, which is responsible for temporary store and integrate different types of information (Juffs & Harrington, 2011).

The elements of working memory can be measured through behavioral tasks, which can be simple or complex working memory tasks. According to Maurits, Bosh and Hugdahl (2006), simple working memory tasks deal only with the storage element of working memory while complex working memory tasks deal with the storage element as well as the information processing. One example of a simple working memory task is the digit span task, which requires that the participant repeat a set of numbers as read by the experimenter in the exact same order. One example of a complex working memory task is the reading-span task (by Daneman & Carpenter, 1980), in which the participant is required to read aloud sets of sentences. Additionally, the participant should remember the last word from all the sentences in each set. The simple and complex working memory tasks can be presented to the participants visually with the aim of assessing the visuo-spatial element of working memory or orally with the aim of assessing verbal working memory. In order to assess working memory capacity, the tasks must measure the cognitive capacity to store and/or process information. The scores in the tasks reflect the individual working memory capacity (Juffs & Harrington, 2011).

Researchers interested in investigating L2 learning and processing have been interested in understanding how individual differences measured by means of working memory capacity might explain the individual differences in L2 acquisition (Juffs & Harrington, 2011). For instance, Maurits et al’s (2006) study found that working memory capacity was associated with language proficiency. In the present study, a working memory task was used with the aim of understanding the role of the individual differences in L2 processing. The working memory task chosen for this study was the Letter-Number Ordering Task, which is a complex working memory task (explained in detail in Chapter 3). This task is non-linguistic and assesses the capacity to maintain and recall non-linguistic information while processing information (ordering the letters and numbers) (Maurits et al, 2006). Higher scores on the Letter-Number Ordering Task suggest a higher working memory capacity while lower scores suggest a lower working memory capacity. The only variable analyzed in the Letter-Number Ordering Task is accuracy.

The working memory task (Letter-Number Ordering Task) was included in this study to investigate if the processing of inflectional morphology of English as L2 is correlated with working memory capacity. A significant correlation between the two tasks might suggest that participants with a higher working memory capacity would have higher accuracy and faster response times in the past tense production task. A correlation would mean that individual working memory capacity affects the processing of inflectional morphology of English as L2.

Tasks which measure the executive control functions, such as working memory capacity and inhibitory control, are assumed to reflect cognitive individual differences (Park & Payer, 2006). In the present study, an inhibitory control task (Simon Arrow Task) and a working memory task (Letter-Number Ordering Task) were included to examine the role of individual differences in the processing of inflectional morphology of English as L2. Bialystok, Craik and Freedman (2007) suggest that when a person knows two languages s/he relies on a mechanism to inhibit the information from the language that is not being used to focus the attention on the language that is being used. Thus, in the present study, the participants with a higher working memory capacity and a more efficient inhibitory control are expected to present the faster response times in the Frequency Effects Task. These participants would be able to focus their attention on the relevant language (inhibiting the irrelevant language) with less effort than the participants with a lower working memory capacity and a less efficient inhibitory control. Summarizing, individual differences measured through inhibitory control and working memory capacity are expected to affect the past tense production of English regular and irregular verbs in the Frequency Effects Task.

CHAPTER 3
METHOD

This chapter describes the methodology adopted to conduct the present study. For the sake of organization, this chapter is divided into six sections. Section 3.1 presents the objectives of the study as well as the research questions and hypotheses. Section 3.2 describes the profile of the participants that took part in this study. Section 3.3 describes in detail the materials that were employed in this study. Section 3.4 presents the procedures for data collection. Section 3.5 presents the data analysis. Finally, section 3.6 describes the two phases of the pilot study.

3.1 Objectives and Research questions

The present study pursued two objectives: (1) to investigate the influence of frequency effects and proficiency in the storage and composition of regular and irregular verbal morphology of English as L1 and L2, and (2) to investigate the role of inhibitory control and working memory capacity on the processing of English verbal morphology. In order to accomplish these objectives, this study focused on the following research questions:

Research Question 1: Are there frequency effects on the processing of English regular verbs by native speakers of English and by Brazilian Portuguese speakers of English as L2 at two different proficiency levels (high and low)?

Research Question 2: Are there frequency effects on the processing of English irregular verbs by native speakers of English and by Brazilian Portuguese speakers of English as L2 at two different proficiency levels (high and low)?

Research Question 3: Is there a significant correlation between response times in the Frequency Effects Task (FET) and performance on the inhibitory control task?

Research Question 4: Is there a significant correlation between response times in the Frequency Effects Task (FET) and working memory capacity?

Four hypotheses are proposed to answer each one of the research questions presented above.

Hypothesis 1: There will be frequency effects on the processing of English regular verbs only for the Brazilian Portuguese speakers of

English as L2 at the low proficiency level, since they tend to memorize the regular forms in declarative memory. The native speakers of English and the Brazilian Portuguese speakers of English as L2 at the high proficiency level will compute the regular forms online in procedural memory, not presenting frequency effects.

Hypothesis 1 is based on a dual-mechanism account for morphological processing, which suggests that beginning learners of English as L2 store the regular verbs in declarative memory and high proficient learners of English as well as native speakers compute the regular verbs in procedural memory (Brovetto & Ullman, 2001; Pinker & Ullman, 2002; Ullman, 2001b, 2005; Bowden, 2007; Bowden et al., 2010).

Hypothesis 2: There will be frequency effects on the processing of English irregular verbs for native speakers of English and Brazilian Portuguese speakers of English as L2 at both proficiency levels, high and low.

Hypothesis 2 is supported by both the dual-mechanism and the connectionist single-mechanism accounts for morphological processing. In the dual-mechanism account for morphological processing, English irregular verbs are not rule-based, which means that each of these verbs are memorized as an individual unit in declarative memory (Brovetto & Ullman, 2001, 2005; Pinker & Ullman, 2002; Ullman, 2001b, 2005; Bowden, 2007; Bowden et al., 2010). The connectionist single-mechanism account for morphological processing also supports hypothesis 2 since in this view irregular (and regular) verbal morphology is memorized in one single associative memory (Joanisse & Seidenberg, 1999; McCelland & Patterson, 2002; Rumelhart & McClelland, 1986; Woollams et al,. 2009).

Hypothesis 3: There will be a significant positive correlation between the FET response time and the performance on the inhibitory control task. The participants who presented lower response times in the FET will also be the ones who presented lower reaction times in the executive control task.

Hypothesis 4: There will be a significant negative correlation between the FET response time and working memory capacity. The participants who presented lower response times in the FET will be the ones who presented higher scores in the working memory task.

If significant correlations are found between the FET and both the Simon Arrow Task and the Letter-Number Ordering Task, as proposed in hypotheses 3 and 4, it will be possible to state that inhibitory control and working memory capacity affect the processing of English verbal morphology.

3.2 Participants

Seventy-two adult participants, 36 men and 36 women, took part in this study. The participants' mean age was 35.5 (ranging from 18 to 75 years), they were healthy and right-handed. All of the 72 participants had a high level of education, which encompassed one of the following four levels: (1) a University degree, (2) a Masters degree (3) a PhD degree, or (4) a degree in one of these levels with work experience in his/her area of interest.

The 72 participants were divided into three groups. The Experimental group 1 consisted of 26 participants, native speakers of Brazilian Portuguese with a high proficiency level in English as L2 (referred to as the Advanced group). The Experimental group 2 consisted of 26 participants, native speakers of Brazilian Portuguese with a low proficiency level in English as L2 (referred to as the Beginner group). Group 3, the control group, consisted of 20 participants, native speakers of American English (referred to as the Native group). Each of these three groups is described in detail in Subsections 3.2.1, 3.2.2 and 3.2.3.

All participants took part in this study voluntarily and signed a consent form in their native language. Native speakers of Brazilian Portuguese signed a consent form in Portuguese (Appendix A) and the native speakers of American English signed a consent form in English (Appendix B). Participants also answered a language background questionnaire in their native language. Native speakers of Brazilian Portuguese answered a questionnaire in Portuguese (Appendix C) and the native speakers of American English answered a questionnaire in English (Appendix D). Both questionnaires are described in detail in Subsection 3.3.1.

The participants from the three groups performed the Frequency Effects Task, the Simon Arrow Task and the Letter-Number Ordering Task. Only native speakers of Brazilian Portuguese took an English proficiency test. These materials are described in Section 3.3.

In the next three subsections, a detailed description of each group that took part in this study will be presented.

3.2.1 The Advanced group

This is the first experimental group and it is represented by native speakers of Brazilian Portuguese with a high level of proficiency in English as L2. This group consisted of 26 healthy adults, 13 men and 13 women, with a mean age of 28 years (ranging from 18 to 38 years).

Based on their answers to the language background questionnaire, all participants from this group considered themselves fluent in English. These participants reported to have had contact with English for at least 8 years (ranging from 8 to 15 years of exposure). They also self-evaluated their speaking, listening, reading and writing skills in English as very good or good. All the participants learned English in an instructed context, meaning that they were studying or had studied English at a language school. Fifteen of the Advanced group participants reported having lived in or visited a country where English was the official language. The period of time these participants lived abroad ranged from 3 months to 2 years. None of the participants from this group reported a cognitive disorder, such as dyslexia, aphasia or attention-deficit disorder.

In order to be assigned to the Advanced group, each participant was pre-selected based on one of the following criteria: (1) they should be attending the highest level of advanced English classes in the Extra-Curricular Program at Universidade Federal de Santa Catarina (UFSC), (2) they should have completed all the advanced levels of English classes, or (3) they should be an MA or PhD student in the English Graduate Program at UFSC. After being pre-selected, two instruments were applied to these participants in order to verify their proficiency level in English as L2. The first instrument was a language background questionnaire (described in Subsection 3.3.1), designed to collect information about the participants' language experience with English as L2. The second instrument was an adapted version of a proficiency test, the Preliminary English Test (PET) produced by Cambridge University (detailed information about this proficiency test is provided in Subsection 3.3.2). To be included in the high proficiency group, participants had to answer at least 90% of the PET correctly.

3.2.2 The Beginner group

This is the second experimental group, represented by native speakers of Brazilian Portuguese with a low level of proficiency in English as L2. This experimental group also consisted of 26 healthy adults, 10 men and 16 women, with a mean age of 31.5 years (ranging from 18 to 45 years).

Based on their answers to the language background questionnaire, participants in this group did not consider themselves fluent in English. These participants reported to have had contact with English for at least 2 years (ranging from 2 to 4 years of exposure to the English language). They self-evaluated their speaking, listening, reading and writing skills in English as good or average. At the time of data collection, all participants were learning English in an instructed context and taking English classes at UFSC. Seven participants reported having visited a country where English was the official language. The lengths of these visits ranged from 1 week to 3 months. None of the participants from this group reported a cognitive disorder, such as dyslexia, aphasia or attention-deficit disorder.

In order to be assigned to the Beginner group, the participants should be at a high beginner/ low intermediate level of English. Participants were pre-selected from the fourth level of the Extra-Curricular English Program at Universidade Federal de Santa Catarina (UFSC). The fourth level represents the first semester of the intermediate level which, according to the UFSC Extra-Curricular Program, means that the participants were high beginners or low intermediate students of English as L2. After being pre-selected, two instruments were used to verify the participants' proficiency level in English as L2. The first instrument was a language background questionnaire (described in Subsection 3.3.1), designed to gather information about the participant's language experience with the L2. The second instrument was an adapted version of a proficiency test, the Key English Test (KET) produced by Cambridge University (described in subsection 3.3.2). The participants selected for the Beginner group answered at least 50% and at most 90% of the KET correctly. The 90% criterion was adopted to make sure that the participants' level was not too high for this group, since their level of proficiency should be significantly different from the Advanced group. The 50% criterion was selected to ensure that the proficiency level of the participants from the Beginner group was not too low, since this study requires that they should be able to conjugate English verbs in the simple past tense.

3.2.3 The Native group

This is the control group, represented by native speakers of American English (AE). This group consisted of 20 healthy adults, 13 men and 7 women, with a mean age of 47 years (ranging from 19 to 75 years).

Based on their answers to the language background questionnaire, they were all originally from the United States of America and their mother tongue was American English (AE). However, at the time of data collection, they all had been living in Brazil for at least 1 week (ranging from 1 week to 10 years of residence in Brazil). Six participants had studied Brazilian Portuguese (BP) before arriving in Brazil, 11 participants started to study BP after arriving in Brazil and 3 participants did not know BP. Additionally, 10 participants reported to speak more English than Portuguese in their daily life, 6 participants reported to speak both languages at the same amount and 4 participants reported to speak more Portuguese than English.

In order to be assigned to the Native group, the participants should be native speakers of AE and should be originally from the United States of America. These criteria were determined from the language background questionnaire (described in Subsection 3.3.1).

3.3 Materials

This section describes all the materials used in this study and is divided into five subsections. Subsection 3.3.1 describes the language background questionnaires, the one in Portuguese (used for the experimental groups) and the one in English (used for the control group). Subsection 3.3.2 describes the proficiency tests used in this study. Subsection 3.3.3 describes the Frequency Effects Task, which was used to investigate English morphological processing. Subsection 3.3.4 describes the inhibitory control task used in this study, the Simon Arrow Task. Finally, Subsection 3.3.5 describes the non-verbal working memory task used in this study, the Letter-Number Ordering Task. The description presented in this Section 3.3 refers to the final version of each material used in this study. Section 3.6 describes the pilot study used to test these materials.

3.3.1 Language background questionnaires

Two different language background questionnaires were employed in this study. One questionnaire was designed for the participants that were native speakers of BP (Appendix C) and the other was designed for the participants that were native speakers of AE (Appendix D). All participants answered the questionnaire in their native language. First the questionnaire designed in Portuguese will be described and second the questionnaire designed in English.

The questionnaire in Portuguese (Appendix C) was designed for the experimental groups (the Advanced and Beginner groups). This questionnaire was adapted from Brovetto (2002) and Scherer (2007) and it was divided into 4 sections. Section 1 was designed to collect general information about the participants, such as name, age, nationality, gender, education level and handedness. Section 2 was designed to collect information about the participants' experience with English as L2. Some examples of information collected are: (1) how often they speak English in their daily life, (2) how old they were when they first started learning English as L2, and (3) if they had lived in a country where the native language was English. Also, participants were asked to self-evaluate their reading, writing, listening and speaking skills in English as L2. Section 3 presented questions requiring some clinical information to know if the participants were diagnosed with any cognitive disorder, such as: aphasia, dyslexia, autism, bipolarity and attention-deficit disorder. Finally, Section 4 requested some pharmacological information to know if the participant was under the effect of a medicine while performing the tasks.

The second questionnaire was in English (appendix D) and was designed for the Native group. This questionnaire was adapted from Xhafaj´s (2006) and it was divided into 2 sections. Section 1 was designed to collect general information about the participants, such as name, age, nationality, gender, education level and handedness. Section 2 presented 8 questions about the participants' personal experiences with languages, either their native language (AE) or foreign languages (such as BP). Some examples of the type of information collected are: (1) how long the participants have been away from the U.S, (2) if the participants had studied Portuguese before arriving in Brazil, (3) which language the participant speaks more often in their daily life, (4) what is the participant's native language, (5) how many languages the participant speaks and (6) a self-evaluation of the participant's speaking, listening, reading and writing skills in all languages they know.

3.3.2 Proficiency Tests

Two proficiency tests were adopted for this study, the Key English Test (KET) and the Preliminary English Test (PET) designed by Cambridge University. Two different proficiency tests were necessary since there were two different levels of proficiency (low and high) in the experimental groups. Participants were pre-selected to take either the KET or the PET based on their experience in English as L2. Participants regularly enrolled in English classes level 4 from the Extra Curricular Language Program at UFSC took the KET, while participants that were regularly enrolled at the highest level of English classes in the Extra Curricular Language Program at UFSC or participants that had already completed all levels of English classes took the PET.

The KET is a widely recognized exam that determines if a person is able to use the English language at a basic level. The KET examination adopted was a reduced version of the free sample available in the Key English Test: Handbook for Teachers[3]. A reduced version of the test was adopted because the complete test was too long (1 hour and 50 minutes) for the time the majority of the participants had available. This decision was made after the pilot study (section 3.6), which showed that participants found the test too long and that could increase the mortality rate. The reduced version used in this study consisted of 3 examinations: (1) Reading and Writing, (2) Listening and (3) Speaking.

First, the Reading and Writing examination was divided into 5 parts. Part 1 was a multiple choice activity testing verbal morphology and vocabulary. Part 2 was a multiple choice activity where the participants would have to complete conversations, also testing vocabulary. Part 3 presented a small text testing reading comprehension. Part 4 was a multiple choice activity testing grammatical structures. Finally, part 5 was a guided writing activity testing basic writing skills.

Second, the Listening examination was divided into 3 parts. Part 1 was a multiple choice activity testing the ability to understand simple informal dialogues. Part 2 was a multiple choice activity testing the ability to understand one longer informal dialogue. Part 3 required the participants to fill in the gaps in sentences based on their understanding of a monologue.

Third, the Speaking examination was divided into 2 parts. In the first part, the researcher asked the participant simple personal questions testing their ability to answer questions about themselves. In the second part the researcher used flash cards to assess the participants' ability to ask and answer non-personal questions.

The other proficiency test used in this study, the PET, is also a widely recognized exam, but it tests a higher level of English language knowledge than the KET. The PET evaluates if a person is able to use the English language at an intermediate level. The PET examination

[3] http://www.cambridgeesol.org/resources/teacher/pet.html

adopted was also a reduced version of the free sample available in the Preliminary English Test: Handbook for Teachers[4]. A reduced version of the PET was adopted because the complete test was too long (2 hours and 10 minutes) for the length of time that the majority of the participants had available. This decision was taken after the pilot study (section 3.6) to avoid mortality. The reduced version of the PET consisted of 3 examinations: (1) Reading and Writing, (2) Listening and (3) Speaking.

First, the Reading and Writing examination was divided into 5 parts. Part 1 was a “True or False” activity testing the participants’ reading comprehension. Part 2 was a multiple choice activity also testing reading comprehension. Part 3 was a multiple choice activity where the participants had to choose the correct word to complete a text, testing vocabulary and grammatical structures. Part 4 was a writing activity where the participants had to fill in the blanks in various sentences, testing their knowledge of grammatical structure. Finally, part 5 was a guided writing activity testing the ability to produce a written text in English.

Second, the Listening examination was divided into 3 parts. Part 1 was a multiple choice activity testing the ability to understand simple informal dialogues. Part 2 was a multiple choice activity testing the ability to understand a longer informal dialogue. Part 3 required the participants to fill in the gaps in sentences based on their understanding of a monologue.

Third, the Speaking examination was divided into 3 parts. In the first part, the researcher asked the participant simple personal questions testing their ability to answer questions about themselves. In the second part the researcher used flash cards to assess the participants’ ability to ask and answer non-personal questions. In the third part the researcher presented a picture and gave the participant 3 minutes to describe the picture and to talk about the situation drawn in the picture.

As explained in Section 3.2, the participants selected for the Beginner group were the ones who answered at least 50% and at most 90% of the KET correctly. Furthermore, the participants selected for the Advanced group were the ones who answered at least 90% of the PET correctly.

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[4] http://www.cambridgeesol.org/resources/teacher/pet.html

3.3.3 Frequency Effects Task

The Frequency Effects Task (FET) was used to assess the processing and representation of English verbal morphology. The goal of this task was to investigate whether verb frequency influences the processing of regular and irregular English verbal forms. According to the dual-mechanism account for language processing (described in the Review of Literature), the past tense of high frequency irregular verbs are retrieved from memory faster than low frequency irregular verbs, since these forms are retrieved from memory (Brovetto & Ullman, 2001, 2005; Pinker & Ullman, 2002; Bowden, 2007; Bowden et al, 2010). Thus, the more frequent the irregular verb is, the faster the answer will be produced in the FET and the less frequent the irregular verb is, the slower the answer will be produced in the FET. In contrast, the rule-based regular past tense forms should not present frequency affects, since they are computed online in procedural memory (Brovetto & Ullman, 2001, 2005; Pinker & Ullman, 2002; Bowden, 2007; Bowden et al, 2010).

The FET is a variation of the Past Tense Production Task applied by Brovetto and Ullman (2001). In this section, the FET will be described into two different parts. First, the task itself is explained and then the stimuli used to develop this task are described.

In the FET participants were presented with a verb in the infinitive form, followed by a sentence that contains the verb in the simple present tense, which is then followed by a sentence in the simple past tense where the conjugated verb is missing. For instance:

Look
Every day I look at birds.
Yesterday I ______ at birds.

Another example of a set of stimuli used in this study:

Buy
Every day I buy some chocolate.
Yesterday I _______ some chocolate.

Every set of stimuli was presented at the center of the computer screen at once. The participant had to produce orally the past tense form of the verb in order to complete the sentence. Each set of stimuli was voice triggered, that is, the stimuli remained at the center of the computer screen until the participant produced an oral answer. After each answer, a blank screen appeared for 420 milliseconds followed by a fixation cross. Each fixation cross remained in the computer screen for 1 second and was followed by a beep. This beep signifies that the next set of stimuli will appear on the screen. Similar designs of the FET were used in many previous studies tackling frequency effects (e.g. Van der Lely & Ullman, 2001; Brovetto & Ullman, 2001, 2005; Walenski et al., 2007; Prado and Ullman, 2009).

The FET instructions for the Advanced and Beginner groups were in Portuguese and the instructions for the Native group were in English. The researcher read the instructions to the participant while s/he was looking at the instructions written at the center of the computer screen. Following the instructions there was a learning session showing the participant what s/he was expected to do. After the learning session there was a practice session with 5 sets of stimuli. The participant was allowed to repeat the practice session as many times as s/he desired. When the participant understood what s/he was expected to do, the experiment session was started. The experiment session was divided into 2 parts. First, 32 sets of stimuli were presented, followed by a pause. Then, when the participant was ready to restart (by pressing the space key in the keyboard) another 32 sets of stimuli were presented. After this total of 64 sets of stimuli the task was finished.

The FET was developed in the E-prime 2.0 and the participants' response time for each set of stimuli was registered in an electronic file generated by the E-prime software. Additionally, the participants' response times were recorded by the Serial Response Box (SRBOX) through a high quality microphone. The stimuli for the FET were taken from a study carried out by Newman et al. (2007). However, as mentioned before, the design of this task was based on Brovetto and Ullman's (2001) Past Tense Production Task. The choice for the list of verbs from Newman et al. (2007) study instead of the list of verbs from Brovetto and Ullman's (2001) study was made due to the learning context of the participants from the experimental groups. Both verb lists were analyzed, and a greater amount of verbs from Newman et al.'s (2007) list was found in the Interchange books. These books are used in the Extra Curricular Language Program at UFSC, that is, the books used for the majority of the participants from the experimental groups. The list from Newman et al.'s (2007) study presented a total of 128 verbs in English, 64 regular verbs (32 of high and 32 of low frequency) and 64 irregular verbs (32 of high and 32 of low frequency). The complete list from Newman et al. (2007) is presented in Appendix E. The frequencies of these verbs were recalculated according to the Corpus of Contemporary American English (COCA), which is the biggest online corpus of American English words available for free on the internet with over 410 million words (at the time of the data collection). After recalculating and reorganizing the verbs frequencies in a decreasing order, the natural logarithm of the frequencies was calculated and a T-test was applied. This new list of verbs with their frequency based on the COCA is provided in Appendix F. For the FET stimuli, 64 verbs were selected from this new list, 32 regular verbs (16 of high and 16 of low frequency) and 32 irregular verbs (16 of high and 16 of low frequency). The complete list of verbs used for the FET is provided in Appendix G.

The choice for a total of 64 verbs was based on a number of behavioral studies investigating frequency effects with a total of 64 verbs (e.g. Van der Lely & Ullman, 2001; Walenski et al., 2007; Prado et al., 2009; Woollams et al., 2009).

The structure for all sentences was the same. As previously demonstrated, the sentences in the present tense started with *Every day I*, followed by the main verb in the infinitive form and two post-verbal complements. All the sentences in the simple past started with *Yesterday I*, followed by a blank space (where the participant had to complete it orally with the past tense form of the main verb). After the blank two post-verbal complements were presented. The sentences created for this study were also based on the stimuli of Newman's (2007) study. In addition, a native speaker of American English who works as a professional writer in the USA reviewed the sentences and made some changes when necessary. After that, another native speaker of American English reviewed the sentences to make sure they sounded natural. The complete list of stimuli used for the FET, with the 64 verbs and the sentences used in this study is provided in Appendix H. This list is organized from the most frequent to the less frequent verb. The two variables analyzed in this production task were response time and accuracy. These variables are essential for analyzing the validity of hypotheses 1, 2, 3, and 4, and will be an important component for answering the research questions described in section 3.1.

3.3.4 Simon Arrow Task

The objective of the Simon Arrow Task is to assess participants' ability to inhibit irrelevant information. This task is a non-linguistic inhibitory control task and it is based on a stimulus-response relationship (Bialystok et al., 2004; Bialystok, 2006; Bialystok et al., 2008).

In the Simon Arrow Task, a red arrow is presented on the computer screen. If the arrow is pointing to the right, the participant should press the right key of the Serial Response Box (SRBOX) to indicate the arrow direction. Conversely, if the arrow is pointing to the left, the participant should press the left key of the SRBOX. However, the arrow sometimes is presented on the right side of the computer screen and other times the arrow is presented on the left side of the computer screen. The participant needs to focus on the direction that the arrow is indicating and inhibit the information about where the arrow is located.

The Simon Arrow Task presents congruent and incongruent trials (Bialystok, 2006). Congruent trials are trials where the direction and the location of the arrow are the same (Bialystok, 2006). For instance, if the arrow is pointing to the right and is presented on the right side of the computer screen it is considered a congruent trial. Conversely, incongruent trials are trials where the direction and the location of the arrow are different (Bialystok, 2006). For instance, if the arrow is pointing to the right and is presented on the left side of the computer screen it is considered an incongruent trial. The difference in the participants' reaction times between the congruent and the incongruent trials is called the Simon Effect (Bialystok et al., 2004).

The Simon Arrow Task was developed in E-prime 2.0 and the instructions for this task were presented in two versions. One version presented the instructions in Brazilian Portuguese (BP) and another version presented the instructions in American English (AE). Each participant was introduced to the task with instructions in his/her native language to avoid misunderstanding. The researcher read the instructions to the participant while s/he was looking at the instructions written at the center of the computer screen. The Simon Arrow Task was divided into three sessions, the learning, the practice and the trial sessions. The learning session presented 2 stimuli showing the participant what s/he was expected to do. The practice session presented 8 stimuli and the participant was only allowed to start the trial session after scoring 100% on these practice stimuli. The trial session presented 32 stimuli (16 congruent and 16 incongruent).

The participants' reaction time for each stimulus was registered in an electronic file generated by E-prime. The variables analyzed in the Simon Arrow Task were reaction time and accuracy. The objective of this task in this study is to investigate if inhibitory control and processing of regular and irregular verbs have a correlation. The performance in the Simon Arrow task will be analyzed to determine the validity of hypothesis 3 with the aim of answering research question number 3.

3.3.5 Letter-Number Ordering Task

The Letter-Number Ordering Task is a non-linguistic working memory task. The task used in this study is an adapted version of the working memory task applied by Maurits, Bosh and Hugdahl (2006). This task measures the capacity to maintain and recall non-linguistic information while processing the information (ordering the letters and numbers).

In the Letter-Number Ordering Task, a series of numbers and letters are presented visually on a computer screen and auditorily in the participants' native language. The letters and numbers appear one at the time followed by a set of question marks. The participant is allowed to answer only when the question marks appear on the center of the computer screen. The participants must repeat just the numbers in increasing order followed by the letters in alphabetical order. For instance, after seeing and listening to the following set of stimuli: 6 – G – A – 8 – X, the participant must say: 6 – 8 – A – G – X. The task starts with 2 items consisting of 1 letter and 1 number (e.g. 6-Q), with the number of items gradually increasing up to 8 items, consisting of 4 letters and 4 numbers (e.g. C – 1 – R – 9 – A – 4 – J – 3).

For each set of correct answers the participant scores one point, with a total of 21 sets, the maximum score is 21 points. In the Maurits et al.'s (2006) study the task was stopped after the participant erred on three sets of stimuli in a row. However, in this study the task was not stopped even if the participant missed three or more sets in a row. This decision was based on results from the pilot study, where some participants proved to be able to correctly repeat some sets of stimuli after having missed three sets in a row.

The Letter-Number Ordering Task was also developed in E-prime 2.0 and the instructions for this task were presented in two versions. One version presented the instructions in BP for the experimental groups and the other version presented the instructions in AE for the control group. The instructions were presented in a written format in the computer screen as well as in an auditory format through headphones. This task was divided into three sessions, the learning, the practice and the trial sessions. The learning session presents 2 sets of stimuli showing the participant what s/he was expected to do. The practice session presents 6 sets of stimuli and the participant can choose to repeat it as many times as necessary to understand the task. When the participant is ready, the trial session starts. The trial session finishes after 21 sets of stimuli and the participant's answers for each set of stimuli are recorded on the computer.

The stimuli for this working memory task were based on the complementary material of a study carried out by Maurits et al. (2006). The original stimuli for this task were slightly modified in order to adapt it for Brazilian Portuguese speakers. The letters k and w that were in the original stimuli were substituted by the letters j or l and x or z respectively, because the letters k and w were only recently added to the Brazilian Portuguese alphabet. The letters k and w could make the task especially harder for Brazilians when putting these specific letters in alphabetical order, as the order of these letters is relatively new for them. Also, a total of 8 sets of stimuli were added in the Maurits et al.'s (2006) stimuli list. Two sets were added for the learning session and 6 sets of stimuli were added for the practice session. The complete list containing the 21 sets of stimuli used in trial session is provided in Appendix I.

The only variable analyzed in the Letter-Number Ordering Task was accuracy. The objective of this task in this study is to investigate if working memory capacity and processing of regular and irregular English morphology correlate. The performance in the Letter-Number Ordering Task will be analyzed to determine the validity of hypothesis 4 with the aim of answering research question number 4.

3.4 Data collection procedures

All the data was collected at the Laboratório da Linguagem e Processos Cognitivos (LabLing) at UFSC. Each of the instruments employed in this study were tested in a pilot study and some changes were made where necessary before starting the final data collection. In this section, only the procedures for the final data collection will be explained. For the final data collection, only the participant and the researcher were allowed inside the LabLing, since all the tasks were to be performed individually and accompanied by the researcher. Each Brazilian participant took around 2 hours to complete all the activities, while each American participant took around 40 minutes to complete all the activities, as the latter did not need to take a proficiency test.

The data collection for the Advanced and Beginner groups consisted of 6 steps. First, the participant read and signed the consent form in Portuguese (Appendix A). Second, the participant completed the Language Background Questionnaire in Portuguese (Appendix C). Third, the participant took the proficiency test (described in Subsection

3.3.2). Fourth, the participant performed the Frequency Effects Task. Fifth, the participant performed the Letter-Number Ordering Task. Lastly, the participant performed the Simon Arrow Task.

The data collection for the Native group consisted of 5 steps. First, the participant read and signed the consent form in English (Appendix B). Second, the participant completed the Language Background Questionnaire in English (Appendix D). Third, the participant performed the Frequency Effects Task. Fourth, the participant performed the Letter-Number Ordering Task. Lastly, the participant performed the Simon Arrow Task.

For all the three proficiency groups, the researcher read out loud the instructions for each one of the tasks. The instructions of the tasks were in the native language of the participant, that is, native speakers of BP would receive the instructions in Portuguese, while native speakers of AE would receive the instructions in English. After participating in this study, the Brazilian participants received feedback related to their proficiency test and a certificate of participation in the research.

3.5 Data Analysis

The Statistical Package for Social Sciences 20 (SPSS 20) was used for the statistical analysis in this study. The analysis was divided into three main parts, the normality test, the descriptive statistical analysis and the inferential statistical analysis. First, the Shapiro-Wilk test was run to assess if the data collected was normally distributed. The results showed that the data distribution was non-normal. Based on this result, a non-parametrical analysis was chosen for this study. The statistical analysis was applied to the original data and no transformations were made to the data. In order to avoid noise from the non-normal distribution, the medians (instead of the means) were used to give aggregate results.

The descriptive statistics were calculated for the three proficiency groups (Native, Advanced and Beginner) for all three tasks: the FET, the Simon Arrow Task and the Letter-Number Ordering task. For the FET, the median response times of regular high frequency, regular low frequency, irregular high frequency and irregular low frequency verbs were calculated separately for each proficiency group. Also, the accuracy (percentage of correct answers) was calculated for the regular high frequency, regular low frequency, irregular high frequency and irregular low frequency verbs for each proficiency group. For the Simon Arrow Task, the median reaction times were calculated for congruent and incongruent trials separately and for all trials together. Accuracy (percentage of correct answers) was also calculated for congruent and incongruent trials separately and for all trials together. In addition, the Simon Effect was calculated for the three proficiency groups. For the Letter-Number Ordering Task the median scores were calculated for the Native, Advanced and Beginner groups.

Inferential statistics were calculated and were divided into three main sections. The first section uses the non-parametric Mann-Whitney test on response times to analyze if regular and irregular verbs presented frequency effects in the FET within proficiency groups. For instance, the median response times of high frequency regular verbs were compared with the median response times of low frequency regular verbs in the Beginner group. Additionally, the Chi-square test was run in order to verify if there was a significant difference in the accuracy within proficiency groups. The second section uses the same tests, but with the aim of analyzing the response times and accuracy between the proficiency groups. For instance, the median response time of high frequency regular verbs in the Beginner group is compared with the median response time from same type of verbs in the Advanced group. The third section uses the Pearson correlation to investigate if there was a correlation between the FET response times and the Simon Arrow task reaction times. Also, the Pearson correlation was used to investigate if there was a correlation between the FET response times and the Letter-Number Ordering Task scores. The Pearson test is a parametric test and was used because there were some repeated values in the data collected which disallows the usage of the equivalent, non-parametric, Spearman test. The Pearson correlations were only done for the Advanced and Beginner groups because the goal was to investigate if individual differences (working memory capacity and inhibitory control) correlate with proficiency in an L2. Thus, the data collected from the Native group for the working memory task and for the inhibitory control task were not analyzed in the inferential statistics, since it was not possible to control the proficiency of the Native group in an L2 (as described in Section 3.2.3, some of the participants knew Portuguese as L2 and some did not know any L2).

3.6 Pilot study

The pilot study was carried out at Laboratório da Linguagem e Processos Cognitivos (LabLing) at UFSC and it was divided into two phases, the pre-pilot phase and the pilot phase. All the tasks used in this study were tested in both phases of the pilot study.

The pre-pilot phase was carried out with a total of 14 participants, 4 men and 10 women. Nine of them were students in the English Graduate Program at UFSC and were pre-classified as part of the Advanced group. The other 5 participants were undergraduate students in the second semester of the English course at UFSC and were pre-classified as part of the Beginner group. There was no control group in the pre-pilot phase of this study. All participants answered the language background questionnaire and three participants from the Advanced group made suggestions about the questionnaire. The participants pre-classified for the Advanced group took the PET proficiency test and the participants pre-classified for the Beginner group took the KET proficiency test. The majority of the participants complained that the proficiency test (PET or KET) took too much time. The participants from the Advanced group took an average of 3 hours to complete the test and the participants from the Beginner group took an average of 3h and 20 minutes to complete the test. Two participants from the Beginner group did not finish all parts of the proficiency test due to lack of time.

The FET, the Simon Arrow Task and the Letter-Number Ordering Task were also tested with these participants. Some participants from both groups complained about the size of the letters/numbers displayed on the computer screen. One participant asked to stop the test to get their glasses and then continue the task.

When the participants were performing the Letter-Number Ordering Task, some participants were able to provide correct answers even after giving incorrect answers for three sets of stimuli in a row. According to Maurits et al. (2006) the task should be stopped after the participant repeated incorrectly three sets of stimuli in a row. However, for the second phase of the pilot study the task continued to the end, and participants had a chance to repeat the next sets of stimuli even after making three or more mistakes in a row.

For the second phase of the pilot study minor changes were made in the language background questionnaire, changing the format of two questions. The letters/numbers displayed on the computer screen were changed to a bigger size in the three tasks, FET, Simon Arrow Task and Letter-Number Ordering Task. Moreover, both proficiency tests, PET and KET, had their sizes reduced. Finally, the consent form was tested only in the second phase of the pilot study.

The second phase of the pilot study was carried out with a total of 20 participants, 7 men and 13 women. Ten of them were students in the

English Graduate Program at UFSC and were pre-classified as part of the Advanced group. Eight participants were students in the level 4 of the Extra Curricular English Program at UFSC and were pre-classified as part of the Beginner group. Two participants were native speakers of American English and were selected for the control group.

The participants from the Beginner and Advanced groups signed the consent form, answered the questionnaire, took the reduced version of the proficiency test (PET or KET) and performed the three tasks: FET, Simon Arrow Task and Letter-Number Ordering Task. The two participants from the control group signed the consent form, answered the questionnaire and performed the three tasks: FET, Simon Arrow Task and Letter-Number Ordering Task. After the second phase of the pilot study no more changes were made in the materials used in this study.

CHAPTER 4
RESULTS AND DISCUSSION

The purpose of this chapter is to present and discuss the results of the statistical analyses performed in order to answer the research questions of this study. As explained in the previous chapter, this study has two experimental groups and one control group. Hereafter, the control group represented by native speakers of American English is going to be referred to as Native group. The first experimental group represented by native speakers of Brazilian Portuguese with a high level of proficiency in English as L2 is going to be referred to as Advanced group. Finally, the second experimental group represented by native speakers of Brazilian Portuguese with a low level of proficiency in English as L2 is going to be referred to as Beginner group.

This chapter is divided into three main sections. Section 4.1 presents the results of the descriptive statistics for the three proficiency groups' performance in each task. Section 4.2 presents the inferential statistical analysis and it is subdivided into three parts. Subsection 4.2.1 brings the comparison of the Frequency Effects Task (FET) results within the three proficiency groups. Subsection 4.2.2 brings the comparison of the FET results between the proficiency groups. Subsection 4.2.3 brings the Pearson correlations for (a) the FET and the Simon Arrows Task and (b) the FET and the Letter-Number Ordering Task. Finally, section 4.3 presents the answers for the 4 research question of the present study.

4.1 Descriptive statistical analysis

The main variable of this study, proficiency, is presented in each of the following 4 tables. Tables 4.1 and 4.2 contain the descriptive statistical results for the Frequency Effects Task (FET). Table 4.3 contains the descriptive statistical results for the Simon Arrow Task and Table 4.4 contains the descriptive statistical results for the Letter-Number Ordering Task.

As described in the Method, when the Frequency Effects Task was running, the participant's response time to a verbal stimulus was recorded through a SRBOX (Serial Response Box), which captures the time each participant takes to produce the past tense form of each verb. The following table reports the descriptive statistics for the Frequency

Effects Task with the median response times and accuracy by verb group (regular and irregular) and verb frequency (high and low) for the three proficiency groups.

Table 4.1

Descriptive Statistics for the Frequency Effects Task –Median Response time and Accuracy by verb frequency for the three proficiency groups.

Proficiency Group	Verb Group	Verb Frequency	Number of verbs	RT (in ms)	Accuracy (%)
Native (N=20)	**Regular**	**High**	**16**	**680**	**97**
		Low	**16**	**729**	**97**
	Irregular	**High**	**16**	**741**	**93**
		Low	**16**	**763**	**94**
Advanced (N=26)	**Regular**	**High**	**16**	**904**	**98**
		Low	**16**	**1089**	**94**
	Irregular	**High**	**16**	**1018.5**	**90**
		Low	**16**	**1094**	**58**
Beginner (N=26)	**Regular**	**High**	**16**	**1146**	**96**
		Low	**16**	**1568**	**84**
	Irregular	**High**	**16**	**1549**	**63**
		Low	**16**	**1733**	**29**

Note. N= number of participants, RT= response time, ms= milliseconds.

Comparing the verb groups and the verb frequency for the Native group, Table 4.1 shows that the median response times for regular verbs (high and low frequency) and for irregular verbs (high and low frequency) were very similar. Therefore, the Native group conjugated all verbs almost at the same speed (680ms and 729ms for regular verbs and 741ms and 763ms for irregular verbs). Also, there were no differences in accuracy between high and low frequency regular verbs (97%) and concerning irregular verbs the difference between high and low frequency was only 1% (93% and 94%, respectively). Consequently, the data suggest that the frequency of the verbs does not interfere either in the response time speed or in the accuracy for the Native group.

According to the median response times in Table 4.1 for the Advanced group the answers for high frequency verbs was slightly faster than the low frequency verbs. However, this speed difference is slightly larger inside the regular verb group (904ms versus 1089ms). Thus, the Advanced group tended to conjugate high frequency regular verbs slightly faster than low frequency regular verbs. The results from the Advanced group also indicates that the number of correct answers was larger for the high frequency verbs than for the low frequency verbs (98% versus 94% in the regular verbs and 90% versus 58% in the irregular verbs group), that is, the higher the frequency of the verb the more accurately the Advanced group conjugated it. Also, the number of correct answers was larger for regular verbs than for irregular verbs. In addition, the lowest accuracy (58%) was recorded when the Advanced group had to conjugate the low frequency irregular verbs. Therefore, the data suggest that it was considerably more difficult for the Advanced group to conjugate the low frequency irregular verbs.

Comparing the data from the Beginner group, Table 4.1 shows that the Beginner group conjugated the high frequency verbs slightly faster than the low frequency verbs. Nevertheless, this difference in the speed was greater in the regular verb group (1146ms versus 1568ms). Based on the raw data from Table 4.1, it is possible to suggest that the higher the regular verb frequency, the faster the regular verb was conjugated by the Beginner group. Table 4.1 also shows a large variation in accuracy between both verb groups and frequency groups for the Beginner group. This proficiency group had more correct answers when conjugating the high frequency verbs than the low frequency verbs. This can be an indicator that the higher the frequency of a verb, the easier it was for the Beginner group to conjugate it correctly. Also, the accuracy for regular verbs was much higher than the accuracy for irregular verbs (96% and 84% versus 63% and 29%, respectively). This suggests that it was easier for the Beginner group to conjugate the regular verbs. In addition, the low frequency irregular verbs, which presented the lowest accuracy (29%), seemed to be the most difficult for the Beginner group to conjugate.

Comparing the results from the three proficiency groups, Table 4.1 shows that there is a large difference in the median response times between the three proficiency groups. The median response times were much faster for the Native group than for both Beginner and Advanced groups. Moreover, the Advanced group’s median response times were much faster than the Beginner group. These results indicate that proficiency was strongly linked to response time speed, since the higher the proficiency in English, the faster the participant conjugated the English verbs. The comparison between the proficiency groups also shows two similarities between the Advanced and the Beginner groups: (a) both conjugated the high frequency regular verbs slightly faster than the low frequency regular verbs and, (b) both presented a higher accuracy in the responses for high frequency verbs than for low frequency verbs, with a larger difference in the Beginner group.

Table 4.2 contains the descriptive statistics for the Frequency Effects Task with the number of correct and incorrect responses for each proficiency group.

Table 4.2

Descriptive Statistics for the Frequency Effects Task – Number of correct and incorrect responses by proficiency groups.

		Regular Verbs		**Irregular Verbs**	
Proficiency Group	**Verb Frequency**	**Total Correct**	**Total Incorrect**	**Total Correct**	**Total Incorrect**
Native (N=20)	**High**	**309 (97)**	**11 (3)**	**298 (93)**	**22 (7)**
	Low	**309 (97)**	**11 (3)**	**301 (94)**	**19 (6)**
Advanced (N=26)	**High**	**409 (98)**	**07 (2)**	**374 (90)**	**42 (10)**
	Low	**389 (94)**	**27 (6)**	**242 (58)**	**174 (42)**
Beginner (N=26)	**High**	**399 (96)**	**17 (4)**	**264 (63)**	**152 (37)**
	Low	**351 (84)**	**65 (16)**	**121 (29)**	**295 (71)**

Note. Percentages (%) of correct and incorrect responses are in parentheses, N= number of participants.

Table 4.2 shows that the Advanced and Beginner groups had more correct answers when processing high frequency verbs whereas the Native group did not present difference in accuracy due to verb frequency. Also, the Advanced and Beginner groups had more correct answers when processing regular verbs than irregular verbs. In contrast, the Native group did not present a large difference in the number of correct answers between regular and irregular verbs. These results suggest that the percentage of correct answers is linked to verb frequency and verb group only for the Advanced and Beginner groups.

The data show a large difference in percentage of correct answers within the three proficiency groups. The differences due to verb group and verb frequency were much larger for the Beginner group (ranging from 29% to 96% of correct answers) than for the Advanced group (ranging from 58% to 98% of correct answers), while the Native group showed a much smaller change (ranging from 93% to 97% of correct answers). Thus, the higher the proficiency in English the lower the change in percentage of correct answers due to verb group and verb frequency. Taken together, the results from Tables 4.1 and 4.2 show that accuracy and response times are closely related to proficiency.

The next Table, Table 4.3, contains descriptive statistics for the Simon Arrows Task for the three proficiency groups. As described in the Method, the Simon Arrow Task was used to investigate inhibitory control processes. Differing from the FET, the Simon Arrow Task is non-linguistic and presented congruent and incongruent trials. Participants had to focus on the relevant information (the direction that the arrow was indicating) and ignore the irrelevant information (the arrow location on the screen). In this task participants' reaction times were recorded.

Table 4.3

Descriptive Statistics for Simon Arrow Task – Median Reaction Time and accuracy by proficiency groups

				Congruent		Incongruent		
Proficiency Group	**N**	**RT (in ms)**	**Accuracy (%)**	**RT (in ms)**	**Accuracy (%)**	**RT (in ms)**	**Accuracy (%)**	**SE**
Native	**20**	**466**	**96**	**432**	**96**	**433**	**96**	**1**
Advanced	**26**	**464**	**92.5**	**461**	**93**	**471**	**92**	**10**
Beginner	**26**	**465**	**96.5**	**451**	**97**	**469**	**96**	**18**

Note. N= number of participants, RT= Reaction time, ms= milliseconds, SE= Simon Effect

Table 4.3 shows that there were almost no differences in the overall median reaction times for the three proficiency groups (median RT ranging from 464ms to 466ms). However, the results for accuracy in all trials indicate that the Advanced group was less accurate (92.5%) than the Native (96%) and Beginner (96.5%) groups. Table 4.3 also shows that the Simon Effect was smaller for the Native group (1ms) than for the Advanced (10ms) and Beginner (18ms) groups. In addition, the Simon Effect was smaller for the Advanced group than for the Beginner group. According to Bialystok et al. (2004), a reduced Simon Effect reflects a more efficient inhibitory function control. Thus, comparing only the participants from the experimental groups, whose proficiency in the L2 was controlled, it is possible to suggest that the higher the proficiency in the L2, the more efficient inhibitory control processes are (Advanced group' SE= 10ms and Beginner group' SE= 18ms). This reduced Simon Effect presented by the Advanced group (when compared to the Beginner group) can be understood as an advantage in inhibitory control function caused by the ability that these participants developed in switching between their native language (Brazilian Portuguese) and their L2 (English). According to Bialystok (2006), both languages (L1 and L2) are cognitively activated when a bilingual is communicating. However, bilinguals do not mix the languages (L1 and L2) when communicating because they developed the ability to inhibit the language that is not being used to focus on the language that is being produced (Green, 1998). In the context of the present study, the Advanced group may have this ability to inhibit the irrelevant language more developed than the Beginner group, since they have more experience with the L2, that is, more practice inhibiting one language to focus on the other. In addition, Bialystok (2006, p. 69) states that "[t]he need to constantly switch between languages may also amplify the ability of bilinguals to execute response switches in other domains", and this ability could have affected the participants performance on the Simon Arrow Task.

Table 4.4 contains descriptive statistics for the non-linguistic working memory task (Letter-Number Ordering task) with the standard deviation, mean and median scores for each one of the three proficiency groups. The highest possible score in this task is 21 (when all answers are correct) per participant and the lowest is 0 (when all answers are incorrect). This task measured the capacity to maintain and recall non-linguistic information while processing the information (ordering the letters and numbers).

Table 4.4

Descriptive Statistics for Letter-Number Ordering Task – Median score by proficiency groups

Proficiency Group	N	Median Score	Mean Score	Standard Deviation
Native	**20**	**15**	**15.3**	**3.23**
Advanced	**26**	**14.5**	**14.5**	**3.50**
Beginner	**26**	**12**	**12.3**	**3.98**

Note. N= number of participants.

Table 4.4 shows that there were almost no difference in the performance between the Native and the Advanced groups (M=15 and M= 14.5, respectively). However, the Native and the Advanced groups outperformed the Beginner group (M=12). When comparing only the participants from the experimental groups, whose proficiency in the L2 was controlled, these raw data can be an indicator that non-linguistic working memory capacity may improve with L2 proficiency, that is, high proficiency in the L2 may promote an advantage in non-linguistic working memory. Many studies found a connection between working memory capacity and L2 proficiency, Maurits et al (2006, p.294) affirm that “complex working memory tasks do support the hypothesis that working memory capacity interacts with language proficiency.” As previously explained, the Letter-Number Ordering Task used in this study is a complex working memory task and the results from the descriptive statistics showed a higher median score in the task for the participants who have higher proficiency in English as L2. Therefore, in the present study, language proficiency also presented an interaction with working memory capacity.

Summarizing the descriptive statistics, the raw data for the FET suggest that the frequency of the verbs interferes in the responses accuracy for speakers of English as L2. For instance, according to the accuracy data, it is considerably more difficult for both experimental groups to conjugate the low frequency irregular verbs than the high frequency irregular verbs. In addition, the frequency of the verbs was also found to interfere in the response time’s speed for the speakers of English as L2, mainly for the regular verbs group. Furthermore, the raw data for the FET indicate that response time speed and accuracy are related to proficiency, meaning that a higher proficiency is linked to faster response times.

Concerning the Simon Arrow Task, the results of the descriptive statistics indicate that inhibitory function efficiency is related to L2 proficiency, meaning that a high proficiency in the L2 may promote an advantage on inhibitory control function. Finally, the descriptive results from the Letter-Number Ordering Task show that L2 proficiency may improve non-linguistic working memory capacity. According to Bialystok et al (2007, p.460), “bilingualism has been shown to enhance attention and cognitive control”. This proposition is supported by the results of the descriptive statistics presented, in which the Advanced group, represented by the participants with high proficiency level in the L2, presented a higher working memory capacity (Advanced group M= 14.5 vs. Beginner group M= 12) and a more efficient inhibitory control function (Advanced group SE= 10 vs. Beginner group SE= 18) than the participants from the Beginner group, represented by the participants with low proficiency level in the L2. These results may be understood as an indication that bilingualism (in the context of the present study represented by a high proficiency level in the L2) leads to more efficient cognitive functions (working memory capacity and inhibitory control function).

After presenting the descriptive statistical analysis based on the data collected, the inferential statistical analyses are presented for a deeper examination of the data. In the present study, inferential statistical analysis is used to decide whether or not the median differences observed in the data presented are significant.

4.2 Inferential statistical analysis

This section presents the results from the statistical analyses run to decide whether or not the median differences in the participants' response times and accuracy were significant. Since the data distribution was non-normal, the inferential analysis was non-parametric and no transformations were made in the original data. The non-parametric tests run in this study were Mann-Whitney and Chi-square. The Pearson test was used for correlations, since the fact that there were repeated values in the data collected disallowed the usage of the non-parametric Spearman test.

This section is divided into three subsections. Subsection 4.2.1 presents the comparison within proficiency groups for the FET. Subsection 4.2.2 presents the comparison between the proficiency groups for the FET. Finally, Subsection 4.2.3 presents the correlation between the FET and the Simon Arrow Task as well as the correlation between the FET and the Letter-Number Ordering Task.

4.2.1 Comparisons of FET results within proficiency groups

This subsection presents the analyses within proficiency groups in order to verify if there are statistically significant differences in the response times and accuracy between the verbs with high and low usage frequency. The Mann-Whitney test was used to analyze the response times (RT) and its results are presented in Table 4.5. The Chi-square test was used to analyze the accuracy (ACC) and its results are presented in Table 4.6.

To start with, the objective of using the FET in this study was to investigate the distinction between storage and composition of regular and irregular verbal morphology of English. According to Stockall and Marantz (2006), the past tense debate of English inflectional morphology falls into two main views, on the one hand the dual-mechanism view and on the other the connectionist single-mechanism view. However, according to Stockall and Marantz (2006), there is an alternative view, the full decomposition model of morphological complexity (Stockall & Marantz, 2006), which differs from both of these main accounts. These three views were explained in the review of the literature, and will be briefly reiterated again as it follows.

In the dual-mechanism account, frequency effects are expected only for the past tense of irregular verbs, which are retrieved from memory (Ullman et al, 1997; Marslen-Wilson & Tyler, 1998; Ullman, 2001a, 2001b, 2001c, 2004, 2005; Pinker & Ullman, 2002; Newman et al, 2007; Bowden et al, 2010). In this context, past tense irregular verbs are stored in the lexical memory as entire words. Consequently, high frequency irregular verbs should be retrieved from the mental lexicon faster and more accurately than low frequency irregular verbs. By contrast, past tense regular verbs should not present frequency effects since these verbs are rule-based. That is, past tense regular verbs being computed in the memory, instead of stored as an entire word, should not present significant difference in accuracy and response time between the high and low frequency forms.

In the connectionist single-mechanism account, irregular and regular past tense verbs are acquired as whole forms (there are neither symbols nor rules) and both verb groups are processed and stored in an associative memory. Irregular and regular forms are accounted by only one integrated mechanism (Rumelhart & McClelland, 1986; Plunkett & Marchman, 1993; McCelland & Patterson, 2002; Woollams et al., 2009). In this view, regular and irregular verbs should present frequency effects, since these forms are retrieved from one association-based memory. More specifically, both verb groups should present a statistically significant difference in response time and accuracy between high and low frequency forms, since a more frequent verb should be retrieved from the memory faster and with more accuracy.

Another single system account is the full decomposition model proposed by Stockall and Marantz (2006). In this model all past tense forms are decomposed, there is rule-based decomposition for regular and irregular forms. The main difference between this full decomposition model and the dual-mechanism models is that irregular inflections are rule generated (Stockall & Marantz, 2006). Thus, according to the full decomposition model, the data from the FET should not present frequency effects neither for the regular nor for the irregular verbs, since both forms are predicted to be rule-based.

Table 4.5 brings the results from the Mann-Whitney test which was used to analyze if the response times differences between high and low, regular and irregular verbs, were statistically significant, within the proficiency groups.

Table 4.5

FET median RT comparisons between high and low frequency, regular and irregular verbs, within proficiency groups.

Proficiency Group	N	Verb Group	Comparison	P-Value
Native	**20**	**Regular**	**High/Low**	**0.048**
		Irregular	**High/Low**	**0.681**
Advanced	**26**	**Regular**	**High/Low**	**0.000***
		Irregular	**High/Low**	**0.364**
Beginner	**26**	**Regular**	**High/Low**	**0.000***
		Irregular	**High/Low**	**0.257**

Note. N= number of participants. *= difference is statistically significant.

According to Table 4.5 there was no significant difference between high and low frequency irregular verbs in any proficiency group ($p>0.001$). Thus, contrary to our expectations, the irregular verbs did not present frequency effects, which means that these verbs were not stored as a whole in the mental lexicon (as predicted by the dual-mechanism and the connectionist single-mechanism views), but they were decomposed, as predicted in the full decomposition model. The control group, represented by native speakers of American English, did not present frequency effects for the regular verbs either ($p>0.001$), meaning that these participants also decomposed the regular forms as predicted by the full decomposition model. In contrast, both experimental groups presented frequency effects on the processing of the regular verbs ($p<0.001$), this is an outlier for the full decomposition model. As seen in the review of the literature, a frequency effect for regular verbs means that these verbal forms were not decomposed, and this is one of the predictions of the connectionist single-mechanism account for the past tense inflection (e.g. Rumelhart & McClelland, 1986; McCelland & Patterson, 2002). However, this connectionist view as well as the dual-mechanism view predicts frequency effects for irregular verbs, which were not found in any of the three proficiency groups from this study. Consequently, these frequency effects found in the regular verbs may be attributed to the proficiency variable, since the proficiency groups processed the English regular verbs in a different manner. That is, the participants from the Native group decomposed the regular forms while the participants from the Advanced and Beginner groups did not.

An explanation for this phenomenon can be offered in favor of the full decomposition model. As explained in the review of the literature, this model requires that all lexical items and morphological rules must be learned and memorized before being linked. Therefore, it could be that the L2 participants did not decompose the regular forms because they may not have internalized the morphological rules involved in the past tense production of the allomorph *–ed*. As previously explained, this allomorph has three different pronunciations (*/Id/*, */t/* and */d/*) according to the morphological rule being used. Thus, before learning and memorizing these morphological rules, decomposition is not possible, and that may have been what caused the outliers in the data. It may be that when the speakers of English as L2 become proficient enough, they will decompose all forms (regular and irregular) as the native speakers did in this study.

Summing up, the participants from the three proficiency groups (Native, Advanced and Beginner), represented by speakers of English as L1 and L2, did not present frequency effects when processing the irregular verbs ($p>0.001$), meaning that they decomposed the irregular verbs. From the theories reviewed in this study, the full decomposition model of morphological complexity is the only one which accounts for irregular verb decomposition. Thus, as a conclusion, the full decomposition model offers the strongest account for the results found in the present study. Additionally it is clear that the speakers of English as L1 and L2 behaved differently when processing English regular verbs, most likely due to proficiency differences in the English language.

After analyzing the response times within proficiency groups I turn now to the accuracy results. Table 4.6 contains the FET accuracy results comparing high and low frequency, regular and irregular verbs, within each proficiency group.

Table 4.6

FET ACC results between regular and irregular verbs within proficiency group

Proficiency Group	N	Verb Group	Statistics	P-Value
Native	**20**	**Regular (High/Low)**	**0.167**	**0.683**
		Irregular (High/Low)	**0.023**	**0.881**
Advanced	**26**	**Regular (High/Low)**	**11.070**	**0.001***
		Irregular (High/Low)	**107.308**	**0.000***
Beginner	**26**	**Regular (High/Low)**	**29.884**	**0.000***
		Irregular (High/Low)	**97.484**	**0.000***

Note. N= number of participants. *= difference is statistically significant.

The Native group did not present differences in the accuracy of their responses to high and low frequency verbs, neither for regular nor for irregular verbs ($p>0.001$), i.e., verb frequency did not affect the Native group's response accuracy. In contrast, the Advanced and Beginner groups presented a statistically significant difference in the response accuracy between high and low frequency verbs for both, regular and irregular forms ($p<0.001$). Thus, the results from Table 4.6 indicate that the verb frequency affected the accuracy of past tense conjugation of regular and irregular verbs only for speakers of English as L2. For these participants, the higher the frequency of the verb, the easier it was to conjugate it correctly.

Frequency effect for accuracy is one of the predictions of the connectionist single-mechanism model, which predicts that high frequency verbal forms are accessed faster and with higher accuracy than low frequency verbs. However, the Native group, represented by the speakers of English as L1, did not present frequency effects in accuracy neither for regular ($p= 0.683$) nor for irregular ($p= 0.881$) verbs. Thus, the English language knowledge may have affected the accuracy results in the FET, that is, the frequency effects for accuracy found for both experimental groups might be attributed to the proficiency variable, since the speakers of English as L1 did not present frequency effects for accuracy. Therefore the L2 participants' lack of knowledge of some past tense forms of low frequency verbs may have caused the statistically significant difference between high and low frequency verbs ($p= 0.000$). This pattern is different for speakers of English as L1 because they have much more contact and experience with English language than the L2 participants.

Summing up, the results presented in Table 4.6 showed no frequency effects in the accuracy for the Native group but showed frequency effects for the Advanced and Beginner groups. These results mean that verbal frequency did not affect the response accuracy of the past tense production for speakers of English as L1. However, it affected the response accuracy for speakers of English as L2. Concluding, the results from the accuracy analysis also show that L1 and L2 speakers behaved differently when processing English verbal morphology.

4.2.2 Comparisons of FET results between proficiency groups

This subsection brings the statistical results between the three proficiency groups, Native, Advanced and Beginner. In order to analyze the FET response times between the proficiency groups the Mann-

Whitney test was run and its results are reported in Table 4.7. Accuracy was analyzed by means of the Chi-square test and is presented in Table 4.8.

Table 4.7 brings the results from the Mann-Whitney test which was used to analyze if the response times differences between high and low, regular and irregular verbs, were statistically significant, between the proficiency groups.

Table 4.7

FET median RT comparisons between high and low frequency, regular and irregular verbs, between proficiency groups

Verb Group	Verb Frequency	Comparison	P-value
Regular	**High**	**Native/Advanced**	**0.000***
		Native/Beginner	**0.000***
		Advanced/Beginner	**0.000***
	Low	**Native/Advanced**	**0.000***
		Native/Beginner	**0.000***
		Advanced/Beginner	**0.000***
Irregular	**High**	**Native/Advanced**	**0.000***
		Native/Beginner	**0.000***
		Advanced/Beginner	**0.000***
	Low	**Native/Advanced**	**0.000***
		Native/Beginner	**0.000***
		Advanced/Beginner	**0.000***

Note. *= difference is statistically significant.

All comparisons reported in Table 4.7 presented a statistically significant difference in the response times between the proficiency groups ($p<0.001$). These results mean that the Native group's answers were significantly faster than the Advanced and Beginner groups' answers for all verb groups (regular and irregular) and verb frequencies (high and low). Also, the Advanced group's answers were significantly faster than the Beginners' answers for all verb groups and frequencies. These results indicate that proficiency and response time speed are strongly related. Furthermore, the results reported in Table 4.7 confirm that the proficiency level in English was significantly different between the three groups, since the response times between the three proficiency groups were all significantly different.

Table 4.8 shows the FET accuracy results comparing high and low frequency, regular and irregular verbs, between the three proficiency groups.

Table 4.8

FET accuracy results between regular and irregular verbs, between proficiency groups.

Verb Group	Verb Frequency	Comparison	Statistics	P-value
Regular	**High**	**Native/Advanced**	**1.660**	**0.198**
		Native/Beginner	**0.069**	**0.793**
		Advanced/Beginner	**3.475**	**0.062**
	Low	**Native/Advanced**	**0.881**	**0.348**
		Native/Beginner	**80.147**	**0.000***
		Advanced/Beginner	**79.865**	**0.000***
Irregular	**High**	**Native/Advanced**	**1.162**	**0.281**
		Native/Beginner	**22.731**	**0.000***
		Advanced/Beginner	**16.730**	**0.000***
	Low	**Native/Advanced**	**108.955**	**0.000***
		Native/Beginner	**296.739**	**0.000***
		Advanced/Beginner	**70.373**	**0.000***

Note. *= difference is statistically significant.

According to Table 4.8, there was no significant difference in accuracy between the three proficiency groups when processing high frequency regular verbs ($p>0.001$). In contrast, there was a significant difference in accuracy between the three proficiency groups when processing low frequency irregular verbs ($p<0.001$). Therefore, the processing of high frequency regular verbs was the least affected by language proficiency whereas the processing of low frequency irregular verbs was the most affected by language proficiency.

Overall, the Native and the Advanced groups did not present significant difference in accuracy when conjugating the majority of the verbs ($p>0.001$). The only conjugation in which these groups presented difference in accuracy was the low frequency irregular verbs conjugation ($p=0.000$).

Comparing the Beginner group with the Advanced and Native groups, the Beginner group presented a significant difference in accuracy in almost all verb groups (regular and irregular) and verb frequencies (high and low), except when responding to high frequency regular verbs. Consequently, the lower the proficiency in the language, the harder it is to process verbal morphology correctly. Also, the lower the proficiency, the more the frequency of the verbs will affect the accuracy.

Summing up, there were no significant differences in accuracy between the answers from the Native and Advanced groups, except in their responses to irregular low frequency verbs. However, there was a significant difference between these two groups in response time speed. Taken together, these results indicate that even though the Advanced group knew the correct past tense of the verbs, they took longer to process and orally produce the past tense form, i.e., inflectional verbal morphology of English as L2 took more time to be processed than English as L1. Finally, the results from the tests between the three proficiency groups suggests that the FET accuracy and response time speed are strongly related to proficiency in the English language.

4.2.3 Pearson Correlations

This subsection presents the Pearson correlations between the tasks applied in this study (TEF, Simon Arrow task and Letter-Number Ordering Task) in order to verify if there was a positive or a negative correlation between the tasks and if the correlation was statistically significant. This subsection is divided into two main parts: (a) first, Table 4.9 is presented reporting the correlation results between the FET and the Simon Arrow Task and, second, (b) Table 4.10 is presented showing the correlation results between the FET and the Letter-Number Ordering Task.

First, the Pearson Product-Moment correlation was run to investigate if there was a relationship between the response times for the FET and for the Simon Arrow Task. The objective was to find out if inhibitory control processes would affect participants' performance on the FET. The expected result would be a positive correlation, where the participants with the lowest response times in the FET (as result of a high proficiency in English as L2) would be the same ones with the lowest response times in the Simon Arrow Task. Thus, the Advanced and the Beginner groups' processing of the verbal morphology of English as L2 would be influenced by their individual inhibitory control processes. Table 4.9 contains the Pearson correlations between the FET and the executive control task (Simon Arrow Task) as well as the p-values for both experimental groups.

Table 4.9

Pearson Correlations – FET and Simon Arrow Task for both experimental groups.

Proficiency Group	Correlation	P-value
Advanced	**0.052**	**0.801**
Beginner	**0.101**	**0.625**

As expected, the Pearson results show a positive correlation between FET and Simon Arrow Task for both proficiency groups, Advanced and Beginner (r=0.052 and r=0.101, respectively). When comparing the proficiency groups in Table 4.1 the results show that the Advanced group's median response times in the FET were much faster than the Beginner group. In addition, Table 4.3 shows that the median response time in the Simon Arrow Task was 1ms faster for the Advanced group than for the Beginner group. Therefore, it is possible to understand the positive correlations showed in Table 4.9, since the Advanced group presented the faster response times in the FET and in the Simon Arrow Task while the Beginner group presented the slower response times in the FET and in the Simon Arrow Task. However, these positive correlations are not statistically significant ($p>0.001$), probably because the difference in the response times for the Simon Arrow Task between the experimental groups was only 1ms. These results imply that there is no significant correlation between the response times in these tasks. As a conclusion, these results can be taken as evidence that inhibitory control function did not influence the results obtained in the FET, meaning that this individual difference did not affect the processing of English verbal morphology by L2 speakers.

Second, the Pearson correlation was run to investigate if there was a relationship between the response times on the FET and performance in the Letter-Number Ordering Task for both experimental groups. The objective was to find out if individual differences in working memory capacity would affect performance in the FET. The expected result would be a negative correlation in which the participants with the lowest response times in the FET (as result of a high proficiency in English as L2) would be the same ones with the highest scores in the Letter-Number Ordering Task. As a result, the Advanced and the Beginner groups' processing of English verbal morphology would be influenced by their individual working memory capacity.

Table 4.10 shows the Pearson correlations between the FET and the non-linguistic working memory task (the Letter-Number Ordering Task) for both experimental groups.

Table 4.10

Pearson Correlations – FET and Letter-Number Ordering Task for both experimental groups.

Proficiency Group	Correlation	P-value
Advanced	**-0.059**	**0.774**
Beginner	**-0.274**	**0.175**

Table 4.10 shows a negative correlation between the FET and the Letter-Number Ordering Task, for both experimental groups, Advanced and Beginner (r= -0.059 and r= -0.274, respectively). Again, when comparing the proficiency groups in Table 4.1 the results show that the Advanced group's response times were much lower than the Beginner group in the FET. In addition, Table 4.4 shows that the median scores in the Letter-Number Ordering Task are higher for the Advanced group than for the Beginner group (M= 14.5 and M=12, respectively). Consequently, it is possible to understand the negative correlations showed in Table 4.10, since the Advanced group presented the lowest response times in the FET and the highest scores in the Letter-Number Ordering Task while the Beginner group presented the highest response times in the FET and the lowest scores in the Letter-Number Ordering Task. However, as shown in Table 4.10, these negative correlations are not statistically significant (p>0.001). These results indicate that there is no significant correlation between the response times in these tasks. As a conclusion, these results can be taken as evidence that differences on working memory capacity did not influence the results obtained in the FET, meaning that this individual difference did not affect the processing of English verbal morphology by L2 speakers.

Summing up, the individual differences measured by executive control and working memory tasks did not present a statistically significant correlation with the FET. Thus, neither of these individual differences affected the results obtained in the FET, meaning that inhibitory control function and working memory capacity do not influence the processing of English verbal morphology by L2 speakers.

As a final conclusion, English verbal morphology processing by L2 speakers is only affected by the linguistic nature of the English language. This conclusion comes from the fact that the linguistic knowledge of the language (read as proficiency) affected the English language morphological processing (as concluded in subsection 4.2.2). However, the individual differences measured through non-linguistic tasks (such as inhibitory control and working memory) did not affect the English morphological processing.

4.3 Answers to the research questions

The purpose of this section is to readdress the 4 hypotheses and the 4 research questions pursued by this study as well as to present the answers for each one of them. The answers for the research questions are based on the data presented and discussed in this Chapter, summarizing the results obtained.

Research question 1: Are there frequency effects on the processing of English regular verbs by native speakers of English and by Brazilian Portuguese speakers of English as L2 at two different proficiency levels (high and low)?

Hypothesis 1: There will be frequency effects on the processing of English regular verbs only for the Brazilian Portuguese speakers of English as L2 at the low proficiency level, since they tend to memorize the regular forms in declarative memory. The native speakers of English and the Brazilian Portuguese speakers of English as L2 at the high proficiency level will compute the regular forms online in procedural memory, not presenting frequency effects.

Hypothesis 1 was not supported by the results found in the present study.

There were no frequency effects on the processing of regular verbs by native speakers of English. This result from the Native group supports the full decomposition model of morphological complexity proposed by Stockall and Marantz (2006). On the other hand, both proficiency groups of Brazilian Portuguese speakers of English as L2 presented frequency effects when processing regular verbs. This result is an outlier for the full decomposition model, since according to this model regular verbs should be processed by a morphological rule. Nevertheless, the lack of frequency effects on the processing of irregular verbs (as presented in the three proficiency groups) opposes the predictions of the connectionist single-mechanism and the dual-mechanism views, in which irregular forms are memorized and should present frequency effects. Consequently, the frequency effects found in the regular verbs were attributed to the proficiency variable. It was argued that the L2 participants, not being as fluent in English as the native speakers, did not decompose the regular forms because they may not have internalized the morphological rules involved in the past tense production of the allomorph *–ed*. Thus, before learning and memorizing the specific morphological rules, decomposition is not possible (Stockall and Marantz, 2006). This may have been what caused the outliers in the data for speakers of English as L2, since the knowledge of the morphological rules involved in the pronunciation of the allomorph *–ed* require a lot of proficiency and experience in the L2. It may be that when the speakers of English as L2 become proficient enough, they will decompose all forms (regular and irregular) as the native speakers did in this study.

Research question 2: Are there frequency effects on the processing of English irregular verbs by native speakers of English and by Brazilian Portuguese speakers of English as L2 at two different proficiency levels (high and low)?

Hypothesis 2: There will be frequency effects on the processing of English irregular verbs for native speakers of English and Brazilian Portuguese speakers of English as L2 at both proficiency levels, high and low.

Hypothesis 2 was not supported by the results found in the present study.

There were no frequency effects on the processing of English irregular verbs neither by the native speakers of English nor by the speakers of English as L2 at high and low proficiency levels. This finding indicates that all participants from this study, regardless of their proficiency group, decomposed the irregular verbs. From the theories reviewed in this study, the full decomposition model of morphological complexity is the only one which accounts for irregular verbs decomposition. Thus, as a final conclusion, the full decomposition model offers the strongest account for the results found in the present study.

Research question 3: Is there a significant correlation between the FET response time and performance in the inhibitory control task?

Hypothesis 3: There will be a significant positive correlation between the FET response time and the performance on the inhibitory control task. The participants who presented lower response times in the FET will also be the ones who presented lower reaction times in the executive control task.

Hypothesis 3 was not supported by the results found in the present study.

There was a positive correlation between the FET response time and performance in the inhibitory control task, but this correlation was not statistically significant. This result indicates that inhibitory control processes did not affect English verbal morphology processing by L2 speakers.

However, when comparing the Simon Effect between both experimental groups, it was found a reduced Simon Effect for the Advanced group. This result suggests an advantage in inhibitory control function for speakers of English as L2 with a high proficiency level, which could be caused by the ability that these participants developed in switching between their native language (Brazilian Portuguese) and their L2 (English).

Research question 4: Is there a significant correlation between the FET response time and working memory capacity?

Hypothesis 4: There will be a significant negative correlation between the FET response time and working memory capacity. The participants who presented lower response times in the FET will be the ones who presented higher scores in the working memory task.

Hypothesis 4 was not supported by the results found in the present study.

There was a negative correlation between the FET response time and working memory capacity, but this correlation was not statistically significant either. Therefore, this result indicates that working memory capacity did not affect English verbal morphology processing by L2 speakers.

CHAPTER 5

FINAL REMARKS

The present study was carried out with two primary objectives: (1) to investigate the influence of frequency effects and proficiency in the storage and composition of regular and irregular verbal morphology of English as L1 and L2, and (2) to investigate the role of inhibitory control and working memory capacity on the processing of English verbal morphology. This chapter concludes this study by summarizing its results. This chapter is divided into three sections. Section 5.1 contains the main conclusions of the present study. Section 5.2 describes the limitations of this study and includes suggestions for further research. Finally, Section 5.3 presents the methodological and pedagogical implications of this study.

5.1 Conclusions

This section presents the main results and conclusions of the present study and is divided into two subsections. Subsection 5.1.1 presents the results and conclusions from the FET (Frequency Effects Task) based on the statistical analyses. Subsection 5.1.2 presents the results and conclusions concerning inhibitory control and working memory tasks, as well as the results concerning the correlations between the FET, the Simon Arrow Task and the Letter-Number Ordering Task.

5.1.1 Frequency effects and the processing of English verbal morphology

This subsection restates the primary results from the FET, which were explained in detail in the inferential statistical analysis section. Specifically, the conclusions described in this subsection concern the tests run within proficiency groups (Subsection 4.2.1) and between proficiency groups (Subsection 4.2.2). The following conclusions present the different aspects of the FET analyzed in this study, such as proficiency, response times, accuracy, frequency effects and regular/irregular verbal processing (the past tense debate). The final conclusions are:

1. Proficiency was strongly related to the speed of processing regular and irregular verbs. The results show that higher proficiency

implied lower response time for all verbal forms (regular and irregular, high and low). This conclusion is based on the results presented from the Mann-Whitney test (Table 4.7) which show that the differences in response time of the three proficiency groups were statically significant for regular and irregular, high and low frequency verbs (p=0.000).

2. Proficiency also affected the accuracy of past tense conjugation. The results show that participants with lower language proficiency had more difficulty processing verbal morphology correctly. This conclusion is based on the results presented from the Chi-Square test (Table 4.8) which showed that the participants from the Beginner group had significantly lower accuracy than the other proficiency groups (p=0.000) for almost all verbs. The only verbal form where the Beginner group did not show a significant difference in accuracy was the high frequency regular verbs.

3. Speakers of English as L1 decomposed both verbal forms, regular and irregular. This conclusion is based on the results from the Mann-Whitney test (Table 4.5), which demonstrated that frequency effects were not found in the processing of either regular or irregular verbs by the Native group (p>0.001).

4. Speakers of English as L2 at both proficiency levels (high and low) also decomposed irregular verbs. This conclusion is based on the results from the Mann-Whitney test (Table 4.5), which demonstrated that frequency effects were not found in the processing of irregular verbs for the Advanced and Beginner groups (p>0.001).

5. Speakers of English as L2 at both proficiency levels did not decompose regular verbs. This conclusion is also based on the results of the Mann-Whitney test (Table 4.5), which demonstrated that frequency effects were found in the processing of regular verbs for the Advanced and Beginner groups (p=0.000).

6. Speakers of English as L1 and as L2 behave differently when processing inflectional morphology, since L1 speakers decomposed all verbs while L2 speakers decomposed only the irregular verbs. This conclusion is based on the results presented in the Mann-Whitney test (Table 4.5), which presented no frequency effects for regular (p>0.001) and irregular (p>0.001) verbs for the Native group and in contrast presented frequency effects for regular verbs (p<0.001) for the Advanced and Beginner groups.

7. Participants from the Native group, which is represented by speakers of English as L1, processed regular and irregular verbs as predicted in the full decomposition model of morphological complexity.

As explained in the review of the literature, this model predicts that all regular and irregular forms are decomposed.

8. The participants from the Advanced and Beginner groups, represented by speakers of English as L2, processed irregular verbs as predicted in the full decomposition model of morphological complexity, that is, irregular verbs were decomposed by these participants. However, they presented frequency effects when processing regular verbs ($p=0.000$), meaning that they did not decompose these verbs. This result is an outlier for the full decomposition model since, according to this model, regular verbs should be processed by a morphological rule. Nevertheless, the lack of frequency effects on the processing of irregular verbs (as presented in the three proficiency groups) challenges the predictions of the connectionist single-mechanism and the dual-mechanism views, in which irregular forms are memorized and should present frequency effects. Consequently, the frequency effects found in the regular verbs may be attributed to the proficiency variable.

An explanation for this phenomenon can be offered in favor of the full decomposition model. The model requires that all lexical items and morphological rules must be learned and memorized before being linked. Therefore, it could be that the L2 participants did not decompose the regular forms because they may not have internalized the morphological rules involved in the past tense production of the allomorph *–ed*. This allomorph has three different pronunciations (*/Id/*, */t/* and */d/*) according to the morphological rule being used. Thus, before learning and memorizing these morphological rules, decomposition is not possible, and that may have been what caused these outliers in the data. It may be that when the speakers of English as L2 become proficient enough, they will decompose all forms (regular and irregular) as the native speakers did in this study.

Summing up the conclusions, the participants from the three proficiency groups, represented by speakers of English as L1 and L2, did not present frequency effects when processing the irregular verbs ($p>0.001$), meaning that they decomposed the irregular verbs. From the theories reviewed in this study, the full decomposition model of morphological complexity is the only one which accounts for irregular verb decomposition. Thus, as a final conclusion, the full decomposition model offers the strongest account for the results found in the present study. Additionally it is clear that the speakers of English as L1 and L2 behaved differently when processing English regular and irregular inflectional morphology, most likely due to proficiency differences in the English language.

5.1.2 Inhibitory control, working memory and the processing of English verbal morphology

This subsection presents the conclusions regarding inhibitory control and working memory tasks as well as the conclusions regarding the correlation between these tasks and the FET. The data were analyzed only for the speakers of English as L2, since their proficiency in the L2 was controlled. The data from the speakers of English as L1 were not analyzed because their proficiency in an L2 (such as Portuguese) was not controlled. The final conclusions are:

1. A higher proficiency in the L2 is suggested to lead to a more efficient inhibitory control function. This conclusion comes from the Simon Effect (SE) comparison between the Advanced and the Beginner groups (Advanced group' SE= 10ms and Beginner group' SE= 18ms). According to Bialystok et al. (2004), a reduced Simon Effect reflects a more efficient inhibitory control function.

2. Also a higher proficiency in the L2 is suggested to improve non-linguistic working memory capacity. This conclusion comes from the working memory median scores comparison between the Advanced and the Beginner groups (M=14.5 and M=12, respectively). The score in this working memory task could vary between 0 and 21 points. The higher the score in this task, the higher working memory capacity was.

3. Overall, proficiency is suggested to influence the cognitive processes represented by inhibitory control function, working memory capacity and speed of processing. This conclusion comes from the suggestion that proficiency affected inhibitory control and working memory (as described above) as well as the response speed and accuracy in the FET (as described in the Subsection 5.1.1).

4. Participants' inhibitory control function did not influence their speed on processing English verbal morphology. This conclusion is based on the results from the Pearson Correlations test (Table 4.9) which shows that there was no statistically significant correlation between the response times in the FET and in the inhibitory control task ($p>0.001$).

5. Participants' working memory capacity did not influence their speed on processing English verbal morphology either. This conclusion is based on the results from the Pearson Correlations test (Table 4.10) which shows that there was no statistically significant correlation between the response times in the FET and the scores in the working memory task ($p>0.001$).

6. As a final conclusion, the results from the FET concerning the processing of English verbal morphology by L2 speakers were not affected by individual cognitive differences (meaning inhibitory control and working memory capacity), but only by the linguistic nature of the English language. This conclusion comes from the fact that the linguistic knowledge of the language (read as proficiency) affected the language morphological processing in the FET (as explained in subsection 5.1.1). On the other hand, the individual differences measured through non-linguistic tasks (such as inhibitory control and working memory tasks) did not affect English morphological processing.

5.2 Limitations of the study and suggestions for further research

The present study was carefully planned and carried out at all stages. However, even with strict methodological procedures this study suffered from a few limitations which will be described below.

Since this study was carried out in Brazil, the participants represented by the native speakers of American English (control group) had at least some knowledge in an L2. This L2 was generally Brazilian Portuguese and their experience with the L2 varied from a week of exposure to the language to many years. As previously explained, proficiency in an L2 is suggested to influence some cognitive processes. Thus, the ideal control group should consist of monolingual speakers of English as L1, or if bilinguals, these participants should have their proficiency in their L2 controlled.

The amount of valid data collected from the Beginner group for low frequency irregular verbs in the Frequency Effects Task (FET) was smaller than expected. This was due to the fact that a large number of mistakes were committed by the participants from this group when conjugating the low frequency irregular verbs. Using more verbs in the FET could have been an efficient procedure to avoid this problem.

Another limitation found was the impossibility to control the gender variable (male/female) because it was extremely difficult to find female native speakers of American English in Florianópolis at the time of the data collection. However, as some studies have shown (e.g. Babcock et al. 2012), gender can have a significant effect on language processing.

Finally, with the reduced number of participants per group, 26 participants in each experimental group and 20 in the control group, the data distributions were found to be non-normal. This may be alleviated with a much larger sample set of participants in each group.

For further research, a lexical decision task involving the English past tense would be a good tool to study the processing of English as L2. The objective would be to investigate how L2 participants behave when processing the past tense regular allomorph *–ed* in a lexical decision task as compared to the FET. This comparison would make it possible to investigate if the oral production of the allomorph *–ed* affected the decomposition of the regular verbal forms, since in a lexical decision task the participants would not need to pronounce the allomorph.

5.3 Methodological and pedagogical implications

This section presents some of the most relevant methodological implications followed by only one pedagogical implication, since it is difficult to draw pedagogical implications from a psycholinguistic study such as the present study.

Starting with methodological implications, in behavioral studies dealing with participants' response times, it is important to collect all data from participants individually and in a carefully controlled environment specifically designed to collect data for behavioral studies. This avoids distractions and helps to rule out environmental changes that may affect the results. Additionally, having the same researcher collect all data ensures that the method is strictly followed, and that all participants receive instructions in the same manner.

A key requirement of any behavioral study is that a pilot study be carried out prior the final data collection. This tests the instruments to be used in data collection and avoids unexpected issues which can invalidate the data being collected. Having a pre-pilot phase in addition to a pilot phase is also important. This allows the researcher to test, adjust when necessary and retest each instrument before being used in the final data collection phase.

For behavioral studies dealing with participants' response time, it is important to use a system which captures the participants' response times with higher precision than a computer keyboard. The Serial Response Box (SRBOX) used in this study is widely used in behavioral studies because it precisely collects and stores the timing information of each response provided by the participant. Besides ensuring that response times are recorded reliably, this device also facilitates the participants' performance and focus on the task, since it only has 5 keys.

In studies dealing with participants with different proficiency levels in English as L2, a helpful manner of pre-selecting participants is to invite students who are studying English as L2 courses at the level required. This saves time because it avoids having a large number of potential participants failing the proficiency test requirements for the study. In addition, when carrying out a study with visual tasks like the ones used in this study, it is important to ensure that the participants are able to see the stimuli presented on the screen comfortably. For example, if the letters of a linguistic stimulus are too small, this will make it difficult to read, and can cause response time delays not because of the time to process the stimulus, but because of visual problems.

As for pedagogical implication, the results from this study highlight a difficulty that Brazilian speakers of English as L2 have in processing the three pronunciations of the allomorph *–ed*. Thus, this study contributes to the teaching and learning of English as L2 literature by pointing out that it is important to teach L2 students the pronunciation rules of the allomorph *–ed* when introducing them to the simple past tense. If teachers could focus on these morphological rules earlier in the learning process, this could facilitate the students' regular past tense production in English. After developing this competency the student should be able to process English regular past tense in the same way that they process English irregular past tense, by decomposing these verbal forms as native speakers do.

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APPENDIX A

Consent form in Portuguese

Carta de consentimento livre e esclarecido

Título do projeto: "Efeitos de Frequência e o Processamento da Morfologia Verbal por Falantes de Inglês como L1 e L2"
Gostaria de lhe convidar para participar de um projeto de pesquisa sobre aquisição de segunda língua e a memória de trabalho em inglês. Você está sendo convidado (a) para participar deste estudo por possuir o nível de proficiência em língua inglesa almejado nesse estudo. Se você aceitar participar, por favor leia este consentimento e, se concordar com a informação aqui apresentada, assine onde indicado. Uma cópia ficará comigo, pesquisadora responsável pelo projeto, e outra com você.

Objetivo do estudo: analisar o processamento da morfologia verbal do inglês como L2 em participantes falantes nativos do português brasileiro. Os dados coletados neste estudo serão utilizados na minha dissertação de Mestrado que tem como orientadora a Prof. Dra. Mailce Borges Mota (CNPq/UFSC/PPGI/PGL – mailce@cce.ufsc.br).

Procedimentos: ao participar deste estudo, você será solicitado a realizar as seguintes tarefas: (a) responder uma prova de proficiência em língua inglesa; (b) responder um questionário sobre seu contato com a língua inglesa; (c) realizar três tarefas no computador, uma será sobre conjugação de verbos da língua inglesa no passado simples, outra com números e letras que você deverá ordenar e a última tarefa você terá que indicar o sentido das flechas que aparecerão na tela do computador. Em todas as tarefas, suas respostas serão gravadas para posterior análise. Ao final da pesquisa, os resultados do estudo serão tornados públicos, mas sua identidade será totalmente preservada e não será incluída nenhuma informação que possa identificá-lo (a). Somente a pesquisadora deste projeto e sua orientadora terão acesso aos dados coletados.

Natureza voluntária do estudo: Sua decisão de participar ou não deste estudo não irá afetar você ou sua relação com a Universidade de

nenhuma forma. Você não é obrigado de forma alguma a participar desta pesquisa, sua participação é totalmente voluntária.
Pesquisadora responsável: Laura Mesquita Baltazar (lauramesquit@hotmail.com)

Declaração de consentimento:

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

Nome: ____.

Data: _____/_____/_________.

____
Assinatura do participante

____
Assinatura da pesquisadora responsável

APPENDIX B

Consent form in English

CONSENT FORM

Project title: "Frequency Effects and the Processing of Verbal Morphology by L1 and L2 Speakers of English"
I'd like to invite you to take part in a research Project about second language acquisition. You are being invited to participate in this research for being a native speaker of American English. Please, read this consent form and if you agree with the information contained here and you are willing to take part in the study please sign where appropriate. One copy of the form will stay with me, the researcher in charge of the project, and the other will be yours.

Objective of the study: To analyze the processing of English verbal morphology as first and second language. The data collected in this study will be used in my M.A. thesis which is being advised by Dr. Mailce Borges Mota (UFSC/ CCE /DLLE /PPGI /PGL – mailce@cce.ufsc.br).

Procedures: If you accept to participate in this research, you will be asked to answer a profile questionnaire and to complete four cognitive tasks in English in the computer. These activities should be completed at the language laboratory, located at Centro de Comunicação e Expressão (CCE), UFSC, bloco B. The tasks will be recorded for further analysis. The completion of the questionnaire and the tasks should take no more than 40 minutes.

Risks and benefits of the study: There are no risks in taking part in this research, and you will be helping the research development in Brazil. Before performing each one of the tasks, you will have time to get familiarized with them and ask questions until you feel comfortable with them. At the end of the research the results of the study will be made public, but your identity will be preserved and no information will be provided that might make your identification possible. Only the researcher and her advisor will have access to the data collected.

<u>Volunteer nature of the study:</u> Your decision in taking part or not in this study is voluntary. If you decide to participate and later on decide to give up, there's no problem, you can quit at any moment.

<u>Researcher:</u> Laura Mesquita Baltazar (lauramesquit@hotmail.com).

I declare I have read the above information. When necessary I made questions and received clarifications. I agree in taking part of this study.

Name: ____

Date: _______________

______________________ ______________________

Participant's signature Researcher's signature

APPENDIX C

Questionnaire applied to the Brazilians

UNIVERSIDADE FEDERAL DE SANTA CATARINA
CCE - DLLE
Programa de Pós Graduação em Inglês e Literatura Correspondente

Seção 1: Informações gerais do participante:

1. Data: ____/____/_________
2. Nome do participante: ____________________________________
3. Data de nascimento: ____/____/_________
4. Idade: _________________ anos.
5. País de nascimento: _____________________________________
6. Nacionalidade: ____
7. Sexo: ( ) M ( ) F
8. Grau de escolaridade:__________________________________
9. Formação: ____
10. Ocupação atual: _______________________________________
11. Informações para contato:

Telefones: ____
E-mail: ____

12. Você é destro ou canhoto? _____________________________

Seção 2: Informações sobre a Segunda Língua:

1) Quantas línguas você fala (incluindo português)?

____

2) Quais são?

____

3) Com que idade você começou a aprender inglês?

____

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

____

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

____

____

6) Você já morou num país onde você ficou exposto à língua inglesa?
( ) Sim ( ) Não

Se 'sim', responda as perguntas abaixo:
a. Em quais?
____
b. Que idade você tinha quando foi morar nesses países?
____
c. Quanto tempo você ficou?
____
d. Durante o tempo em que você morou no exterior, em que contexto (s) você utilizou a língua inglesa? (Ex.: em casa, na escola)____
____

7) Você frequentou aulas de inglês num curso de línguas?

( ) Sim ( ) Não
Se 'sim', quanto tempo você frequentou as aulas?
____

8) Você continua tento aula de inglês?

( ) Sim ( ) Não

9) Se 'sim', qual o seu nível?
____

10) Faça uma avaliação do seu desempenho na língua inglesa e alguma outra língua que você saiba. Abaixo de cada habilidade escreva (1) para muito bom (2) para bom (3) regular e (4) ruim

Idiomas	Fala	Entendimento Oral	Leitura	Escrita
Inglês				

Outro:				
Outro:				

Seção 3: Informações Clínicas:

1. Você ou alguém da sua família (pai, mãe e irmãos) já foi diagnosticado como portador de alguma doença degenerativa como o Alzheimer, Parkinson ou Huntington?

Sim ( ) Não ( )

Se 'sim', responda as perguntas embaixo:

a. Quem?

____

b. Que doença?

____

c. Data de Diagnóstico

____

d. Tratamento

____

Seção 4: Informações Farmacológicas:

1. Informe os medicamentos utilizados por você nos últimos 12 meses (pílula, comprimido, injeção, etc). Incluir (1) remédios com prescrição, (2) remédios sem prescrição como remédio para resfriado e (3) remédios alternativos como fitoterápicos e ervas medicinais.

Tipo de medicamento	Nome do medicamento	Data de início (ano)	Duração do tratamento	Observações: reações alérgicas, overdoses, etc
Com prescrição				
Com prescrição				
Com prescrição				
Com prescrição				
Com prescrição				

Com prescrição				
Sem prescrição				
Sem prescrição				
Sem prescrição				
Sem prescrição				
Sem prescrição				
Alternativos				
Alternativos				
Alternativos				
Outro				
Outro				

APPENDIX D

Questionnaire applied to the Americans

UNIVERSIDADE FEDERAL DE SANTA CATARINA
CCE - DLLE
Programa de Pós Graduação em Inglês e Literatura Correspondente

PROFILE QUESTIONNAIRE:

Name: ____
Male ( ) Female ( )
Age: ______________________________
Handedness:__________________________
Country of birth: ___________________________
Nationality: _____________________
Education: ________________________ Career: __________________
Professional activity (if any)___________________________________
E-mail address:____

1. How long have you been away from the U.S.?

____

2. How long have you been living in Brazil?

____

3. Have you studied Portuguese before you arrived in Brazil? (Either formally or by yourself) For how long?

____

4. Currently, in your daily life, do you speak more Portuguese or English? Or you would say you speak about the same amount of each?

____

5. What is your mother tongue?

____

6. When you were growing up, were you exposed to another language, besides English, at home? If yes, which one?

7. a. How many languages do you speak? Which ones?

b. How old were you when you started learning each one of them?

c. In which contexts did you learn them?

8. If you have some knowledge in another language(s), please complete the chart below specifying the language and writing (1) excellent, (2) for good, (3) for regular, (4) for weak for each one of the skills.

Language	Speaking skill	Listening skill	Reading skill	Writing skill

APPENDIX E

Newman et al.´s (2007) complete list of stimuli ordered from the most to the least frequent verbs

Regular verbs		Irregular verbs	
Frequent	**Infrequent**	**Frequent**	**Infrequent**
Look	Pour	Think	Ring
Seem	Urge	Feel	Shoot
Ask	Plan	Take	Spend
Call	Share	Tell	Sing
Walk	Roar	Run	Spin
Used	Snap	Write	Bear
Try	Sign	Bring	Sink
Stop	Tie	Keep	Teach
Pass	Beg	Lose	Cling
Work	Owe	Speak	Stride
Drop	Weigh	Break	Eat
Watch	Care	Grow	Swear
Play	Score	Catch	Steal
Stay	Strain	Seek	Bend
Stare	Stripp	Swing	Creep
Pull	Dare	Hold	Feed
Serve	Sail	Drive	Deal
Wish	Whip	Ride	Weep
Fail	Sway	Build	Swim
Raise	Stir	Send	Hide
Talk	Frown	Throw	Grind
Help	Dry	Win	Fling
Cause	Drown	Buy	Bind
Roll	Fan	Sell	Lend
Join	Scrawl	Mean	Bleed
Hope	Spray	Strike	Dig
Step	Glue	Sweep	Sling
Jump	View	Fly	Freeze
Change	Store	Fight	Wring
Slip	Spy	Sleep	Sting
Cry	Dye	Stick	String
Sigh	Vie	Slide	Breed

APPENDIX F

Newman et al.´s (2007) list of verbs reorganized according to the natural logarithm of the raw frequencies from COCA, ordered from the more frequent to the least frequent

Reg. stems	NL	Reg. past	NL	Irreg. stems	NL	Irreg. past	NL
Look	12,191	Looked	11,729	Think	13,270	Thought	11,964
Help	11,888	Helped	10,691	Take	12,620	Took	11,966
Use	11,813	Used	12,135	Tell	12,065	Told	12,055
Work	11,7889	Worked	11,126	Mean	11,976	Meant	10,514
Talk	11,562	Talked	10,565	Keep	11,851	Kept	10,948
Try	11,517	Tried	11,169	Feel	11,809	Felt	11,546
Call	11,484	Called	12,019	Run	11,258	Ran	10,634
Ask	11,465	Asked	11,934	Bring	11,248	Brought	11,145
Play	11,272	Played	10,827	Buy	10,928	Bought	10,328
Stay	11,097	Stayed	9,8664	Hold	10,891	Held	11,230
Stop	11,081	Stopped	10,640	Speak	10,696	Spoke	10,368
Seem	11,075	Seemed	11,293	Win	10,685	Won	10,819
Change	11,003	Changed	10,783	Write	10,628	Wrote	10,863
Watch	10,723	Watched	10,397	Eat	10,598	Ate	9,255
Hope	10,722	Hoped	9,5279	Spend	10,587	Spent	10,956
Serve	10,522	Served	10,400	Build	10,539	Built	10,693
Walk	10,503	Walked	10,652	Lose	10,496	Lost	11,265
Care	10,338	Cared	8,663	Send	10,472	Sent	10,751
Pass	10,267	Passed	10,693	Sell	10,394	Sold	10,392
Share	10,257	Shared	9,572	Grow	10,357	Grew	10,380
Raise	10,242	Raised	10,549	Deal	10,299	Dealt	8,863
Pull	10,165	Pulled	10,537	Break	10,194	Broke	10,017
Join	10,157	Joined	10,185	Drive	10,178	Drove	9,839
Wish	10,124	Wished	8,991	Fight	10,091	Fought	9,504
Cause	10,009	Caused	10,200	Teach	10,084	Taught	10,130
Drop	9,718	Dropped	10,252	Catch	9,984	Caught	10,565
Plan	9,635	Planned	9,667	Seek	9,883	Sought	9,740
Step	9,569	Stepped	9,786	Sleep	9,826	Slept	9,041
Sign	9,494	Signed	10,017	Throw	9,807	Threw	9,636
Fail	9,386	Failed	10,152	Fly	9,650	Flew	9,197
Stir	9,346	Stirred	8,113	Shoot	9,583	Shot	10,250
Roll	9,303	Rolled	9,441	Sing	9,500	Sang	8,810
View	9,257	Viewed	9,471	Bear	9,447	Bore	8,205
Jump	9,28	Juped	9,364	Hide	9,363	Hid	8,136
Cry	9,159	Cried	9,272	Stick	9,318	Stuck	9,617
Pour	9,005	Poured	8,830	Ride	9,296	Rode	8,699
Slip	8,689	Slipped	9,205	Feed	9,254	Fed	9,338
Tie	8,663	Tied	9,644	Strike	9,011	Struck	9,785
Stare	8,581	Stared	9,631	Dig	8,651	Dug	8,535

Score	8,563	Scored	9,448	Steal	8,647	Stole	8,502
Dare	8,561	Dared	7,838	Slide	8,484	Slid	8,812
Owe	8,500	Owed	8,067	Swim	8,403	Swam	7,633
Weigh	8,420	Weighed	8,304	Swear	8,383	Swore	7,577
Store	8,386	Stored	8,522	Swing	8,283	Swung	8,570
Dry	8,364	Dried	8,105	Ring	8,278936	Rang	8,602
Snap	8,168	Snapped	8,782	Freeze	8,26178468	Froze	7,779
Urge	8,007	Urged	8,851	Bend	8,24722005	Bent	9,129
Beg	7,991	Begged	7,857	Sink	8,20385137	Sank	8,205
Fan	7,741	Fanned	6,872	Lend	8,1850714	Lent	7,472
Sail	7,716	Sailed	7,765	Spin	8,01664788	Spun	8,238
Spray	7,560	Sprayed	7,310	Sweep	7,76174498	Swept	8,924
Strain	7,425	Strained	7,487	Bind	7,41938058	Bound	9,218
Drown	7,422	Downe	7,748	Breed	7,33171497	Bred	7,442
Whip	7,419	Whipped	7,765	Cling	7,28482091	Clung	7,605
Strip	7,375	Stripped	8,147	Grind	7,22183583	Ground	7,434
Sway	6,928	Swayed	7,289	Bleed	7,18462915	Bled	6,885
Vie	6,840	Vied	5,442	Weep	7,00215595	Wept	7,455
Glue	6,752	Glued	7,305	Creep	6,95081477	Crept	7,705
Spy	6,720	Spied	6,810	Sting	6,35957387	Stung	7,311
Roar	6,437	Roared	7,629	Fling	6,26720055	Flung	7,798
Sigh	6,120	Sighed	8,874	String	6,19847872	Strung	7,323
Frown	5,823	Frowned	8,270	Wring	6,13122649	Wrung	6,045
Scrawl	4,094	Scrawled	6,516	Stride	5,99645209	Strode	7,468
Dye	1,609	Dyed	6,523	Sling	5,1590553	Slung	7,048

APPENDIX G

Complete list of verbs (16 irregular frequent, 16 irregular infrequent, 16 regular frequent and 16 regular infrequent) used for the design of the Frequency Effects Task, ordered from the most frequent to the least frequent verbs

Regular Verbs		Irregular Verbs	
Stem	**Past Tense**	**Stem**	**Past form**
Look	Looked	Think	Thought
Help	Helped	Take	Took
Use	Used	Tell	Told
Work	Worked	Keep	Kept
Talk	Talked	Feel	Felt
Try	Tried	Run	Ran
Call	Called	Bring	Brought
Ask	Asked	Buy	Bought
Play	Played	Hold	Held
Stay	Stayed	Speak	Spoke
Stop	Stopped	Write	Wrote
Change	Changed	Eat	Ate
Watch	Watched	Spend	Spent
Hope	Hoped	Lose	Lost
Serve	Served	Sell	Sold
Walk	Walked	Grow	Grew
Roll	Rolled	Sing	Sang
View	Viewed	Hide	Hid
Jump	Jumped	Ride	Rode
Cry	Cried	Feed	Fed
Pour	Poured	Dig	Dug
Tie	Tied	Steal	Stole
Stare	Stared	Slide	Slid
Score	Scored	Swim	Swam
Store	Stored	Swear	Swore
Dry	Dried	Ring	Rang
Beg	Begged	Freeze	Froze
Sail	Sailed	Bend	Bent
Spray	Sprayed	Sink	Sank
Glue	Glued	Lend	Lent

Spy	Spied	Spin	Spun
Dye	Dyed	Bleed	Bled

APPENDIX H

The list of sentences used as contexts for the Frequency Effects Task

Regular Verbs	Irregular Verbs
Every day I look at birds. Yesterday I ...	Every day I think about work. Yesterday I ...
Every day I help my mother. Yesterday I …	Every day I take a pill. Yesterday I …
Every day I use my computer. Yesterday I …	Every day I tell a joke. Yesterday I…
Every day I work from home. Yesterday I …	Every day I keep a secret. Yesterday I …
Every day I talk to Sue; Yesterday I…	Every day I feel very happy. Yesterday I ...
Every day I try new things. Yesterday I …	Every day I run five kilometers Yesterday I …
Every day I call my father. Yesterday I…	Every day I bring a gift. Yesterday I…
Every day I ask a question. Yesterday I…	Every day I buy some chocolate. Yesterday I …
Every day I play a game. Yesterday I…	Every day I hold my baby. Yesterday I …
Every day I stay well informed. Yesterday I …	Every day I speak with her. Yesterday I ...
Every day I stop at McDonalds. Yesterday I…	Every day I write a paragraph. Yesterday I ...
Every day I change my clothes. Yesterday I …	Every day I eat a banana. Yesterday I …
Every day I watch a movie. Yesterday I…	Every day I spend my money. Yesterday I ...
Every day I hope for success. Yesterday I …	Every day I lose my keys. Yesterday I ...
Every day I serve hot tea. Yesterday I…	Every day I sell some flowers. Yesterday I ...
Every day I walk four blocks. Yesterday I …	Every day I grow a little. Yesterday I ...
Every day I roll the dice. Yesterday…	Every day I sing a song. Yesterday I …

Every day I view the mountains. Yesterday I…	Every day I hide my wallet. Yesterday I…
Every day I jump really high. Yesterday I …	Every day I ride my bike. Yesterday I …
Every day I cry a lot. Yesterday I…	Every day I feed my dog. Yesterday I …
Every day I pour some milk. Yesterday I	Every day I dig up dirt. Yesterday I …
Every day I tie my shoes. Yesterday I…	Every day I steal a kiss. Yesterday I…
Every day I stare at you. Yesterday I…	Every day I slide on ice. Yesterday I…
Every day I score some points. Yesterday I …	Every day I swim a mile. Yesterday I ...
Every day I store some candy. Yesterday I …	Every day I swear in traffic. Yesterday I…
Every day I dry the dishes. Yesterday I…	Every day I ring the doorbell. Yesterday I …
Every day I beg for food. Yesterday …	Every day I freeze some vegetables. Yesterday I
Every day I sail my boat. Yesterday I…	Every day I bend my back. Yesterday I …
Every day I spray my roses. Yesterday I …	Every day I sink into snow. Yesterday I …
Every day I glue things together. Yesterday I …	Every day I lend six dollars. Yesterday I ...
Every day I spy on people. Yesterday I …	Every day I spin my wheels. Yesterday I ...
Every day I dye some fabric. Yesterday I …	Every day I bleed too much. Yesterday I...

APPENDIX I

Complete list of stimuli and expected correct answers for the Letter-Number Ordering Task

Stimuli	Correct answers
L – 2	2 – L
6 – Q	6 – Q
C – 5	5 – C
F – 7 – L	7 – F – L
R – 4 – A	4 – A – R
G – 1 – 8	1 – 8 – G
S – 9 – A – 3	3 – 9 – A – S
J – 1 – X – 5	1 – 5 – J – X
7 – R – 4 – L	4 – 7 – L – R
8 – A – 6 – G – 1	1 – 6 – 8 – A – G
L – 2 – C – 7 – S	2 – 7 – C – L – S
5 – Q – 3 – X – 9	3 – 5 – 9 – Q – X
J – 4 – C – 7 – Q – 2	2 – 4 – 7 – C – J – Q
Z – 8 – J – 5 – F – 3	3 – 5 – 8 – F – J – Z
6 – G – 9 – A – 2 – S	2 – 6 – 9 – A – G – S
R – 3 – A – 4 – Z – 1 – G	1 – 3 – 4 – A – G – R – Z
5 – S – 9 – J – 2 – X – 7	2 – 5 – 7 – 9 – J – S – X
F – 1 – L – 8 – R – 4 – C	1 – 4 – 8 – C – F – L – R
5 – G – 9 – S – 2 – L – 6 – A	2 – 5 – 6 – 9 – A – G – L – S
C – 1 – R – 9 – A – 4 – J – 3	1 – 3 – 4 – 9 – A – C - J – R
7 – J – 2 – S – 6 – F – 1 – Z	1 – 2 – 6 – 7 – F – J – S – Z