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CORRESPONDENTE

WORKING MEMORY CAPACITY, LEXICAL ACCESS AND PROFICIENCY LEVEL IN L2 SPEECH PRODUCTION

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To my family

You are my strength

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ABSTRACT

WORKING MEMORY CAPACITY, LEXICAL ACCESS AND PROFICIENCY LEVEL IN L2 SPEECH PRODUCTION

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UNIVERSIDADE FEDERAL DE SANTA CATARINA

2009

Supervising Professor: Dr. Mailce Borges Mota

This study investigates (i) whether bilingual lexical access is predicted by working memory capacity (WMC) and proficiency level in L2; (ii) whether WMC and L2 proficiency interact in predicting bilingual lexical access, and (iii) the extent to which within-language competition affects bilingual lexical access. One hundred learners of English as a foreign language (L2) were submitted to three data collection sessions which comprised three tests to measure WMC, two tests to measure L2 proficiency and one test to assess bilingual lexical access. The task used to assess the main L2 ability under investigation – bilingual lexical access -, was a picture-naming task carried out under the semantic competitor paradigm. This task was composed of a control and an experimental condition. Whereas in the former subjects were required to name pictures without any interfering stimuli, in the latter they were asked to retrieve the lexical items to name the pictures under the presence of semantically related L2 word distractors. Data were analyzed quantitatively and the statistical procedures (multiple regressions, ANOVA, ANCOVA and partial correlations) revealed that, in general terms, WMC and L2 proficiency both significantly predicted bilingual lexical access. Higher spans retrieved lexical items faster than lower spans. Moreover, the facilitation effects of semantically related L2 word distractors on L2 picture-naming were shown to be an effect of task order. However, more proficient bilinguals obtained faster reaction times during the retrieval of L2 lexical items than less proficient ones, regardless of performing the control or the experimental condition first. The findings of the present study are explained mainly in respect to the interplay between automatic and controlled processes in memory retrieval and their impact on the development of L2 proficiency. Special attention is given to the way semantic/lexical representations develop, are stored, retrieved and connected in a bilingual mental lexicon.

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RESUMO

CAPACIDADE DE MEMÓRIA DE TRABALHO, ACESSO LEXICAL E NÍVEL DE PROFICIÊNCIA EM L2

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Este estudo investiga (i) se o acesso lexical bilíngüe pode ser explicado pela capacidade de memória de trabalho (CMT) e pelo nível de proficiência em L2; (ii) se ambos os construtos interagem para explicar o acesso lexical bilíngüe e, (iii) o efeito da competição entre representações lexicais em L2 no acesso lexical bilíngüe. Cem aprendizes de Inglês como língua estrangeira foram submetidos a três sessões de coleta de dados envolvendo 3 testes para medir a capacidade de memória de trabalho, 2 testes para medir o nível de proficiência em L2 e 1 teste para mensurar o acesso lexical bilíngüe dos aprendizes. A tarefa utilizada para medir o acesso lexical foi uma tarefa de nomeação de figuras conduzida sob o paradigma de competição semântica. Essa tarefa era composta de uma condição controle e uma experimental. Enquanto na primeira condição os aprendizes deviam nomear figuras em L2 sem nenhum estímulo interferente, na segunda os mesmo deviam nomear figuras na presença de distratores semanticamente relacionados aos nomes das figuras. Os dados foram analisados quantitativamente. Os resultados revelaram que, em termos gerais, CMT e nível de proficiência em L2 explicam parte da variação em acesso lexical significativamente. Aprendizes com maior CMT recuperaram os itens lexicais mais rapidamente que aprendizes com menor CMT. Os efeitos facilitatórios produzidos por distratores semanticamente relacionados aos nomes das figuras na tarefa de nomeação em L2 foram conseqüência da ordem de execução das condições controle e experimental. Os aprendizes mais proficientes, por sua vez, apresentaram tempos de resposta mais rápidos do que aprendizes menos proficientes, independentemente de realizar a condição controle ou a experimental primeiro. Os resultados deste estudo são explicados, principalmente, em relação à interação entre processos automáticos e controlados na recuperação de informação da memória de longo-prazo e no desenvolvimento da proficiência e das representações lexicais em L2.

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CHAPTER 1

INTRODUCTION

1.1 Preliminaries

The production of intentional and fluent speech[1] has been said to require the orchestration of a number of mental operations involving conceptual and linguistic processes (Levelt, 1989). From an information-processing perspective (Shiffrin and Schneider, 1977), some of these processes are performed automatically and some are performed under attentional control. In his L1 adult speech production model, Levelt (1989) acknowledges that conceptualizing a message to be verbalized in one's language and monitoring the output of such verbalization are processes that require attention to be executed since they are controlled by the speaker himself. On the other hand, linguistic processes such as selecting and retrieving words to express the conceptual message, giving sound to the message and articulating it are highly automatic processes that do not depend on attention to be performed.

As proposed by Levelt, the core process of speaking is word selection, upon which all other linguistic processes operate. Word selection or lexical access[2], as it is usually referred to in the literature on speech production, is said to occur under competition. That is, when a concept, specified in the conceptual message, activates a word in the mental lexical, this activation spreads along the lexico-semantic network,

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[1] Following Schmidt (1992) and Skehan (1996), fluency is taken here as speakers' ability to mobilize their linguistic resources in order to produce speech in real time.

[2] For the purposes of the present study, lexical access is the act of "retrieving a word […] from the mental lexicon, given a lexical concept to be expressed" (Levelt et al, 1999, p. 4). Throughout this dissertation the term lexical access will be used interchangeably with the terms: word selection, lexical retrieval, and lexical selection.

and several related words (words that share meaning or any other related characteristic) also become activated, competing for selection. The extent to which such competition interferes with the selection of the appropriate word is said to be related to how strong the connections between words are (de Groot, 1992). How this competition is solved by the lexical retrieval system is still a matter of contention but, more important is that, because accessing words in L1 is so automatized, few selection errors are made and speech production generally proceeds smoothly to articulation.

The panorama seems to be a very different one when speech is produced in L2[3]. It is now widely accepted that L2 speakers hold a great amount of explicit and underdeveloped knowledge of the second language, thus resorting to more controlled processing, especially in initial learning[4] phases (Kormos, 2006). Because the L2 lacks automatization, speech production in the second language runs serially, thus causing L2 speech to be more hesitant, disfluent and open to L1 influence (Poulisse, 1997; Fortkamp, 2000; Kormos, 2006). Word retrieval, in this scenario, besides suffering from lack of automaticity, is also affected by lexical representations that lack strong connections with the L2 conceptual system, forming a less integrated lexicon in relation to L1(Kormos, 2006; de Grot, 1995), and by competition from other L2 and L1 related items. Serial processing of explicitly stored retrieval procedures, weaker lexical representations, and lexical competition render L2 lexical access an attention-demanding task.

With that in mind, it seems crucial to examine the role of working memory capacity (WMC) in bilingual[5] lexical retrieval, since research on WMC and retrieval has

[3] In this study, the terms foreign and second language will be used interchangeably and will be referred to as L2. The term L2, in turn, is understood as a language one speaks other than his mother tongue (L1).
[4] Throughout this dissertation, the terms acquisition and learning will be taken as synonyms.
[5] Following the research tradition on lexical access, the term bilingual lexical access will be used as a synonym for lexical access in L2. In addition, the term bilingual will be used to designate L2 learners and L2 speakers, which, in turn, are used interchangeably in this dissertation.

shown that individuals with larger and smaller WMC differ in their ability to use controlled attention to generate relevant cues to delimit the search set adequately, to block misleading information, and to monitor for correct retrieval (Conway and Engle, 1994; Rosen and Engle, 1997; Rosen and Engle, 1998; Unsworth and Engle, 2007). What these studies have shown is that individual differences in WMC are even more evident when retrieval entails response competition.

Although several studies have investigated the relationship between WMC and retrieval, or the importance of WMC to the inhibition of lexical items from one of the languages of a bilingual speaker when the other one is being used for communication, none of them, to the best of my knowledge, address the role of WMC in bilingual lexical access when retrieval entails within-language competition. Moreover, little attention has been given to the extent to which WMC affects bilingual lexical access at different levels of proficiency.

The present study, therefore, aims at investigating whether WMC and L2 proficiency predict bilingual lexical access in a picture-naming task carried out under the semantic competitor paradigm[6].

1.2 Statement of the purpose

The reasoning behind this investigation is that bilingual lexical access qualifies as a controlled serial search task sub-served by a resource-limited-capacity system – Working Memory (WM). Following from that, it is assumed that individual differences in the ability to use controlled attention (that is, in WMC) plus the degree of

[6] In a semantic competitor paradigm, a picture to be named is primed by a semantically related item which acts as a competitor during the retrieval of the target word (the name of the picture). L1 lexical access studies have shown that competition takes longer to resolve when competitor words are semantically related to the target and precede picture onset (Schriefers, Meyer and Levelt, 1990; Levelt, Schriefers, Vorberg, Meyer, Pechmann and Havinga, 1991a).

automatization of the L2 (proficiency) are likely to constrain lexical access when retrieval entails response competition.

In order to test the aforementioned assumptions, the present study pursued three specific objectives: (i) to investigate whether bilingual lexical access is predicted by WMC and proficiency level in L2; (ii) to investigate whether WMC and L2 proficiency interact in predicting bilingual lexical access, and (iii) to examine the extent to which within-language competition affects bilingual lexical access.

1.3 Significance of the study

The present study contributes to the discussion of individual differences in WMC and bilingual lexical access in three different, but complimentary ways. First, as previously pointed out, this study, different from other studies which have investigated the role of WMC in retrieval and language inhibition, specifically addresses the contribution of WMC to bilingual lexical access taking into account the competitive nature of retrieving words in the non-dominant language. Second, the present study will contribute to the understanding of the cognitive processes that are common to bilingual lexical access and WM by envisaging word retrieval in L2 as a controlled serial search task susceptible to attentional limitations. Third, it adds to empirical and theoretical work on speech production and lexical access by discussing how proficiency (knowledge of the L2) relates to process automatization and, as a result, affects the quantity and quality of L2 speaking.

The present study brings together findings from both working memory and lexical access research with the ultimate goal of addressing the complexities of the L2, usually the less practiced and less dominant language of a bilingual speaker.

1.4 Organization of the doctoral dissertation

In order to report on the experiment conducted to explore the relationship between WMC, bilingual lexical access and proficiency, the present dissertation is organized into 6 chapters, including this introductory one (Chapter 1).

Chapter 2 reviews theoretical and empirical work on lexical access. Initially, issues regarding the representation of words in memory are discussed. Then, an account of L1 and L2 models of lexical access is provided. Also, theories of language selection and control and its implications for bilingual lexical access are reviewed.

Chapter 3 addresses the theory of WMC adopted in the present study and reports on empirical evidence supporting the relationship between bilingual lexical access, L2 proficiency and WMC.

Chapter 4 describes the methodological procedures adopted in the present study, including a description of participants, instruments of data collection and analysis, task procedures, and the statistical tests run with the data gathered. In addition, this chapter poses the research questions and hypotheses guiding this investigation.

Chapter 5 reports the results of the statistical analysis which are discussed in Chapter 6 by addressing the research questions and hypotheses posed.

Finally, Chapter 7 summarizes the main findings of this investigation and draws some conclusions based on the findings and on the literature in the field. The chapter also points out the limitations of the study, makes suggestions for further research and presents some pedagogical implications concerning L2 speech production.

CHAPTER 2

REVIEW OF LITERATURE ON LEXICAL ACCESS

According to De Bot and Schereuder (1993), lexical access in bilinguals does not fundamentally differ from lexical access in monolinguals. As pointed out by these theorists, however, any empirical endeavor seeking to investigate lexical retrieval mechanisms in bilingual speech production cannot deny that keeping L1 and L2 apart is a difficult task given that the L2 is frequently the language less practiced, consequently causing speakers to face difficulties in suppressing L1 elements in L2 speech.

The objective of this chapter is to lay out a path to understand the research tradition in lexical access. This includes theoretical work related to lexical developmental and retrieval models as well as empirical studies conducted in the field. In order to lead the reader through this path, this literature review starts by presenting, in the first section, two different approaches to the representation of words in both monolingual and bilingual memories and their assumptions regarding lexical retrieval in L2. The second and the third sections describe the most comprehensive accounts of L1 and L2 lexical processing, respectively. Finally, section four reviews the theories of language selection and control (and their implications for bilingual lexical access), leading into Chapter 3, in which the role of WM in controlling language processing will be highlighted.

2.1 The representation of words in semantic memory: issues on lexical access

The chief issue around the representation of words in memory centers on whether words are stored and retrieved from semantic memory on the basis of a list of features and attributes or on the basis of abstract representations (memory nodes) which serve as codes for conceptual specifications in memory (Roelofs, 1992; 1993; 1996; 1997).

From a non-decompositional[7] view of semantic memory[8] (Collins and Loftus, 1975), each word (lexical entry) in the mental lexicon has a corresponding element in the vocabulary of messages[9], which is an abstract representation such as APPLE[10] (X, Y), for instance. These abstract representations or memory nodes are connected to other nodes in the lexicon network through pointers or links that specify their relationship. APPLE (X, Y) is connected to FRUIT (X, Y) through an IS-A link, which means that APPLE is a kind of FRUIT. Once the notion APPLE is to be expressed in a particular language, for example, its respective concept (memory) node APPLE (X, Y) receives a bust of activation. This activation then spreads to other related nodes in the network, such as ORANGE (X, Y).

On the non-decompositional view, information concerning the conceptual features (primitives) of any lexical entry is considered background information about words. The primitives are assumed to be stored and associated in memory, but are not

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[7] A non-decompositional view of semantic memory maintains that each semantically complex word is represented and stored in semantic memory as an independent memory node (Roelofs, 1992; 1993; 1997; 2000).

[8] According to Ashcraft (1994), "semantic memory is our permanent memory store of general world knowledge, variously described as a thesaurus, a dictionary, or an encyclopedia. Semantic memory is where your knowledge of language and other conceptual information is stored. It is the permanent repository of information you use to comprehend and produce language, to reason, to solve problems, and to make decisions." (p. 254).

[9] According to Roelofs (1997), the vocabulary of messages constitutes the set of mental representations that will activate the words needed to express one's communicative intentions.

[10] Throughout the present dissertation, concepts will be represented by uppercase letters and words (lemmas) will be shown in lowercase bold format. Conceptual features will appear between [ ] in uppercase writing.

directly involved in word retrieval per se (Roelofs, 1992, 1993, 1997). For a word to be retrieved from a non-decompositional point of view, the only pre-requisite is its related concept to be present in the intended message. That is, once the concept APPLE is part of the preverbal message, the word apple will be retrieved. Put differently, for each word in the mental lexicon there must be a single element/representation at the conceptual level. Once one knows which elements of the vocabulary of messages will serve their communicative intentions and lead to verbalization in one's language, one will be able, other things being equal, to select the appropriate words for that (Roelofs, 1997).

In a decompositional view[11] of the lexicon, on the other hand, words are represented in memory by a set of features called primitives (Smith, Shoben and Rips, 1974). When a concept such as APPLE is chosen for verbalization, its primitives become active in memory and as a consequence activate the word in the mental lexicon that best matches the features specified by the concept. In this case, the word **apple** is retrieved. A relevant issue concerning word retrieval based on primitives is that it is hard to conceive of a set of features to define abstract concepts such as LOVE, DEMOCRACY, HATE, to cite just a few (Roelofs, 1997).

Another well known problem in lexical access regarding the representation of words in memory is the so-called convergence or hyperonym problem. This problem concerns the fact that when one decides to verbalize the concept DOG, for instance, all the semantic specifications of the concept ANIMAL are also satisfied (Levelt, 1989; Levelt et al., 1999; Roelofs, 1992). Moreover, several other semantically related

[11] The decompositional view has been the preferred view taken to explain word representation in memory. As a consequence, this view has strongly influenced several models of conceptually driven word retrieval (Roelofs, 1997). Its central thesis is that each word is represented in memory by a set of conceptual specifications. If the intention is to express the notion of DOG, for instance, specifications such as [ANIMAL], [MAMAL], [HAS FOUR LEGS], [BARKS] need to be activated so that the word **dog** can be retrieved.

concepts become activated as well such as CAT, FISH, among others. How is then, that the retrieval mechanism converges into the right lemma node, since several lexical items share conceptual primitives in memory?

The decompositional approach has difficulty explaining why one verbalizes **animal** for **dog**. On the other hand, if one assumes a non-decompositional view of the mental lexicon, one will not experience the convergence problem when retrieving words since a lexical item is not represented by primitives but rather by its proper memory code. Roelofs (1997) states that "convergence is a general property of the […] non-decompositional spreading-activation model" (p.59).

In contrast, La Heij (2005) points out that the hyperonym problem supposedly raised by decompositional approaches must be interpreted carefully, since it is not clear that all features of a hyponym are also relevant to its hyperonyms. In the case of words such as **mother** and **parent**, for example, the former has the particular [+GENDER] feature, which is a completely irrelevant feature for **parent** – its hyperonym. In addition, La Heij argues that the claim put forward by Roelofs (1992) in favor of completely discarding decompositional views based mainly on the argument that words and their corresponding phrase-synonyms express the same conceptual meaning, has to be taken with caution. According to La Heij, this should not be a problem for decompositional theories in retrieving the correct lemma because words such as **mother** and **female parent**, just to cite the previous example, seem not to express the same meaning. While **mother** carries more emotional and personal characteristics, **female parent** seems to imply a more impersonal tone. Besides, if interlocutors react differently when listening to these two words, they probably mean different things (La Heij, 2005).

In La Heij's viewpoint, the meaning of words comprises more than just features or definitions, it also contains pragmatic and affective aspects, which makes the conceptual representation a complex and rich entity. Following from this, La Heij assumes that the preverbal message - the mental representation of the to-be-verbalized concepts - contains all the necessary conditions for the activation and retrieval of the appropriate words that will convey the speaker's communicative intention.

So far I have shown that the debate between the decompositional or non-decompositional approaches to semantic memory has long been object of disagreement among researchers. Nonetheless, it appears that assuming one of the two will have different consequences for the way words are represented and used in L2. The next subsection outlines the models proposed in the literature to explain bilingual lexical representation and development.

2.2 Lexical representation in bilinguals

According to de Groot (2002), there exist three models of lexical representation in bilinguals: (i) one that postulates the existence of separate representations in each language (L1 and L2) – the language specific, segregation, or selective access model; (ii) a second one that assumes that memory representations are shared between L1 and L2 – the language non-specific, integration, or non-selective access model; and (iii) a third one which proposes that concepts (meaning) are shared but words are specific to each of the languages – the mixed model.

The mixed model, also called the hierarchical, two-layer or three-component model has received great attention in bilingual lexical access research over the past decades. Given that this model stands at an intermediate point between the first two in relation to the organization of concepts and words in memory, a better look at its assumptions may be worthwhile.

There are four versions of the hierarchical, three component model – (i) the word association model; (ii) the concept mediation model; (iii) the developmental model; and the (iv) the asymmetrical model. As postulated by the word-association model, L2 meaning is accessed via L1 word meaning, which is, in turn, connected to the conceptual store. On the other hand, the concept-mediation model assumes that the L2 is indirectly connected to L1. That is, L2 word meaning is accessed directly via the connection between the L2 word representation and the conceptual store.

Combining these two models, the developmental model proposed by Potter et al. (1984) assumes that lexical representations in L2 develop as a function of proficiency in the language. Less proficient bilinguals supposedly have had less practice in the language and thus are likely to have more word-association links in memory. On the other hand, more proficient bilinguals are expected to have practiced the language to a greater extent thus developing more concept-mediation links among L2 words and their meanings. Potter et al. did not find support for their model, however, since less and more proficient bilinguals showed similar processing patterns, as measured by reaction time. Results of their study indicated concept-mediation for both proficiency groups. Potter et al. explained the lack of support for their model by acknowledging that their low-proficiency subjects might not have been low enough, thus performing similarly to high-proficiency bilinguals. Kroll and Curley (1985, in de Groot, 2002) and Chen and Leung (1989, in de Groot, 2002), on the other hand, found evidence supporting the developmental model. Less proficient bilinguals presented word-association response patterns, whereas more proficient bilinguals presented concept-mediation response patterns.

Finally, in 1994, Kroll and Stewart proposed the revised hierarchical model (RHM) also known as the asymmetrical model. According to the revised version, with increased L2 proficiency, the connections between words of the two languages, which were initially at the lexical/word level, shift to connections at a conceptual level. The asymmetrical costs predicted in the model when translating from L1 to L2 and vice-versa are explained in terms of the strength of the connections between words in the two languages and the relative dominance of the L1 over the L2 (Kroll and Stewart, 1994, p. 157).

In other words, based on previous models of bilingual lexicon representations, Kroll and Stewart propose that at initial stages of L2 learning, words in the second language are associated with words in the first language and therefore the connections from L2 to L1 words are supposedly stronger than the connections in the opposite direction. The model also predicts that the links from L1 to the conceptual store are stronger than the links from L2 to the conceptual store. This is so because, as proposed by the authors, L2 meaning is not fully developed at initial stages of acquisition. In this sense, the meaning of an L2 word, to put differently, is the meaning of an L1 word. As proficiency in L2 develops, it is assumed that conceptual links for L2 words are also acquired allowing for a direct access to meaning in the second language. As explained by Kroll and Stewart, " […] it is the ease of accessing connections between L2 words and concepts that changes most dramatically as proficiency in L2 increases" (p. 167).

Assumptions of another, not very recent, model of lexical representation, were brought back into consideration by a new framework of bilingual speech production proposed by Kormos (2006) (see section 3 for details on the framework) - de Groot's (1992) distributed model. According to de Groot's proposal, the meaning of a word is composed by a set of primitives. Activating a word thus means activating its primitives, which are likely to be shared between L1 and L2. In a translation task from English into Portuguese, for instance, when the word **father** is presented, all the primitives for **pai** receive activation as well. Concrete and cognate words are likely to share the same conceptual primitives. However, as claimed by de Groot (1992), non-concrete and non-cognate words in L1 and L2 might be composed of different primitives and therefore are not activated to the same extent. The rationale behind these claims is that the more primitives are shared between a word conceptual meaning in L1 and in L2, the more activation is sent along the semantic network and consequently, the faster and more accurate performance will be.

The model also assumes that words in one language share conceptual primitives with semantically related words in the same language and with the translation counterparts of these words. Support for within language activation comes from lexical decision tasks showing faster reaction times for words primed by a semantically related word. For example, priming the word **father** activates the shared representations (primitives) of the word **mother**, thus facilitating performance. Priming effects for semantically related words are larger within a language than between languages. This is so because within a language these words share more conceptual primitives than between languages and therefore the greater the number of elements that overlap, the greater the activation the target word node will receive (de Groot, 1992).

Finally, de Groot (1992) argues that bilingual lexical representations (words in L1 and in L2) may have some of their conceptual representations stored in a language-specific memory and others stored in a language non-specific store. The extent to which words' primitives are shared between and within languages seems to determine the organization of lexical and conceptual representations in a bilingual memory.

According to de Groot and Hoeks (1995), all versions of the three-component model present the same caveats. First, different types of lexical knowledge about words are not specified, nor are they represented or processed. Second, the models should contain more layers with richer specifications to include syntactic, morphological, orthographic and phonological representations. Third, words in L1 and in L2 are not likely to share meaning completely; consequently, they might not share a conceptual store in its entirety.

Proposals aiming at accounting for the different types of knowledge and representations involved in lexical access have been implemented in several ways by different models of speech production, both in L1 and in L2. The next two sections review these proposals by zooming in on the lexical selection process from the moment of message conceptualization to word selection.

2.3 Lexical processing in L1 speech production

2.3.1 The original and revised blueprint for the speaker

In 1989, Levelt put forward a comprehensive and ambitious model of speech production to explain speaking by monolinguals. The main thesis of the model is that speaking involves the conceptualization of a pre-verbal message which is further converted into external speech through formulation and articulation processes. Formulation processes, as advocated by Levelt, are lexically driven. That is to say that the lexicon mediates between what is conceptualized and what is linguistically formulated for all syntactic building procedures that will determine the construction of a noun- or a verb-phrase, for instance, are activated upon the selection of lexical items that match the conceptual specifications of the pre-verbal message.

According to Levelt (1989), syntactic and phonological information encoded by formulation processes is stored in the mental lexicon, more specifically in structures called lemmas and lexemes, respectively. The lemmas, in this model, contain semantic information decomposed into conceptual primitives. That is, the meaning of the lexical item **boy**, for example, is represented by features such as [+MALE], [+CHILD], [-ADULT]. Because lexical items are likely to share conceptual features with other items in the lexical network, more than a single item may be activated above threshold and become available for selection. To ensure the selection mechanism will zoom in on the appropriate lexical item, Levelt proposes that each particular item has a specific core meaning that has to be satisfied if it is to be considered for selection. The item that shares the greatest number of specifications with the to-be-expressed concept is retrieved. On this view, it is worth noting that lexical selection in Levelt's (1989) model is a highly automatic process which depends only on the specifications of the conceptual structures present in the pre-verbal message.

A different approach to lexical access was proposed by Levelt, Roloefs and Meyer (1999). The model, which elaborated on Levelt's (1989) model and was implemented in a computation model (WEAVER++), aimed at accounting for recent reaction time and brain imaging data on monolingual word production. The main feature differentiating the revised from the original model is that the former no longer assumes that lexical entries (items) have conceptual features as their constituent parts. This means that semantic information previously stored in the lemmas is now stored in the so-called conceptual nodes. These conceptual nodes, in turn, give access to conceptual features in memory. Lexical items are not selected by the activation of their conceptual features, but rather by the activation of their own concept nodes. In other words, the retrieval of the word **father**, for instance, already starts with the activation of the concept node FATHER (X). The conceptual features of FATHER (X) are considered, in this model, background information stored in semantic memory and do not take an active part in the lemma retrieval process per se. Additionally, in this model, the memory representations of words (concept nodes) are linked to each other in the network through pointers that specify the nature of their relationship . “The concept node FATHER (X), for example, is linked to the concept node PARENT (X,Y) by an IS-A link, and the concept node MALE (X) is connected to FATHER (X,Y) by a SEX-OF link” (Roelofs, 1996, p. 317). As the activation of a particular lemma node already starts with its respective concept node, this lemma node will receive a greater amount of activation and will thus reach the threshold level more quickly. Although another lemma node such as **parent** might be activated as well, it will not be activated to the same level of **father** because it will receive only a proportion of the full proportion of activation that the lemma node for **father** got.

In the model, the mental lexicon is conceived as a network of independent strata of nodes. The first level of nodes, the so-called conceptual stratum, contains the concept nodes, which are linked to their respective lexical concepts. The second is a lemma stratum, comprising lemma nodes and their syntactic properties. Once lemma selection occurs, activation spreads to the next stratum – the form stratum, in which morpheme and segment nodes are stored (Levelt et al., 1999; Roelofs, 1992).

The theory of lexical access implemented in Levelt et al.’s (1999) model was first put forward by Roelofs (1992) and has been shown to account for several findings concerning picture naming, picture categorization and word categorization. Regarding picture naming, basic findings suggest a semantic inhibition effect at early

SOA[12] (100 ms before or after picture presentation), when a semantically-related distractor word is presented in relation to an unrelated distractor. The theory explains these findings as follows. The inhibition effect reflects the competition between lexical nodes during selection. Because the distractor word and the picture's name are related in the lexical network, the time response to the retrieval of the picture lemma node is expected to be longer than if the distractor and the name of the picture were not related.

In picture categorization, for example, the hyperonym of the pictured object has to be retrieved. Overall findings indicate a semantic facilitation effect, that is, faster response time, when a hyponym – a semantically-related distractor word - is presented before picture presentation in relation to an unrelated one. This happens because the lemma node of the word-related hyponym will activate its related hyperonym, whereas the lemma node of the unrelated hyponym will activate the wrong hyperonym. Word categorization, in turn, implies the retrieval of the hyperonym of words presented with distractor pictures. Similarly, a semantic facilitation effect is observed when semantically-related distractor pictures are presented up to 200 ms after word presentation, a result explained in the same way of picture categorization effects.

2.3.2 Lexical processing in L2 speech production

Although L1 speech production models such as Levelt (1989) and Levelt et al. (1999) have provided a comprehensive account of the mental/cognitive processes involved in monolingual lexical access, several issues remain unresolved when turning to bilingual speech processing. Adding an L2 component to L1 models is far from being

[12] SOA (Stimulus Onset Asynchrony) is the time interval between the onset of the picture and the onset of the interfering stimulus, usually covering a range from 400 ms before picture presentation to 400 ms after picture presentation, in steps of 100 ms (Glaser and Düngelhoff, 1984).

an easy and straightforward solution for it raises a number of questions particularly in relation to message conceptualization, mental lexicon organization and lexical retrieval.

As regards message conceptualization, the central issue refers to whether the preverbal plan built in the Conceptualizer is language-specific. Because this is the only stage speakers can have access to knowledge of the external world, contextual and environmental clues, and to discourse model information, there is a consensus among bilingual researchers that language choice is in itself a specification of the conceptual message. Consequently, all the following processes regarding lexical, syntactic and phonological encoding are to be produced according to the language specified in the form of a language tag in a conceptualization stage called microplanning (de Bot, 1992; de Bot and Schereuder, 1993; Poulisse and Bongaerts, 1994; La Heij, 2005; Kormos, 2006).

Another question that needs to be addressed by an L2 speech production model is whether items in a bilingual lexicon are stored together in the same network, how they differentiate, and whether they contain semantic, syntactic and phonological information. According to most L2 researchers, L1 and L2 are stored in the same lexical network and are tagged for language. They are also assumed to share a single conceptual system and to contain conceptual primitives as their constituent parts (La Heij, 2005; de Bot and Schereuder, 1993; Poulisse and Bongaerts, 1994). Recently, there has been some interest in investigating the relations among L1 and L2 lexical items and how these relations affect access to meaning and form during word translation and picture naming tasks (Kroll and colleagues).

Lexical retrieval, in turn, is directly affected by the way speech is conceptualized and the way the mental lexicon is conceived. This is particularly true because it is the concepts specified in the preverbal message that will determine which lexical items will be selected to verbalize the message one wants to express. These items will then be retrieved on the basis of their primitives or another mental representation and may activate related items in the intended and non-intended languages. The question of whether lexical items of both languages compete for selection has received great attention in bilingual research. There is nowadays plenty of evidence in favor of a language non-specific approach to lexical selection (see Section 4 for a review of studies about language non-selectivity). On this view, items of both languages that share the same characteristics with the preverbal message are activated, competing for selection at the semantic and phonological level. Cascading models of L1 speech production have shown that not only the selected items send activation to their corresponding phonemes, but also non-selected ones have their phonological information activated (Morsella and Miozzo, 2002).

As an attempt to address the issues involved in L2 speech production, Kormos (2006) proposed an L2 speaking model based on Levelt et al.'s (1999) revised blueprint for the speaker. In this recent model, Kormos makes important assumptions regarding knowledge automatization in L2 and the way it affects speech production processes. According to her, because several lexical encoding procedures are not fully automatized in L2, it is paramount to propose that bilingual speakers have access to an additional knowledge store – a declarative store for syntactic L2 rules. With increasing proficiency the declarative knowledge of L2 rules may become automatized and then lexical processing may develop on a continuum, from serial to parallel processing, allowing for a more native-like speech production. As long as speakers depend on the use of declarative knowledge, lexical encoding can only be serially carried out, requiring more attentional control to be executed.

Following Levelt et al.'s model, Kormos proposes the existence of three other main components in the model – the Conceptualizer, the Formulator and the Articulator. In her model, language is also selected at the conceptual level and is represented by a language cue which is added to the concepts in the pre-verbal message. Moreover, both selected and non-selected lexical nodes can activate their phonological counterparts. The model also consists of a long-term memory store which hosts a store for L1 and L2 episodic memory, the mental lexicon and the syllabary (a store for automatized gestural scores). The mental lexicon is assumed to be part of the semantic memory which stores linguistic and non-linguistic concepts and their respective meaning-related memory traces. These memory traces would correspond to the primitives that make up lexical items. Lemmas, in this model, are assumed to contain only syntactic information, like in Levelt et al.'s proposal.

L2 speech production, as proposed by Kormos, initiates with the activation of the concepts that will convey the intended message. Each concept features its own language cue and is therefore language-specific. Thus, a preverbal message may contain some concepts specified in L1 and others in L2. This proposal explains how bilingual speakers are able to produce mixed-language sentences such as "the tree is next to la maison" since it allows for parallel retrieval of L1 and L2 lexical items (Roelofs, 1998). The concepts are assumed to be shared between L1 and L2, but the extent to which this is true depends on, as proposed by de Groot (1992), whether words are concrete or abstract nouns, the L2 acquisition environment, and the proficiency level of the speaker. Most relevant for the present study is the effect of proficiency on conceptual representations in L2. According to de Groot, in the beginning of the learning process, L2 concepts are not yet fully specified. Access to meaning is then made possible through direct links between L2 and L1 concepts. As proficiency increases the L2 conceptual specifications develop and access to meaning is not mediated by L1 semantics anymore.

The next step in the process is lexical encoding, which takes place within the Formulator component. In this stage, activated concepts pass activation on to the lemmas that match their specifications both in L1 and in L2. Semantically-related lemmas also receive activation and as a consequence compete for selection. The winning lexical item is the one the matches all the specifications of its corresponding concept plus the language cue. This entails that no additional mechanism of control or checking needs to be implemented to guarantee lexical selection in the intended language.

What is not clear in this framework, however, is whether this assumption is coherent with other assumptions of the bilingual model sine Kormos, like Levelt et al. (1999), assumes that lemmas do not contain semantic information as their constituent parts. Lemmas, in both models, are supposed to store only syntactic information whereas meaning is stored in the semantic memory as memory traces and does not take part in the selection process per se. If lexical selection is accomplished by mapping the meaning specifications of a concept onto the meaning specifications of its corresponding lemma, there is no other way than to assume that lemmas contain semantic information as well. The approach to lexical selection proposed by Kormos, contrary to that of Levelt et al., does not seem to prevent the convergence problem from arising if one assumes that the conceptual message is not detailed enough to lead to the selection of the right lemmas from the mental lexicon. Language selection theories and their predictions regarding bilingual lexical access and retrieval are reviewed in the next section.

2.4 Language selection: implications for bilingual lexical processing and control

One of the most discussed issues in bilingual lexical access is how language for production is selected and when in the speaking process it takes place (Kroll, Bobb and Wodniecka, 2006). There are two views on how language for production is selected. The first one holds that language selection is determined by the structure and functioning of the lexicon itself. That is, words in the lexicon are cued for language. Such cues direct a greater amount of activation to the set of words belonging to the language a speaker wants to communicate in. Competition for selection, under this view, is taken as a consequence of activation spreading along the lexical network and is more likely to occur within the target language rather than across languages.

The second view, conversely, holds that language selection is determined and modulated by a control mechanism that directs attention to the target language as well as inhibits the activation of the non-target language. On this view, the language cue does not suffice to prevent activation of competitors in the non-target language. It serves only to identify the set of words, or candidates, for selection.

Language selection, according to Kroll et al. (2006) can occur at four different stages of the speech production process: (i) at the conceptual level; (ii) at the lemma level; (iii) at the phonological level; and (iv) beyond the phonological level. Language selection at the conceptual level involves assuming that the L2 feature [+L2] is part of the conceptual specification of the L2 lexical item. In this case, the language cue specifies in which language speech will be further processed – L1 or L2. As pointed out by La Heij (2005), the assumption that language is part of the pre-verbal message had already been postulated by Levelt (1989) in his blueprint for the speaker.

Support for language selection at the lemma level comes from a study by Hermans, Bongaerts, de Bot and Schereuder (1998), who replicated the semantic inhibition effect at short SOA's found in monolingual studies of lexical access (Glaser and Düngelhoff, 1984; Schriefers, Meyer and Levelt, 1990; Levelt, Schriefers, Vorberg, Meyer, Pechmann and Havinga, 1991a, 1991b) by examining picture naming in L2 under the interference of spoken distractor words. The semantic inhibition effect manifests itself through longer response times when the name of the picture and the distractor word are semantically related, thus reflecting lexical competition. Inhibition is mostly observed when the distractor is presented at early SOA (usually from 100 ms to 0 ms in relation to picture onset) and is explained as to occurring due to the connection between the target word and the distractor word in the lexical network, which leads to the activation of both lemma nodes thus, increasing response times in relation to unrelated distractor words.

Language selection at the phonological level is supported by Colomé (2001). In this particular study, participants were required to confirm whether the phoneme presented with a drawing was part of the name of the depicted picture. Overall results indicated slower response times when the phonemes belonged to the translations of either Catalan or Spanish words than when the phonemes did not belong to any picture name from the two languages. As explained by the researcher, these results may be a consequence of a common activation of concepts which, in turn, spread activation to L1 and L2 lemmas of the depicted pictures, producing an inhibitory effect.

Additional evidence supporting the notion that the two languages of a bilingual are activated in parallel and that selection can take place at the level of phonological encoding comes from Costa, Caramazza and Sebastián-Gallés (2000). In their study, participants were asked to name pictures paired with cognate words as distractors. A cognate was the translation of the target word and should be phonologically and orthographically similar in L1 and L2. Results indicated that speakers produced faster response times when naming a picture in L1 paired with an L2 cognate in relation to L1 pictures paired with non-cognate words. This facilitation effect occurred, as explained by the researchers, because the picture's name was highly activated due to the fact that all or at least part of the phonemes of the distractor word (cognate) in L2 were constituent parts of the target lexical item in L1.

A study conducted by Kroll, Dijkstra, Janssen and Schriefers (2000) suggests that the locus of language selection, in some circumstances, can be placed beyond the phonological level. Their findings indicated that the phonology of an L2 word activates the phonology of its L1 alternative which, in turn, sends activation backward to its respective lemma, producing then competition at the lemma level.

According to Kroll, Bobb and Wodniecka (2006), lexical access is a fully interactive process, allowing for the activation to flow forward and backward, from lemma to lexemes and vice-versa. As argued by these theorists, there are five factors determining how far in the process the speech production system is open to cross-language influence: (i) proficiency level, (ii) language dominance, (iii) task demands, (iv) the degree of activation of the non-target language and, (v) how well concepts define specific words in a particular language. Given that factors one, two, and four bear a direct relationship with the subject matter being investigated in the present study, a further look into them seems necessary.

Regarding language dominance and L2 proficiency, it seems obvious that because the L1 is usually the dominant language and the L2 is frequently less practiced and less active than the L1, the connections between L2 words and their conceptual specification are likely to be weaker than L1 connections. Therefore, lexical selection in L2 is supposedly slower and the process is more vulnerable to interference and competition than the same process in L1. The magnitude of the interference effect is larger for less proficient bilinguals who presumably possess a smaller repertoire of L2 words which, in turn, are weakly mapped into their conceptual specifications.

As explained by Costa and Santesteban (2004), “for bilinguals who acquire the two languages early in life, there is some evidence to suggest that they have acquired not only the languages themselves but also the attentional skills that allow them to more effectively select the intended language relative to unbalanced bilinguals” (p. 128). On this view, as proficiency in L2 increases, so does automaticity in language use, thus reducing cognitive demands, leading to a more efficient performance.

According to information processing models (McLaughlin, Rossman and McLeod, 1983; Hulstijn and Hulstijn, 1984), L2 learning involves the development of a cognitive skill that requires practice and attentional resources to develop (McLaughlin and Heredia, 1996). One of the best known theories of skill acquisition is the ACT* model proposed by Anderson (1983). The model assumes that skill acquisition and development involve the proceduralization of initially declarative knowledge, which is said to be explicitly stored and used in the first learning phases. In Anderson’s view, a skill is fully acquired when the rules for its execution are compiled, becoming thus implicit, automatic and used effortlessly. As pointed out by Segalowitz (2003), “automaticity, then, describes an end point in the acquisition of skill in this model” (p. 395). With that in mind, it seems feasible to argue that more proficient bilinguals may have reached a further stage in skill acquisition than less proficient ones and, as a result, might have developed more automatic procedures and a greater amount of implicit knowledge of the language. In other words, it might be that due to lack of automaticity in early stages of L2 acquisition, less proficient bilinguals need to rely on mechanisms of control to inhibit the influence of the non-target language (mostly L1 when speaking in L2). These mechanisms would correspond to the allocation of controlled attention to suppress irrelevant but activated information. More proficient bilinguals, on the other hand, may shift from the intense reliance on attentional resources to the use of more implicit, proceduralized knowledge. As acknowledged by Segalowitz and Hulstijn (2005), "it seems likely that language production, as an example of a complex cognitive skill, will be performed differently as bilinguals become more proficient in the L2" (p. 128).

The extent to which both languages are activated can also modulate cross-language influence and consequently, language selection and lexical retrieval. As explained by Kroll et al. (2006), language activation may be determined by (i) the context in which speech is to be produced, and/or (ii) by the availability of individuals' cognitive resources. It has been proposed that speakers seem to operate on a continuum between two poles – a monolingual and a bilingual one (Grosjean, 1998) which may vary depending on the contextual demands in the communicative environment, such as the language or languages the interlocutor is able to understand, who the interlocutor is, and the purpose for producing speech in one language or the other. The choice of the language mode will, consequently, determine the level of activation of each language of a bilingual speaker.

Alternatively, Kroll and colleagues have proposed that bilinguals with a greater amount of cognitive resources available are better able to selectively attend to one language only when producing speech. Because processing L2 (usually the weaker language of a bilingual speaker) is assumed to tax cognitive resources to a greater extent, it is reasonable to suggest that lexical access for bilinguals with fewer resources will probably be more vulnerable to cross-language influence.

The amount of cognitive resources needed to avoid cross- and within-language influence, as argued by Kroll and colleagues, depends on how well the connections between concepts and lexical items in L2 are developed. In other words, the weaker the connections, the more controlled attention is needed to select the appropriate lexical item. On this view, connections between lexical items and their conceptual specifications develop as a function of proficiency. Therefore, more proficient bilinguals are likely to have stronger connections and, as a consequence, to need less attentional/cognitive capacity to selectively access the appropriate word.

A distinct proposal regarding the use of attentional resources to lexical selection is the one offered by Green (1998). In his Inhibitory Control Model, Green assumes that inhibition is necessary to suppress the activation of lexical items in the non-target language as well as related items within the intended language. The amount of activation needed to suppress inappropriate items is relative to the level of activation of other activated items and to the level of proficiency of the bilingual speaker. According to Green, the L2 requires less inhibition than the L1 because it is often the less practiced language thus, weaker in relation to the L1. Contrary to Kroll and colleagues, Green assumes that as proficiency in L2 increases and the language becomes more practiced and stronger, it also becomes more difficult to inhibit it, thus more attentional resources are needed to selectively suppress lexical items of that language when speaking in L1. With that in mind, it is reasonable to suggest that, for within-language competition, more proficient bilinguals will need more attention to inhibit related L2 lexical items which are simultaneously activated, for the L2 has been developed to a greater extent relative to less proficient bilinguals.

The proposal that language selection and, consequently, lexical retrieval, is controlled by inhibitory mechanisms that suppress the activation of the non-target language (Green, 1998) was challenged by Roelofs (1998). As advocated by him, lemmas in a bilingual mental lexicon are cued for language and selected according to production-rules that refer to both the wanted and unwanted languages. Following Anderson's (1983) ACT* model of skill acquisition, Roelofs porposes that the word-production system in bilinguals would contain production rules of the kind: "<IF the concept is HOUSE (X) and the language is French, THEN select "maison">" (Roelofs, 1998, p. 95). In addition, the production-rule mechanism could explain the fact that bilinguals are able to keep L1 and L2 separate in monolingual conversations, but still use them interchangeably if they want to and with a great retrieval speed. This is only possible, as claimed by Roelofs, because bilingual speakers do not need to inhibit one language in order to verbalize the other. Lemmas for both languages may be kept active, thus allowing for parallel retrieval.

Because bilingual speakers, especially less proficient ones, lack automaticity in L2, it seems reasonable to suggest that the production rules for L2 lexical retrieval proposed by Roelofs would be stored in the form of declarative knowledge in the declarative memory for L2 rules proposed by Kormos (1996) in her bilingual speech production model. With increased practice these rules would become automatized and could then be stored as procedural knowledge as part of the encoding system, just as postulated by monolingual speech production models (Levelt, 1989; Levelt et al., 1999). The use of procedural knowledge of L2 rules would withdraw attention from rule-based processing, allowing bilingual speakers to produce speech somewhat fluently.

Although Roelofs' (1998) theory of bilingual lexical access has not been put to test, support for Green's IC model comes from studies investigating language switching in speech production. Costa and Santesteban (2004) aimed at testing whether lexical access in one of the languages of a bilingual speaker was achieved by the implementation of inhibitory mechanisms and how theses mechanisms would operate on different levels of L2 proficiency. The authors depart from the assumption that bilingual lexical access entails inhibitory control. Inhibition of the unintended language depends on the level of proficiency of that language and on the level of activation of the target language (Green, 1998). As hypothesized by Costa and Santesteban, in highly proficient bilinguals, L1 and L2 status will be similar and therefore will require similar amounts of inhibition in tasks requiring language switching. In this case, the asymmetrical costs of naming in language X compared to naming in language Y, which are usually seen when switching from L2 to L1 (Meuter and Allport, 1999), will approach no significant difference. For less proficient bilinguals, on the other hand, it was hypothesized that the magnitude of the switching cost would be greater from L2 to L1, for the L2, the less proficient language, requires less inhibition than the L1, the more proficient language. Therefore, the inhibition of the L1 is slower and more difficult to be overcome.

Overall results of Costa and Santesteban's picture naming tasks requiring language switching indicated that "…the degree to which lexical selection in bilingual speakers entails inhibitory control depends on whether they have achieved a high proficiency level in any pair of languages" (p. 506). In other words, it seems that for non comparable proficiency levels, inhibitory control mechanisms are necessary to ensure the selection of the lexical representations in the target language. Increase in L2 proficiency, then, leads to a shift from the reliance on inhibitory control to the reliance on a language-specific selection mechanism (Costa and Santesteban, 2004).

The proficiency hypothesis (as herein named Costa and Santesteban's proposal) is not fully supported by Costa, Santesteban and Ivanova (2006). In one of their experiments, they explored language switching costs for highly proficient bilinguals switching between their two weaker languages – L3 and L4. The objective was to check whether the symmetrical switching costs previously found for highly proficient bilinguals switching between a stronger and a weaker language would hold for switching between two weak languages. If highly proficient bilinguals do make use of different control mechanisms, then no asymmetrical cost should be observed in the latter condition in which proficiency levels were hypothesized to be similar. Results did not support the predictions since highly proficient bilinguals took four times longer to switch from L4 to L3 than the opposite.

A further experiment of Costa et al. (2006) also explored language switching performance of a group of L2 learners versus a group of highly proficient bilinguals in a task involving recently learned words in a different language and L1. The predictions were that if highly proficient bilinguals resort to a control mechanism that does not require inhibition such as the one used by L2 learners (less proficient bilinguals), then no asymmetrical cost should be observed in their performance. The opposite pattern was, conversely, expected for less proficient bilinguals.

Results showed the existence of asymmetrical switching costs for both proficiency groups, indicating that at the very initial stages of acquisition both less and more proficient bilinguals take longer to overcome the inhibition of their stronger, more dominant language. This finding challenges the hypothesis put forward by Costa and Santesteban (2004) that bilinguals seem to shift from inhibitory to language specific control mechanisms as proficiency in their less dominant language increases. What the patterns of results arising from this experiment seem to suggest is that highly proficient bilinguals sometimes make use of language specific lexical selection mechanisms to ensure production in the intended language. Such a shift leads to variations in switching costs.

Costa et al. concluded that language specific mechanisms can only operate on lexical representations that effectively form an integrated lexicon whose connections are strongly and well established to enable availability for selection, which seems to be the case for the stronger and more dominant language of a bilingual. That is, the more well established the lexical representations in the weaker language, the easier it is for language specific selection mechanisms to operate, thus leading to symmetrical switching costs. In a task involving a bilingual's weaker language, on the other hand, selection of lexical items in the intended language is guaranteed by inhibitory mechanisms that suppress activation of lexical representations in the more dominant and stronger language, regardless of whether these representations are well established in the weaker and less dominant language.

Taken together, the studies reviewed in this section have shown that there are costs involved in activating, maintaining activation, and retrieving words in the target language under the competition of other target-related and non-target related items. The magnitude of such costs seems to be mediated by the availability and use of WM attentional resources in the control, selection and inhibition of undesired lexical alternatives. The next chapter presents the approach to individual differences in WMC adopted in the present study as well as reviews empirical work on the relevance of controlled attention to retrieval in general and more specifically to bilingual lexical retrieval.

CHAPTER 3

REVIEW OF LITERATURE ON WORKING MEMORY

The literature review on lexical access (Chapter 2) has shown that the exercise of "popping in" and "popping out" one language at a time constitutes one of the main abilities of a bilingual speaker. Equally important seems to be the ability to selectively attend to appropriate information in order to retrieve the correct words under the competition of related items. Language selection, as proposed by Kroll, Bobb and Wodniecka (2006), can be determined by the availability of bilingual speakers' attentional resources. In this sense, the focus of this chapter is to highlight the role of working memory (WM), more specifically, of controlled attention in accessing and retrieving lexical representations in the intended language.

This chapter is divided into two main sections. In the first section, the framework adopted in the present study to explain individual differences in working memory capacity (WMC) is reviewed. This section also reviews studies addressing the relationship between WMC and retrieval from long-term memory as well as the relationship between WMC and language processing. Next, in the same section, empirical evidence supporting the relationship between WMC, bilingual lexical access, and L2 proficiency is highlighted. Finally, in the second section, a pilot study which served as the departure point for the present investigation is described.

3.1 Working Memory: limitations on its capacity

Since the earliest accounts of information processing (Atkinson and Shiffrin, 1968), there seems to be a consensus among cognitive psychologists that processing and maintenance of information in service of higher order cognition entails the use of limited capacity resources. These computation and storage processes are assumed by most cognitive researchers to be the basic executive functions of Working Memory (Baddeley and Hitch, 1974; Daneman and Carpenter, 1980; Turner and Engle; 1989; Daneman 1991; Engle, Cantor and Carullo, 1992; Cowan, 1995, among others). When procedures for executing a certain task are not fully automatized, working memory resources are needed to selectively direct attention to those aspects of the task that need controlled processing to be executed. On this view, working memory limitations refer to limitations in the ability to control attention in order to focus on information which is relevant to the execution of the task by ignoring irrelevant stimuli. This view has been consistently supported by Engle and his colleagues (Turner and Engle, 1989; Conway and Engle, 1996; Kane, Beckley, Conway and Engle, 2001; Engle, 2002), who were the first to demonstrate that WMC differences could not be exclusively due to processing efficiency, as initially proposed by the proponents of the Processing-Efficiency view of WM (Daneman and Carpenter, 1980; Daneman and Green, 1986; Daneman, 1991). Turner and Engle (1989) showed that the statistical correlations between WM and measures of reading comprehension in Daneman and Carpenter's (1980) study were sustained even when the processing component of the task (reading) was changed. Different from the Reading Span Test and the Speaking Span Test, the Operation Span test devised by the researchers was not task specific in the sense that its processing component required the resolution of arithmetic problems instead of sentence reading and oral sentence production as in the former tests, respectively.

Ever since then, Engle and colleagues have proposed that WMC is not related to the processing efficiency capacity in a particular cognitive task but rather represents a more general ability to process information. In other words, capacity refers to individuals' ability to bring pieces of information from long-term memory into an active state and temporarily maintain that information for further processing by preventing other irrelevant stimuli to enter the focus of attention. This ability is, as explained by Engle (2001), essential for the performance of attention-demanding cognitive tasks which require the same processes: activation of relevant information, momentary maintenance of that information and blocking of interference. All of that is assumed to be possible only by means of controlled attention. Therefore, according to Engle,

> WM capacity is […] about limitations in the ability to use controlled processing to maintain information in an active, quickly retrievable state. […] WM capacity is not about storage and processing but is about retention over a period in which there is distraction or shift of attention away from the stored information. The need for this quick accessibility is particular salient when there is interference from competing information. WM capacity is not directly about memory – it is about attention. WM capacity is about memory only indirectly. WM capacity is about attention in the service of memory. Greater WM capacity means that more items can be maintained in the focus of attention, but it also means that information can more effectively be blocked from the focus of attention. (p. 301-2)

The controlled attention view of WMC was adopted in the present study because it is closely related to the cognitive task being investigated, namely lexical access. In the present study, lexical access involves naming a picture in the face of interference. To be able to execute this task efficiently, L2 speakers need to block interference in order to keep the main objective of the task active in WM and thus, retrieve the lexical items from long-term memory quickly and accurately. Being able to suppress interfering stimuli is essential to perform the picture-naming task and it is also one of the processes performed by WM.

Following Rosen and Engle's (1997; 1998) model of retrieval, I propose that bilingual lexical access, as operationalized by a picture-naming task, proceeds as follows: first, there is the automatic spreading of activation triggered by the picture or by the distractor word. Then there is self-monitoring so as to guarantee that the incorrect picture name will not be selected. Third, suppression is needed in order to avoid interference of distractors. Finally, a controlled/strategic search is performed so as to retrieve the appropriate/correct picture name. From all these processes, Rosen and Engle claim that only spreading activation runs freely, whereas the other three (monitoring, suppression and strategic search) depend on one's controlled attention capacity, in other words, WMC.

If it is the case that accessing L2 words qualifies as a controlled serial search carried out under the limitations of WM, a better understanding of the role of WM in retrieval may be informative. The next subsection reviews evidence suggesting that efficient retrieval is an important component of WMC differentiating between lower and higher WMC individuals.

3.1.1 Working Memory Capacity and Retrieval

Very frequently adult bilinguals have been put into disadvantage in relation to their monolingual counterparts with respect to language processing. The literature on bilingualism, especially on bilingual lexical access, has gathered plenty of evidence to support the claim that later L2 learners face great difficulty in tasks that require semantic processing of lexical representations in the weaker language (L2) (Michael and Gollan, 2005). This difficulty is apparently modulated by the degree to which word retrieval is automatized.

According to Levelt, lexical access in monolinguals is a highly automatic process which does not require controlled attention to be executed. However, as mentioned before, because the L2 is usually the less dominant and less practiced language, retrieving words in this language involves dealing with weaker connections between words and concepts, semantic competition due to overlap in meaning, as well as procedures which operate on explicit L2 knowledge, especially in initial L2 learning stages (Kormos, 2006). With that in mind, I propose that bilingual lexical access constitutes a controlled serial strategic search susceptible to individual differences in working memory capacity. The studies reviewed in this subsection contribute to strengthen this claim.

Conway and Engle (1994) set out to investigate the role of WM in retrieval. Based on previous evidence that high- and low-span subjects differed in a fact-retrieval task (Cantor and Engle, 1993), Conway and Engle hypothesized that individual differences in WMC might affect the retrieval of information from what they called primary and secondary memory in different ways. Primary memory (PM) was assumed to be the storage of information in an active state, that is, working memory. Secondary memory (SM) was taken as the repository of information stored for a longer period of time, that is, long-term memory.

A series of experiments using speeded search and verification tasks was carried out with 20 high-span subjects and 20 low-span subjects as determined by their scores on the OSpan. Subjects were submitted to a learning phase and a verification phase. In the learning phase, subjects were required to memorize 4 or 6 sets containing from 2 to 12 letters or words. During verification, two procedures were adopted: either the letter/word was preceded by the presentation of a number indicating the set in which it appeared during the learning phase, or it was displayed together with the set number.

Whereas the first procedure was meant to measure primary memory search, the second ensured that information was inactive in second memory until both set number and probe were presented.

Experiments 1 and 2, designed to allow for interference effects due to the overlap in set membership, showed that high-span subjects differed from low-span subjects in retrieval from primary memory but not from secondary memory, as measured by RT scores. Experiments 3 and 4 were designed so as to avoid interference effects. That is, a letter/word could be the target in only one specific set. Results of experiment 3 replicated previous results showing that high- and low-span subjects did not differ in retrieval from secondary memory. However, the same experiment revealed that in the absence of interference, high- and low-spans performed similarly. Experiment 4, which aimed at replicating these findings with word rather than letter retrieval, also showed that high- and low-spans' RTs were not statistically different, suggesting that their performance was similar when retrieving items from primary memory without having to deal with response competition.

Taken together, the experiments conducted by Conway and Engle support the idea that when retrieval from primary active memory involves handling response competition, individual differences in the ability to suppress misleading information will account for better task performance. In other words, subjects with greater WMC are better able than those with less capacity to execute a set search that requires attentional and inhibitory resources. Set searching in secondary memory, on the other hand, was taken as an automatic process since the time taken to bring the relevant information to an active state in primary memory did not vary as a function of individual differences in the ability to inhibit the activation of the wrong set. Clearly, the role of WM in retrieval proposed by the researchers is only prominent when competition and conflict need to be resolved.

Rosen and Engle (1997) further addressed the role of individual differences in WMC in retrieval. The basic assumption underlying their study follows Moscovitch's idea (1995, in Rosen and Engle, 1997) that retrieval can occur either through associative or strategic processes. In associative retrieval, the presentation of a cue automatically leads to the retrieval of the target information. In strategic retrieval, on the other hand, the cue functions as a clue to where controlled search should start from. In other words, strategic retrieval implies that attention is necessary to delimit the search set appropriately. Consequently, WMC, which is supposedly unimportant to automatic retrieval, seems to play a salient role in strategic retrieval.

Most important to the present study is that picture naming in L2 seems to entail strategic procedures. When a picture is displayed, activation spreads along the lexical-semantic network and subjects associate the picture with its concept, either through L1 mediation or directly through L2 conceptual links. Once the concept is activated, a search for the correct word is initiated. This search is potentialized when the semantically-related word distractor is presented. Because the L2 lexical network is likely to be less intricate in relation to the L1 network, any item that shares common characteristics with the target will probably facilitate retrieval.

Rosen and Engle's main objective was to examine the importance of WMC to strategic retrieval. The set of experiments was designed basically to test whether high- and low-spans differed in the number of category exemplars they were able to retrieve while avoiding repetitions in load and no-load conditions. In a no-load condition, higher-span subjects generated more category exemplars than lower-spans. In contrast, under cognitive load, only higher-spans reduced the number of names retrieved. Lower-spans were unaffected by the concurrent digit-tracking task. The researchers suggested that because lower-spans did not have sufficient attentional resources to avoid repetitions, to generate cues to retrieving new names and to track digits simultaneously, they were unable to inhibit previous responses thus retrieving items more automatically than higher-spans. Higher-spans, on the other hand, experienced a reduction in the number of exemplars retrieved due to their greater ability to monitor for repetitions and search for new names at the same time, leading them to retrieve items in a more controlled fashion.

The explanation provided by Rosen and Engle for their findings seems to imply that the ability to suppress proactive interference is not the only one necessary to guarantee efficient retrieval from secondary memory. It seems that generating cues to delimit the response set and guide the search is also an important controlled attention task to be performed if retrieval is to be accomplished successfully. This claim has been further supported by Rosen and Engle (1998). Through a series of paired-associate tasks, the researchers demonstrated that lower WMC subjects had problems generating internal cues to guide the search for the correct item in secondary memory in relation to higher WMC subjects. Lower spans were both slower and less accurate during recall of items that were previously learned with a different pair-associate because they could not block intrusions from previous items.

In a more recent study, Unsworth and Engle (2007) demonstrated that retrieval of information from secondary memory, that is, from information outside the focus of attention (WM) , stored in long-term memory , is governed by a discrimination process that involves the use of adequate contextual cues and controlled attention. Those contextual cues can be set by the task context and/or internally generated by the speaker and determine what information is relevant for the retrieval process and what must be displaced. Success in retrieval, then, as proposed by Unsworth and Engle (2007), depends on individuals' ability to use contextual cues effectively to delimit the search set. That is to say, the greater the number of items activated by the contextual cues and consequently included in the search set, the lower the probability that retrieval will occur fast and accurately.

Extending Unsworth and Engle's ideas to a bilingual context, retrieving L2 words from secondary memory is likely to function in basically the same way as in L1. However, an observation must be made. Because lexical retrieval procedures are not fully automatized in L2, any semantically-related cue presented close to the retrieval period is likely to help bilinguals to execute the serial search for the appropriate word, facilitating performance. In other words, semantically-related lexical items tend to belong to the same lexical semantic field and thus may serve as cues to delimit the search set adequately. Once the search set is efficiently delimited, sampling and retrieval become easier. Without such cues, more non-target items are possibly included in the search set and a more extensive search is need. The extent of such a controlled search is likely to be related to the quantity and quality of L2 knowledge one possess. Less proficient bilinguals, on the one hand, may have to perform the search more extensively, looking for items either in their less complete L2 mental lexicon or possibly in their L1 lexicon, which would probably be more time-consuming, increasing their reaction times and chances for error. The opposite is likely to be the case for more advanced bilinguals.

In Unsworth and Engle's proposal for retrieval from secondary memory, after the search set is delimited, a serial sample for the correct item is initiated. Once an item is sampled, a decision/monitoring process is responsible for checking whether the item is the target one to be retrieved. Again, in L2 lexical retrieval, a search for the correct item is even more likely to occur serially, since retrieval procedures operate under controlled processing. Another assumption regarding bilingual retrieval is that decision/monitoring processes may be a function of L2 proficiency. That is, because less proficient bilinguals tend to have a smaller repertoire of L2 lexical items stored in secondary memory and most of them might lack strong conceptual representations, it seems plausible to suggest that less proficient bilinguals will face greater difficulty to decide whether the selected item is indeed the more adequate one to be retrieved. More proficient bilinguals, on the other hand, know more L2 words for which conceptual connections are well established and therefore will probably monitor for mismatches more easily.

The studies reviewed in this section indicate a strong link between WM and retrieval. What seems to sustain this link are the processes assumed to be involved in determining individual differences in WMC - active maintenance of relevant information and controlled serial search (and decision/monitoring process, in the case of L2 lexical retrieval), both made possible through the allocation of attention. The next subsection highlights the effects of individual differences in WMC on L2 speech production.

3.1.2 Working Memory Capacity and L2 speech processing

Research following Daneman and Green (1986) and Daneman (1991) shows that WM plays a significant role in the production of speech in L1. One of the major reasons WMC as a construct has been the core interest of many researchers in L2 language learning is the fact that it has been shown that measures of WMC correlate significantly with measures of higher order cognitive tasks performed in L2: the production of fluent, complex, accurate and lexically dense speech (Fortkamp, 1999;

Fortkamp, 2000; Finardi and Prebianca, 2006; Xhafaj, 2006; Fontanini et al., 2005); vocabulary acquisition (Mendonça, 2003); speech development (Weissheimer, 2007), and grammar acquisition (Finardi, 2009).

Of special interest for the present investigation are Fortkamp's (2000) and Weissheimer's (2007) studies. Fortkamp investigated the relationship between WMC aspects of L2 speech production such as fluency, grammatical accuracy and complexity, and lexical density. Results showed that higher-spans were more fluent, accurate and grammatically complex in both a picture description and a narrative task relative to lower-spans. However, against predictions, higher-spans produced less lexically dense L2 speech than lower-spans in both speaking tasks, thus indicating a negative correlation between WMC and lexical density. In order to explain her results, Fortkamp assumed that the relationship between fluency, accuracy, complexity, lexical density and WMC reflected the cognitive processes that occurred during grammatical enconding (to follow Levelt's (1989) terminology). According to the researcher, grammatical encoding in L2 qualifies as a controlled processing activity which requires controlled attention to bring information into an active state, temporarily maintain such activation, inhibit irrelevant stimuli and monitor for errors (Engle and Oransky, 1999). The contribution of Fortkamp's study to the present investigation lies in the fact that she was able to show that only individuals who had a larger WMC (more controlled attention resources) could manage the cognitively demanding sub-processes involved in L2 speaking. In other words, she was able to show which processes were important in the relationship between L2 speech production and WMC. More important, it is worth noting that it is at the grammatical encoding level, the one Fortkamp considered a controlled processing activity, that lexical choices are made and words are retrieved.

Weissheimer (2007) set out to investigate whether lower and higher span individuals would experience any kind of improvement on WM scores as a function of L2 speech development. Intermediate English learners performed the L2 speaking span tests in the two phases of the experiment. Results showed that only lower span individuals improved WM scores from one phase to the other. Weissheimer concluded that this might be attributed to the fact that higher spans were already more efficient in the SST from the start thus having little room for improvement. Lower spans, on the contrary, might have improved their WM scores due to their improvement on L2 speech proficiency between experimental phases. In fact, results showed that both lower and higher spans tended to experience gains in the L2 speech measures investigated, namely speech rate, accuracy, complexity and weighted lexical density. Taken together, these results suggest that the improvement on WM scores may not be related to L2 proficiency only, since higher and lower spans improved on speech production measures, but only lower spans had their WMC affected by that. The researcher then suggested that future studies should assess individuals' WMC at several moments during the course of L2 acquisition/learning so as to verify to what extent WM scores vary as a function of L2 proficiency. As advanced by several researchers (Harrington, 1992; Harrington and Sawyer, 1992; Berquist, 1998), L2 proficiency might be the key factor determining the low correlations between L1 and L2 working memory scores, suggesting that, whereas the former may refer to a biological endowment, the latter may be related to the amount of knowledge of the language one possesses. To scrutinize the relationship between WMC in L1 and in L2 and to examine the effects of L2 proficiency on WM scores variation are the secondary goals of the current study.

In this subsection, it has been shown that individual differences in WMC are important factors impacting upon L2 speech performance. Given that performance can be taken as a mirror reflecting the results of under surface ongoing mental processes, it seems fair to ask how individual differences in WMC affect the core process of speech production, namely lexical access. In the next subsection, some recent work addressing the role of WMC in L2 lexical access and retrieval is reviewed.

3.1.3 Working Memory Capacity and L2 lexical access

The body of research regarding bilingual lexical access and working memory capacity reviewed so far clearly suggests that accessing and retrieving words in an L2 under competition of related lexical representations in the language in use is an attention-demanding cognitive task subject to individual differences in goal maintenance and inhibition of distracting information. Furthermore, the Inhibitory Control model proposed by Green (1998) and the Revised Hierarchical Model put forward by Kroll and Stewart (1984) provide insightful frameworks to understand the relationship between bilingual lexical access, working memory capacity and L2 proficiency level. Studies investigating this relationship have been most interested in tasks such as word reading, word translation and picture naming tasks that require both L1 and L2 or at least L2 to be active during performance.

Kroll, Michael, Tokowicz and Dufour (2002) examined lexical access in L1 and L2 through word reading (naming) and word translation across proficiency levels. Whereas word naming involved primarily lexical- (word) level processing; word translation involved access to meaning (according to Levelt, 1989; lexical selection is meaning driven). Regarding the word naming task, experiment 1 showed that more proficient bilinguals named words faster and more accurately than less proficient ones. Surprisingly, less fluent bilinguals were also slower and less accurate when naming words in their L1. The reasons for that, as explained by Kroll et al. (2002), might be individual differences in WMC and the restructuring of lexical representations and control structures due to the influence of L2 over the L1.

Overall results of the translation task showed that more proficient bilinguals translated words faster and more accurately than less proficient ones. Both proficiency groups performed faster when translating from L2 to L1 (backward) than from L1 to L2 (forward). However, the largest effect for proficiency was when translating words required conceptual processing, that is, from L1 to L2, as predicted by the RHM. Translation was also more accurate when translating from L2 to L1 than from L1 to L2.

In experiment 2, Kroll et al. used a different pool of subjects and included Waters and Caplan's (1996) Reading Span Test (RST) as a measure of WMC. Subjects were classified into less and more proficient bilinguals according to a lexical decision task in L2. Results of the word naming task showed that more proficient bilinguals named words faster than less proficient ones both in L1 and in L2, mirroring results of experiment 1. Reading words in both languages did not differ for more proficient bilinguals. More proficient bilinguals named words more accurately than less proficient ones and, as expected, less proficient bilinguals were more accurate when naming words in L1 than in L2.

As regards the translation task, more proficient bilinguals translated words faster than less proficient ones. Both proficiency groups translated words faster from L2 to L1 than from L1 to L2. More proficient bilinguals were more accurate in the translation task overall, but no main effect for translation direction and no interaction between proficiency by translation direction were found.

The RST used in experiment 2 aimed at investigating why less proficient bilinguals were slower when naming words in L1 in comparison to more proficient bilinguals. Results of the RST showed that, although the test was performed in L1, more proficient bilinguals obtained higher WMC scores than less proficient ones. This result was further corroborated by Prebianca (2007).

Further analyses were carried out in order to examine the effects of WMC on word naming and word translation. Subjects were divided into two groups composed of lower and higher spans, according to their scores on RST. Whereas within the lower span group no reaction time differences were found between more and less proficient bilinguals for word naming; within the higher span group, less proficient bilinguals were significantly slower than more proficient ones. Kroll et al. concluded that differences in WMC do not account for the patterns of word naming found in L1 regarding differences in proficiency level. To explain this unexpected result, Kroll et al. suggested that learning an L2 affects L1 processing due to changes it may cause in lexical representations as new information is learned.

As for the translation task, data analysis including WMC scores was carried out only with less proficient bilinguals since there were not enough subjects at each span level in the more proficient group. Within the less proficient group then, higher spans were slower to translate cognate words from L1to L2 and also from L2 to L1, but were faster to translate non-cognate words in both directions in comparison to lower spans. In sum, higher span less proficient bilinguals tended to allocate their attentional resources to process information at the conceptual rather than at the word level, even at some kind of processing cost.

Finally, Kroll et al., in line with studies on bilingualism (Bialystok, 2005), suggest that "bilingualism may confer cognitive benefits to language processing" (p. 164), and "less proficient bilinguals may rely on external cues to language processing" (p. 164). Fluent bilinguals, on the other hand, may have automatized (developed more control over) procedures to process lexical representations – a characteristic that seems to be missing for bilinguals at lower levels of proficiency. Increased L2 proficiency then seems to contribute to quantitative and qualitative lexical improvement in bilinguals.

The idea that a lifetime of bilingualism may contribute to the ability to deal with interfering and misleading information in task performance has been supported by a number of studies investigating the cognitive development of bilingual children. Although these studies have been carried out with children performing non-linguistic tasks, overall results have shown that bilinguals demonstrated an advantage when the tasks required selective attention and suppression of irrelevant information. The ability to prevent misleading information from interfering with what needs to be focused attention on develops and matures during childhood. Children who grow up in a bilingual environment need to constantly suppress mental representations of the language not in use and thus are supposedly better able to channel attention to what is relevant by ignoring what is not (Bialystok, 2005).

If this is really the case, it seems plausible to suggest that more proficient bilinguals are more able than less proficient ones to perform tasks that require attention to be driven away from distracting information. Keeping in mind that accessing words in an L2 is a process that involves fighting off competition from semantically related words, it is likely that being a bilingual in a relatively more advanced stage may contribute to a better performance on this task. Likewise, working memory span tests such as the SST and the OSpan require individuals to block interference from stimuli that accumulates across set and trials of the tests so as to maintain the to-be-remembered words active in memory for further recall. Extended bilingual experience may render this exercise an easier one.

Tokowicz, Michael and Kroll (2004) investigated the effects of study-abroad experience (SAE) and working-memory capacity (WMC) on the types of errors made by bilinguals during word translation from L1 to L2. Two error types were examined: non-response and meaning errors. WMC was measured by the OSpan (Turner and Engle, 1989).

The rationale underlying their study was that more SAE leads to a greater desire to communicate in L2. Because of that, when the intended lexical items are not known or unavailable for communication, bilinguals with SAE tend to use semantically related words to verbalize their messages. Moreover, it was also hypothesized that bilinguals with more SAE and higher WMC would have a greater knowledge of the L2, know more words, and as a result, be more accurate relative to bilinguals without SAE and lower WMC. Higher spans would also produce more meaning errors than non-response errors. The rationale underlying this assumption was that meaning errors would require the stimulus to be maintained in WM while related words are activated. Maintaining relevant information active in WM requires a more efficient allocation of attentional resources, for the related concept/word must be activated to a greater extent than the concept/word activated by the stimulus.

Tokowicz et al. found a trend indicating that individuals with more SAE were more accurate than those with less SAE, and individuals with higher WMC were more accurate than those with lower WMC. In addition, only higher spans and individuals with more SAE made as many meaning errors as non-response errors when translating from L1 to L2.

Christoffels, de Groot and Kroll (2006) examined whether bilinguals with different proficiency levels and higher WMC were better able to control the activation of L2 by inhibiting the unintended activation of the L1 when producing L2 speech. Three groups of bilinguals were compared – (1) university students who were classified as less proficient bilinguals; (2) English teachers who were highly proficient in their L2, and (3) simultaneous interpreters who were also highly proficient L2 speakers. Subjects' L1 was Dutch and their L2 was English. WMC was measured by the RST, the SST and the Word Span. Lexical retrieval tasks were picture naming and word translation. Both memory and lexical tasks were carried out in L1 and in L2.

The reasoning behind the study was that simultaneous interpreting is a complex cognitive task which involves comprehending input in one language and producing output in another. In order to do that, interpreters need to be able to selectively attend to only one language at a time, despite the fact that both need to be ready for use (activated above threshold simultaneously). Because there is mounting evidence suggesting that cognitive capacity affects language processing and language processes such as word retrieval are the basis for speech production, it was hypothesized that interpreters would obtain a better performance on both language and memory tasks relative to university students and English teachers.

In experiment 1, Christoffels et al. compared only students and interpreters. Regarding picture naming, interpreters were significantly faster than students. There was an interaction between proficiency and language. Both groups were faster at naming pictures in L1. When naming pictures in L2 however, the students were slower than the interpreters. Moreover, there was an effect of cognate words on RT's in L2. Cognates were named faster than non-cognates. Students also made more errors than the interpreters when naming pictures in L2.

For word translation, interpreters translated faster than the students both from English into Dutch and Dutch into English. In both translation directions, cognate words were translated faster than non-cognates. The students made significantly more errors than interpreters and translated faster from L1 to L2 than from L2 to L1. All memory span tests showed that the interpreters outperformed the students on both versions of the test – L1 and L2.

Experiment 2 examined the differences between interpreters and teachers – two groups of more proficient bilinguals. Overall, interpreters did not differ significantly from teachers in picture naming. Both groups were faster when naming pictures in L1 than in L2. In L2, pictures whose names were cognates were named faster than non-cognate names. As regards to accuracy, teachers and interpreters did not differ significantly in the percentage of errors. However, more errors were made when pictures were named in L2 than in L1.

As for word translation, no significant differences in performance were found between teachers and interpreters in both translation directions – L1 to L2 and L2 to L1. No differences were found between the groups for the number of errors either. However, overall, more errors were made when words were translated from L1 to L2. Mirroring the results of experiment 1, the interpreters had a better performance on all memory tests regardless of the language of the test. Teachers performed better in L1 than in L2.

Two critical findings of Christoffels' et al. with respect to issues of proficiency and WMC for lexical access are relevant here. First, lexical access in L2 is mediated by proficiency level, that is, more proficient bilinguals outperformed less proficient ones both in terms of time spent to retrieve the words and number of words correctly retrieved. Second, two groups with the same level of L2 proficiency differed in WMC. This finding poses some questions on the relationship between WMC and tasks that involve or are subject to proficiency effects. As proposed by Christoffels' et al., it might be that proficiency determines greater cognitive capacity and not the other way around (Bialystok, 2005).

The review in this subsection indicates that individual differences in WMC play an important role in tasks requiring the activation of L1 and L2 either separately or together, such as in translations and interpreting tasks. Most studies, by the way, have been conducted under the translation word paradigm. In addition, the studies associating WMC and bilingual lexical access reviewed so far (see Section 4 as well) have either been looking at the use of controlled attention to inhibit lexical items from the non-intended language, or used the approach to individual differences in WMC as a simple alternative to explain differences in performance for less and more proficient bilinguals. None of them, to best of my knowledge, have specifically aimed at examining the extent to which WMC affects L2 lexical retrieval under within-language competition of semantically-related words at different levels of proficiency. In other words, the empirical evidence gathered so far does not tell us which processes are common to both bilingual lexical access (when retrieval entails L2 response competition) and WMC that cause them to be related or whether those processes change with increased proficiency in L2.

Given that retrieving words in L2 is not only about blocking L1 activation but also about fighting off L2 lexical competitors by adequately delimiting the search set and monitoring for adequate retrieval within a language system under development, in which lexical connections lack rich conceptual specifications and lexical retrieval procedures are not yet fully automatized relative to the ones in L1, there seems to be room for an investigation concerning the relationship between individual differences in WMC, bilingual lexical access and proficiency level in an L2 picture naming task conducted under the picture-word interference paradigm. A first attempt in this direction was a pilot study conducted by Prebianca (2007).

3.2 Pilot Study

The pilot study was carried out in December 2007 in order to test the study design, instruments and procedures for data collection used in the present investigation. Forty-one Brazilian Portuguese native speakers enrolled in an English course of a private English Institute in Blumenau, Santa Catarina, volunteered to participate in the pilot study. There were 15 males and 26 females between 13 and 44 years old. Participants were divided into two groups according to their level of proficiency – intermediate and advanced. The intermediate group consisted of 19 students and the advanced group, of 22. The school classification of the participants' level of proficiency was used as the criterion to assign them to the intermediate or the advanced groups. The study design of Prebianca (2007) was different from the design for the present study in that in the former, besides the fact that L2 proficiency was not assessed, WMC was measured only by the SST. Moreover, there was not a counterbalancing between the two versions of the SST or between the experimental and control conditions of the picture naming task. Participants performed three tasks – (i) the Speaking Span Test (SST) in L2; (ii) the SST in L1, and (iii) an L2 picture-naming task. Data collection was split into two sessions with a time interval of one month between them. In the first data collection session participants performed both the L2 and L1 SST's. In the second, they performed the picture-naming task. Prebianca's (2007) design can be seen in Table 1.

Table 1

Research design for Prebianca (2007)

	Data Collection	
Participants	**1st Session**	**2nd Session**
41 English learners	L2 Speaking Span Test L1 Speaking Span Test	Picture Naming Task = control + experimental condition

One of the objectives of the pilot study was to investigate whether L2 proficiency would determine both bilingual lexical access and WMC of intermediate and advanced learners. Regarding WMC, it was initially predicted that there would be a difference in the mean working memory capacity scores in L1 and in L2. Results confirmed the prediction indicating a statistically significant mean difference between L1 and L2 strict and lenient working memory capacity scores, with L1 surpassing L2 performance in both proficiency groups. In other words, both intermediate and advanced participants obtained a better performance in the L1 version of the SST, as can be seen in Table 2.

Table 2

Paired Sample T-tests for working memory scores in L2 and L1 in the Intermediate and Advanced groups

	Paired Differences				
	Mean	**St. Dev.**	**t**	**df**	**Sig. (2-tailed)**
Intermediate					
SSTL1STR X SSTL2STR	**11.00**	**5.91**	**-8.10**	**18**	**.000***
SSTL1LEN X SSTL2LEN	**9.18**	**5.15**	**-7.76**	**18**	**.000***
Advanced					
SSTL1STR X SSTL2STR	**8.54**	**5.63**	**-7.11**	**21**	**.000***
SSTL1LEN X SSTL2LEN	**7.25**	**4.72**	**-7.19**	**21**	**.000***

N=19

*p< 0.05

SSTL2STR= strict scores on the L2 Speaking Span Test

SSTL2LEN= lenient scores on the L2 Speaking Span Test

SSTL1STR= strict scores on the L1 Speaking Span Test

SSTL1LEN= lenient scores on the L1 Speaking Span Test

The fact that the L1 version of the SST yielded higher scores for both proficiency groups was, according to Prebianca, due to the less automatic fashion of L2 formulation processes which are likely to require more controlled attention (WMC) to be executed. Less automatized procedures might have loaded speakers' WM resources to a greater extent, thus generating their lower scores for the L2 version of the SST.

However, the researcher did not rule out the possibility that the L1 SST scores might have been affected by practicing effects since the test was conducted right after the L2 SST, in the same data collection session.

Another expected result was that working memory scores would be different for intermediate and advanced learners in L2, but similar in L1. Contrary to predictions, working memory scores (strict and lenient) varied significantly in both L1 and L2 across proficiency groups, with advanced learners outperforming intermediate ones, as revealed by the results of the Independent T-test displayed in Table 3.

Table 3

Independent Sample T-tests for WM scores in L2 and L1 in the Intermediate and Advanced groups

	T-test for the equality of means			
	Mean differences	**t**	**df**	**Sig. (2-tailed)**
SSTL2STR Intermediate X Advanced	**7.82**	**-3.84**	**39**	**.000***
SSTL2LEN Intermediate X Advanced	**7.78**	**-4.40**	**39**	**.000***
SSTL1STR Intermediate X Advanced	**5.37**	**2.67**	**39**	**.011***
SSTL1LEN Intermediate X Advanced	**5.85**	**-3.16**	**39**	**.003***

N=41

*p< 0,05

SSTL2STR= strict scores on the L2 Speaking Span Test

SSTL2LEN= lenient scores on the L2 Speaking Span Test

SSTL1STR= strict scores on the L1 Speaking Span Test

SSTL1LEN= lenient scores on the L1 Speaking Span Test

Regarding WMC in L2, Prebianca (2007) argued that advanced learners might have developed a more automatized knowledge of the L2 and as a result were better able to focus controlled attention on L2 speaking formulation processes, by inhibiting proactive interference and maintaining task relevant information activated (Kane et al., 2007). On the other hand, regarding the results for WMC in L1, it was suggested that one of the reasons why advanced learners outperformed intermediate learners in the L1 SST might be related to individual differences in WMC within the advanced group itself. Another explanation for this unexpected result given by Prebianca was that, if L2 speakers did experience some kind of practice effect as a result of having performed the L1 SST right after the L2 SST, it might be that advanced learners were strategical so as to take advantage of it. A third explanation offered to explain advanced learners' supremacy in the L1 SST might be related to a possible restructuring of speakers' L1 system through the development of L2 expertise. Taken together, the results concerning WMC and L2 proficiency suggested that knowledge of the language did play a role in L1 and L2 SST scores variation for both intermediate and advanced learners.

A further goal of Prebianca (2007) was to investigate the possible effects of presenting semantically related word distractors in the language-in-use (L2) by analyzing two different measures of L2 lexical access: reaction time (RT) and naming accuracy (NA). Once again, against her initial predictions, results indicated a facilitatory effect of semantically-related word distractors on L2 picture-naming for both proficiency groups (intermediate and advanced), as opposed to the inhibitory effects found in L1 lexical access research, as can be observed in Table 4.

Table 4

Paired Sample T-tests for RT and NA control and experimental scores in the Intermediate and Advanced groups

	Paired Differences				
	Mean	**St. Dev.**	**t**	**df**	**Sig. (2-tailed)**
Intermediate Group					
RTcontr X RTexp	**119.99**	**140.91**	**3.61**	**17**	**.002***
NAcontr X NAexp	**-2.22**	**2.60**	**-3.62**	**17**	**.002***
N=18 / *p< 0.05					
Advanced Group					
RTcontr X RTexp	**104.07**	**133.60**	**3.65**	**21**	**.001***
NAcontr X NAexp	**-2.13**	**2.33**	**-4.29**	**21**	**.000***
N=22					
*p< 0,05					

RTcontr = mean reaction time in the control condition

RTexp = mean reaction time in the experimental condition

NAcontr = mean naming accuracy in the control condition

NA = mean naming accuracy in the experimental condition

The facilitatory effect found in Prebianca (2007) was attributed to the fact that, because lexical access in L2 qualifies as a controlled serial search task, a semantically-related word distractor resented before picture onset would help learners to execute the serial search for the name of the picture, facilitating performance and consequently, reducing retrieval time. On the other hand, it might be that picture naming was facilitated in the experimental condition because learners had performed the control condition, in which the target pictures were displayed without any interfering stimuli, first. This methodological decision might have affected retrieval time for the experimental condition since learners had already seen the target pictures.

In addition, results showed that advanced and intermediate learners did not differ in terms of reaction time (RT), but did on naming accuracy (NA) for both control and experimental conditions. In other words, results of an Independent Sample T-test showed that only the mean difference between NA scores of intermediate and advanced learners reached statistical significance, as can be seen in Table 5.

Table 5

Independent Sample T-tests for RT and NA control and experimental scores in the Intermediate and Advanced groups

	T-test for the equality of means			
	Mean differences	**t**	**df**	**Sig. (2-tailed)**
RTcontr Intermediate X Advanced	**65.69**	**1.364**	**38**	**.181**
RTexp Intermediate X Advanced	**49.76**	**1.459**	**38**	**.153**
NAcontr Intermediate X Advanced	**-2.76**	**-2.531**	**38**	**.016***
NAexp Intermediate X Advanced	**-2.67**	**-3.404**	**38**	**.002***

N=40

*p< 0,05

RTcontr = mean reaction time in the control condition

RTexp = mean reaction time in the experimental condition

NAcontr = mean naming accuracy in the control condition

NA = mean naming accuracy in the experimental condition

According to Prebianca, the fact that advanced learners named more pictures correctly than intermediate learners may be simply because advanced learners have a greater knowledge of the L2 in relation to intermediate learners and consequently, a greater repertoire of L2 lexical items. On the other hand, the finding that advanced learners did not differ from intermediate ones in terms of retrieval speed was accounted for by trade-off effects between time spent to respond to the target pictures and number of correct responses, supporting empirical evidence for limitations in WMC. Without enough attentional resources, L2 speakers might have prioritized the aspect of the task which seemed more important to them – naming pictures correctly, in this case.

Another interesting result of Prebianca's (2007) study was the lack of correlation between RT and NA scores in the intermediate group for both control and experimental conditions, and in the advanced group between RT scores for the experimental condition and NA scores for both conditions, since initial predictions were for a significant correlation among all these variables. On the other hand, significant, moderate and negative correlations were found between RT scores in the control condition and NA scores in the experimental and control conditions in the advanced group as revealed by Pearson correlations displayed in Table 6.

Table 6

Pearson Product Moment Coefficient of Correlation for RT and NA scores in the Intermediate and Advanced groups

	Intermediate		**Advanced**	
	NAcontr	**NAExp**	**NAcontr**	**NAexp**
RTcontr	**-.276**	**-.192**	**-.636****	**-.719****
RTexp	**-.459**	**-.199**	**-.234**	**-.316**
**p < .01	N=18		N=22	

RTcontr = mean reaction time in the control condition

RTexp = mean reaction time in the experimental condition

NAcontr = mean naming accuracy in the control condition

NA = mean naming accuracy in the experimental condition

These results apparently indicate the existence of trade-off effects between the time taken to name the pictures and the number of pictures correctly named. In other words, neither advanced nor intermediate learners were able to name pictures correctly in a short interval of time.

Motivated by these findings and intrigued by the unexpected WM and lexical access results in respect to proficiency level, Prebianca (2007) suggested there seems to be a tendency towards a possible interaction between bilingual lexical access, WMC and L2 proficiency level. Investigation of this possible interaction constitutes the main drive of the present research endeavor. However, in order to reach this objective and be able to come to more grounded conclusions concerning the findings of Prebianca (2007), some methodological changes were implemented in the present study. First, L2 proficiency was assessed both through a more general speaking measure and through a measure that resembles the speaking process being herein investigated – lexical access.

Second, a measure of WMC which is not language related was introduced so as to gain a better understanding of the relationship between WMC and L2 proficiency, as well as to be able to check whether the SST and the OSpan are both good predictors of bilingual lexical access. Third, in order to avoid practice effects, both versions of the SST and the control condition of the picture naming task were counterbalanced. Finally, following Prebianca's (2007) suggestions, some modifications of the stimuli for the L1 SST were made so as to avoid any kind of association that could aid memorization of the words. Therefore, words in plural form (i.e., toalhas, abelhas, camisas), words that could induce any kind of orthographic pattern (i.e., natação, palhaço) and words presented in a sequence within the same testing set that could allow for semantic associations (i.e., caderno, laranja) were replaced. The participants, the tasks and the procedures for data collection and analysis implemented after Prebianca (2007) are outlined in Chapter 4.

CHAPTER 4

METHOD

Aiming at investigating the relationship between individual differences in WMC, bilingual lexical access and L2 proficiency level, an experimental quantitative study was carried out with speakers of English as a foreign language from Universidade Regional de Blumenau (FURB) and from private language institutes.

This chapter outlines the methodological procedures adopted in the present investigation as well as the research questions, objectives and hypotheses addressed. Then, it presents a description of the participants, instruments and procedures for data collection, the research design, and a table summarizing the variables created to operationalize and assess WMC, lexical access and proficiency in the present study. Finally, it reposts the statistical tests run with the data gathered.

4.1 Objectives

The objectives of the present study are:

1. To investigate whether bilingual lexical access is predicted by WMC and proficiency level in L2;
2. To investigate whether WMC and L2 proficiency interact in predicting bilingual lexical access;
3. To examine the extent to which within-language competition affects bilingual lexical access

4.2 Research Questions

In order to pursue the aforementioned objectives, the present investigation attempted to answer the following research questions. Whereas research question 1 addresses objectives 1 and 2, research question 2 relates to objective 3.

1. Do working memory capacity and L2 proficiency predict bilingual lexical access?

2. Do semantically-related L2 distractor words affect bilingual lexical access in terms of retrieval speed?

4.3 Hypotheses

Drawing on the research questions and objectives outlined above, a set of hypotheses was formulated. The first set - hypotheses 1 to 4 -, is concerned with the relationship between WMC, L2 proficiency, and bilingual lexical access. They are based on the assumption that lexical access qualifies as a controlled serial search task (Engle and Oransky, 1999) subject to (i) working memory limitations, and (ii) the amount of automatized L2 knowledge one possesses (Kormos, 2006).

- Hypothesis 1: Working memory capacity and L2 proficiency will both predict bilingual lexical access;
- Hypothesis 2: Working memory capacity, as measured by the L2 SST, will be a better predictor of bilingual lexical access than working memory capacity as measured by the L1 SST and the OSpan;
- Hypothesis 3: Higher spans will retrieve lexical items faster than lower spans;

- Hypothesis 4: More proficient bilinguals will retrieve lexical items faster than less proficient bilinguals, irrespective of task order.

The fifth hypothesis below refers to the effect of within-language competition on the mean retrieval speed of lexical items in an L2 picture-naming task. This hypothesis is based on evidence in Prebianca (2007) showing shorter reaction time scores for pictures named when semantically related word distractors were displayed 100ms before picture onset for more and less proficient bilinguals than when pictures were named without interference.

- Hypothesis 5: The mean retrieval speed of lexical access in bilinguals will be facilitated by L2 semantically related word distractors;

4.4 Research Design

In order to address the research questions and hypotheses of the present study, the following research design was implemented:

Table 7

Research design

	Data Collection		
Participants	**1st Session**	**2nd Session**	**3rd Session**
N=50	Toefl iBT Speaking Test	SST L2	Picture Naming – Control + Experimental Conditions
	SST L1	OSpan L1	Semantic Categorization Task
N=50	Toefl iBT Speaking Test	SST L1	Picture Naming – Experimental + Control Conditions
	SST L2	OSpan L1	Semantic Categorization Task
Total N= 100			

As can be seen in Table 7, the present study was conducted with 100 participants who performed two proficiency tests (Toefl iBT Speaking Test and semantic categorization), three WMC tests (the SST in L1, the SST in L2 and the OSpan in L1), and an L2 picture naming task. The tests were applied in three different sessions and were counterbalanced in order to avoid practice effects. All data collection instruments will be fully described in the subsequent sections of this chapter.

4.5 Participants

One hundred and one L1 Brazilian students of English as a foreign language composed the original pool of participants of the present study. All of them volunteered to participate and signed a consent form (see Appendix A). The cohort consisted of 82 learners from private language schools, 16 undergraduate students of the Letras course at Universidade Regional de Blumenau – 7 of them enrolled in the sixth semester and 9 in the seventh semester - , and 3 private English teachers. Participants were 27 males and 74 females, ages raging from 13 to 57 with an average of 22,5 years, therefore a predominantly adult population. Because participants were studying English at different educational institutions and because proficiency in L2 is a key factor in the present investigation, all participants were tested twice to check their proficiency levels – first performing a sample task of the TOEFL iBT Speaking Test and second performing a semantic categorization task. Both proficiency tests will be described in subsection 4.6.2. of this chapter. After the first proficiency test, one of the participants decided to quit the study due to personal problems with schedules for the data collection sessions. The remaining 100 participants had three individual meetings each with the researcher either at the university or at their language schools. Meetings lasted about 25 minutes each and were conducted during the months of April and June of 2008.

Participants were all invited to volunteer for the study by the researcher herself, who emphasized the relevance of the research and explained the procedures in case they decided to participate. As a way of rewarding participants for their willingness and availability, 9 readers, 2 English-Portuguese-English dictionaries and a grammar book were raffled among all participants at the end of the data collection process. The researcher also offered help with English tips, grammar exercises and general learning issues on-line by giving all participants her e-mail address so that they could keep in touch any time they needed. The intense support of the teachers from the Letras course and from the language schools also contributed to learners' participation. Mortality rate, probably due to all these incentives, was almost zero.

4.6 Instruments of data collection

The instruments of data collection used in the present investigation comprised (i) three tests designed to assess working memory capacity: two Speaking Span Tests (one in L1 and one in L2) and the Operation Span Test in L1; (ii) two proficiency tests: a sample of the TOEFL iBT Speaking Test and a semantic categorization task in L2; and (iii) a picture-naming task designed so as to assess lexical access in L2 speaking. In what follows, a detailed explanation of all the tests will be provided.

4.6.1 Assessment of Working Memory Capacity

4.6.1.1 The Speaking Span Test in L1

The Speaking Span Test (SST) was first developed by Daneman and Green (1986) and Daneman (1991) in order to investigate the relationship between individual differences in working memory capacity of native speakers of English and their oral production. The assumption underlying the SST was that working memory capacity reflected individuals' ability to process and store information simultaneously while performing a demanding cognitive task such as speaking. Therefore, the larger one's working memory capacity, the better his performance on the speaking span task.

The Brazilian Portuguese version of the SST administered in the present study was designed by Fortkamp (1999), based on Daneman's (1991) test, and was partially adapted by the present researcher so as to be more similar to the L2 version of the test with 3 test blocks rather than 2 as in the original. It consisted of 60 unrelated words presented in sets of 2, 3, 4, 5 and 6 words each. The words were 7 letters long and were displayed in the center of a computer screen for 1 second (see Appendix B for the words used in the test). After 10 milliseconds the next word of the set would appear. After all words of a specific set had been displayed, question marks on a black screen followed by a beep would signal it was the time for participants to start formulating the oral sentences for each word they had seen in that set. The number of question marks always referred to the number of words participants should recall and make a sentence with. Though there was no restriction in terms of complexity and length for the oral sentences, participants were informed that only semantically and syntactically accurate sentences in Brazilian Portuguese, produced for words in their exact form and order of presentation, would be accepted. An additional one-block L1 SST was used as demonstration and training so that participants could get acquainted with the test. A test set consisting of three words would look like the following:

FUTEBOL – ABÓBORA – CIMENTO

After reading the words silently on the computer screen for 1 second each, a participant was able to produce the following sentences:

- Eu não jogo futebol
- Eu odeio abóbora
- O chão é de cimento

Participants' oral sentences were recorded with the sound editing software Audacity 1.2.6, converted into mp3 files, transcribed and scored. Scoring procedures followed Daneman and Green (1986) and Daneman (1991), in which 1 point was awarded to every syntactically and semantically accurate L1 sentence generated for the words in the exact form and order of presentation thus yielding a strict score. For instance, in a test set of five words, a participant who was able to produce two sentences obeying the above described criteria, would be awarded 2 points. For example:

GRÁFICA – VIVEIRO – PALHAÇO – AVENTAL - RELÓGIO

- Você tem que mandar imprimir essas coisas na gráfica (1 point)
- Os pássaros estão no viveiro (1 point)

The total SST score for each participant was calculated by summing up all points credited to the sentences correctly formulated. Sentences which could not be understood due to recording problems were excluded from analysis. The maximum score was 60 and the measure yielded by this scoring procedure is herein named **SSTL1** (individual scores on the L1 SST can be found in Appendix C).

Differently from Daneman and Green (1986) and Daneman (1991), a lenient score, in which ungrammatical sentences or sentences formulated with words in a different form and/or order of presentation than the original were credited half a point, was not calculated. This decision was based on the findings of several studies investigating the relationship between WMC and L2 speech production showing unsystematic and inconsistent results regarding lenient span measures (Prebianca, 2006; Finardi, 2007; Finardi, 2009). In addition, the lenient score seems to be too subjective a measure since it allows for different interpretations of what is to be considered syntactically correct or not, depending on participants' level of proficiency and their communicative intentions, which consequently makes this measure too broad in scope, allowing for too much room for miscoring.

4.6.1.2 The Speaking Span Test in L2

The SST used to measure participants' working memory capacity in L2 in the present study was an L2 version of Daneman's (1991) original test and was designed by Weissheimer (2007). Three major criteria were used in the construction of the L2 SST: (1) only one syllable words were included; (2) words with similar phonological and semantic patterns were avoided within the same test set and, (3) word frequency in the language was attested by means of two websites[13] (see Weissheimer, 2007 for details).

Like the L1 version, in the L2 SST, participants were required to memorize words in English for later recall and use them in the production of L2 (English) semantically and syntactically accurate oral sentences. There were 60 unrelated words displayed in sets of 2, 3, 4, 5, and 6 words each (see Appendix E to see the list of words used in the test). Detailed instructions were given in the participants' native language together with three blocks of practice (see Appendices D and E for instructions and words for the practicing blocks, respectively).

Participants' individual span scores corresponded to the total number of words for which they were able to produce a grammatical and meaningful sentence in English, mirroring the criteria used to calculate the scores of the L1 SST. The measure of WMC resulting from this analysis is herein called SSTL2. This variable was then transformed into standardized (z) scores to be inserted into the model for the multiple regressions run to answer research question 1 of the present investigation. It was herein named zSSTL2 (see Appendix C for individual scores on the L2 SST).

4.6.1.3 The Operation Span Test

The version of the Operation Span Test (OSpan) applied in the present study differed from the original task designed by Turner and Engle (1989) in that the words to be recalled were in Portuguese instead of English. This adaptation was done so as to

[13]http://www.paulnoll.com/China/Teach/English-3000-common-words.html and http://www.comp.lancs.ac.uk/ucrel/bncfreq/lists

conduct the test in participants' native language since informal piloting of the stimuli in L2 with three learners revealed great difficulty in reading aloud the operations in English. The L1 words used in the test were all dissyllabic words unlikely to be unknown by native speakers (see Appendix F for the OSpan list of words).

The OSpan consisted of three test blocks of four sets each. Within each set, trials could vary from 2 to 5 in a pre-established order. For instance, block 1 was composed of 4 sets of 3, 5, 3 and 2 trials, respectively. In total, there were 42 trials – 19 displayed a mathematical operation string with a correct response and 23 displayed operations with an incorrect one.

In each trial, participants saw an operation-word string with a possible outcome followed by a word. The stimulus was displayed in the center of a computer screen. The math operations were a composite of multiplication or division problems followed by the subtraction or addition of an integer, for example, (9/1) -5, and were the same used in the original OSpan test (Turner and Engle, 1989). The outcome of the math operation should be verified YES or NO depending on whether it was the correct result for the problem. For the above example, participants would see (9/1) -5 = 4 ?, and were expected to say whether 4 was the correct outcome of this operation (see Appendices F and O to see the math operations and instructions for the test, respectively). After reading and solving the operation, participants were required to read aloud the subsequent word for later recall, in this case, **balde**. Thus, the whole trial consisted in reading aloud the math operation, solving it as fast and as accurately as possible without pausing and then immediately after verification, reading the word out aloud. As soon as participants completed each trial, the researcher pressed the space bar on the keyboard so that the next operation-word string appeared in the center of the screen. At the end of all trials of a set, question marks cued participants to recall the words they had read in that particular set in the exact order and form of presentation. The number of question marks corresponded to the number of the words they were supposed to recall. A practice block consisting of 4 sets of gradually increasing 2, 3, 4 and 5 trials was administered before the actual experiment so as to make learners familiar with the test (operation-word strings for the practice block can be found in Appendix F). Participants' oral responses were recorded with the help of a sound editing software (Audacity 1.2.6) and a microphone. Recordings were then converted into mp3 files for further transcription and scoring.

Two different scoring procedures were used to calculate individual OSpan scores. The first procedure was meant to be consistent with the procedure adopted for the speaking span tests, in which both processing and storage demands on WMC were given equal importance. Thus, following this criterion, 1 point was credited to each word recalled in the exact form and order of presentation. That is, in a test set of three trials for example, a participant who was able to solve at least two math operations correctly and then recall their corresponding words obeying form and order of presentation, was awarded 2 points. Consider the test set below. In this set, a participant saw in the computer screen three math operations followed respectively by the words telha, vinho and foto. For the first operation, 2 is not the correct output thus, the participant should have responded NO instead of YES. For the second and third operations, the participant responded correctly. Although the participant was able to recall all 3 words, he was credited only 2 points because the word telha was part of the operation-word string to which was given an incorrect response.

Math operation	Participant's response	Word for later recall
(3 x 1) + 2 = 2 ?	**YES**	**telha**
(4 ÷ 2) + 1 = 6 ?	**NO**	**vinho**
(5 ÷ 5) + 1 = 2 ?	**YES**	**foto**

Recalled words:
TELHA (0 point) – VINHO (1 point) - FOTO (1 point) = **2 points**

The second procedure, on the other hand, was not so strict in terms of processing efficiency. Following several studies which have consistently used the OSpan to measure WMC (Turner and Engle, 1989; Kane, Beckley, Conway and Engle, 2001; Unsworth et al., 2005; Kane, Conway, Hambrick and Engle, 2007, among others), a criterion of 85% accuracy on the mathematical operations was required. According to Unsworth et al. (2005), this criterion is useful in order to ensure that participants do not trade-off between processing the mathematical operations and storing the words. In this sense, all words recalled obeying the form and order of presentation and the criterion of 85% accuracy were credited 1 point. For example, consider that the OSpan consisted of 42 trials distributed in 12 sets. Following the 85% criterion, the total number of errors on math operations a participant could have was 6. If the participant responded to a specific operation of a particular set incorrectly but later on was able to accurately recall the word following that operation, he was credited one point as long as he had not reached 6 errors yet. For scoring a point in this case, it did not matter if the other words in the set were not recalled correctly, because what was taken into consideration was the total number of errors the participant had so far. Below there is an example of two test sets with 3 and 2 trials, respectively. The stimuli displayed in the first and third columns are the ones a participant saw on the screen. The second column refers to participant's responses to the math operation. Suppose that in the first set the participant responded wrongly to the first operation, but was able to recall its respective matching word later at recall time together with the matching word for the third operation (which was responded to correctly). At this point, the participant obtained 2 points – one for recalling the word **fila** and another one for recalling the word **maçã**. In the second set then, the participant solved the first operation correctly but not the second one. However, he was credited 2 points because even responding to the second operation incorrectly, he was able to recall its matching word (**jornal**) and he only had one math operation error so far. That is, he was within the 85% accuracy criterion.

Math operation	Participant's response	Word for later recall
(8 x 4) – 2 = 32 ?	**YES**	**fila**
(9 x 3) – 3 = 24 ?	**YES**	**água**
(4 ÷ 1) + 1 = 4 ?	**NO**	**maçã**

Recalled words:
FILA (1 point) – MALA (0 point) - MAÇA (1 point) **= 2 points**

Math operation	Participant's response	Word for later recall
(10 ÷ 1) - 1 = 9 ?	**YES**	**ferro**
(8 x 4) + 2 = 34 ?	**NO**	**jornal**

Recalled words:
FERRO (1 point) – JORNAL (1 point) = **2 points**

The two scores yielded by the OSpan test were named as OSPan and OSPerc and were checked for co-linearity in order to ensure reliability of the scoring procedures and to select a measure of WMC to be used in the follow-up statistical tests needed to address the research questions and hypotheses of this study (see Appendix C for individual scores on these measures). As can be seen in section 4.9.2.2 of this method chapter, a methodological decision was made in favor of OSPan as an index of WMC. This index then generated, together with SSTL1, a new variable calculated by converting OSPan and SSTL1 into standardized scores and averaging them. The resulting index was herein called WMCL1z and was inserted in the model for the multiple regressions run so as to answer research question 1.

4.6.2 Assessment of L2 Proficiency

4.6.2.1 The TOEFL iBT Speaking Test

In order to assess learners' proficiency level in L2 speaking, a sample task of the TOEFL iBT Speaking Test was used in this study. The task selected for eliciting participants' speech production was an independent task in which learners were asked to talk about a familiar topic – giving opinion about the best way to get the news – drawing on their own personal experience and knowledge of the world (see Appendix G for task topic). The task was taken from a CD-Rom containing samples of speaking tasks from Barron's TOEFL iBT Audio Book, by Pamela Sharpe (2006), and, as in the original version, it was divided into two parts – (1) a pre-speaking planning session of 15 seconds and, (2) a speaking session of 45 seconds. Participants listened to the question and had their answers recorded with the help of two softwares - Windows Media Player 10.0 and Audacity 1.2.6. The procedures for this task will be fully described in subsection 4.7.1 of this chapter.

The criteria for scoring and rating participants' speech mirrored the criteria of the original test. According to The Official Guide to the New TOEFL (2006), speech samples are to be rated holistically taking into consideration speech delivery, language use and topic development. Therefore, regarding delivery, raters were asked to observe features such as adequate use of pronunciation and intonation patterns, rhythm, pace, fluidity and clarity of speech. Regarding language use, raters should pay attention to grammatical accuracy and complexity of speech and adequate use of vocabulary. As far as topic development was concerned, raters were required to check whether the ideas were developed logically, clearly and coherently within the time window allotted for it. Following the original rubrics for the TOEFL iBT Speaking Test then, participants' speech samples were rated from 0 (no attempt from participants to respond to the question) to 4 (maximum score) (see Appendix H for the original test rubrics). There were 3 external raters (all non-native speakers of English) – (1) a private English teacher with years of experience in teaching basic, intermediate and advanced level students; (2) a professor and a PhD in Applied Linguistics having defended her dissertation on metacognitive processes in L2 speech production, and (3) a Phd candidate in Applied Linguistics studying the relationship between working memory capacity and L2 acquisition. They all received a CD-Rom with participants' speech samples in mp3 format and a pdf file with the test rubrics. A mean rating score was calculated for each participant based on the individual scores of each rater (see Appendix I for rating scores) by using the formula (RATER1+RATER2+RATER3 divided by 3). The resulting scores were labeled as PROFToe (individual scores on this variable can be seen in Appendix R). In addition, in order to examine the effects of semantically related L2 word distractors on the retrieval speed of L2 lexical items in different proficiency levels, an extra index of proficiency based on PROFToe was calculated by standardizing the scores for this variable. This statistical procedure yielded a new variable herein called zPROFToe.

4.6.2.2 The Semantic Categorization Task

The Semantic Categorization task implemented in the present investigation was devised based on Dufour and Kroll (1995). The objective of this task was to assess participants' L2 proficiency level in a more specific manner by narrowing the scope of the response set. That is, when producing somewhat free speech, as in the TOEFL iBT Speaking Test, participants could rely on a great amount of linguistic information and knowledge to answer the questions they were required to. Therefore, a much bigger set of responses was likely to be generated. Besides, the scores given by raters on the TOEFL iBT Speaking Test seem to refer to a more general view of the speaking process in the sense that they account for non-linguistic features such as intonation patterns, pace, coherence, development of logical ideas, among others. In addition, the rating scale for this test seems to be too narrow in scope in relation to the number of features it proposes to analyze for it ranges only from 0 to 4 (see Appendix H for test rubrics). The second issue that led to the proposal of an additional measure of L2 proficiency has to do with one of the cognitive processes being analyzed in the present study – lexical access. Despite its great importance in the formulation of speaking, lexical access is a micro process within speech production and, as such, has some peculiarities which might not be captured by such broad measures as the scores on the TOEFL iBT Speaking test. Therefore, in an attempt to have a measure of proficiency in L2 which resembled the main process being investigated (lexical access), a semantic categorization task was implemented.

In this task, participants were presented with names of L2 superordinate categories followed by L2 subordinate target nouns. Their task was to decide whether the subordinate nouns belonged to the superordinate categories. The stimuli for the task consisted of 50 English concrete nouns divided into 10 categories: clothing, color, occupation, fruit, transportation, drink, body part, vegetable, school object and animal (all nouns used in this task can be seen in Appendix J). There were 6 target categories – *animal*, *body part*, *fruit*, *transportation*, *vegetable* and *school object* – and 4 filler categories – *clothing*, *color*, *drink* and *occupation*. All categories were randomly chosen and defined as targets or fillers. All superordinate categories and subordinate nouns were extracted from a picture dictionary[14] used by the researcher in her private classes to teach vocabulary to beginners. In the whole semantic categorization experiment, each category appeared 10 times and all 50 subordinate nouns were displayed twice – once for the same-category condition and once for the different-category condition, summing up a total of 100 responses – 50 affirmative and 50 negative. The 100 trials were displayed in 5 blocks of 20 trials each, 10 trials belonging to the same-category condition (YES response trials) and 10 to the different-category condition (NO response trials). The order of presentation of categories and nouns was partially randomized, that is, the combinations of categories for the NO response trials were kept the same each time the experiment was run but their respective subordinate nouns were selected randomly. Combinations of categories for the NO trials were: *clothing/fruit*, *drink/transportation*, *color/occupation*, *school object/animal*, and *vegetable/body part*. Thus, in a particular block, for instance, any subordinate noun of the category *animal* could be paired with the superordinate category *school object*, prompting a negative response. Categories were displayed in upper-case letters whereas subordinate nouns in lower-case, both in Arial font, bold, 35 point. The experiment was designed and run using E-Prime 1.2.

Every single trial within the 5 experimental blocks was run as follows. First, a fixation point represented by the symbol (+) in Arial font, 30 point, appeared on the computer screen for 300 milliseconds (ms). Then, the superordinate category name replaced the fixation point for 400 ms. 450 ms after category onset, a subordinate noun appeared in the center of the screen for 450 ms. At this moment, participants should press 1 on the keyboard if the subordinate noun was a member of the category

[14] 1000 plus pictures for teachers to copy by Wright (1994)

preousvily displayed and 2 if it was not. After an intertrial interval of 1.5 seconds, the next superordinate category name appeared on the screen automatically. At the end of each experimental block, participants were required to press the space bar to proceed to the next block. The message displayed on the screen was: *Fim de Bloco. Pressione a barra de espaço para continuar*[15]. At the end of all blocks, a message indicated the experimental session was over: *O experimento terminou. Obrigada por participar!*[16].

The scoring procedures applied in the present study to determine participants' proficiency level according to their performance in the Semantic Categorization task differed from the procedures used by Dufor and Kroll (1995). In Dufor and Kroll's study participants whose mean accuracy on categorization was 75% or greater were classified as more proficient bilinguals, whereas those who performed under this figure were considered less proficient bilinguals. In this study, three different measures resulted from the Semantic Categorization task - (i) total number of subordinate nouns correctly categorized for target and non-target superordinate categories (**TOTGeral**); (ii) total number of subordinate nouns correctly categorized for target superordinate categories only (**TOTCateg**); and (iii) mean reaction time for categorization including target and non-target categories (**meanRTGer**) (see Appendix K to see the individual scores for each measure). Statistical procedures were applied to these data in order to select the most appropriate index for the Semantic Categorization task. As explained in section 4.9.2.1 of this method chapter, the index selected was TOTCateg which, so as to allow for the investigation of differences between proficiency levels in L2 picture naming task, was converted into standardized scores yielding a new index of L2 proficiency herein named **zTOTCateg**.

[15] End of block. Press the spacebar to continue (author's translation).
[16] The experiment is over. Thank you for participating! (author's translation).

Finally, a third proficiency index was obtained by calculating the average of z scores for zTOTCateg and zPROFToe (standardized scores for PROFToe), yielding a new variable herein referred to as **Meanz**. The standardized variables – zTOTCateg, zPROFToe and Meanz yielded, in turn, three other variables, namely **PRO1**, **PRO2** and **PRO3**. These variables were computed by checking for the upper and lower quartiles of the distributions for zTOTCateg, zPROFToe, and Meanz, respectively, and aimed at sorting out more and less proficient bilinguals. PRO1, PRO2, and PRO3 were included in the ANCOVA procedures conducted so as to answer research question 2, as between subject factors.

An additional objective in relation to L2 proficiency was to investigate whether it interacted with WMC in predicting bilingual lexical access. In order to do so, multiple regressions were carried out with a variable computed specifically to check for interaction effects. This variable was defined herein as **L1byPRO** and calculated by multiplying WMCL1z by Meanz when only working memory capacity measured by L1 span tests (SSTL1 and OSPan) was inserted in the regression model. To analyze the interaction between WMC as measured by the SST in L2 and proficiency, another measure was obtained by multiplying the ZsstL2 by Meanz, yielding the variable herein called **L2byPRO**.

4.6.3 Assessment of Bilingual Lexical Access

4.6.3.1 The Picture-Naming Task

The picture-naming task was designed to assess participant's lexical access in L2 in terms of retrieval speed following most studies conducted under the picture-word interference paradigm (Roelofs, 1993; Damian and Martin, 1998; Costa et al., 1999). In this task, participants were required to name pictures in the presence of word distractors (the experimental condition). Pictures portrayed concrete objects visually displayed as black line drawings on a white computer screen and were to be named as fast and accurately as possible. Word distractors also referred to concrete objects and were of two different types: (1) semantically related and (2) phonologically related to the name of the picture. For instance, the picture of a DOG appeared with the word distractors **cat** and **fog**, respectively. Distractors were presented at three different points in time, following the Stimulus Onset Asynchrony Paradigm (SOA). Word distractors appeared together with the picture (SOA=0), 100 ms before picture onset (SOA=-100) and 100 ms after picture onset (SOA=+100).

All word distractors and names of the pictures were monosyllabic words in order to avoid an effect of articulation time on RT's. Semantically related distractors were words from the same category such as *dog* and *cat*. For phonologically related distractors, words that shared the greatest number of phonological segments with the name of the target picture were selected. A native speaker of American English and a Brazilian professor of English phonetics and phonology analyzed and agreed on the phonological relationship between word distractors and the names of the pictures. Pictures and distractors that start with –s clusters were avoided due to the fact that Brazilian learners of English tend to insert a vowel in front of words like *school*, *stove*, *store*, for instance, to aid pronunciation (the name of the pictures and word distractors used in the test can be found in Appendix L), resulting in two syllables. Word distractors were presented in capital letters, Arial font, bold, 25 point. To avoid the matching of pictures and letters, all word distractors were displayed in blue font.

The task was divided into two different testing sessions – a control and an experimental session. A split half design was applied in this study regarding the picture-naming task in order to avoid practicing effect. That is, 50 participants were run in the control session first, followed by the experimental session, and 50 were run in the inverse order. Pictures were divided into 3 sets – a set of 25 target pictures displayed in the experimental and control conditions, a set of 30 filler pictures to complete the experimental condition, and a set of 20 training pictures to be presented in the training session. Fillers and training pictures were paired with unrelated word distractors presented at picture onset. The pictures and word distractors of the training session were not used in the main experiment. In total, participants saw 75 different pictures and produced 267 vocal responses.

The experimental session consisted of 6 blocks of 40 trials which, in turn, consisted of 25 target pictures plus 15 filler pictures, summing up a total of 240 responses per participant. Overall, the 25 target pictures produced 150 different combinations since each one was paired with two different types of distractors – semantically and phonologically related -, and was presented in three different time conditions – -100 ms, 0ms and +100ms. Combinations were of the following kind:

► A pictured DOG was paired with:

- a semantically related distractor presented at -100ms
- a semantically related distractor presented at 0 ms
- a semantically related distractor presented at +100 ms
- a phonologically related distractor presented at -100ms
- a phonologically related distractor presented at 0 ms
- a phonologically related distractor presented at +100 ms

Within a block in the experimental condition, a target picture and its particular combination could not appear more than once. This means that from the 6 combinations of each picture, just one of them appeared in a particular block. The order of pictures and their respective combinations within blocks was randomized. The first three trials of each experimental block consisted of filler pictures which were meant for further practice, besides the practicing session prior to the experiment itself. The order of presentation of the resulting 12 fillers (there were 15 in total within a block) was also randomized.

Every experimental trial had the following structure. First, a fixation point appeared in the center of the computer screen for 700 ms followed by a blank interval of 500 ms. Then, the picture was presented in the center of the screen. The picture and the word distractor remained on the screen until the participant produced a vocal response or a maximum of 1500 ms and then disappeared (Damian and Martin, 1998; Roelofs, 1993). There was an intertrial interval of 1.5 s. Then, the next picture appeared on the screen automatically (Costa et al., 1999).

At the end of each block of the experimental condition, that is, after each 40 trials, participants were instructed in their L1 to press the space bar to proceed to the next block. The message was: *Próximo bloco. Pressione a barra de espaço para continuar*[17]. After having completed all 6 blocks, participants saw a message indicating the experiment was over: *O experimento terminou. Obrigada por participar!*[18].

Although the picture-naming experiment was designed so as to provide data concerning the effects of different kinds of word distractors (namely, phonologically- and semantically-related) displayed at different moments in relation to picture onset (100 ms before, together with and 100 ms after picture onset), only the data regarding semantically-related word distractors presented 100 ms before picture onset were taken into consideration for data analysis. This was so due to the kind of data needed to

[17] Next block. Press the spacebar to continue (author's translation).
[18] The experiment is over. Thank you for participating! (author's translation).

answer the research questions and hypotheses addressed by the present investigation (see sections 4.2 and 4.3 of this chapter).

Four lexical access measures were obtained through the picture-naming task: reaction time scores for the control and experimental conditions and, naming accuracy scores for control and experimental conditions. Whereas in SOA= -100, reaction time measures in the experimental condition reflected the time participants took to name the picture from the offset of picture presentation on, in SOA=+100 they corresponded to the time participants took to name the picture from the onset of distractor presentation on. In addition, pictures were also named in a control condition, that is, without any word distractor presentation. This was done in order to generate a baseline measure to be compared with reaction time and naming accuracy measures produced by participants when naming pictures in the face of interfering stimuli. Naming accuracy (NA) was operationalized as the number of pictures participants were able to name correctly, regardless of how long they took to name them. This measure was useful in selecting which responses would be taken into consideration to calculate the mean reaction times for the control and experimental conditions. That is, only the RT's for pictures correctly named were included in the calculations for the mean, thus pictures named inaccurately or not named at all were excluded from the calculations – a procedure frequently adopted in lexical access studies. The mean RT's for the control and experimental conditions analysed in the present study were labeled RTctr and RTexp, respectively (refer to Appendix C to see individual sores on these variables). These variables were then considered as within subject factors for the dependent variable herein defined as COND in the analyses carried out to answer the second research question of this study (i.e., Do semantically-related L2 distractor words affect bilingual lexical access in terms of retrieval speed?). Still for these analyses, a new variable herein defined as TASKOrder was created by assigning participants who performed the control condition first to the group CTRfirst and the ones who performed the experimental condition first to the group EXPfirst. These variables were necessary to run a statistical procedure aimed at testing for practice effects.

Moreover, in order to answer the main research question of the present study (i.e. Do WMC and proficiency predict bilingual lexical access?), only RTexp was taken into consideration, for it comprises the scores of the experimental condition in the picture naming task. It is likely that, because bilingual speakers had to name pictures in L2 under interference, their working memory capacity was pushed to its limits since they had to suppress irrelevant stimuli, maintain task relevant information under the focus of attention and simultaneously retrieve the correct name for the picture (Kane et al., 2007). Therefore, to conduct the statistical tests for analyzing the extent to which WMC and L2 proficiency predict bilingual lexical access in terms of retrieval speed, RTexp was converted into standardized scores so as to be in line with the standardized score for L2 proficiency - Meanz. The new index of RTexp was herein named **zRTexp**. The whole picture naming experiment was developed and run using E-prime 1.2, which displays the pictures and word distractors and collects the reaction times in milliseconds for each picture named. Naming accuracy measures were note taken by the researcher.

4.7 General Procedures

The procedures for data collection followed in the present investigation were decided based on Prebianca (2007), who suggested looking for an interaction between WMC, bilingual lexical access and L2 proficiency. As can be seen in Table 7 of this method section, participants performed 6 tests each in individual meetings with the researcher. At first, it was the researcher's intention to invite only students from the

Letras course, who usually have two to three 1h40m classes of English a week. However, due to limitations in the number of students per class (semesters), the researcher had to look for students at other language schools. As a consequence, most participants of the present study were students taking English classes at different levels in different language schools.

After having a meeting with the coordinators of the Letras course at Universidade Regional de Blumenau and of the language schools to explain to them the purpose and procedures for the study, the researcher pre-selected the groups of prospective participants according to number of students the researcher could meet on the same day, taking into consideration that each meeting would last approximately 25 minutes. Having done that, the researcher then asked their respective teachers permission to interrupt their classes for about 15 minutes to invite the students to volunteer for the research project. In this first talk, students were told the main objective of the research and what kinds of activities they would be performing in case they decided to participate. In addition, it was emphasized that these activities would have nothing to do with their current English classes in terms of approval or failure. On the other hand, as a kind of motivation, the researcher told them English materials such as dictionaries, readers and a grammar book would be raffled at the end of the data collection among all the students who committed to all the three meetings with the researcher. After one week the researcher came back to the same groups and checked which students would be willing to participate. Volunteers then received the consent form to read and sign (see Appendix A), followed by a more detailed explanation of what they were expected to do during their data collection sessions. Full names, phone numbers and e-mail addresses were collected for further contact and scheduling.

4.7.1 Procedures for the first data collection session

The first data collection session was carried out in April, 2008 and the first task all 100 participants performed was the TOEFL iBT Speaking Test as follows. First, participants were informed that they would listen to a female voice explaining the procedures for the task, followed by a man who would tell them the topic they would have to talk about. To ensure participants would not misunderstand the topic, a written version of the question was given to them while they listened to it. After listening to the question, participants heard a sound signal and a voice indicating they had 15 seconds to plan what they wanted to say. Participants were informed there was no restriction in terms of the content of their planning notes and that they were allowed to use their written notes while recording their answers. At the end of the planning session, a new sound signal and voice informed participants they should start speaking. The end of the task (after 45 seconds) was also indicated by a sound signal. Participants were informed that they were not allowed to interact with the researcher while performing the task and that they should try to full fill the 45 seconds allotted for speaking with intelligible speech (see Appendix M for speech transcriptions). All instructions were given in L1 by the researcher prior to task performance in order to avoid misunderstandings (see Appendix N for instructions).

Right after the TOEFL iBT Speaking Test (on the same data collection session), 50 participants performed the L2 SST and 50 performed the L1 SST. Before starting the training session for the memory span test, participants were informed the SST was a kind of test that measured their capacity to recall words in a certain order and use them to produce oral sentences in English or Portuguese. The researcher emphasized the test required their full attention especially when the words appeared in the computer screen. Before performing the test, a training phase consisting of a three-block test for the L2 SST and of one-block test for the L1 SST was conducted so as to make participants familiar with the procedures. Participants were allowed to repeat the training as many times as they felt necessary. During this time they were free to interrupt and ask any questions they might consider important regarding the execution of the task (see Appendices B and E for the list of words of the training blocks). When participants confirmed they felt comfortable to start, the researcher explained how they would record their answers, gave them a microphone and told them they should not ask questions or stop the test at any moment. They were also explicitly told to keep their sentences short and simple. The researcher also told them that avoiding rehearsal would result in a truer score for the test. Because of that, they were required to start speaking as soon as they heard the signal and visualized the question marks on the screen. To avoid misunderstandings regarding test procedures and requirements, all instructions were given in participants' native language (see Appendix D for the instructions).

4.7.2 Procedures for the second data collection session

In the second data collection session, conducted in May, 2008, participants performed only memory tasks – a SST in L1 or in L2 (depending on what version of the test they had performed in the first data collection session), and the OSpan in L1. The procedures for the SST carried out in the second session were exactly the same applied for the SST already performed in the first data collection session (see subsection 4.7.1). At the end of the SST, the researcher had an informal chat with the participants for 2 to 3 minutes and then introduced the OSpan Test. For this test, the researcher explained to participants they would need to focus on the presentation of arithmetic operations besides trying to memorize for further recall the words displayed with each operation. Because the experiment was researcher paced, participants were explicitly told to try to solve the operations as soon as possible avoiding rehearsal of the words. After a set of instructions given in participants' L1 (Brazilian Portuguese), participants performed the training phase which consisted of an OSpan test resembling the real test (see Appendices F and O for the list of operation-word strings used in the training phase and test instructions, respectively) . During this phase, participants were encouraged to ask any questions they had regarding test procedures. When they reported feeling prepared to perform the test, the researcher asked them to hold a microphone to record their answers and instructed them not to interact with the researcher during task performance.

4.7.3 Procedures for the third data collection session

The third and last data collection session was held in May, 2008 for some participants, and in June, 2008 for others. In this session, participants performed two tasks – the picture naming task aiming at assessing speakers' bilingual lexical access in terms of speed retrieval, and the semantic categorization task meant to assess speakers' L2 proficiency level from a narrower perspective. The picture naming task was divided into two parts – the control and the experimental condition. Half of participants performed first the control condition whereas the other half performed the experimental condition first. This procedure was adopted to rule out the possibility of semantic facilitatory effects, found in Prebianca (2007), caused by practicing of the target pictures presented in both conditions. The picture naming task proceeded as follows. First, following Costa et al. (1999), participants were informed that they would see picture-word pairs and that their task was to name the pictures as fast and accurately as possible. They were also told to try to ignore the words and avoid hesitations and self-corrections and/or repetitions while performing the task (see Appendix P for instructions). Differently from most lexical access studies, participants were not allowed to study the 75 pictures along with their expected English names (Costa et al., 1999) before the experiment itself. This procedure was adopted so as not to bias learners' naming responses, since naming accuracy was necessary to determine participants' RT scores, which in turn, were expected to be different for less and more proficient bilinguals. The order of presentation of both pictures and word distractors was randomized. After receiving the instructions, a set of 20 pictures was used as training so that participants could learn the test procedures better (see the list of picture names and word distractors for the training session in Appendix L). This was the opportunity participants had to clarify their doubts and repeat the practice as many times as necessary.

Reaction time data was collected with the help of an E-prime serial response box and a microphone. Because of the high sensitivity of the microphone, speakers were explicitly instructed to avoid coughing, breathing heavily, or doing any other kind of noise with their mouth that could trigger sound capture and consequently, record inadequate RT's. The researcher also emphasized the importance of trying to name the greatest number of pictures correctly and as fast as possible, ignoring the interfering stimuli in the case of the experimental condition. In addition, participants were told that the experimental condition would be longer than the control condition due to the greater number of pictures they would have to name and that once started, the test could not be interrupted. The whole experiment took about 20 to 25 minutes.

The semantic categorization task was much faster, between 5 to 10 minutes. For this task, participants were required to respond whether or not a subordinate noun belonged to the previously presented superordinate category. Participants were told to press 1 on the keyboard if the response was YES and 2 if it was NO. Because the nouns appeared in the computer screen for only 450 ms, the researcher instructed the participants to try to keep focused and respond to the nouns as quickly as they could so that most nouns could be categorized.

The task proceeded as follows. First, a screen containing instructions in participant's L1 (Brazilian Portuguese) and examples in L2 appeared (see Appendix Q for task instructions). The researcher then asked the participants to read the instructions in silence and offered to clarify any question they had before starting the task. When participants reported they had understood the procedures for performing the task, the researcher proceeded to the training session. The training session was composed of a single test block. Within this block, participants were presented with two superordinate categories – food and drink -, and 10 subordinate nouns, displayed for both same- and different-category conditions, mirroring the procedures for the actual experimental session (see Appendix J for the subordinate nouns used in the training session).

During training, participants were required to press 1 if the subordinate noun belonged to the previous presented superordinate category and 2 if not, just like in the experiment itself. The instructions were the same used for the main experiment. At the end of the training session, participants saw a written message in the center of the computer screen indicating an option to repeat training or proceed with the experiment. The message was: *Pressione 1 para repetir o treinamento. Pressione 2 para começar o experimento*[19]. If participants pressed 1, the instruction screen reappeared and the space bar had to be pressed again in order to repeat the training session. If 2 was pressed, the main experiment started. Then L1 instructions for the task were displayed again in the computer screen. Participants pressed the space bar to start the experiment as soon as they felt prepared. The most common difficulty during the training phase reported by

[19] Press 1 to repeat training. Press 2 to start the experiment (author's translation).

most participants was to coordinate the fingers in order to press the correct button on the keyboard. Because of that, most participants asked to repeat the training.

4.8 Summary and Operationalization of Variables

In the present investigation, the assessment of L2 proficiency, working memory capacity and bilingual lexical access was operationalized as shown in Table 8.

Table 8

Summary and operationalization of variables

	Instrument	Measure	Variable
Proficiency	TOEFL iBT Speaking Test	scores ranging from 0 to 4 - less to more proficient speakers, respectively	PROFToe
	L2 Semantic Categorization Task	total number of words correctly categorized excluding non-target categories	TOTCateg
		total number of words correctly categorized including target and non-target categories	TOTGeral
		mean reaction time for categorization including target and non-target categories	meanRTGer
		standardized (z) scores for TOTCateg	zTOTCateg
		standardized (z) scores for PROFToe	zPROFToe
		Mean z scores for TOTCateg and PROFToe	Meanz
	Computed variables	Proficiency index based on TOTCateg highest and lowest quartiles	PRO1
		Proficiency index based on PROFToe highest and lowest quartiles	PRO2
		Proficiency index based on Meanz highest and lowest quartiles	PRO3
WMC	L1 Speaking Span Test	total number of L1 semantically and syntactically sentences produced for words in the exact form and order of presentation (strict score).	SSTL1
	L2 Speaking Span Test	total number of L2 semantically and syntactically sentences produced for words in the exact form and order of presentation (strict score).	SSTL2
	L1 OSpan Test	total number of words recalled only for the mathematical operations accurately solved	OSPan

		total number of words recalled for the mathematical operations solved within the 85% accuracy criterion	OSPerc
	Computed variables	Standardized (z) scores for SSTL1	zSSTL1
		Standardized (z) scores for SSTL2	zSSTL2
		Standardized (z) scores for OSPan	zOSPan
		Mean z scores for zSSTL1 and zOSPan	WCML1z
		Mean z scores for zSSTL2	WMCL2z
Interaction: WMC by Proficiency		WMCL1z multiplied by PRO3	L1byPRO
		WMCL2z multiplied by PRO3	L2byPRO
Bilingual Lexical Access	Picture Naming Task	Mean reaction time responses for pictures accurately named in the control condition	RTctr
		Mean reaction time responses for pictures accurately named in the experimental condition	RTexp
	Computed variables	Standardized (z) scores for RTexp	zRTexp
		Within subject factor with two levels: RTctr and RTexp	COND
		Between subject factor with tow levels:	TASKOrder
		Level1 Level 2	CTRfirst EXPfirst

4.9 Data Analysis

The analysis of data conducted in the present study was done with the Statistical Package for Social Science (SPSS) - Version 10.0, and comprised descriptive statistics, bivariate correlational analyses, multiple regressions, comparison of means, and partial correlations. Due to the exploratory nature of the present study, all correlations were two-tailed and the alpha level for all statistical tests was set at .05. In what follows, the statistical tests run on the data are described.

4.9.1 Descriptive Statistics

Descriptive Statistics were run in order to describe and summarize the basic features of the data gathered for the present study as well as to check for normal distribution of all variables. Determining whether the data were normally distributed helped the researcher to make appropriate methodological decisions regarding the set of inferential statistical tests that would have to be run so as to answer the research questions and hypotheses described previously in this Method chapter. Descriptive statistical analyses included mean, standard deviation, minimum, maximum, skewness and kurtosis scores.

4.9.2 Bivariate Correlational Analysis

The correlational statistics tests applied in the present study aimed at (i) analyzing the relationship between the variables derived from the Semantic Categorization task in order to select an index of L2 proficiency; (ii) checking for inter-rater reliability among TOEFL iBT Speaking Test scores; (iii) verifying whether these scores related to the proficiency scores obtained through the Semantic Categorization task; and (iv) analyzing whether there was a relationship among WMC scores.

4.9.2.1 Indices of L2 proficiency and Inter rater reliability

In order to determine the index of proficiency in L2, two sets of data were analyzed: (1) the mean scores for the TOEFL iBT Speaking Test, and (2) the scores for the L2 Semantic Categorization task. Because the scores for the Semantic Categorization task were found to be normally distributed, Pearson bivariate correlations were run among all the variables. As shown in Table 9, TOTGeral and TOTCateg are highly and significantly correlated. However, though statistically significant, meanRTGer is only weakly correlated to these variables, suggesting that categorization time and number of correctly categorized words might not covary linearly.

Table 9

Pearson Product Moment Correlation Coefficients for Semantic Categorization variables

	TOTCateg	meanRTGer
TOTGeral	.962**	.307**
meanRTGer	.260**	

N= 100

**p < .01

TOTGeral = total number of words correctly categorized including target and non-target categories

TOTCateg = total number of words correctly categorized excluding non-target categories

meanRTGer = mean reaction time for categorization including target and non-target categories

Taking into account that the main purpose of the Semantic Categorization task was to assess participants' level of proficiency in L2 in terms of semantic knowledge, and based on the correlations found among the variables, a methodological decision was made in favor of the TOTCateg variable as an index of L2 proficiency, since it represents the total number of words accurately categorized within the 6 target categories defined (see section 4.6.2 of this Method chapter).

Regarding the TOEFL iBT Speaking Test, the scores yielded by the raters were also found to be normally distributed. As a consequence, Pearson bivariate correlations were run to check for inter-rater reliability. The criteria assumed for accepting the scores for mean calculations (for PROFtoe variable, see Appendices I and R) was to find a positive high significant correlation among the scores of the three raters. As can be seen in Table 10, this criterion was met.

Table 10

Pearson Product Moment Correlation Coefficients for raters' scoring on TOEFL iBT Speaking Test

	RATER2	RATER3
RATER1	.812**	.734**
RATER3	.826**	

N= 100

**p < .01

Although the correlations indicated raters were consistent in their analyses, the correlation between RATER1 and RATER3 was slightly weaker than the others. Because of the restricted range of the rating scale and the amplitude of the response set of the TOEFL iBT Speaking Test, there seems to be room to suspect that the mean on the three raters' scores (PROFToe) is a too broad measure of L2 speaking involving issues of subjectivity (see section 4.6.2 of this Method chapter). Therefore, so as to check whether the TOEFL iBT Speaking Test and the Semantic categorization task were measuring the same construct – L2 proficiency – Pearson bivariate correlations were run. A decision was made to accept only a positive moderate to strong statistically significant correlation between TOTCateg and PROFToe. As displayed in Table 11, the correlation was positive and significant at $p<.01$, indicating that the two proficiency measures may be tackling similar aspects of speech production. Because of that, both TOTCateg and PROToe were taken into consideration when addressing the research questions and hypotheses dealing with L2 proficiency.

Table 11

Pearson Product Moment Correlation Coefficients for indices of proficiency

	PROFToe
TOTCateg	.557**

N= 100

**p < .01

4.9.2.2 Indices of WMC

WMC was assessed in the present study by means of the SST (monolingual and bilingual versions) and the OSpan (monolingual version). Two different criteria were used to calculate the scores for the OSpan. Whereas the first criterion took into account the total number of words correctly recalled only for a 100% of the mathematical operations accurately solved (OSPan), the second referred to the total number of words correctly recalled for 85% of the operations correctly solved (OSPerc). Both OSpan scores were found to be normally distributed. Pearson bivariate correlations showed that OSPan and OSPerc were highly and significantly correlated, indicating that the different scoring procedures yielded similar results, as can be seen in Table 12 below.

Table 12

Pearson Product Moment Correlation Coefficients for OSpan scores

	OSPerc
OSPan	**.927****

N= 100

**p < .01

Based on the just reported results and so as to have a measure of the OSpan which approximates the scoring criteria followed to calculate the scores for the SST's used in the present study, only the variable OSPan was included in the statistical tests dealing with WMC, more specifically, the ones addressed by research questions 2 and 3, and their respective hypotheses.

4.9.2.2.1 WMC Estimates of Reliability

Because the WMC tests applied in the present study are adaptations of original tests, internal-consistency estimates of reliability were calculated for the OSpan, the SST in L1, and the SST in L2 by using the Cronbach alpha statistical procedure. In order to get a Cronbach alpha coefficient for each WMC test, all items (total number of trials of the test; e.g. the Ospan had 42 trials) from each test were converted into the same scale, in which 1 referred to a correct-response trial and 0 referred to an incorrect or no-response trial. As can be seen in Table 13, reliability estimates ranged from .87 to .90, indicating satisfactory reliability (see Cronbach, 1990).

Table 13

WMC estimates of reliability

	Ospan	SSTL1	SSTL2
Coefficient alpha	.90	.87	.87

4.9.3 Multiple Linear Regressions

Multiple regressions were run in order to test whether WMC and proficiency significantly predicted bilingual lexical access (research question 1). This statistical procedure was applied due to the fact that it supports continuous rather than nominal data, which allowed for the inclusion of the proficiency scores for all 100 participants. By running multiple regressions, it was also possible to establish how much of the variance in bilingual lexical access was accounted for by WMC and L2 proficiency only and how much by the interaction between the two variables.

Two regression analyses were carried out. The first one regarded the contribution of WMC to bilingual lexical access as measured by L1 memory span tests (L1 SST and OSpan). In order to have a strength-of-relationship index which indicated the degree to which WMC in L1 predicts bilingual lexical access, a new variable was computed so as to encompass SSTL1 and OSPan measures in a single index. The new variable -WMCL1z – was calculated by turning SSTL1 and OSPan into z scores and averaging them. The second multiple linear regression dealt with the predictive power of WMC to bilingual lexical access as measured by the L2 SST. In order to investigate the strength of this relationship, another new variable, **zsstL2** was computed by standardizing SSTL2 scores.

For both multiple linear regressions run, two measures of proficiency were analyzed: TOTCateg and PROFToe. However, in order for them to be in line with the variables for WMC in L1 and in L2, TOTCateg and PROFToe were also transformed into standardized scores and averaged. The resulting variable is herein called Meanz.

Finally, the last independent variables to be included in the multiple regression models were L1byPRO and L2byPRO. These composite variables were computed by multiplying WMCL1z by Meanz and zsstL2 by Meanz, respectively, and aimed at investigating whether there was an interaction between WMC and L2 proficiency in predicting bilingual lexical access. The interaction variables were inserted in the second block within the regression models, whereas the WMC and proficiency variables were inserted together in the first block as a different set of predictors.

In order to identify outliers in the data, WMCL1z, zsstL2, and Meanz were regressed onto zRTexp with the aim of obtaining Cook's *D* statistic for each participant. The maximum Cook's *D* found was .146 for WMCL1z and Meanz, and .154 for zsstL2 and Meanz. Because all Cook's *D* values obtained in the data were less than 1(a value that is usually considered large and an indication that a particular participant is an outlier; see Cook, 1977), no participant was considered an outlier.

4.9.4 One Way Repeated Measures ANOVA

This statistical procedure aimed at analyzing whether semantically related L2 word distractors facilitated bilingual lexical access in terms of retrieval speed, taking into consideration task order effects (research question 2). In order to do so, a within-subjects factor was defined in the General Linear Model Repeated-Measures procedure, named COND. This variable was composed of two levels, representing subjects' scores on RTexp and RTctr. The between-subjects factor was defined in the model as TASKOrder and also comprised two levels – CTRfirst and EXPfirst.

4.9.5 One Way Analysis of Covariance – ANCOVA

The ANCOVA procedure was run so as to analyze whether the mean retrieval speed of lexical access for more and less proficient bilinguals differed irrespective of task order effects (research question 2). Therefore, following the ANOVA procedure, the within-subjects factor was COND with two levels – Rtexp and RTctr. The between-subjects factor, on the other hand, regarded main effects for L2 proficiency and was defined as PRO1 for the first ANCOVA test, PRO2 for the second, and PRO3 for the third one. All between-subjects factors had two levels – more and less proficient bilinguals. The respective levels were computed by checking for the upper and lower quartiles of the distribution of each proficiency variable (see Appendix R for descriptive statistics and frequencies).

For PRO1(proficiency index based on TOTCateg), the upper quartile refers to subjects who scored 55 or higher and the lower quartile refers to subjects who scored 45 or lower, resulting in a *N* of 26 in each proficiency level. For PRO2 (proficiency index based on PROFToe), the upper and lower quartiles included subjects who 3.67 or higher, and 1.67 or lower, respectively. The total *N* for more proficient bilinguals was 21, whereas for less proficient ones it was 22. Regarding PRO3 (proficiency index based on Meanz), the upper quartile includes subjects who scored .74 or higher, and the lower quartile comprises subjects who scored .64 or lower, resulting in a *N* of 24 subjects in each proficiency level.

The covariate inserted in the model so as to evaluate whether the means for more and less proficient bilinguals were the same across the levels of the within-subjects factor - RTexp and RTctr, was defined as TASKOrder with two levels - CTRfirst and EXPfirst, following the ANOVA procedures.

4.9.6 Partial Correlations

The partial correlations run in the present study attempted to evaluate the degree to which L2 proficiency contributed to WMC when measured by memory span tests in L1, such as the L1 SST and the OSpan, and when measured by a memory span test in L2, such as the L2 SST. With this statistical procedure it was possible to determine an effect size index for particular variables, partialling out the effects of a control variable. Therefore, because in the present study two measures of proficiency and three measures of WMC were calculated, 6 partial correlations were run separately.

The first set of partial correlations dealt with WMC, as measured by the L1 SST, and proficiency as represented by TOTCateg and PROFToe. Within this set, the first analysis regarded the effects of TOTCateg on WMC, controlling for PROFToe, whereas the second analysis referred to the effects of PROFToe on WMC, holding constant TOTCateg. The second and third sets of partial correlations followed exactly the same testing order as regards to proficiency measures, but differed in terms of WMC measures. Whereas the second evaluated the contributions of proficiency to WMC as measured by the L2 SST, the third one referred to proficiency effects on WMC, as measured by the OSpan.

CHAPTER 5

RESULTS

This chapter reports the results of the statistical analyses conducted so as to address the research questions and hypotheses presented in the method chapter of this dissertation. To reiterate, the present study pursued three main objectives – (i) to investigate whether bilingual lexical access was predicted by WMC and L2 proficiency; (ii) to investigate whether WMC and L2 proficiency interacted in predicting bilingual lexical access; and (iii) to examine the extent to which within-language competition affects bilingual lexical access. These objectives were addressed by two research questions and five hypotheses. Research question 1 and hypotheses 1 to 4 dealt with the relationship between WMC, L2 proficiency and bilingual lexical access. Research question 2 and hypothesis 5 assessed the effects of semantically related L2 word distractors on bilingual lexical access in terms of retrieval speed.

This chapter is organized into five main sections. Section 1 presents the results for the descriptive statistical analyses run on all working memory, proficiency and lexical access variables. Section 2 reports the results of the multiple linear regressions, partial correlations and analyses of covariance – ANCOVA - run to answer research question 1 and address hypotheses 1 to 4. In section 3, the results for the comparison of means - ANOVA procedures, are presented in order to address research question 2 and hypothesis 5. Finally, section 4 outlines the summary of all findings and their respective hypotheses.

5.1 Descriptive statistics

As previously described in the Method chapter of this dissertation (see section 3.8), three measures of WMC - SSTL1, SSTL2 and OSPan -; two measures of L2 proficiency – TOTCateg and PROFToe; and two measures of bilingual lexical access – RTctr and RTexp – comprised the main set of variables analyzed in the present study. In order to obtain an overview of the data represented by those variables as well as to check for normal distribution, descriptive statistical analyses were run. Table 14 displays the results.

Table 14

Descriptive Statistics for WMC, proficiency and lexical access

	Min.	**Max.**	***M***	***SD***	**Skeweness**	**Std. Error**	**Kurtosis**	**Std. Error**
Working Memory Capacity								
SSTL1	6	42	23.84	8.24	.043	.241	-.635	.478
SSTL2	1	38	13.62	7.53	.787	.241	.411	.478
OSPan	1	40	15.96	8.68	.432	.241	-.388	.478
Proficiency								
TOTCateg	30	60	49.44	6.91	-.870	.241	.475	.478
PROFToe	1	4	2.64	.91	-.132	.241	-1.098	.478
Lexical Access								
RTcontr	472	1216	877.10	166.54	-.245	.241	-.579	.478
RTexp	469	1300	851.05	137.60	.191	.241	.901	.478
N= 100								

As can be seen in Table 14, the scores for all WMC, proficiency and lexical access variables were found to be normally distributed. Regarding WMC, the lowest score found was for the L2 SST - 22.7 % of a possible total score of 60. The overall means of the L1 SST and the OSpan were also relatively higher than the mean for the L2 SST, 39.7% and 38% of possible total scores of 60 and 42, respectively. Together these results appear to indicate that, in general, subjects obtained a better performance in the WMC tests in L1 than in L2. It should be pointed out, however, that the maximum possible span scores for the SST's and the OSpan were different.

As regards L2 proficiency, two interesting results were found. First, for PROFToe the maximum possible score was obtained – 4. Second, the *SD* for PROFToe, apparently lower than the *SD* for TOTCateg, was, in fact, proportionally higher since it corresponds to 34.5% of the *Mean* and 22.8% of the total score obtained in this test – 4. Regarding TOTCateg, the *SD* corresponds to only 14% of the *Mean* and 11.5% of the maximum score obtained for this test - 60.

For the RT control (RTcontr) and experimental (RTexp) variables, minimum and maximum scores could vary from 0 to 1500 milliseconds, which was the interval of time participants had to name each picture. In this case, higher scores represent longer reaction times, whereas lower scores correspond to faster responses. An interesting result displayed in Table 14 is that the mean for RT scores in the control condition was higher than the mean for RT scores in the experimental condition (M = 877.10 and M = 851.05, respectively). These results point to a facilitation effect of semantically related L2 word distractors on picture-naming. That is, subjects actually took longer to name pictures without any interfering stimuli than when pictures were presented with word distractors. Nevertheless, further mean comparisons and analyses of variance are necessary in order to ensure this difference is of statistical significance and is not only an effect of task order (see section 5.3).

5.2 WMC, proficiency and bilingual lexical access

The main objective of this study was to investigate whether WMC and L2 proficiency predicted bilingual lexical access in terms of retrieval speed. A related and also important goal was to verify whether both constructs – WMC and proficiency – would interact in predicting variances in bilingual lexical access scores. It has been argued in the literature on bilingual language selection and lexical access that an important issue is to find out the extent to which working memory capacity constrains language switch and affects the selection of words across languages (Kroll et al., 2005). However, it seems that for one to understand the effects of WMC on bilingual language selection and word retrieval across languages it is necessary to have a clear picture of how both processes might be affected by WMC within the non-dominant language (L2). Therefore, in order to examine the contribution of WMC to bilingual lexical access, multiple linear regression analyses of WMC in L1 and in L2 onto bilingual lexical access were run separately.

For the first regression analysis, the first predictor - WMC in L1 -, was operationalized by transforming SSTL1 and OSPan into standardized scores and averaging them, yielding WMCL1z. The second predictor – Meanz, was obtained by calculating the z scores for indices of proficiency in L2 - TOTCateg and PROFToe – and averaging them. The criterion variable - bilingual lexical access, in turn, was measured by calculating mean reaction time responses for pictures accurately named in the experimental condition of the picture-naming task (RTexp) and transforming them into standardized scores, yielding zRTexp. WMCL1z and Meanz were entered in the regression model first, whereas the interaction of both variables – L1byPRO (calculated by multiplying WMCL1z by Meanz) was entered second. As can be seen in Table 15, results of the first multiple regression showed that WMC in L1 and L2 proficiency significantly predicted bilingual lexical access. Together they accounted for 41% of the variance in zRTexp: $F(2, 97) = 33.72$, p=.000.

Table 15

Regressions of WMC and proficiency on bilingual lexical access

	zRTexp (criterion)						
Predictors	*N*	R^2		B	Zero	Partial	Semi
Regression WMC in L1							
1st set							
			WMCL1z	-.330	-.507*	-.364*	-.300*
WMCL1z + Meanz	100	.410*	Meanz	-.429	-.566*	-.453*	-.391*
2nd set							
L1byPro	100	.419	L1byPro	-.096	-.006	-.120	-.092
Regression WMC in L2							
1st set							
			zSSTL2	-.185	-.452*	-.182	-.150
zSSTL2 + Meanz	100	.342*	Meanz	-.458	-.566*	-.416*	-.371*
2nd set							
L2byPro	100	.347	L2byPro	.079	.034	.087	.071

*p<.05

As individual predictors, WMCL1z and Meanz both proved to contribute uniquely to zRTexp: t = -3,85, p = .000 and t = -5.01, p = .000, respectively, as depicted in Figure 1.

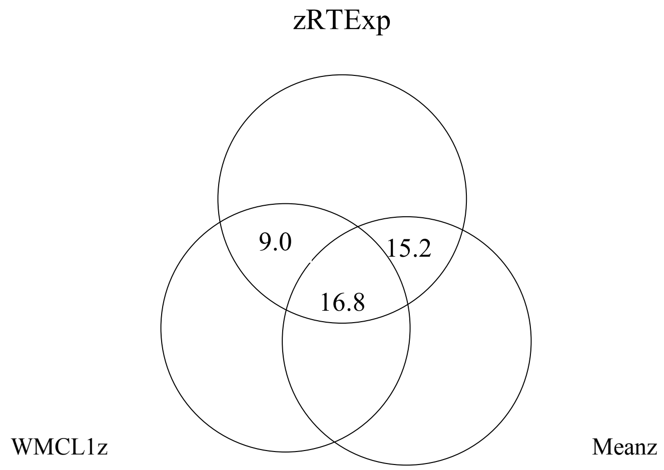

Figure 1. Percentage of unique and shared contributions of WMC in L1 and L2 proficiency to bilingual lexical access

However, no interaction effect for L1zbyPRO was found since its unique contribution to zRTexp was less than 1% [t = -1.18, p = .239], as can be clearly observed in Figure 2.

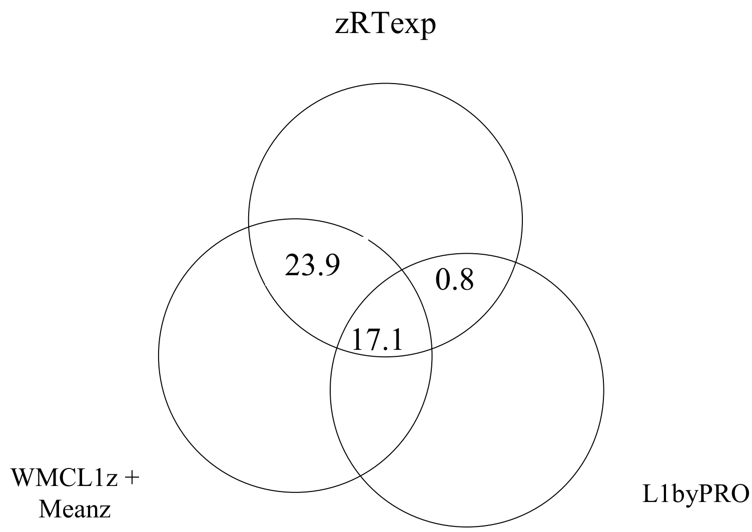

Figure 2. Percentage of unique and shared contributions of WMC in L1 plus L2 proficiency as a single set of predictors and of the interaction between these variables (L1byPRO) to bilingual lexical access

To address more directly how much WMC in L2 contributed to predicting bilingual lexical access above and beyond WMC in L1 and so as to examine how much of the variance in the criterion variable (bilingual lexical access) was determined by L2 proficiency and by the interaction of these two predictors (WMC and proficiency), zSSTL2 and Meanz were regressed onto zRTexp. The first set of predictors included in the model comprised a measure of WMC in L2 – zSSTL2, obtained by standardizing the scores for SSTL2; and the average for standardized scores of L2 proficiency (Meanz) – zTOTCtaeg and zPROFToe. The interaction between WMC in L2 and L2 proficiency – L2byPRO (calculated by multiplying zSSTL2 by Meanz) was entered second in the regression model, as a separate set of predictors. Table 15 above displays the results.

Together, zSSTL2 and Meanz accounted for about 34% of the variance in zRTexp: $F(2, 97) = 25.25$, $p = .000$. As can be seen in Figure 3, the unique contribution of WMC in L2 was much smaller (only a little more than 2%) than the unique contribution of L2 proficiency and not statistically significant: $t = -1.824$, $p = .071$.

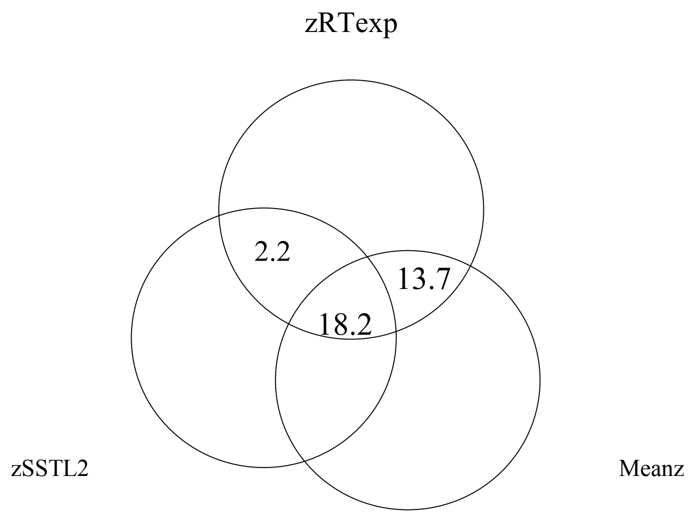

Figure 3. Percentage of unique and shared contributions of WMC in L2 and L2 proficiency to bilingual lexical access

On the other hand, L2 proficiency contributed significantly above and beyond WMC in L2 (about 18%): $t = -4.51$, $p = .000$. The interaction effect of WMC in L2 and L2 proficiency on bilingual lexical access did not reach statistical significance either, since L2byPRO unique contribution was again less than 1% [$t = .857$, $p = .394$], mirroring the results of the first multiple regression, as shown in Figure 4.

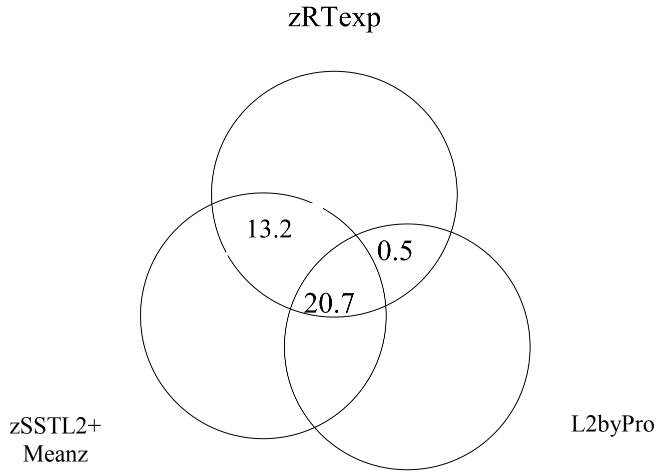

Figure 4. Unique and shared contributions of WMC in L2 plus L2 proficiency as a single set of predictors and of the interaction between these variables (L2byPRO) to bilingual lexical access

In sum, the multiple regression results suggest that, though WMC in L1 and in L2, and L2 proficiency together significantly predict a proportion of the variance in bilingual lexical access (supporting Hypothesis 1), it seems that the predictive power of the L2 SST is rather reduced when entered in the regression model together with a measure of L2 proficiency. Put differently, because SSTL2 and Meanz are significantly correlated ($r(100) = .584$, p = 000), zSSTL2 loses power when explaining bilingual lexical access in the presence of Meanz. A post hoc analysis showed that this was in fact the case. When WMC in L2 was inserted in the regression model as a separate set of predictors (apart from proficiency), its main effect proved to be statistically significant: $t = -5.02$, p = .000 (see Appendix U).

A strong relationship between WMC in L2 and L2 proficiency is further supported by the results of zero order and partial correlations run with the two proficiency variables – PROFToe and TOTCateg - , separately, as can be seen in Table 16.

Table 16

Zero order and partial correlations among L2 proficiency and working memory capacity

	Zero order correlations	**Partial correlations**
		Controlling for PROFToe
SSTL1 X TOTCateg	**.409***	**.321***
SSTL2 X TOTCateg	**.492***	**.275***
OSPan X TOTCateg	**.337***	**.279***
***p<.05**		
N = 100		
		Controlling for TotCateg
SSTL1 X PROFToe	**.273***	**.060**
SSTL2 X PROFToe	**.538***	**.365***
OSPan X PROFToe	**.197***	**.012**
***p<.05**		
N = 100		

Zero order correlational analyses revealed significant relationships between L2 proficiency (TOTCateg and PROFToe) and the L2 SST. Likewise, holding constant one of the L2 proficiency measures, partial correlations also showed that both –

TOTCateg and PROFToe contributed uniquely to SSTL2 at a p value <.05. Shared and unique contributions of these variables can be observed in Figure 5.

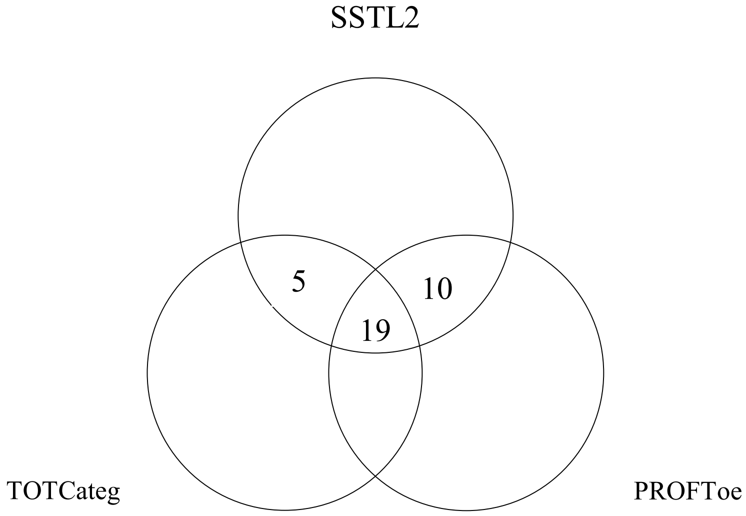

Figure 5. Percentage of unique and shared contributions of L2 proficiency to WMC in L2 as measured by the L2 SST

As displayed in Table 16, partial correlations also revealed that TotCateg is a better predictor than PROFToe for the SST in L1 and OSpan. However, it is not for the SST in L2. PROFToe does not predict SST L1 and OSpan uniquely. However, it does predict SST L2 over and above TotCateg. Shared and unique contributions of TOTCateg and PROFToe to SSTL1 and OSPan can be seen in Figures 6 and 7, respectively.

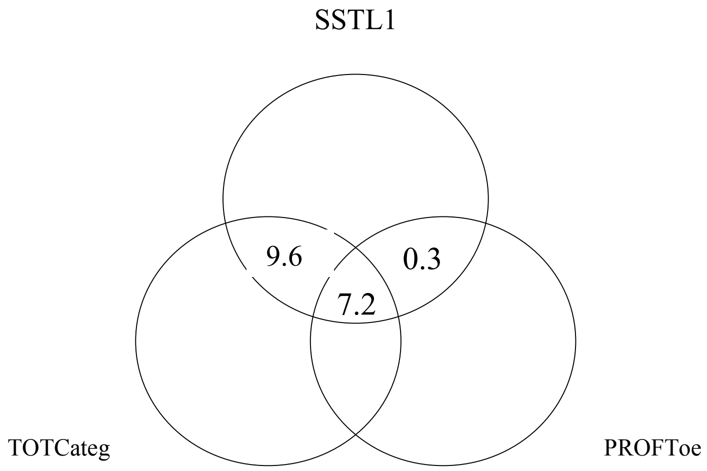

Figure 6. Percentage of unique and shared contributions of L2 proficiency to WMC in L1 as measured by the L1 SST

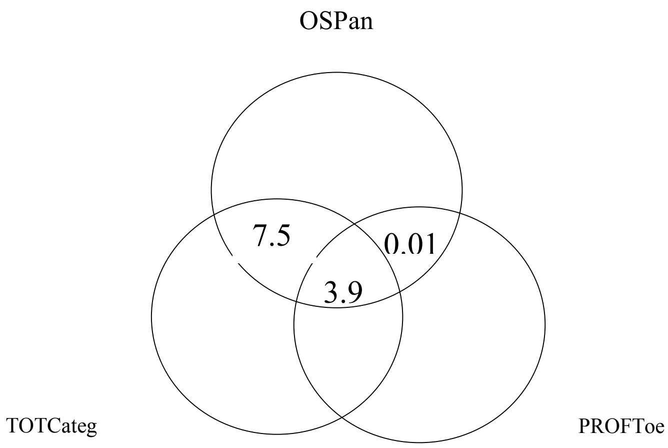

Figure 7. Percentage of unique and shared contributions of L2 proficiency to WMC in L1 as measured by the OSpan

The results of zero order and partial correlations just reported indicate that L2 proficiency significantly explains a proportion of the variance in WMC, as measured by the SST in L2 (the shared contribution of TOTCateg and PROFToe to SSTL2 is 19%), supporting the claim that the L2 SST confounds WMC and proficiency (Finardi, 2009)

WMC in L1 (SSTL1 and OSPan), on the other hand, even being entered in the regression model together with L2 proficiency as a single set of predictors, contributed significantly to explaining a proportion of the variance in zRTexp, thus rejecting the initial prediction that L2 lexical access would be best predicted by the L2 SST (Hypothesis 2).

Regarding individual differences in WMC in L1 and in L2, and in proficiency level in relation to bilingual lexical access (Hypotheses 3 and 4), current approaches to bilingual language selection and consequently to lexical access assume that the extent to which proficiency in L2 develops, knowledge of the target language becomes more automatic, freeing attentional resources and leading to a faster and more accurate retrieval of L2 lexical items (Kroll et al., 2002; 2005). Despite the relative triviality that such an assumption might imply, there seems to be reason to argue that it is still not clear to what extent attention/working memory capacity and knowledge of the language (L2 proficiency) determine language selection (Kroll et al., 2005).

Equally important, however, is the need to understand the extent to which proficiency by itself contributes to the selection of L2 lexical items in a task in which subjects, besides having to deal with weaker lexical alternatives (to use Kroll's et al., 2005 terminology), and this implies fighting off L1 interference (the dominant language), presumably need to employ a greater amount of controlled attention so as to inhibit lexical competitors within the language-in-use, delimiting the appropriate search set and maintaining active access to it while serially searching for the correct lexical item (Unsworth and Engle, 2007). With that in mind, a further objective of the present study was to investigate whether higher and lower spans and more and less proficient bilinguals would differ in the performance of an attention consuming task such as picture-naming in L2 under the interference of semantically related L2 word distractors, as previously stated in the third objective and second research question of this investigation (see sections 3.1 and 3.2 of the Method chapter).

To this end, subjects were divided into groups of higher and lower spans, and less and more proficient bilinguals. Higher spans and more proficient bilinguals were the ones who scored 1 standard deviation above the mean, whereas lower spans and less proficient ones were those who scored 1 standard deviation below the mean. In this case, because the variables WMCL1z and Meanz were standardized scores, the mean was zero for both and the calculations computed to determine their respective *SD* were based on their beta coefficients in the regressions described (see Table 15 in this section and Appendix S for the calculations).

Recall that Hypothesis 3 predicted that higher spans would retrieve lexical items faster than lower spans. As depicted in Figures 8 and 9, this prediction was confirmed since higher spans obtained shorter naming response times than lower spans irrespective of proficiency level. In addition, more proficient bilinguals were faster than less proficient ones irrespective of WMC. Within the less proficient group, for instance, both high and low spans were slower than high and low spans within the more proficient group. These results also support Hypotheses 4 which predicted that more proficient bilinguals would retrieve lexical items faster than less proficient ones.

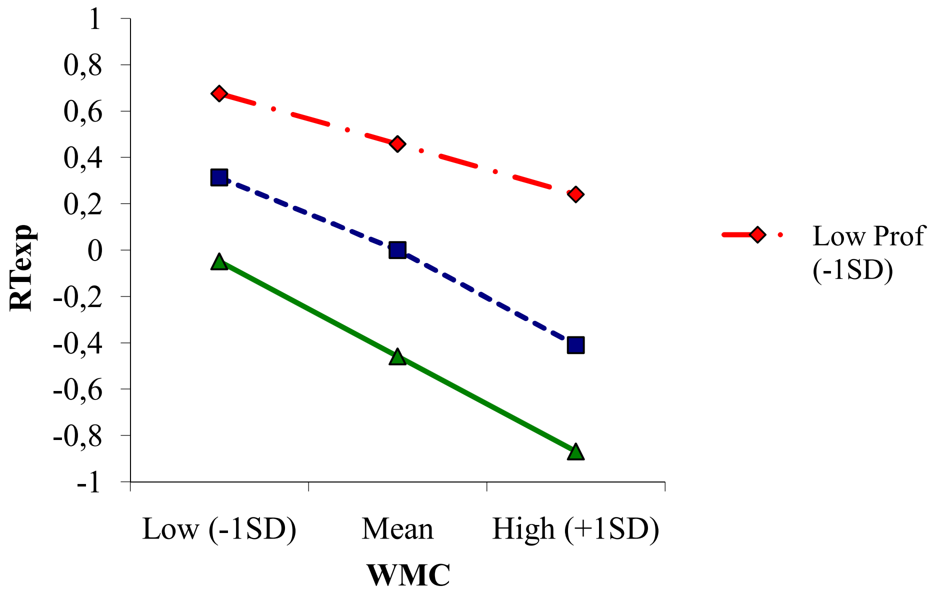

Figure 8. Less and more proficient bilinguals' and higher and lower spans' (WMC in L1) behavior in bilingual lexical access (mean standardized scores for RTexp)

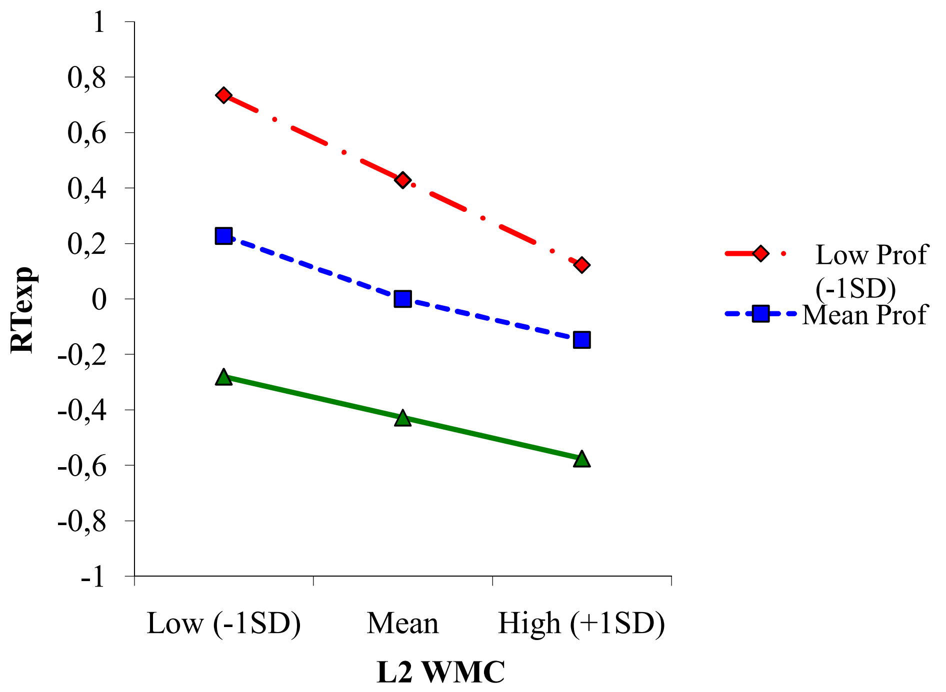

Figure 9. Less and more proficient bilinguals' and higher and lower spans' (WMC in L2) behavior in bilingual lexical access (mean standardized scores for RTexp)

Hypothesis 4 also predicted that more proficient bilinguals would outperform the less proficient ones regardless the order in which the control and experimental conditions were performed. To test this hypothesis, 2 x 2 x 1 analyses of covariance (ANCOVA) were run with condition as a within-subjects factor (RTctr and RTexp), proficiency as a between-subjects factor (more and less proficient bilinguals), and task order as a covariate (CTRfirst and EXPfirst). The first ANCOVA was run with the proficiency index based on TOTCateg highest and lowest quartiles – PRO1. The second procedure was computed considering the proficiency index based on PROFToe highest and lowest quartiles - PRO2. Finally, the third ANCOVA analyzed the variable PRO3 – the proficiency index based on Meanz (the mean standardized scores for TOTCateg and PROFToe) highest and lowest quartiles. Table 17 displays the means and standard deviations for the variables included in the analyses of covariance.

Table 17

Means and standard deviations by Condition and Proficiency

		Condition	
		RTctr	**RTexp**
PRO1	**More proficient**		
	M	786.69	775.77
	SD	138.85	102.30
	N=26		
	Less proficient		
	M	962.77	938.23
	SD	151.78	133.81
	N=26		
		RTctr	**RTexp**
PRO2	**More proficient**		
	M	779.19	755.24
	SD	146.59	110.59
	N=21		
	Less proficient		
	M	963.82	938.64
	SD	151.18	135.50
	N=22		
		RTctr	**RTexp**
PRO3	**More proficient**		
	M	812.96	771.29
	SD	153.23	111.18
	N=24		
	Less proficient		
	M	984.42	956.29
	SD	160.60	130.29
	N=24		

Results for the first ANCOVA revealed that the main effect for proficiency based on PRO1 scores was significant: $F(1, 49) = 27.94$, p=.000. Partial η2 indicated that 36% of the variance in Condition was accounted for by L2 proficiency, after partialling out task order effects. Regarding the results for PRO2, the second ANCOVA revealed a main effect for proficiency: $F(1, 40) = 28.95$, p=.000, after partialling out task order effects. The partial η^2 of .42 also suggests a strong relationship between Condition and Proficiency. A similar pattern was found for PRO3 since the main effect was also statistically significant: $F(1, 45) = 27.75$, p=.000, controlling for task order effects. Partial η^2 indicated that 38% of the variance of the dependent variable (Condition) was accounted for by proficiency, holding constant the covariate (Task order).

In sum, as can be seen in Table 17, the means for the more proficient bilinguals as measured by all three proficiency indexes were higher than the means for the less proficient ones. Mean differences proved to be statistically significant after partialling out the effects of task order, as revealed by the ANCOVA procedures. These results support Hypotheses 4, showing that more proficient bilinguals were faster than less proficient ones irrespective of performing the control or the experimental condition first, as can be easily observed in Figures 10, 11 and 12.

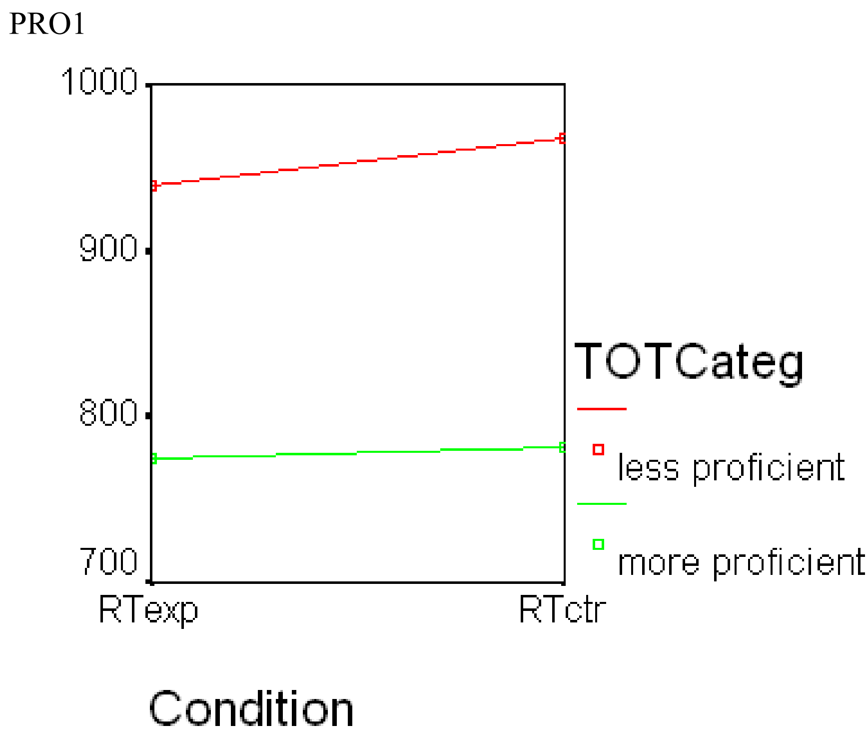

Figure 10. Less and more proficient bilinguals' behavior in RTctr and RTexp based on TOTCateg standardized scores

PRO2

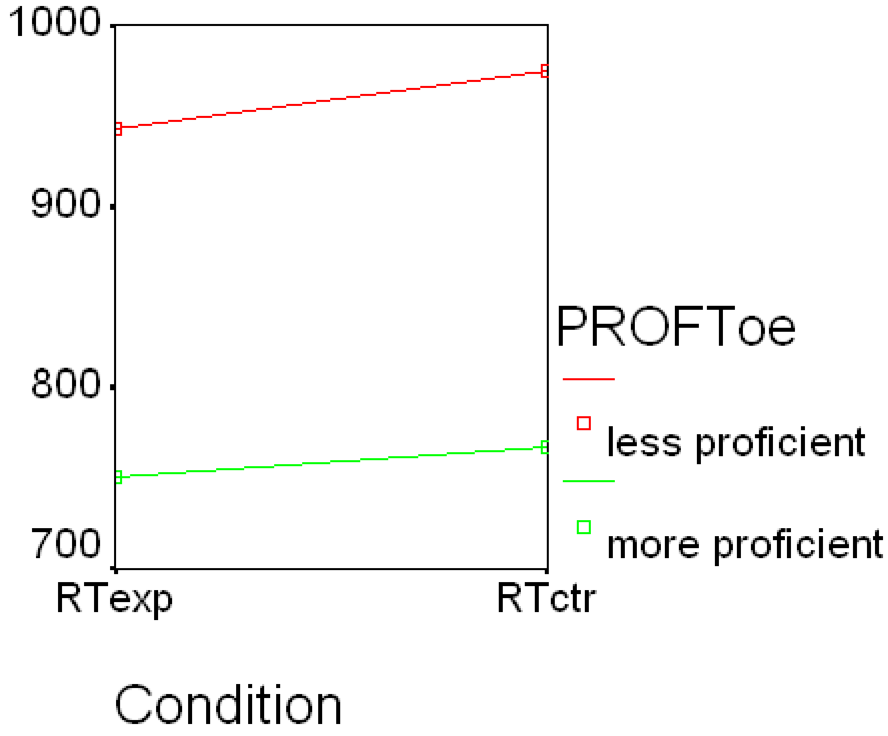

Figure 11. Less and more proficient bilinguals' behavior in RTctr and RTexp based on PROFToe standardized scores

PRO3

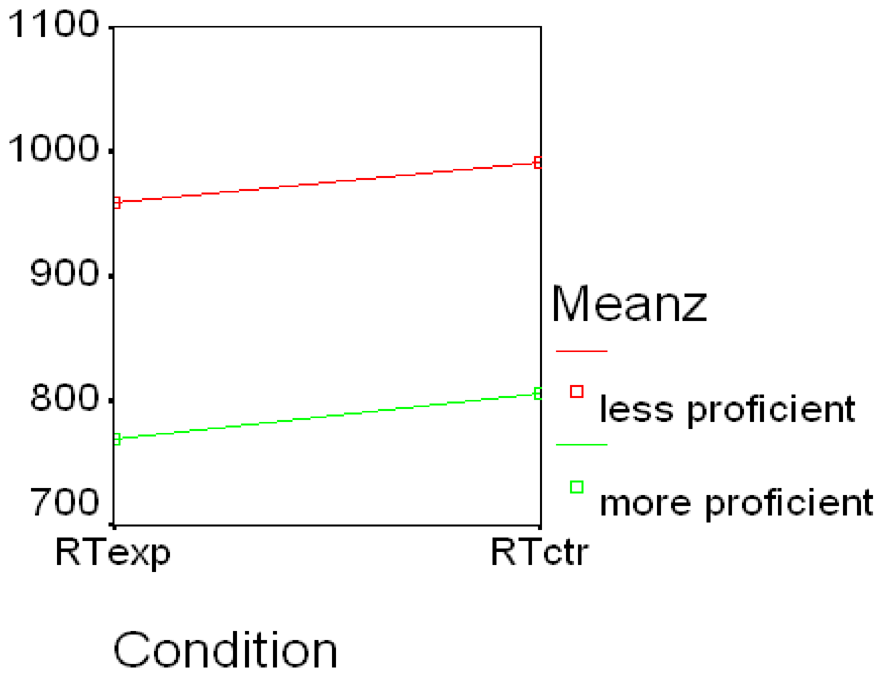

Figure 12. Less and more proficient bilinguals' behavior in RTctr and RTexp based on the mean standardized scores for TOTCateg and PROFToe

5.3 Semantically related word distractors and bilingual lexical access

The issue of whether the selection of words from the bilingual lexicon is facilitated or inhibited by the simultaneous activation of lexical items in both languages seems to depend largely on two factors: (1) whether distractors resemble any semantic or phonological activation to the item being retrieved, and (2) whether the distractors are presented in the language-in-use or as equivalent translations in the language-not-in-use. Either one way or the other, competition for selection cannot be ruled out from the lexical retrieval process, which in L2 entails the ability to (i) use external and internal cues to adequately delimit the search set, (ii) perform a serial search for the correct lemma (to use Levelt's (1989) terminology), and (iii) monitor for correct lexical selection in the face of interference (Unsworth and Engle, 2007). This ability, in turn, seems to tackle the very basic processes carried out by working memory in the performance of higher order cognitive tasks because it is only possible through controlled attention. In addition, because of the less automatized nature of the L2 retrieval processes (Kormos, 2006), it is likely that the serial search for the correct lemma under the interference of related distractors is even more cognitively demanding for less proficient bilinguals who seem to handle an incomplete L2 knowledge base in terms of lexical, syntactic and phonological specifications (Poulisse, 1993).

Therefore, as an attempt to unveil competition for selection issues and their relationship to L2 proficiency, analyses of means were run so as to investigate the effects of semantically related word distractors in the language-in-use on the retrieval speed of L2 lexical items. In order to specifically address Hypothesis 5, which, based on previous results (Prebianca, 2007), predicted that the mean retrieval speed of lexical access in bilinguals would be facilitated by semantically related L2 word distractors, a 2 X 2 mixed-model factorial ANOVA was run with condition (RTctr, RTexp) as a within-subjects factor and task order (controlfirst, experimentalfirst) as a between-subjects factor. Table 18 displays the means and standard deviations for each variable in the ANOVA procedure.

Table 18

Means and standard deviations by Condition and Task Order

Task Order			Condition	
			RTctr	**RTexp**
	Control First			
		M	888.78	823.16
		SD	157.63	143.07
	N=50			
	Experimental First			
		M	865.42	878.94
		SD	175.82	127.27
	N=50			

As can be seen in Table 18, the means for both conditions – RTctr and RTexp, show a different pattern varying, from slower to faster response times depending on the order in which conditions were performed. The ANOVA results revealed the main effect for condition was marginally significant, $F(1, 98) = 3.81$, p = .054. The effect for task order, on the other hand, was not, $F(1, 98) = .352$, p = .554. More importantly, however, condition interacted significantly with task order, $F(1, 98) = 8.79$, p = .004, suggesting that the facilitation effect of semantically related L2 distractor words on the retrieval speed of lexical access in bilinguals depends on task order. That is, the facilitation effect depends on whether subjects performed the control or the experimental condition first. After examining the interaction effect in Figure 13, it is evident that for subjects who performed the control condition first, RTexp was faster and RTctr was slower, whereas for subjects who did the experimental condition first, RTexp was slower and RTctr was faster. These results partially support Hypothesis 5.

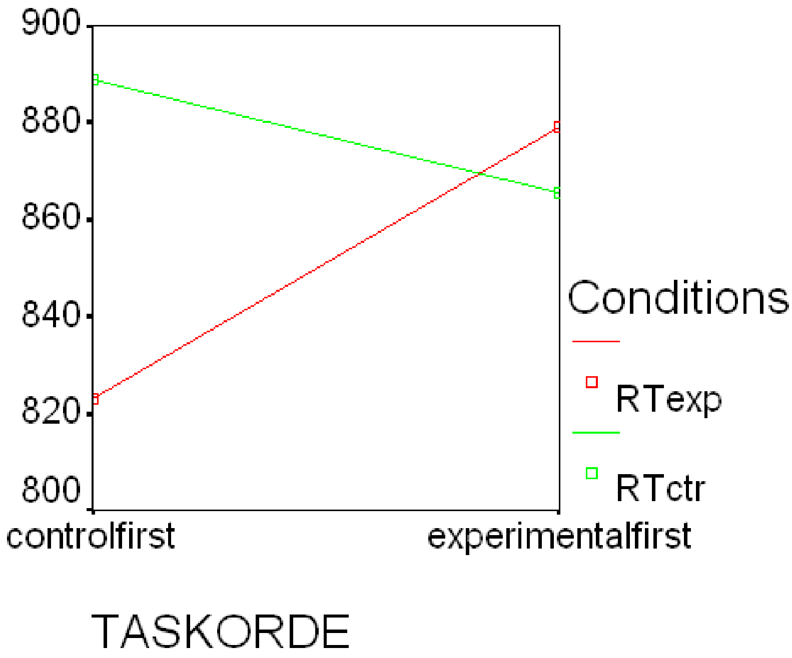

Figure 13. Interaction between Condition and Task Order in bilingual lexical access

5.4 Summary of Hypotheses and Results

Table 19 displays a summary of the results obtained through the statistical analyses carried out in order to answer the research questions and hypotheses raised in the Method chapter of the present dissertation.

Table 19

Summary of hypotheses and major results

HYPOTHESES	INITIAL PREDICTIONS	MAJOR RESULTS
Hypothesis 1	*Working memory capacity and L2 proficiency will both predict bilingual lexical access*	**Supported**. WMC and L2 proficiency significantly predict bilingual lexical access. Main effects for WMC in L1 and L2 proficiency were significant. The main effect for WMC in L2 was only significant in the absence of L2 proficiency.
Hypothesis 2	*Working memory capacity, as measured by the L2 SST, will be a better predictor of bilingual lexical access than working memory capacity as measured by the L1 SST and the OSpan*	**Not supported**. The main effect for WMC in L2 was not significant. WMC as measured by the L1 SST and the OSpan is a better predictor of bilingual lexical access than WMC as measured by the L2 SST.
Hypothesis 3	*Higher spans will retrieve lexical items faster than lower spans*	**Supported**. High spans were always faster than lower spans, regardless of proficiency level.
Hypothesis 4	*More proficient bilinguals will retrieve lexical items faster than less proficient bilinguals irrespective of task order*	**Supported**. More proficient bilinguals were always faster than less proficient bilinguals, regardless of WMC and task order. Partialling out the effects of task order, the mean retrieval speed of lexical access for more and less proficient bilinguals proved to be statistically different for all 3 measures of proficiency. That is, less proficient bilinguals were slower than more proficient ones regardless of performing the control or the experimental condition first
Hypothesis 5	*The mean retrieval speed of lexical access in bilinguals will be facilitated by L2 semantically related word distractors*	**Partially Supported.** The facilitation effect of semantically related L2 word distractors on the retrieval speed of lexical access in bilinguals depends L1 WMC X Proficiency level on whether subjects performed the control or the experimental condition first.

The following chapter presents the discussion of the results reported above in light of the literature reviewed in Chapters 2 and 3, addressing, mainly issues regarding the interplay between automatic and controlled processes on memory retrieval and on the development of L2 proficiency and L2 lexical representations.

CHAPTER 6

DISCUSSION

The aim of this chapter is to discuss the results of the statistical analyses carried out in order to investigate the relationship between individual differences in WMC, bilingual lexical access and L2 and proficiency level in L2 speech production. The chapter is divided into three main sections. Section 6.1 deals with the predictive power of WMC and L2 proficiency to bilingual lexical access by addressing hypotheses 1, 2 and 3. Section 6.2 explores the role of proficiency in bilingual lexical access as exploited in hypothesis 4. Finally, section 6.3 discusses the issue of within-language competition in bilingual lexical access by addressing hypothesis 5.

To reiterate, three main objectives were pursued in the present study: (i) to investigate whether bilingual lexical access is predicted by WMC and L2 proficiency uniquely; (ii) to investigate whether WMC and L2 proficiency interact in predicting bilingual lexical access; and (iii) to examine the extent to which within-language competition affects bilingual lexical access. In what follows, I will attempt to address the objectives and hypotheses underlying the present study in light of the literature on working memory capacity and bilingual lexical access reviewed in chapter 2 of this dissertation.

6.1 Working memory capacity, bilingual lexical access and proficiency

The discussion in this section attempts to explain the results of the statistical analyses regarding the relationship between WMC, bilingual lexical access and L2 proficiency. It addresses, more specifically, hypotheses 1, 2, and 3.

Hypothesis 1 predicted that WMC and L2 proficiency would predict bilingual lexical access. Results of multiple linear regressions showed that WMC and L2 proficiency significantly predict bilingual lexical access. The main effects for WMC in L1 and L2 proficiency were significant. The main effect for WMC in L2, on the other hand, was only significant in the absence of L2 proficiency. Overall, these results support hypothesis 1.

In order to explain why WMC successfully predicts variation in the performance of a higher-order cognitive task such as bilingual lexical access, two important issues need to be taken into account: (1) the nature of WM processes, and (2) the nature of retrieval processes. In what follows, I will attempt to show what these processes are, how they contribute to performance on the measures of WMC and L2 picture-naming of the present study and finally, how they relate.

The basic view of WM taken in this study is that WM refers to a set of memory traces activated above threshold and temporarily maintained in a short-term buffer for further processing (Kane, Conway, Hambrick and Engle, 2007; see Chapter 3, section 3.1). Activation and maintenance of information are considered attention demanding tasks, especially when distraction drives attention away from the information being currently maintained. In this sense, attention is also needed to prevent irrelevant representations from entering the WM focus. Under this view, WMC reflects one's ability to (i) retrieve task relevant information from long-term memory when it has been already displaced or could not be kept in the attentional focus; (ii) keep it active and readily accessible, and (iii) inhibit distraction (Kane, Bleckley, Conway and Engle, 2001). Research has consistently shown that high and low span individuals are equally able to retrieve information from long-term memory in terms of speed and accuracy in the absence of interference (Conway and Engle, 1994). When interference is at play, however, only high span individuals can effectively block irrelevant stimuli. According to Kane et al. (2007), “the extent to which executive attention is engaged by a task, for maintenance, retrieval, or for blocking, is critically determined by the degree of interference or conflict presented by the context.”(p. 22-23).

In the context of the complex span tasks used to measure WMC in the present study, it is likely that the interference was caused by the intrinsic characteristics of the WMC tests. Recall that both the SST and the OSpan required participants to recall sets of an increasing number of unrelated words in serial order while shifting attention to process intermittently the L2 sentences or mathematical operations, leading to the building up of interference across test blocks and trials.

In other words, as the number of to-be-remembered items increased from block to block and began to accumulate across trials, access to relevant information became more difficult. Proactive interference resulted, in this case, from the competition between the number of words presented in previous blocks and the words that should be recalled in that particular block. Access to relevant information (to the to-be-remembered items, in the case of the span tests) is disrupted, as explained by Kane et al. (2007), because the processing task – sentence formulation or solving the math operations in the case of the SST and OSpan, respectively -, prevents the rehearsal of the to-be-remembered items, thus increasing the chances for proactive interference to grow. Controlled attention is then necessary to recover or keep access to the target items under proactive interference.

In the picture naming task, different from what happened in the WMC tasks, interference does not seem to have originated from test stimuli specifically, but to have been caused by the association between the name of the target picture and other semantically-related items in the mental lexicon. For instance, when the picture of a dog is presented activating the word DOG in long-term memory, all other lexical items that share semantic constituents with the word DOG also become active thus interfering with retrieval[20] and possibly leading to cue overloading (Watkins, 1979 in Unsworth and Engle, 2007a).

Cue overloading, according to Unsworth and Engle, occurs when several memory representations are subsumed to the same cue. If the cue to retrieval is overloaded, more items are selected from memory to be part of the search set and, as a result, retrieval will take longer and be more susceptible to errors. Coming back to the previous example, the word DOG and its semantically-related competitors would be subsumed to the same retrieval cue[21] – animals. Because there are several lexical candidates within the category animals, controlled attention is needed to execute a serial search and sample the most adequate one.

Based on what has been said so far, it seems that one reason why measures of WMC and bilingual lexical access covary is due, at least in part, to the need to allocate controlled attention to block interference (proactive or retroactive), by keeping access to target items and retrieving task relevant information in the presence of

[20] This kind of interference is known as retroactive interference. According to Searleman and Herrmann (1994), it "…occurs when newer information acts backward in time to inhibit recall of older information." (p.108). Proactive interference, on the contrary, "…occurs when previously learned information acts forward in time to inhibit recall of more recently learned material." (Searleman and Herrmann, p. 108).

[21] As will be further discussed in this section, cue generation is a crucial sub-process underlying retrieval from secondary memory. Unsworth and Engle (2006; 2007) have demonstrated that retrieval of information from secondary memory, that is, from information outside the focus of attention (WM) - stored in long-term memory - , is governed by a discrimination process that involves the use of adequate contextual cues and controlled attention. Those contextual cues are set by the task context and determine what information is relevant for the retrieval process and what must be displaced. Success in retrieval, as proposed by Unsworth and Engle (2007), depends on individuals' ability to use contextual cues effectively to delimit the search set.

activated competitors. This idea is presented by Unsworth and Engle (2007a) when they state that " …interference susceptibility is an important contributor to performance on putative measures of WMC and their relation to higher-order cognitive abilities." (p.247).

The role of WMC in inhibiting interference has also been discussed in studies in the field of bilingualism, which have suggested that lifelong bilingualism enhances executive functions responsible for selective attention and inhibitory control. Bialystok and colleagues (Bialystok, Craik, Klein and Viswanathan, 2004) depart from the assumption that bilinguals constantly need to maintain access to target information thus focusing on mental representations of the wanted language and inhibiting those of the unwanted one. This cognitive exercise, as suggested by the researchers, seems to lead to the improvement of bilinguals' ability to discard misleading information relative to monolinguals. A series of experiments conducted by Bialystok et al. (2004) comparing the performance of monolinguals and bilinguals in the Simon task and measures of WMC supported this hypothesis. Bilinguals outperformed monolingual speakers in conditions in which inhibition was needed to suppress irrelevant but active information and also in trials in which there were no response competition.

Though Bialystok and colleagues have warned us that it is not clear whether the cognitive advantages presented by the balanced bilinguals investigated extend to bilinguals with less L2 experience, I hypothesize that non-balanced bilinguals with more L2 practice, that is, the more proficient learners of this investigation, might also be more efficient at suppressing interference in order to focus attention on what is relevant for task execution in relation to bilinguals who have less experience in the L2, that is, the less proficient learners. In other words, I suggest that more proficient bilinguals are better able than less proficient ones to perform tasks that require attention to be driven away from distracting information. Keeping in mind that accessing words in an L2 is a process that involves fighting off competition from semantically-related words, it is likely that being a bilingual at a relatively more advanced stage may contribute to a better performance on this task. Likewise, working memory span tests such as the SST and the OSpan require individuals to block interference from stimuli that accumulates across set and trials of the tests so as to maintain the to-be-remembered words active in memory for further recall. Extended bilingual experience may render this exercise an easier one. In other words, the fact that simultaneous bilinguals (i.e., those with approximately the same level of proficiency in the 2 languages), in general, are better able to inhibit interference may also be reflected in their ability to inhibit information in the span tasks.

Another possible explanation for why WMC significantly predicted variation in bilingual lexical access is that WM resources are usually required to impede automatic behavior when the context calls for a new response (Unsworth and Engle, 2007b), similar to what occurs in Stroop tasks. In the picture naming task conducted in this investigation, for instance, attention may have been used to override automatic responses such as reading the word distractors presented prior to picture onset, instead of focusing on retrieving the name of the picture. Take the example of the picture of a dog. One hundred milliseconds before visualizing this picture, participants would see the word distractor **cat**. If one does not make use of his/her attentional resources to overcome this intrusion, it is likely that one will automatically read the word distractor instead of naming the picture of the dog displayed right after it. Moreover, the fact that task instructions emphasized the need to ignore the word distractors and name the pictures might also have contributed to the use of controlled processing to solve response competition. It is also important to highlight that the word distractors were semantically related to the names of the pictures and thus may have been even harder to suppress than unrelated word distractors which are not likely to belong to the same semantic field. Therefore, I reiterate that in order to perform the L2 picture-naming task properly, the bilingual speakers of the present study needed to use controlled attention to maintain the task goal active in memory thus impeding irrelevant information to enter the focus and disrupt performance.

Still regarding the relationship between WMC and bilingual lexical access, another possible explanation for the pattern of results born out here might be related to the nature of the cognitive processes involved in determining individual differences in WMC and retrieval. In a recent model of WMC and retrieval, Unsworth and Engle (2007a,b) view WMC as the ability to maintain relevant information active in primary memory plus the ability to reactivate relevant information from secondary memory in situations where there is internal or external competition. According to the authors, the key to recovering relevant information from secondary memory lies on one's efficiency at delimiting the search set appropriately. In order to do that, one needs to attend to cues provided by the task and use them to restrict the number of possible target representations to search among. Once the search set is delimited adequately, a sampling process starts. In this process, controlled attention is needed to execute the serial search for the target representation. As soon as it is selected, monitoring is initiated. This process is then responsible for checking whether the selected representation is the correct one and can proceed to retrieval.

With that in mind, I suggest that what causes WMC and bilingual lexical access to be related is the fact that they share common processes such as cue-generation, set delimitation, sampling and monitoring, all of them being subserved by the allocation of attention. Thus, it is feasible to argue that bilingual lexical access qualifies as a controlled serial search that taps the same processes executed by WM in situations in which representations need to be kept active in the presence of interference.

The relationship between WMC and bilingual lexical access also seems to be mediated by L2 proficiency. As revealed by the results of the present study, WMC in L2 predicted bilingual lexical access significantly only when proficiency was excluded from the multiple regression model. However, L2 proficiency significantly predicted bilingual lexical access above and beyond WMC in L2. This finding can be explained by the fact that, in order to perform the picture naming task, participants inevitably searched for L2 words they knew and were stored in their mental lexicon. In other words, they needed to know L2 names to be able to perform such a task. In sum, the relationship between L2 proficiency and bilingual lexical access lies on the L2 word knowledge one possesses.

This idea is supported by the Revised Hierarchical Model (RHM) of bilingual lexical representation proposed by Kroll and Stewart (1994), which assumes that semantic and conceptual mental representations evolve in a bilingual mind as a function of proficiency (see Chapter 2, section 2.2). That is, the model presumes that at the beginning of the learning process, when the L2 knowledge base is still incomplete and underdeveloped in relation to the L1, L2 words are learned and used through associative links with their L1 counterparts. This is so because L1 words are more strongly connected to their meanings, in the conceptual store, than L2 words. Connections between concepts and words in L2 are considered not to be fully established and, as a result, may lack some conceptual specifications (Poulisse, 1993). L1 connections, on the other hand, are stronger, well practiced and fully established in the lexicon. If this reasoning is correct, it seems safe to conclude that retrieval of L2 words for learners with less L2 practice takes place by means of an L1 conceptually-driven matching process. Put differently, because there is no lexical retrieval without conceptual activation, in order to select L2 words, one has first to access the L1 word and its concept. The L1 concept will then activate L1 and L2 words that match its semantic characteristics. Because the goal is to retrieve the word in L2, the lexical item that shares the L2 language cue and the greatest number of conceptual features with the L1 concept will then receive a boost of activation and be selected.

According to the RHM, with increased proficiency the initially weaker connections between L2 words and their concepts become stronger, allowing for a direct access to meaning. That is to say that L1 meanings are not needed for L2 retrieval anymore, which probably saves cognitive effort and processing time. I will return to this point when discussing the relationship between bilingual lexical access and proficiency in more details in Section 6.2.

Hypothesis 2 predicted that working memory capacity, as measured by the L2 SST, would be a better predictor of bilingual lexical access than working memory capacity as measured by the L1 SST and the OSpan. This prediction was based on Fortkamp (2000) and Weissheimer (2007) who demonstrated that the L2 SST significantly predicted measures of L2 speech performance such as fluency, grammatical accuracy and complexity and weighted lexical density. Because accessing words efficiently is especially important to the processes that involve the formulation of L2 speech, such as constructing the syntactic relations among items in a sentence, and encoding the morphological and phonological information to the message, it was expected that variance in bilingual lexical access would be significantly accounted for by a measure of WMC that taps the very same processes, such as the L2 SST. Moreover, as explained by Levelt (1989), speech production is word driven, which implies that all the other linguistic processes involved in speaking up to articulation can only proceed if a word has been selected from the mental lexicon. Therefore, it was expected that a measure of WMC which involves accessing words to produce grammatically accurate L2 sentences, such as the L2 SST, would significantly explain a proportion of the variance in L2 picture naming. However, as revealed by the multiple regression tests, this hypothesis was not confirmed by the results of the present study, since the main effect for WMC in L2 was not significant.

WMC as measured by the L1 SST and the OSpan, on the other hand, proved to be a better predictor of bilingual lexical access than WMC as measured by the L2 SST. One reason why the L2 SST did not show statistical significance in predicting bilingual lexical access is that the variance in this measure of WMC is mostly explained by L2 proficiency. That is, in order to perform the SST one needs, besides storing words for further building up the sentences, make use of L2 lexical and syntactic knowledge to formulate those sentences. Obviously, a bilingual speaker with more knowledge of the L2 will have an advantage over another speaker who is in a relatively lower level of proficiency. The idea that L2 proficiency determines variation in the L2 SST is supported by the partial correlations showing the degree to which the measures of proficiency used in this study related to WMC. PROFToe – the measure of proficiency derived from the Toefl iBT Speaking Test -, proved to be a better predictor of the L2SST than of the OSpan and the L1SST. This was so probably because in order to perform the Toefl Speaking Test, bilingual speakers needed to produce somewhat continuous speech by applying their knowledge of the language in the same way necessary to construct the sentences of the L2 SST.

As proposed by Levelt (1989), oral production entails a series of processes including deciding what to communicate and how to express these communicative intentions; selecting the most appropriate lexical items that will match the communicative intentions; encoding syntactic, morphological and phonological information to the message; and finally articulating it. In order to be able to produce speech to express their opinions in the Toefl iBT Speaking Test, participants needed inevitably to carry out all these mental processes for which a considerable amount of L2 knowledge was paramount to deliver speech free of hesitations, form and meaning errors, and excessive pausing.

TotCateg – the additional L2 proficiency measure analyzed in this study -, proved to be a better predictor than PROFToe for the SST in L1 and the OSpan. One reason for that is related to the fact that this measure does not entail speech production per se. Instead, the semantic categorization task, from which TOTCateg was derived, aimed at measuring participants' knowledge of L2 words and their semantic relations. To perform the semantic categorization task adequately, participants had to carefully attend to subordinate words displayed on the computer screen, access their meanings and check whether they related semantically to the superordinate word previously presented. Mental operations such as accessing words' meanings, retrieving their conceptual features and executing a matching process require resources from WM to be carried out. That is, these processes are likely to be attentional consuming, especially in L2, in which lexical connections are weaker and not fully established yet. Because the superordinate words appeared several times with different subordinate nouns during the experiment, participants also needed to use WM resources – controlled attention -, to inhibit the building up of proactive interference from trials in which they had seen such a category with a different subordinate word if performance was to be accurate. Taken together, these factors render the semantic categorization in L2 a controlled processing activity (Engle and Oransky, 1999) just like the SST in L1 and the OSpan.

With regard to individual differences in WMC and bilingual lexical access, it was hypothesized that higher spans would retrieve lexical items faster than lower spans (Hypothesis 3). Previous research relating WMC and L2 speech production has systematically shown that individuals with larger WMC produce speech which is more fluent, grammatically accurate and complex and less lexically dense (Fortkmap, 2000; Xhafaj, 2006; Finardi and Prebianca, 2006; Weissheimer, 2007) than individuals with shorter WMC. The statistical analyses carried out in the present study showed that, in fact, high spans retrieved words in L2 faster than lower spans irrespective of proficiency level, thus supporting hypothesis 3.

The fact that higher spans outperformed lower spans in a bilingual lexical access task involving retrieval of L2 words can be explained by the interplay of processes which underlie both WMC and retrieval from secondary memory. As Engle (2001) noted, WMC is not simply about storage and processing, but rather about one´s ability to maintain pieces of information in an active memory in the presence of distraction. On this view, differences in WMC mean that misleading information is more efficiently kept outside the focus of attention and that controlled processes are more effectively used to resolve response competition.

The bilingual lexical access task applied in this study was a task in which bilinguals were supposed to retrieve L2 names under the interference of semantically-related information. In order to accomplish this task fast and accurately, participants needed to (i) notice and/or generate cues to help delimiting the search set adequately; (ii) perform a strategic search in order to retrieve the most appropriate item to match the to-be-verbalized concept, and (iii) engage into a decision/monitoring process so as to ensure the selected L2 name was the one that should be retrieved. Because all these underlying retrieval processes were carried out in the face of competition, accessing words in L2 in the case of the present study required a great amount of attention to be executed and thus, only higher spans, who are presumably more efficient at allocating attention to these sub-processes, were better able to perform the picture naming task. Put differently, it might be that lower spans did not have enough attentional capacity to devote to all sub-processes involved in retrieval, which may have hindered their performance. It is important to remember that the build-up of interference in the picture naming task was not only triggered by the distractors themselves, but also by the activation of items in memory which were semantically related to the target one. This internal competition was probably better handled by higher spans due to their ability to maintain task relevant information active and block irrelevant competitors.

In fact, previous empirical research has demonstrated that high and low spans differ significantly in their ability to block proactive interference. In Rosen and Engle's (1997) study, for example, higher span subjects were better able than lower spans to exclude the names retrieved in a non-load condition from the set of names retrieved in a load condition. Lowers spans, on the other hand, included more repetitions when retrieving category exemplars in a load condition. These findings suggest that only higher spans had enough controlled attention to inhibit interference, monitor for repetitions and generate cues to retrieve new exemplars simultaneously.

Likewise, Rosen and Engle (1998) also showed that lower spans were unable to block intrusions from words they had previously associated with a particular item, when these words appeared again with a new item. Again, higher spans were faster and more accurate to recall words that were learned with a different pair-associate relative to lower spans.

The retrieval deficits demonstrated by lower spans in the present study may be more specifically accounted for by their inability to generate cues that could lead to a search set composed of target items only. The bilingual lexical access task in this study required participants to name pictures in L2 by ignoring semantically-related items displayed 100 ms before picture onset (the experimental condition). Under these conditions, there were two possible ways to efficiently use cues to delimit the search set: (i) through a conceptually driven process based on the picture itself or (ii) by using the semantic-related item as a cue itself. Both alternatives would lead to the activation of a set of lexical items that are likely to belong to the same semantic field or at least, to share some constituent parts. Either way, in order to selectively attend to this specific set of words, controlled attention was needed to inhibit active, but irrelevant representations (Unsworth and Engle, 2007a). If this was the case, the reason why higher spans searched from a more specific search set than lower spans, besides using controlled attention more efficiently, was because they were either better able to notice the cues given by the task context or to internally generate them based on task stimuli and requirements. As noted by Unsworth and Engle (2007b), lower spans usually make use of noisier cues to guide their search, thus including more representations in the search set. The greater the number of representations in the search set, the lower the probability that retrieval of relevant information will be successful.

The poorer performance of lower spans in L2 naming in relation to higher spans may also be related to differences in their ability to recover lexical items from memory and to monitor for errors. Contrary to Unsworth and Engle's assumption that "individuals differ only in the ability to use cues to delimit the search set and not in either the recovery process or the decision/monitoring process (p. 109), I hypothesize that individual differences are likely to influence the recovery and monitoring processes in L2 due to lack of automatization of L2 retrieval procedures and weak connections between words and their conceptual representations. This idea will be fully developed in subsection 6.2.

6.2 Bilingual lexical access and proficiency

Research on bilingual word representation has theorized that different types of word-meaning connections co-exist in a bilingual mental lexicon. In a less proficient bilingual memory, L2 words are weakly connected to their meaning representations due to lack of knowledge of the language. As knowledge of the L2 begins to accumulate and proficiency increases, the initially weak connections become stronger allowing for an easier and faster access to L2 meaning (Kroll and Stewart, 1994; de Groot, 1995; de Groot and Hoeks, 1995). Prebianca (2007) already demonstrated that more proficient bilinguals differ from less proficient ones in terms of naming accuracy, and tend to present faster retrieval time. As suggested by the researcher, these findings may be a consequence of language automatization, not only in terms of meaning connections in the lexicon, but also in respect to the procedures needed to retrieve these meaning representations and their respective words from memory.

Based on these claims, it was expected that more proficient bilinguals would retrieve lexical items faster than less proficient bilinguals irrespective of performing the control or the experimental condition first (Hypothesis 4). This prediction was confirmed by an analysis of variance which showed that the mean retrieval speed of more proficient bilinguals was statistically different from the mean retrieval speed of less proficient speakers (see Chapter 5, section 5.2). In fact, more proficient bilinguals were always faster than less proficient bilinguals, regardless of WMC. In addition, analyses of covariance run in order to partial out the effects of task order, revealed that the mean retrieval speed of lexical access for more and less proficient bilinguals proved to be statistically different for all three measures of proficiency investigated in this study – PROFToe, TotCateg and Meanz. In other words, less proficient bilinguals were slower than more proficient ones regardless of performing the control or the experimental condition first, thus reaffirming Hypothesis 4.

The fact that more proficient bilinguals were faster to retrieve L2 names relative to less proficient bilinguals may be a consequence, as already suggested by Prebianca (2007), of their more automatized L2 retrieval procedures. According to Kormos (2006), in the beginning of the learning process, several L2 lexical encoding procedures are not fully automatized yet and tend to be represented in a declarative, explicit fashion[22]. This reasoning is in line with Kormos' proposal of a declarative store for L2 rules in her bilingual speech production model. If that is true, it is feasible to suggest that less proficient bilinguals were slower to retrieve L2 names because their procedures to do so were underdeveloped and/or incomplete. In other words, retrieval for them was based on knowledge of the L2 which was explicitly stored and processed serially instead of in parallel. As a consequence, learners took longer to execute the retrieval procedures involving delimiting the search set, sampling the right lexical item and checking for adequate selection. It is also worth mentioning that these lexical retrieval procedures in L1 are supposed to be part of the encoding system and stored implicitly.

Therefore, accessing words in L1 is a highly automatic process which runs in parallel to other sub-processes involved in the production of speech. As explained by Levelt (1989), the great speed with which speaking is produced in L1 can only be accounted for by what he calls incremental processing. That is, the components responsible for processing speech are made up of sub-components able to work in

[22] In her bilingual production model, Kormos (2006) seems to equate declarative to explicit knowledge and, as a consequence, procedural to implicit. Though I tend to agree with the author when referring to L2 learning and use, I acknowledge that there is some controversy over the declarative-explicit relationship.

parallel at different stages from message generation to articulation as long as each component is instantiated with a fragment of its characteristic input.

In L2 speech production, because of the status of the L2 (being the less practiced language), processing is likely to be less incremental, which implies that the processing in one component may only start when the complete output of the previous component is delivered. Once again, the reason for that is the less automatized nature of L2 speech procedures - including lexical access ones -, and underdeveloped L2 knowledge, rendering the speech process a slow, attentional consuming serial task.

Another argument appealing to the idea that level of language automatization may affect lexical retrieval mechanisms is the one proposed by Roelofs (1998). According to him, the retrieval of L2 words is made possible through production rules that specify the concept to be verbalized and the language in which it is to be produced. An example of such rules would be: IF the concept is DOG and the language is Spanish, THEN select “perro”. Productions of these kind are similar to the productions proposed by Anderson (1983) in his ACT* model of skill acquisition. Anderson advocates that a skill only becomes automatic when the procedures for its execution are created and retrieved from memory as a whole, without recourse to declarative knowledge. What determines the probability with which these productions will be retrieved over and over again so as to become automatic is a processing Anderson called strengthening, that is, practice. The more practiced a production rule is, the greater the likelihood it will be used again when the context calls for it.

On this view, the production rules proposed by Roelofs for L2 lexical retrieval can evolve from an explicit, declarative stage of representation to a stage where they are performed effortlessly, leading then to quantitative and qualitative changes in performance. In other words, as knowledge of the L2 develops, it is possible that not only the speed of processing is altered during lexical retrieval but also the way in which the underlying processes are organized and/or carried out by the bilingual speaker. As noted by Segalowitz and Hulstijn (2005), automatic processing should not reflect faster cognitive functioning only, but rather may encompass a set of modifications that can occur beneath the cognitive process surface. It might be, then, that the more proficient bilinguals of the present study retrieved L2 words faster than the less proficient ones because they have been restructuring, reorganizing and re-elaborating the underlying processes involved in retrieval during their longer run in learning the L2 (see Cheng, 1985 for a similar view).

According to Kormos (2006), bilingual lexical access can be considered automatic when the to-be-verbalized concepts strongly activate their corresponding words. Under this reasoning, successful lexical access seems to depend only on the development of well established connections between the conceptual and the lexical store, as suggested by the RHM mentioned previously in this discussion chapter. However, the findings of the present study that bilingual lexical access is significantly predicted by WMC indicates that the strengthening of connections cannot be the only reason why the SST and the OSpan contribute to score variations in L2 picture-naming. As previously discussed in this chapter, retrieval involves underlying processes that require controlled attention to be executed. Clearly, a well established network of concepts and lexical items seems to be of great help when one needs to select a word to match the conceptual specifications of the pre-verbal message (this point will be discussed in details later). However, there seems to be more than meets the eyes. If we consider that bilingual lexical access entails generating relevant cues for delimiting the search set appropriately, serial search and monitoring, it appears safe to suggest that each one of these underlying processes may be automatized to a different extent depending on the quantity and quality of L2 knowledge one possesses. Contrary to Kormos' claims, research on memory retrieval has indicated that retrieval from long-term memory is not likely to be carried out as a "direct, one-step" (p. 47) process.

Therefore, I suggest that less proficient bilinguals, for instance, due to their poorer experience in using the L2, may face greater difficulties in noticing the contextual cues needed to select the set of words from the most adequate category (semantic field) in the lexical network to start searching from. Besides, they may also execute the binding by checking process (as Levet et al. (1999) call the process in charge of checking for the match between concept and the lexical item selected for verbalization), which basically searches for the correct lexical item, in a more serial fashion, by looking for each primitive that makes up any possible lexical candidate and the overlap of these primitives with the primitives of the intended concept.

Monitoring for mismatches, in the case of less proficient bilinguals, also tends to be defective since their reduced L2 knowledge makes it more problematic for them to decide whether the selected item is the correct one. Support in favor of this argument comes from the view that L2 word knowledge evolves as a function of L2 proficiency, as discussed previously (Kroll and Stewart, 1994; de Groot and Hoeks, 1995). To reiterate, I hypothesize that, in the present study, more proficient learners accessed L2 lexical items faster than less proficient ones because they were able to perform the underlying processes involved in retrieval more efficiently, that is, more automatically.

Another interesting way to exemplify the changes that may occur in underlying retrieval processes as L2 proficiency increases is to look at how the connections between words and their meaning representations develop in a bilingual memory. The revised hierarchical model proposed by Kroll and Stewart (1994) postulates that the connections between L2 words and their meanings are established through associative links to L1 words. Access to meaning in initial L2 learning phases is then accomplished only by accessing L1 meaning first. In the same vein, de Groot and Hoeks (1995) claim that different lexical representations co-exist in a bilingual memory: word-association and concept-mediation representations – and develop as proficiency in L2 increases. That is to say, the lexical connections in the bilingual mental lexicon develop in a somewhat continuous fashion, from weak and indirect links to strong and direct links between words and their conceptual representations (meanings). A less proficient bilingual memory, in this case, would consist of two word stores (L1 and L2 lexicons) and a single common conceptual store with access to meaning occurring via L2/L1 associative links (the word-association hypothesis). Because the conceptual store would be shared between the two languages and because the L1 lexicon is likely to contain stronger, direct and automatic links with the conceptual store (Heredia, 1996), it is likely that in order to understand and produce L2 words, a less proficient bilingual needs to access L1 meaning first.

On the other hand, in a highly proficient bilingual memory, although the L1 and L2 mental lexicons also share the same conceptual store, access to meaning is not mediated by L1 lexical representations anymore. Instead, conceptual meaning is accessed via strong and direct connections between words and the conceptual store in each of the languages (the concept-mediation hypothesis). That is to say, comprehending and speaking in L2 for high proficiency bilinguals is likely to occur in a similar fashion as comprehending and producing speech in L1. According to de Groot (1995) and de Groot and Hoeks (1995), bilingual speakers would start accessing L2 meaning via L1 representations at the word level, but with practice they would develop stronger and direct connections between the L2 lexical and conceptual stores.

Because more proficient bilinguals have a greater amount of L2 practice than less proficient ones, it is likely that they have more L2 words represented, and consequently, processed in a concept-mediation mode. For less proficient bilinguals, who presumably have practiced the L2 for a lesser extent, L2 representation and processing probably relies more on a word-association mode, since the connections between words and their conceptual representations will still be weaker in relation to the same connections in a more proficient L2 memory. Consequently, it seems reasonable to argue that for word processing (accessing and retrieving) through a word-association mode, more controlled attention is necessary. Because the connections are weaker, a more serial search is required, and consequently biding by checking and monitoring processes will take longer to be performed. Together, these factors might have contributed to the inferior performance of less proficient bilinguals in L2 picture naming in this study.

6.3 Within-language competition in bilingual lexical access

Throughout this discussion chapter, I have alluded to bilingual lexical access as being a controlled activity which entails retrieval of information from secondary memory in the face of interference. Successful retrieval, in this view, depends on bilinguals' ability to notice or generate adequate cues to guide the search process efficiently. If the cues correctly specify the set of words to search from, retrieval should then be faster and more accurate since fewer candidates get to be included in the search set, enhancing the probability of selecting the correct one (Unsworth and Engle, 2007a,b).

Furthermore, because in L2 retrieval procedures such as cue generation, set delimitation, sampling and monitoring are not fully automatized, especially in initial learning phases (Kormos, 2006), it seems plausible to expect that any contextual information provided by task stimuli might aid bilinguals to perform the task more efficiently. In other words, the interfering distractors could serve as cues themselves so as to guide the search. Take, for instance, the presentation of the picture of a dog primed by the distractor cat. Although both items are likely to compete for selection due to the overlapping of their constituent parts, they also belong to the same semantic category – animals -, and thus, seeing the word cat consequently activates other words from this category, thus, facilitating set delimitation. By the time the picture of a dog is presented, the word dog is already included in the search set which makes sampling easier.

With that in mind and based on the findings of Prebianca (2007), it was predicted that the mean retrieval speed of lexical access in bilinguals would be facilitated by L2 semantically related word distractors (Hypothesis 5). The analyses of variance performed on the data showed that the facilitation effect of semantically related L2 word distractors on the retrieval speed of lexical access in bilinguals depends on whether subjects performed the control or the experimental condition first, partially supporting hypothesis 5.

One reason for the task order effects may be related to a possible methodological flaw. That is, the control and the experimental conditions were performed in separate blocks instead of being confounded into the same experimental block. Had the control condition been inserted into the experimental one, task order effects might not have been so salient. A possible alternative to test the same hypothesis would be to compare mean RT's of the experimental condition to mean RT's for pictures named with unrelated word distractors, which were, in turn, displayed within the experimental blocks.

The task order effects might also have been caused by the fact that the target pictures were displayed several times throughout the whole experiment. Because of the many instances of target picture presentations (including conditions in which these pictures were displayed with phonologically-related distractors and when the time of distractor presentation was other than 100 ms before picture onset), participants might have learned their names and then improved performance. Put differently, participants had already retrieved the names of the pictures at least once before either in the control or in one of the blocks of the experimental condition, and it may be that these words were still active in primary memory to some extent. Their activation level might not have returned to rest yet when the same pictures were presented again, thus leading to a faster performance. Some evidence in favor of this argument comes from a post hoc test run in order to examine whether the average time to retrieve the name of the pictures suffered any kind of improvement across the 6 testing blocks. Results of a repeated measure ANOVA revealed that mean RT's indeed became faster across blocks (see Appendix T).

Although appealing, such findings need to be interpreted with caution, since this analysis does not correspond to the RT's of the experimental condition only (which refers to the target trials only). Instead, it was calculated taking into consideration the overall mean RT's for each block, including non-target trials, due to randomization. That is, the presentation of the 25 target pictures in the experimental condition (target trials) was done in a different order for each participant and therefore, target trials could appear in any of the six blocks of the experiment. In fact, a particular block could have no target trial at all. Thus, the idea that some kind of practicing effect might have occurred as a function of the number of times participants saw the target pictures can be taken only as speculative in nature, discarding any possibility for a more concrete conclusion on that matter.

Despite task order effects, the assumption that semantically related distractors might serve as cues that aid bilinguals to delimit the search set appropriately cannot be totally ruled out. Support for this position comes from network models of semantic memory such as the ones proposed by Collins and Quillian (1969) and Collins and Loftus (1975). According to these models, items in semantic memory are stored in hierarchical networks of interrelated nodes, forming clusters of items that share conceptual properties. These clusters are, in turn, formed by other networks of interrelated items. Take a category such as animals, for instance. One cluster of this category is formed by animals that are mammals, such as cat, dog, cow, and so on. Another cluster would be the one composed of animals that fly, as for example, eagle, canary, falcon, among others. Because vertical (animals – mammal) and horizontal associations (cat – dog) exist among clusters and items within a cluster, when an exemplar of a particular cluster is activated, activation is also sent to items that share all or at least some conceptual characteristics and therefore are likely to form the same cluster. Clustering is then taken to facilitate retrieval. Empirical evidence has shown that interrelated items are usually retrieved consecutively with short response times between the retrieval of items from the same cluster (Rohrer, Wixted, Salmon and Butters, 1995). If retrieval from semantic memory is accomplished through interitem associations, it is then acceptable to propose that the presentation of semantically related distractors before picture onset would lead to faster response times, once both the name of the picture and the word distractor are constituents of the same cluster.

As previously highlighted in this discussion chapter, it is important to remember that the structure of semantic memory and the interitem relations in L2 might not be comparable to their L1 counterparts. In a less practiced language, the networks of items are likely to be composed of fewer items, which, in turn, might lack some conceptual specifications. As a consequence, meaning in L2 is usually processed through word-associations links between L2 and L1 words in the mental lexicon, especially in initial learning phases. This process of accessing L1 meaning first requires more time and cognitive effort than accessing L2 meaning directly. In this case, if the goal is to activate the adequate cluster so as to ensure a faster and more accurate retrieval, the presentation of a cue might be useful in helping speakers to zoom in on the relevant lexical items, without having to access the L1 meaning of items of other clusters, thus saving processing time and effort. Though appealing, this assumption still needs further scrutiny, since it was not supported by the results of the present investigation.

In this chapter, I attempted to draw the lines linking WMC, bilingual lexical access, and L2 proficiency. The crux of this discussion was that bilingual lexical access entails underlying processes such as cue generation, set delimitation, serial search and monitoring, which to be carried out, require the allocation of attention. Attention is limited and, as a result, only higher spans were able to perform these underlying processes automatically. In addition to automaticity of processing, which seems to be a product of practice in L2, it is believed that with increased proficiency connections in the mental lexicon of bilingual speakers become stronger, facilitating clustering (and consequently the search for the correct lexical item) and helping to fight off retroactive within-language interference.

The next chapter outlines the main findings of the present study and provides the conclusions, limitations and suggestions for further research. It also presents some implications for L2 teaching and learning based on the results of this investigation.

CHAPTER 7

CONCLUSION

7.1 Final Remarks

The aim of the present study was threefold: (i) to investigate whether bilingual lexical access was predicted by WMC and L2 proficiency; (ii) to investigate whether WMC and L2 proficiency interacted in predicting bilingual lexical access; and (iii) to examine the extent to which within-language competition affects bilingual lexical access.

The set of experiments reported in this dissertation explored lexical competition within the intended language across L2 proficiency levels as being subserved by a resource limited capacity system – working memory (WM). With that in mind, it was hypothesized that: (1) working memory capacity and L2 proficiency would both predict bilingual lexical access uniquely; (2) working memory capacity, as measured by the L2 SST, would be a better predictor of bilingual lexical access than working memory capacity as measured by the L1 SST and the OSpan; (3) higher spans would retrieve lexical items faster than lower spans; (4) More proficient bilinguals would retrieve lexical items faster than less proficient bilinguals irrespective of task order; and (5) the mean retrieval speed of lexical access in bilinguals would be facilitated by L2 semantically related word distractors.

In order to test the aforementioned hypotheses, one hundred learners of English as a foreign language were submitted to three data collection sessions which comprised three tests to measure WMC, two tests to measure L2 proficiency and one test to assess bilingual lexical access. The task used to assess the main L2 ability under investigation – bilingual lexical access -, was a picture-naming task carried out under the semantic competitor paradigm. This task was composed of a control and an experimental condition. Whereas in the former subjects were required to name pictures without any interfering stimuli, in the latter they were asked to retrieve the lexical items to name the pictures under the presence of semantically related L2 word distractors (a condition in which WM demands were expected to be greater). Data were analyzed quantitatively and the statistical procedures revealed that, in general terms, bilingual lexical access is affected by both individual differences in WMC and L2 proficiency level. A summary of the main findings of this investigation is presented next:

- ✓ <u>Finding 1:</u> WMC and L2 proficiency significantly predict bilingual lexical access. The main effects for WMC in L1, as measured by the L1 SST and the OSpan, and L2 proficiency were significant. The main effect for WMC in L2, as measured by the L2 SST, on the other hand, was only significant in the absence of L2 proficiency. In order to explain why WMC and bilingual lexical access are related, three reasons were suggested. First, both tasks (WMC and L2 lexical access) required controlled attention to inhibit interference in order to maintain access to information relevant to task performance. Second, controlled attention was necessary to override the participants' automatic behavior in the L2 picture-naming task. That is, when presented with the distractors slightly before picture onset, participants' automatic response was to read the word instead of naming the picture. But, because they were instructed to ignore the interfering stimuli and concentrate on retrieving the name of picture, they needed to resort to controlled attention to prevent them from reading the word distractors. Finally, bilingual lexical access and WMC share underlying cognitive processes such as cue generation, set delimitation, serial search and monitoring, which require controlled attention to be executed. With respect to the relationship between L2 proficiency and bilingual lexical access it was argued that the quantity and quality of the connections between L2 words and their meaning representations in the mental lexicon may be different for more and less proficient learners, thus affecting performance in the L2 picture-naming task.

- ✓ Finding 2: The L1 SST and the OSpan proved to be a better predictor of bilingual lexical access than the L2 SST. The explanation to the fact that the L2 SST did not predict variance in bilingual lexical access uniquely was that part of the variance in this WMC task was accounted for by L2 proficiency. When proficiency was removed from the multiple regression model though, the L2 SST was powerful enough to predict variance in L2 picture naming.

- ✓ Finding 3: Higher spans retrieved lexical items faster than lower spans, regardless of proficiency level. This result was explained as follows. First, lower spans lacked sufficient WMC to devote simultaneously to all the underlying processes involved in L2 retrieval. Second, higher spans were better able to apply controlled attention to block competition from distractors as well as from internal semantically-related lexical items. Third, higher spans used controlled attention more efficiently to generate and/or notice cues in order to delimit a search set with fewer lexical candidates. Lastly, lower spans might have faced problems to monitor for adequate lexical selections due to the less automatized nature of the L2 and lack of strong links between L2 lexical and conceptual stores.

- ✓ <u>Finding 4:</u> More proficient bilinguals retrieved lexical items faster than less proficient bilinguals, regardless of WMC and task order. Partialling out the effects of task order, the mean retrieval speed of lexical access for more and less proficient bilinguals proved to be statistically different for all 3 measures of proficiency investigated, which means that less proficient bilinguals were slower than more proficient ones regardless of performing the control or the experimental condition first. In order to explain these results, it was suggested that more proficient bilinguals performed the underlying processes involved in L2 retrieval more automatically than less proficient bilinguals. In addition, less proficient bilinguals may have accessed and retrieved L2 words by associating them to their L1 lexical and conceptual representations – a process which is likely to be more attentional demanding and slower compared to the concept-mediation processes carried out by more proficient bilinguals.

- ✓ <u>Finding 5:</u> The facilitation effect of semantically related L2 word distractors on the mean retrieval speed of lexical access in bilinguals proved to be an effect of task order. Two explanations were provided to account for this finding. First, task order effects may be related to a methodological flaw, since the control condition was performed apart from the experimental one. Second, L2 target names might have been still active in primary memory (WM) when the target pictures were repeatedly presented across experimental blocks.

In sum, the results of this investigation speak in favor of a relationship between working memory capacity, bilingual lexical access and proficiency level. However, it was interesting to find out that, although WMC and L2 proficiency contributed significantly to performance on a task measuring L2 retrieval, they did not interact. It seems that despite the great importance both constructs have for bilingual lexical access, they do not account for the whole picture. The facts that, within the less proficient group, more proficient bilinguals were faster to retrieve L2 names than less proficient ones regardless WMC, and that within the higher span group, higher spans were faster at retrieval than lower spans regardless of proficiency level appear to indicate that other factors are playing a role as well. Which factors these are still remains to be seen. This is just another way to say that more research is needed to unveil this intricate relationship.

7.2 Limitations of the study and suggestions for further research

This research project was an attempt to examine the role of WMC in bilingual lexical access when retrieval entails within-language competition. Moreover, it specifically aimed at investigating the extent to which WMC affected bilingual lexical access in different levels of proficiency. In this sense, the present study tried to bring together state of the art research on WMC and lexical access, delving into the sub processes underlying performance on both constructs. As already mentioned in Chapter 1 of this dissertation, previous research on bilingual lexical access has not given much attention to the reasons that might cause WMC and bilingual lexical access to be connected. The main interest in the field so far has been to determine the role of WMC in suppressing language representations in the unwanted language.

Thus, due to its exploratory nature, the results gathered by this study concerning the relationship between WMC, bilingual lexical access and proficiency level are to be seen as suggestive rather than conclusive. Despite the fact that it has been methodologically and theoretically driven by the literature in the field, the present investigation suffered from several limitations which I now point out, followed by suggestions for further research:

(1) <u>The population investigated:</u> The pool of participants investigated in this study was composed of native speakers of Brazilian Portuguese studying English as a foreign language. Thus, the results and the conclusions drawn from them are related particularly to this population. In order to enable generalization of the findings here presented, further research should consider investigating a greater sample size which included different language backgrounds and perhaps different L2's.

(2) <u>The WMC Tests:</u> According to Kane, Conway, Hambrick and Engle (2007), WMC tests are multiply determined tasks. The measures which derive from these tasks are, as explained by the authors, partly determined by domain-general processes involving executive controlled attention, and partly by domain-specific processes such as rehearsal, coding and chunking. Domain-general processes contribute to span performance regardless of the processing component being tested by the WMC task, whereas domain-specific processes are closely tied up to the knowledge one holds about the stimuli being tested. Consequently, no WMC task can be considered a pure measure of WMC. Although two different WMC tasks have been applied in this study – one requiring the processing of verbal material and another one requiring the processing of mathematical stimuli -, it is advised that future studies include other measures of WMC such as the Reading Span Test (Daneman and Carpenter, 1980) and the Counting Span (Case, Kurland and Goldberg, 1982 in Kane et al., 2007) in order to minimize the effects of domain-specific knowledge related to the processing component of the task on test scores.

(3) The L2 SST: As demonstrated by the partial correlations in Chapter 5 of this dissertation, it was found that 34% of the variance in WMC, particularly in the L2 SST, was determined by L2 proficiency. Considering that several studies on WMC and speech production have shown a statistically significant relationship between the L2 SST and L2 performance (Fortkamp, 1999; Fortkamp, 2000; Finardi and Prebianca, 2006; Xhafaj, 2006; Weissheimer, 2007; Prebianca and D'Ely, in press), it appears crucial to scrutinize how proficiency in the L2 has contributed to this relationship. In other words, it would be of great importance to reassess the validity and reliability of the L2 SST especially in studies which have included this test as the only measure of WMC and a measure of L2 proficiency. If the correlations found between WMC and the cognitive ability being tested holds after partialling out the contribution of L2 proficiency, then the L2 SST can be taken as a valid task to assess WMC.

(4) The picture-naming task: In order to assess bilingual lexical access in the present study, a picture-naming task was implemented. In this task, participants were required to name pictures in L2 under the interference of semantically-related word distractors displayed 100 ms before picture onset. Inferences regarding participants' behavior in the performance of this task in L2 compared to performance in L1 were not possible, because lexical access data was not collected in their native language. Therefore, future research could extend the scope of this investigation by including a picture-naming task in L1. It would also be interesting to include other lexical access tasks quite often used in studies in the field such as word reading and word translation in order to compare performance on different tasks.

(5) The lexical access measure: In this study the only measure of bilingual lexical access analyzed was mean reaction time. It would be very interesting to analyze accuracy measures so as to compare them with a temporal measure such as mean RT. In addition, it may be an option to examine the kinds of errors that will eventually appear and how they relate to the development of lexical representations in memory.

(6) Word distractors: The word distractors displayed before picture onset in the L2 picture-naming task were all semantically-related to the name of the picture. This methodological decision was made in order to allow for an investigation of the competitive nature of lexical selection caused by the semantic connections in the mental lexicon. Despite having pursued this very specific objective, I acknowledge that other types of connections may also play a role in L2 lexical access such as phonological ones. Therefore, future studies should consider including word distractors that are phonologically-related to the name of the picture and perhaps implementing a different time interval between the presentation of the picture and the distractor.

(7) RT baselines: Semantic facilitation on retrieval was measured by comparing the mean RT's for the experimental condition to the mean RT's for the control condition. Whereas in the experimental condition participants were required to name the pictures by ignoring the interfering stimuli, in the control condition they were presented only with the picture to be named. As discussed in Section 5.3 (chapter 5), the fact that the target pictures were presented in a control condition which was not embedded in the experimental one apparently caused the task order effect found in

the data. Further research should then merge both conditions into only one or even compare mean RT's for the target pictures named in the experimental condition to the mean RT's for pictures named under the interference of unrelated word distractors, which were, in turn, part of the experimental condition as well and used as fillers.

Despite the aforementioned shortcomings, it is believed that the present study has contributed significantly to explain the complexities involving retrieval in L2 at different proficiency levels and the reasons why it is a demanding cognitive task.

This empirical work departed from research on models of L2 word representation and processing, on working memory capacity and retrieval, and on L2 speech production studies to suggest that bilingual lexical access qualifies as a controlled serial search task which entails cue generation, set delimitation, sampling and monitoring, all being sub-served by controlled attention mechanisms.

The major contribution of this piece of research is that working memory capacity has proved to play a prominent role in L2 lexical retrieval. That is, individual differences in controlled attention were shown to determine efficient performance on the sub-processes underlying bilingual lexical access. In what follows, I attempt to relate the findings of the present study to L2 teaching and learning, thereby providing some insights into what should or could be focused on in the language classroom in order to foster L2 automatization and strengthen the connections among lexical items in the L2 mental lexicon.

7.3 Pedagogical Implications

Because a great deal of the data gathered in this study can be explained by the lack of automatized L2 resources, both in terms of retrieval procedures and lexicoconceptual connections, my contribution to L2 pedagogy in this section will concentrate on pinpointing how to address these issues in the L2 classroom. More than giving specific suggestions on how to implement teaching activities, I will attempt to call attention to the major implication the findings of this study provide for the teaching and learning of an L2.

The most important conclusion one can draw from the present research is that learning a second language after some critical period (especially in adulthood) is quite a challenge. The literature on SLA and applied linguistics has consistently raised the point that L2 knowledge is usually less automatized than L1 knowledge with procedures operating under attentional control (McLaughlin, 1987; Poulisse, 1997; Fortkamp, 2000; Kormos, 2006). Likewise, L2 lexical items are in a smaller number and weakly established in the mental lexicon as compared to their L1 counterparts (Kroll and Stewart, 1994; Poulisse, 1997). Following from that is the fact that the development of automatization as well as strong lexical representations is intimately related to practice.

Theories of skill acquisition such as the ones proposed by Anderson (1983) and Logan (1988) emphasize the importance of practice in acquiring the necessary knowledge that enables language processing which does not consume attentional resources from the limited- capacity system. In Anderson's view, practice is needed to transform initial declarative knowledge into procedural knowledge that will feed the production-rules responsible for memory retrieval. In this stage, because knowledge is already embedded into productions, no activation, retrieval and maintenance of declarative knowledge in WM is required to perform the skill. Anderson also sees practice as a means of strengthening the likelihood with which productions will be retrieved. Logan's view sharply differs from Anderson's. To him, language automatization does not imply knowledge transformation, i.e. from declarative into procedural, but rather depends on the efficiency of memory retrieval. That is, automatic performance develops as a function of the number of encounters one has had with a particular stimulus. The more one has encountered that stimulus, the greater the probability that memory traces will be formed and encoded in memory for further retrieval. Practice, within this framework, is necessary to strength these memory traces, thereby leading to a supremacy of memory-based over rule-based processing.

In the realm of L2 learning, practice was deliberately equated to repetition by practitioners of the audiolingual method back in the 1960's. On this view, repetition is essential to language learning because it promotes memorization of grammar rules and association between different language structures, thereby leading to automaticity. Though fostering automatization, the traditional drills commonly used by the audiolingual method as a tool to practice L2 structures have been severely criticized. The shortcomings refer to the fact that these drills do not prioritize meaningful language production. On the contrary, their focus is on the practicing of L2 forms. A shift away from the emphasis on forms in language learning was experienced with the introduction of the communicative language teaching (CLT). This approach was meant to account for two important aspects of language use: (1) the conveyance of meaning and (2) the social nature of communication (Bygate, 2001). In this sense, the CLT provided language practice through a series of activities which entailed meaningful communication through the teaching of linguistic functions which focused on social interaction, such as apologizing, making requests, asking for directions, among others. However, the openness of content and linguistic forms that characterized CLT activities did not produce enough repetition to foster knowledge automatization (Segalowitz and Hujstin, 2005).

According to DeKeyser (2001), one way to join the efficiency of traditional grammar drills to the opportunity to practice language in which meaning communication is top priority is to adopt a task-based approach to L2 teaching. Within the task-based approach framework, L2 learning takes place through the practice of tasks designed with the primary objective to promote meaning negotiation and the secondary purpose of developing knowledge of contextualized linguistic forms. According to Skehan (1996), focus on meaning is not sufficient to foster acquisition of a foreign/second language. The author claims that there is linguistic and psychological evidence supporting a need to provide explicit and conscious instruction, manipulate learners' attentional resources allocation, and consider the different language processing modes (i.e. rule- and exemplar-based) if L2 learning is to be achieved. Thus, Skehan proposes that in order to advocate for task-based instruction and its value to interlanguage (IL) development, it is necessary to focus on three different goals of language performance: (i) fluency - "the capacity to cope with real-time communication" (Foster & Skehan, 1996, p. 304); (ii) accuracy - "…learner's belief in norms, and to performance which is native-like through its rule governed nature" (Skehan, 1996, p. 46), and (iii) complexity - the use of more elaborated and organized language with greater variety of syntactic patterning (Foster & Skehan, 1996).

In order to achieve the performance goals proposed by Skehan in the L2 classroom, teachers may design communicative tasks which concomitantly involve a focus on meaning and on form, gradually increasing their complexity and cognitive demands imposed on the memory system. As proposed by Robinson's (2001) Cognitive Hypothesis, the more cognitively difficult the task, the more attention and memory resources are consumed in its performance. Thus, when focusing attention on the completion (performance) of the task, learners are able to attend to input and consequently to pushed output, which in turn may lead to noticing of particular language forms, incorporation and restructuring of information in memory.

Language restructuring, according to McLaughlin (1987) seems to be a product of automatization. That is, from an information-processing perspective, McLaughlin and Heredia (1996) see L2 learning as the learning of a cognitive skill that requires the build-up of a series of automatized routines which can be carried out without the expense of attention. As in any cognitive skill, automatized L2 procedures develop through practice leading to the restructuring of the linguistic system. As proposed by the theorists, the reorganization of the IL system involves production and communications strategies.

With regards to production, it is worth remembering that its role as a tool to promote L2 learning and language automatization has already been emphasized in the SLA literature by Swain (1985, 1995) and Skehan (1998). In her Output Hypothesis, Swain has proposed that language production affords opportunities for learners to engage into L2 syntactic processing especially when they are pushed to convey meaningful messages which are both grammatically and socially appropriate (Ellis, 2003). Skehan, building on Swain's ideas, has suggested that production, besides fostering syntactic processing, allows learners to engage into hypothesis-testing of particular language forms as well as aids the automatization of L2 knowledge already learned. With that in mind, it seems that if the ultimate L2 teaching goal is to foster the automatization of L2 skills, teachers should concentrate on incorporating to the curriculum classroom activities with the potential to promote language production, knowledge restructuring and repetition.

Communication strategies (CS) can also be fruitful tools to be explored in order to teach learners how to overcome their lexical retrieval problems during communicative interactions. As proposed by Prebianca (2004, p. 108), CS instruction provides L2 learners with chances for:

> (i) overcoming their possible communicative problems; (ii) optimizing communication; (iii) bridge the gap between what they know and what they want to say; (iv) developing their metalinguistic awareness, so that they can be able to decide on the best way to reach their communicative goals; (v) playing a more active role in their learning process , thereby expanding their communicative resources through hypothesis-formation processes; (vi) automatizing certain functions of the language such as expressing uncertainty, paraphrasing, asking for help, and using formulaic language.

On top of that, I believe that certain CS can serve as tool to strength the connections among lexical items in the lexico-semantic network. That is, they have the potential to make learners aware of other linguistic forms to convey the same concepts, thereby enlarging the set of conceptual links of these concepts to other concepts in the network as well as to the lexical representations connected to them. The framework of CS proposed by Dörnyei and Kormos (1998) provides some examples of strategies that seem to match this function, such as (i) approximation – which permits the learner to use a similar lexical item that approximates the meaning and conceptual specifications of the intended one, as for instance, **flower** for **tulip**; (ii) circumlocution – which affords learners to convey a problematic lexical item through examples or a description of its features, and (iii) semantic word coinage – which allows learners to create a non-existing L2 word by joining words to form compound nouns. The reasoning behind the teaching of these strategies is to provide learners with the opportunity to use their existing L2 knowledge to build more knowledge and create solutions for their communicative problems. Moreover, each time learners convey a problematic L2 word by replacing it by a similar word, describing its characteristics or mixing up meanings to form a new word, it is likely that they will engage into cycles of analysis and control of linguistic material (Bialystok, 1990), thus reinforcing the existing connections among concepts and words and possibly allowing for the creation of new ones. Because the connections between concepts and lexical items are weak in the L2 mental lexicon and because some items are still underdeveloped in terms of meaning specifications, I believe it is also important to add more lexico-semantic activities to the daily classroom practice such as the study of antonyms, synonyms, cognate words, homophones and hyperonyms in order to help learners to enlarge their lexical networks.

To conclude, the main objective of the present study was to understand the nature of bilingual lexical access mechanisms and how those mechanisms would operate and develop in the course of L2 learning with limited working memory capacity resources. In this sense, I believe it has contributed to refine our knowledge of the processes involved in L2 speech production and their specificities. Despite its experimental nature, this investigation was, from the very beginning, inspired by the magnificent and unique human ability to transform thoughts into words. I hope this work be an inspiration for others aiming at delving into the complexities of human cognition. As wisely pointed out by La Heij (2005, p.03),

> lexical access is a microcosm of cognitive processing: it involves semantic memory, the representation of words, selective attention and other executive functions. If we understand lexical access, we probably know a lot more about cognition in general.

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APPENDICES

APPENDIX A

Consent Form

Universidade Federal de Santa Catarina
Centro de Comunicação e Expressão
Pós Graduação em Letras Inglês e Literatura Correspondente

Prezado (a) Aluno (a):

Você está sendo convidado a participar de um estudo que visa investigar a relação entre capacidade de Memória de Trabalho, nível de proficiência e produção oral em língua estrangeira.

A fim de realizar este estudo, precisaremos coletar dados orais em encontros individuais entre o pesquisador e você. Serão três encontros de aproximadamente 15 minutos de duração cada.

Se você concordar em participar do deste estudo, garantiremos a confidencialidade dos dados a nós fornecidos e nos comprometeremos a não revelar sua identidade em nenhum momento.

Este estudo não é requisito do seu curso, portanto, participar ou não é de sua livre escolha.
Porém, se você decidir ser um de nossos participantes estará nos ajudando a compreender melhor o desenvolvimento da fala em língua estrangeira.

Este estudo está sendo conduzido pela doutoranda Gicele V. Vieira Prebianca e por sua orientadora Dr. Mailce Mota.
Caso necessite entrar em contato conosco, você pode fazê-lo por e-mail (gicelevpreb@gmail.com) ou por telefone – 047 8854-4932.

Agradecemos imensamente sua colaboração!!

Atenciosamente,
Gicele

Termo de Consentimento e Compromisso:

Declaro ter lido as informações que me foram acima prestadas e, ciente delas, expresso aqui minha vontade em participar desta pesquisa de doutorado.

De acordo,

(Nome Completo)

(Assinatura)

(Data)

APPENDIX B

L1 SST - list of words

Training Block	Block 1	Block 2	Block 3
Solução	Telhado	Memória	Nublado
Desenho	Notícia	Correio	Laranja
Negócio	Futebol	Estrela	Remédio
Pêssego	Abóbora	Suborno	Cadeira
Bengala	Cimento	Mochila	Pássaro
Palmito	Carroça	Exilado	Direção
Coleção	Decreto	Leitura	Caderno
Pousada	Estádio	Natação	Lâmpada
Máscara	Hóspede	Armário	Bondade
Vitrine	Azulejo	Gráfica	Planeta
Mordomo	Polícia	Viveiro	Bordado
Imposto	Cérebro	Palhaço	Teatral
Criança	Amizade	Avental	Aquário
Lagosta	Lixeira	Relógio	Cerveja
Justiça	Estação	Cozinha	Besouro
Tubarão	Chinelo	Papelão	Redação
Cintura	Perfume	Assalto	Cortina
Emprego	Galinha	Beliche	Maestro
Hortelã	Tesouro	Matéria	Suporte
Torpedo	Revista	Inverno	Estrada

APPENDIX C

Individual scores on the L1 and L2 SST, the Ospan, the Semantic categorization task, and the Picture-naming task

Participant	SST L2	SST L1	OSPAN	OSPERC	TOTCateg	Rtexp	Rtcontr
01	3	15	10	13	35	1147	1150
02	1	10	2	2	42	1096	1037
03	8	19	9	11	46	1080	1082
04	4	29	21	23	45	1021	1134
05	20	39	24	24	55	783	885
07	13	32	19	21	50	877	863
08	7	24	25	27	44	806	1134
09	6	18	8	10	50	713	728
10	24	27	28	40	56	720	686
11	19	18	10	14	53	750	988
12	20	41	31	37	51	659	799
13	25	27	30	30	59	689	781
14	12	26	8	17	58	726	887
15	10	26	6	13	45	958	901
16	7	22	19	22	52	835	1106
17	23	28	27	29	51	676	717
18	21	24	31	33	54	813	946
19	7	18	21	26	49	674	1043
20	11	30	19	25	42	758	1034
21	10	18	14	14	51	1006	1108
22	11	19	14	19	44	1147	1138
23	7	22	5	8	51	1022	842
24	24	29	27	30	60	691	680
25	14	31	2	2	56	1019	999
26	21	33	17	20	53	828	950
27	25	30	4	4	56	824	907
28	19	22	28	28	56	853	729
29	18	28	21	27	47	862	955
30	8	15	24	24	47	870	917
31	21	23	5	9	44	970	905
32	10	18	8	9	54	871	918
33	19	26	10	14	55	741	766
34	7	15	15	15	55	748	684
35	22	35	21	27	47	892	872
36	10	18	4	12	46	767	991
37	18	36	16	26	55	744	836
38	3	6	10	12	37	858	1108
39	23	39	22	26	49	562	579
40	5	29	34	34	54	516	591
41	25	35	33	33	52	727	890
42	17	20	17	18	55	748	669
43	8	7	28	28	60	824	762
44	16	17	14	14	45	820	831
45	9	15	8	9	44	951	931
46	8	7	7	7	54	862	966
47	17	30	12	14	52	882	964
48	6	24	12	12	53	739	910
49	19	35	17	19	52	618	503

50	35	31	27	27	60	709	824
51	21	27	20	20	56	706	813
52	20	30	18	18	55	770	725
53	20	34	21	22	58	846	1040
54	16	36	37	37	54	792	1002
55	13	14	17	20	46	892	941
56	11	24	16	22	52	880	949
57	15	30	20	20	52	812	688
58	12	24	11	14	53	835	1016
59	12	15	12	14	37	778	929
60	13	14	15	14	53	844	879
61	8	15	6	6	40	853	809
62	10	16	1	9	38	700	760
63	4	16	22	24	49	738	818
64	9	22	26	26	55	857	932
65	10	12	5	5	40	944	808
66	9	15	14	15	36	955	915
67	10	28	19	22	52	961	993
68	6	26	12	15	32	972	990
69	2	13	5	5	32	994	1041
70	3	17	5	5	30	1300	1216
71	7	18	13	22	45	900	732
72	7	16	25	27	46	1032	1028
73	8	13	15	24	42	884	954
74	4	22	5	5	47	889	1021
75	7	35	20	23	51	908	1147
76	13	25	14	16	30	826	613
77	11	18	19	27	43	918	1014
78	15	32	16	16	50	991	1138
79	11	18	5	6	52	1118	936
80	13	16	12	17	52	856	890
81	7	21	13	13	43	1042	1165
82	10	24	18	18	45	908	922
83	16	18	7	9	55	687	796
84	10	25	18	19	56	755	820
85	5	28	12	12	50	938	1014
86	7	25	7	7	60	890	1031
87	24	30	13	13	43	888	861
88	13	31	27	30	50	860	1068
89	29	28	12	19	56	906	668
90	25	23	25	25	46	909	785
91	14	17	21	24	52	877	592
92	17	33	26	29	57	764	585
93	6	8	16	16	49	914	633
94	18	26	24	24	49	922	664
95	11	38	4	24	55	811	598
96	9	23	10	13	46	1090	783
97	17	38	13	19	54	633	607
98	14	16	5	5	51	935	747
99	32	31	5	7	58	890	879
100	24	32	10	18	51	814	657
101	53	57	40	40	59	469	472

APPENDIX D

Instructions for the Speaking Span Tests

No centro da tela do computador aparecerão conjuntos de palavras. Esses conjuntos serão de 2, 3, 4, 5, e 6 palavras cada.
Cada palavra será apresentada na tela do computador por 1 segundo. O intervalo entre as palavras do conjunto será de 10 milissegundos. As palavras não estão relacionadas entre si.

Quando todas as palavras do conjunto forem apresentadas, você verá uma tela com pontos de interrogação que indicarão o número de palavras que você viu naquele conjunto. Juntamente com os pontos de interrogação, você ouvirá um som. Este som é o sinal para você começar a formular orações para cada uma das palavras que você visualizou naquele conjunto.

As orações devem respeitar a ORDEM e a FORMA em que as palavras de cada conjunto foram apresentadas e devem ser gramaticalmente corretas, coesas e coerentes. Podem ser curtas, longas, simples ou complexas.

Vamos considerar um conjunto de 2 palavras: **car** e **club**.
Primeiramente, você verá a palavra **car** no centro da tela do computador por 1 segundo. Ela desaparecerá e após 10 milissegundos a palavra **club** aparecerá também no centro da tela. Quando a palavra **club** desaparecer, você verá 2 pontos de interrogação e ouvirá um som. Nesse momento, você deverá formular 2 orações seguindo a ordem e a forma em que as palavras lhe foram apresentadas. Por exemplo:

I don't have a car.

I usually go to the club on the weekends.

Em seguida, você verá um conjunto de 3 palavras e repetirá os mesmos procedimentos. Depois o conjunto de 4 palavras e assim por diante até o fim do experimento.

Procure se concentrar na tarefa e prestar bastante atenção durante a apresentação das palavras, pois elas permanecerão APENAS 1 segundo na tela do computador.

Você terá três baterias completas de prática antes de começar as três baterias de teste.

Procure não tossir, hesitar, repetir-se e/ou interagir com o pesquisador.
Seu teste será gravado.

APPENDIX E

L2 SST – list of words

Training Block 1	Training Block 2	Training Block 3	Block 1	Block 2	Block 3
House	People	Boss	Arm	Spoon	Ball
Beach	Earth	Island	Course	Bank	Tool
School	Soccer	Tea	Guy	Date	Ice
Hobby	Wife	Mouth	Point	Gas	Bread
Family	Power	Sport	Train	Sky	Sea
Team	World	Baby	Cow	Car	Bag
Night	Summer	Idea	Fire	Dog	Year
Friend	Ocean	Movie	Shoe	Disk	King
Music	Apple	Space	Key	Pen	Band
Snack	Ball	Gift	Snow	Bird	Flag
Drug	Nurse	Clock	Oil	Seat	Job
Honey	truck	Woman	Door	Bath	Air
Light	Actress	Taxi	Boat	Girl	Brain
Face	Room	Fish	Toy	Club	Boy
Coffee	Worker	Milk	Art	Street	Class
Mother	Dress	Problem	Box	Bed	Farm
Prison	Head	Window	Floor	Mind	Bus
Number	City	Lunch	Rock	Mail	TV
Flower	Plant	Party	Coat	Beer	File
Poem	Moon	Money	Book	Pair	Crowd

APPENDIX F

OSPAN – list of operation-word strings

Testing Session

Mathematical Operations	Words
Block 1	
(10 ÷ 2) – 3 = 2 ?	carta
(10 ÷ 10) – 1 = 2 ?	lençol
(7 ÷ 1) + 2 = 7 ?	terra
(3 ÷ 1) - 2 = 3 ?	papel
(2 x 1) - 1 = 1 ?	avó
(10 ÷ 1) + 3 = 13 ?	tinta
(9 x 2) + 1 = 18 ?	guerra
(9 ÷ 1) - 7 = 4 ?	chuva
(8 x 4) - 2 = 32 ?	fila
(9 x 3) - 3 = 24 ?	água
(4 ÷ 1) + 1 = 4 ?	maçã
(10 ÷ 1) - 1 = 9 ?	ferro
(8 x 4) + 2 = 34 ?	jornal
Block 2	
(6 x 3) + 2 = 17 ?	feira
(6 ÷ 3) + 2 = 5 ?	lago
(6 x 2) - 3 = 10 ?	fogão
(8 ÷ 2) + 4 = 2 ?	lixo
(8 ÷ 2) - 1 = 3 ?	dedo
(9 ÷ 1) - 5 = 4 ?	balde
(6 ÷ 2) - 2 = 2 ?	ladrão
(7 x 2) - 1 = 14 ?	rocha
(6 x 2) - 2 = 10 ?	padre

(2 x 2) + 1 = 4 ?	jardim
(7 x 1) + 6 = 13 ?	leite
(3 ÷ 1) + 3 = 6 ?	braço
(10 ÷ 1) + 1 = 10 ?	cobra
(4 x 4) + 1 = 17 ?	fita
(3 x 3) - 1 = 8 ?	irmão
Block 3	
(3 x 1) + 2 = 2 ?	telha
(4 ÷ 2) + 1 = 6 ?	vinho
(5 ÷ 5) + 1 = 2 ?	foto
(2 x 3) + 1 = 4 ?	mala
(9 ÷ 3) - 2 = 1 ?	bruxa
(10 ÷ 2) - 4 = 3 ?	álbum
(5 ÷ 1) + 4 = 9 ?	dente
(10 x 2) + 3 = 23 ?	vidro
(7 ÷ 1) + 6 = 12 ?	trilha
(3 x 2) + 1 = 6 ?	feijão
(6 x 4) + 1 = 25 ?	nuvem
(9 ÷ 3) - 1 = 2 ?	calça
(8 ÷ 1) - 6 = 4 ?	pato
(9 x 1) + 9 = 1 ?	festa

Practice Session

Mathematical Operations	Block 1
(9 ÷ 3) -2 = 2 ?	Lábio
(8 ÷ 4) -1 = 1 ?	Ficha
(6 ÷ 2) + 1 = 4 ?	Jóia
(6 x 3) -2 = 11 ?	Grito
(4 x 2) +1 = 9 ?	Saia
(10 ÷ 2) + 4 = 9 ?	Cofre
(2 + 3) + 3 = 8 ?	Lenda
(7 + 3) - 2 = 8 ?	Pilha
(3 - 1) + 1 = 1 ?	Noite
(9 - 1) ÷ 2 = 4 ?	Perna
(3 x 5) - 2 = 12 ?	Classe
(4 x 3) - 3 = 10 ?	Granja
(2 + 7) + 4 = 12 ?	Loja
(10 – 4) ÷ 2 = 4?	Carne

APPENDIX G

TOEFL iBT test topic

Independent question:

Some people like to watch the news on television. Other people prefer to read the news on a newspaper. Still others use their computers to get the news.

How do you prefer to be informed about the news and why?

Use specific reasons and examples to support your choice.

APPENDIX H

TOEFL iBT test rubrics

TOEFL iBT Speaking Scoring Rubric

Independent Tasks (Questions 1 & 2)

Score	General Description	Delivery	Language Use	Topic Development
4	The response fulfills the demands of the task, with at most minor lapses in completeness. It is highly intelligible and exhibits sustained, coherent discourse. A response at this level is characterized by all of the following:	Generally well-paced flow (fluid expression). Speech is clear. It may include minor lapses, or minor difficulties with pronunciation or intonation patterns, which do not affect overall intelligibility.	The response demonstrates effective use of grammar and vocabulary. It exhibits a fairly high degree of automaticity with good control of basic and complex structures (as appropriate). Some minor (or systematic) errors are noticeable but do not obscure meaning.	Response is sustained and sufficient to the task. It is generally well developed and coherent; relationships between ideas are clear (or clear progression of ideas).
3	The response addresses the task appropriately, but may fall short of being fully developed. It is generally intelligible and coherent, with some fluidity of expression though it exhibits some noticeable lapses in the expression of ideas. A response at this level is characterized by at least two of the following:	Speech is generally clear, with some fluidity of expression, though minor difficulties with pronunciation, intonation, or pacing are noticeable and may require listener effort at times (though overall intelligibility is not significantly affected).	The response demonstrates fairly automatic and effective use of grammar and vocabulary, and fairly coherent expression of relevant ideas. Response may exhibit some imprecise or inaccurate use of vocabulary or grammatical structures used. This may affect overall fluency, but it does not seriously interfere with the communication of the message.	Response is mostly coherent and sustained and conveys relevant ideas/information. Overall development is somewhat limited, usually lacks elaboration or specificity. Relationships between ideas may at times not be immediately clear.

TOEFL iBT Speaking Scoring Rubric

Independent Tasks (Questions 1 & 2)

Score	General Description	Delivery	Language Use	Topic Development
2	The response addresses the task, but development of the topic is limited. It contains intelligible speech, although problems with delivery and/or overall coherence occur; meaning may be obscured in places. A response at this level is characterized by at least two of the following:	Speech is basically intelligible, though listener effort is needed because of unclear articulation, awkward intonation, or choppy rhythm/ pace; meaning may be obscured in places.	The response demonstrates limited range and control of grammar and vocabulary. These limitations often prevent full expression of ideas. For the most part, only basic sentence structures are used successfully and spoken with fluidity. Structures and vocabulary may express mainly simple (short) and/or general propositions, with simple or unclear connections made among them (serial listing, conjunction, juxtaposition).	The response is connected to the task, though the number of ideas presented or the development of ideas is limited. Mostly basic ideas are expressed with limited elaboration (details and support). At times relevant substance may be vaguely expressed or repetitious. Connections of ideas may be unclear.
1	The response is very limited in content and/ or coherence or is only minimally connected to the task, or speech is largely unintelligible. A response at this level is characterized by at least two of the following:	Consistent pronuciation, stress, and intonation difficulties cause considerable listener effort; delivery is choppy fragmented, or telegraphic; frequent pauses and hesitations.	Range and control of grammar and vocabulary severely limit (or prevent expression of) ideas and connections among ideas. Some low-level responses may rely heavily on practiced or formulaic expressions.	Limited relevant content expressed. The response generally lacks substance beyond expression of very basic ideas. Speaker may be unable to sustain speech to complete task and may rely heavily on repetition of the prompt.
0	Speaker makes no attempt to respond OR response is unrelated to the topic.			

APPENDIX I

TOEFL iBT – Rating scores

Participant	RATER 1	RATER 2	RATER 3	Média
01	1	1	2	1,33
02	1	1	1	1,00
03	1	1	2	1,33
04	1	1	1	1,00
05	2	2	2	2,00
07	1	2	2	1,67
08	1	2	2	1,67
09	3	4	3	3,33
10	4	4	4	4,00
11	4	4	4	4,00
12	3	4	3	3,33
13	4	4	4	4,00
14	2	2	3	2,33
15	2	3	3	2,67
16	4	3	4	3,67
17	4	4	4	4,00
18	3	2	3	2,67
19	3	3	4	3,33
20	2	3	2	2,33
21	2	3	2	2,33
22	1	2	3	2,00
23	1	2	2	1,67
24	3	3	2	2,67
25	3	4	3	3,33
26	2	2	3	2,33
27	4	4	4	4,00
28	3	3	4	3,33
29	1	2	3	2,00
30	2	3	3	2,67
31	1	1	2	1,33
32	2	3	3	2,67
33	3	3	3	3,00
34	3	3	3	3,00
35	2	2	3	2,33
36	3	1	2	2,00
37	4	4	4	4,00
38	3	3	3	3,00
39	4	4	4	4,00
40	2	2	3	2,33
41	3	3	4	3,33
42	4	4	4	4,00
43	4	4	4	4,00
44	4	3	4	3,67
45	2	2	2	2,00
46	3	3	3	3,00
47	3	3	2	2,67
48	3	4	4	3,67
49	2	3	3	2,67

50	4	4	4	4,00
51	3	3	3	3,00
52	3	3	4	3,33
53	3	3	3	3,00
54	1	2	2	1,67
55	1	1	1	1,00
56	3	3	4	3,33
57	3	4	3	3,33
58	1	1	2	1,33
59	1	1	1	1,00
60	4	3	4	3,67
61	2	3	2	2,33
62	3	3	4	3,33
63	1	3	1	1,67
64	2	2	3	2,33
65	3	3	4	3,33
66	2	1	3	2,00
67	1	1	2	1,33
68	1	1	2	1,33
69	1	1	1	1,00
70	1	1	2	1,33
71	2	2	2	2,00
72	2	2	2	2,00
73	1	2	2	1,67
74	1	2	2	1,67
75	2	2	2	2,00
76	1	1	2	1,33
77	2	2	3	2,33
78	2	2	3	2,33
79	2	2	3	2,33
80	1	1	2	1,33
81	2	2	2	2,00
82	3	3	4	3,33
83	3	3	4	3,33
84	3	4	4	3,67
85	3	3	3	3,00
86	3	3	4	3,33
87	2	3	3	2,67
88	3	3	3	3,00
89	3	4	4	3,67
90	4	4	4	4,00
91	2	3	2	2,33
92	2	3	3	2,67
93	1	1	2	1,33
94	3	3	3	3,00
95	3	3	3	3,00
96	2	2	3	2,33
97	4	3	4	3,67
98	3	3	2	2,67
99	4	4	4	4,00
100	3	4	4	3,67
101	4	4	4	4,00

APPENDIX J

Semantic Categorization Task – list of words

Superordinate Nouns	**Subordinate Nouns**
TRANSPORTATION	Ferry
	Taxi
	Motorcycle
	Ship
	Subway
FRUIT	Lemon
	Orange
	Pineapple
	Strawberry
	Watermelon
ANIMAL	Sheep
	Whale
	Camel
	Rabbit
	Snake
SCHOOL OBJECT	Ruler
	Pencil
	Eraser
	Notebook
	Map
BODY PART	Leg
	Arm
	Head
	Knee
	Back
VEGETABLE	Lettuce
	Carrot
	Eggplant
	Pea
	Onion

Filler nouns
Ladder
Comb
Guitar
Kite
Pie
Jar
Button
Vase
Stove
Sofa
Cup
Blender
Gate
Feather
Rope
Riffle
Vest
Lipstick
Shirt
Skirt
Plate
Rocket
Iron
Hammer
Sword
Flag
Towel
Rug
Blanket
Lock

APPENDIX K

Semantic Categorization Task – Individual scores on TOTGeral, TOTCateg and MeanRTGer (in milliseconds)

Participant	TOTGeral	TOTCATEG	MeanRTGer
1	64	35	1053,05
2	72	42	797,10
3	81	46	982,22
4	76	45	797,60
5	93	55	751,61
7	90	50	789,04
8	80	44	846,03
9	84	50	594,20
10	95	56	999,70
11	88	53	887,84
12	90	51	819,25
13	98	59	788,01
14	96	58	656,34
15	80	45	830,31
16	87	52	1011,74
17	87	51	704,46
18	88	54	759,86
19	89	49	836,63
20	73	42	883,70
21	87	51	945,48
22	77	44	894,17
23	89	51	959,89
24	97	60	921,10
25	96	56	896,92
26	88	53	986,43
27	94	56	954,78
28	95	56	858,00
29	84	47	1118,49
30	81	47	944,97
31	75	44	926,12
32	91	54	736,20
33	94	55	811,99
34	88	55	679,87
35	82	47	1132,27
36	81	46	906,30
37	93	55	847,99
38	70	37	860,40
39	85	49	535,33
40	92	54	780,47
41	91	52	937,55
42	92	55	832,84
43	99	60	909,05
44	82	45	1028,54
45	77	44	849,20
46	92	54	921,12
47	90	52	865,29

48	90	53	897,85
49	83	52	830,02
50	99	60	1022,78
51	94	56	904,72
52	95	55	829,84
53	92	58	941,33
54	93	54	908,06
55	80	46	973,94
56	87	52	685,95
57	91	52	865,40
58	92	53	599,28
59	68	37	797,80
60	92	53	765,80
61	72	40	731,85
62	61	38	467,45
63	82	49	614,45
64	91	55	925,19
65	72	40	731,85
66	56	36	718,78
67	90	52	924,10
68	57	32	515,11
69	57	32	448,97
70	60	30	700,60
71	78	45	587,59
72	84	46	892,69
73	73	42	1006,89
74	83	47	797,42
75	90	51	829,63
76	57	30	473,13
77	74	43	706,10
78	85	50	988,87
79	88	52	1041,67
80	83	52	662,08
81	70	43	729,95
82	80	45	877,74
83	94	55	817,97
84	91	56	912,89
85	83	50	1092,48
86	99	60	936,70
87	75	43	998,44
88	85	50	961,53
89	92	56	918,60
90	75	46	809,13
91	91	52	637,07
92	95	57	725,92
93	85	49	813,96
94	80	49	831,83
95	94	55	878,87
96	73	46	643,85
97	90	54	632,00
98	86	51	927,21
99	98	58	830,35
100	86	51	711,83
101	99	59	599,36

APPENDIX L

Picture-Naming task – list of words

TARGET PICTURES	SEMANTICALLY RELATED WORD DISTRACTORS	PHONOLOGICALLY RELATED WORD DISTRACTORS
1. Ball	Soccer	Tall
2. Bee	Honey	Fee
3. Bell	Church	Well
4. Cake	Chocolate	Take
5. Car	Bus	Far
6. Cat	Dog	Fat
7. Chair	Table	Fair
8. Clock	Time	Block
9. Cow	Milk	Now
10. Dog	Cat	Fog
11. Door	Window	Floor
12. Egg	Chicken	Beg
13. Eye	Mouth	Tie
14. Fish	Ocean	Niche
15. Glass	Water	Mass
16. Hand	Foot	Band
17. Heart	Love	Art
18. House	Apartment	Mouse
19. Key	Door	Tea
20. Knife	Fork	Wife
21. Leaf	Tree	Brief
22. Moon	Sky	Soon
23. Pen	Pencil	Ten
24. Nurse	Doctor	Purse
25. Sun	Rain	Fun

FILLERS	UNRELATED WORD DISTRACTORS
Bag	Vase
Bear	Hotel
Bed	Ice
Belt	Mop
Bird	Leg
Book	Tie
Box	Tail
Boy	Wind
Bread	Shirt
Chess	Rope
Plant	Vest

Cup	Neck
Finger	Rat
Flower	Beer
Fork	Doll
Frog	Knee
Ghost	Sofa
Grape	Night
Hat	Rose
Horse	Coin
Lamp	Brush
Monkey	Wine
Ring	Bike
Pear	Castle
Pig	Bank
Plane	Hair
King	Road
Sock	Kite
Table	Lake
Train	Lip

TRAINING PICTURES	**UNRELATED DISTRACTORS**
Bat	Towel
Boat	Fox
Bomb	Rice
Boot	Meat
Bus	Mask
Bull	Gas
Fire	Bean
Foot	Bill
Hook	Rug
Rat	Oil
Kiss	Ant
Mug	Grass
Pan	Clown
Chicken	Ash
Rain	Lunch
Roof	Film
Shark	Mind
Tree	Pilot
Tent	Art
Wall	Flea

APPENDIX M

Sample of Speech Transcriptions

SST in L2 and L1, OSPAN and TOEFL iBT Speaking Test

Participant 66

SST L2:
Block 1
2
I do a course at Furb
I use my arm to make my homework

3
Hi, guys!

4
The fire is hot ok
Take the key ok
The cow eat so much

5
Close the door
Use oil to cook

6
I read the book everyday
I love the rock music

Block 2
2
I don't know what is spoon
The bank is nice ok

3
The sky is blue ok

4
My pen is blue
I love my car ok
My dog is Lana ok

5
I will go to club at Saturday
The girl is beautiful

6
My bed is big ok

Block 3
2
The ball is big ok
I don't know what is the other word

3
The sea is big
The bread is so delicious

4
I'm fifteen years old

5
He is a handsome boy ok

6
I hate take bus
I love my class

SST L1:
Block 1
2
A notícia é legal
O telhado é lindo

3
O Flamengo ganhou no futebol   ok

4
Vou assistir o jogo no estádio do Maracanã   ok

5
Jogue o lixo na lixeira
Ela é uma grande amizade
O azulejo está sujo

6
Esta é a melhor estação   ok
Adoro esta revista   ok

Block 2
2
Eu tenho uma péssima memória ok
Mandei pelo correio a sua carta   ok

3
Ela comprou uma mochila rosa
Isto é um suborno

4
Guarde as roupas no armário
Ela ama leitura ok
Eu gosto de fazer natação ok

5
Mande imprimir na gráfica ok
Não esqueça de usar o avental ok

6
Amo a matéria Português
O inverno é um frio gostoso

Block 3
2
Como o dia está nublado ok
Amo esta fruta laranja ok

3
Que pássaro lindo!

4
Escreva certo no caderno ok
Faça apenas bondade ok

5
Não beba cerveja e depois não dirija

6
Eles estão duplicando a estrada ok

OSpan L1:
Block 1
3

Dez dividido por dois menos três igual a dois	SIM - CARTA
Dez dividido por dez menos um igual a dois	NÃO - LENÇOL
Sete dividido por um mais dois igual a	NÃO – TERRA

CARTA
LENÇOL
TERRA

5

Três dividido por um menos dois igual a três	NÃO - PAPEL
Dois vezes um menos um igual a um	SIM - AVÓ
Dez dividido por um mais três igual a treze	SIM - TINTA
Nove vezes dois mais um igual a dezoito	NÃO - GUERRA
Nove dividido por um menos sete igual a quatro	NÃO – CHUVA

CHUVA
PAPEL
TERRA

3
Oito vezes quatro menos dois igual a trinta e dois NÃO – FILA
Nove vezes três menos três igual a vinte e quatro NÃO - ÁGUA
Quatro dividido por um mais um igual a quatro NÃO – MAÇÃ
MAÇÃ
FILA

2
Dez dividido por um menos um igual a nove SIM - FERRO
Oito vezes quatro mais dois igual a trinta e quatro SIM – JORNAL
FOGO
JORNAL

Block 2
5
Seis vezes três mais dois igual a dezessete NÃO - FEIRA
Seis dividido por três mais dois igual a cinco NÃO - LAGO
Seis vezes dois menos três igual a dez NÃO - FOGÃO
Oito dividido por dois mais quatro NÃO - LIXO
Oito dividido por dois menos um igual a três SIM – DEDO
FOGÃO
LIXO
DEDO

4
Nove dividido por um menos cinco igual a quatro SIM – BALDE
Seis dividido por dois menos dois igual a dois NÃO - LADRÃO
Sete vezes dois menos um igual a catorze NÃO - ROCHA
Seis vezes dois menos dois igual a dez SIM – PADRE
FOGÃO
ROCHA
BALDE 1
PADRE

2
Dois vezes dois mais um igual a quatro NÃO - JARDIM
Sete vezes um mais seis igual a treze SIM – LEITE
LEITE

4
Três dividido por um mais três igual a seis SIM - BRAÇO
Dez dividido por um mais um igual a dez NÃO - COBRA
Quatro vezes quatro mais um igual a dezessete SIM - FITA
Três vezes três menos um igual a oito SIM – IRMÃO
COBRA
IRMÃO

Block 3

3	
Três vezes um mais dois igual a dois	NÃO - TELHA
Quatro dividido por dois mais um igual a seis	NÃO - VINHO
Cinco dividido por cinco mais um igual a dois	SIM – FOTO
FOGÃO	
TELHA	
FOTO	
5	
Dois vezes três mais um igual a quatro	NÃO - MALA
Nove dividido por três menos dois igual a um	SIM - BRUXA
Dez dividido por dois menos quatro igual a três	NÃO - ÁLBUM
Cinco dividido por um mais quatro igual a nove	SIM - DENTE
Dez vezes dois mais três igual a vinte e três	SIM – VIDRO
VIDRO	
ÁLBUM	
FOTO	
2	
Sete dividido por um mais seis igual a doze	NÃO - TRILHA
Três vezes dois mais um igual a seis	NÃO – FEIJÃO
TRILHA	
FEIJÃO	
4	
Seis vezes quatro mais um igual a vinte e cinco	SIM - NUVEM
Nove dividido por três menos um igual a dois	SIM - CALÇA
Oito dividido por um menos seis igual a quatro	NÃO - PATO
Nove vezes um mais nove igual a um	NÃO – FESTA
TRILHA	
PATO	
CALÇA	
FESTA	

Toefl Speaking Test:

I like watch the news on TV because I like the see the news. I don’t like computer because I pay attention in the other sides, the other ……. And I don’t pay attention in the news.

Participant 03

SST L2:
Block 1
2
What is arm?
Of course,of course

3
I went by train
That guy is beautiful

4
The cow of my house is black

5
I bought a toy

6
The book is on the desk

Block 2
2
The bank is in Blumenau

3
I fly in the sky

4
I bought a pen
My dog is Shreek
My car is blue

5
I seat at the sofa
My best friend is a girl

6
I drink a beer
I went to bed at 9 o'clock

Block 3
2
I don't know what's tool

3
I put ice in the fridge
4
My bag is big

5
I like my job
I have a boyfriend

6
I go to English class

SST L1:
Block 1
2
O telhado da minha casa quebrou
Eu ouvi uma notícia no rádio

3
Fui ver um jogo de futebol ontem
Comprei cimento pra construir

4
Tem um hóspede na minha casa

5
Fiz uma amizade ontem
A lixeira da minha casa caiu

6
Comprei um chinelo um perfume e uma revista

Block 2
2
Fui no correio
Fiz um teste de memória

3
Vi uma estrela cair do céu
Meu pai teve um suborno
Comprei uma mochila

4
Limpei o meu armário
Me inscrevi num curso de natação

5
Coloquei o meu avental
Meu relógio estragou
Meu pai fez um viveiro pro meu passarinho

6
Estudei para uma matéria ontem

Block 3
2
O céu estava nublado ontem
Fui a feira e comprei laranja

3
Sentei numa cadeira
Comprei um pássaro
Tomei um remédio

4
A lâmpada da minha casa quebrou
Sou uma pessoa com bastante bondade

5
Bebi uma cerveja
Fui ver uma peça teatral
Fiz um bordado

6
Viajei por uma estrada

OSpan L1:
Block 1
3

Dez dividido por dois menos tres é igual a dois	SIM - CARTA
Dez dividido por dez menos um é igual a dois	NÃO - LENÇOL
Sete dividido por um mais dois igual a sete	NÃO - TERRA

CARTA
TERRA

5

Três dividido por um menos dois igual a três	NÃO - PAPEL
Dois vezes um menos um igual a um	SIM - AVÓ
Dez dividido por um mais três igual a treze	SIM - TINTA
Dois vezes nove mais um igual a dezoito	NÃO - GUERRA
Nove dividido por um menos sete igual a quatro	NÃO - CHUVA

CARTA
CHUVA
GUERRA
PAPEL

3

Oito vezes quatro menos dois igual a trinta e dois	NÃO - FILA
Nove vezes três menos três igual a vinte e quatro	SIM - ÁGUA

Quatro dividido por um mais um igual a quatro NÃO - MAÇÃ
FILA
MAÇÃ

2
Dez dividido por um menos um igual a nove SIM - FERRO
Oito vezes quatro mais dois igual a trinta e quatro SIM - JORNAL
FERRO
JORNAL

Block 2
5
Seis vezes tres mais dois igual a dezessete NÃO - FEIRA
Seis dividido por três mais dois igual a cinco NÃO - LAGO
Seis vezes dois menos três igual a dez NÃO - FOGÃO
Oito dividido por dois mais quatro igual a dois NÃO - LIXO
Oito dividido por dois menos um igual a três SIM - DEDO
DEDO
FOGÃO

4
Nove dividido por um menos cinco igual a quatro NÃO - BALDE
Seis dividido por dois menos dois igual a dois NÃO - LADRÃO
Sete vezes dois menos um igual a catorze NÃO - ROCHA
Seis vezes dois menos dois igual a dez SIM - PADRE
ROCHA
BALDE
LADRÃO

2
Dois vezes dois mais um igual a quatro NÃO - JARDIM
Sete vezes um mais seis igual a treze SIM – LEITE
LEITE

4
Três dividido por um mais três igual a seis NÃO - BRAÇO
Quatro vezes quatro mais um igual a dezessete NÃO - FITA
Três vezes três menos um igual a oito SIM - IRMÃO
IRMÃO
FITA
BRAÇO

Block 3
3
Tres vezes um mais dois igual a dois NÃO - TELHA
Quatro dividido por dois mais um igual a seis NÃO - VINHO
Cinco dividido por cinco mais um igual a dois SIM - FOTO
FOTO
TELHA

5
Dois vezes três mais um igual a quatro NÃO - MALA
Nove dividido por três menos dois igual a um SIM - BRUXA
Dez dividido por dois menos quatro igual a três NÃO - ÁLBUM
Dez vezes dois mais três igual a vinte e três SIM - VIDRO
VIDRO
BRUXA

2
Sete dividido por um mais seis igual a doze NÃO - TRILHA
Três vezes dois mais um igual a seis NÃO - FEIJÃO
TRILHA
FEIJÃO

4
Seis vezes quatro mais um igual a vinte e cinco NÃO - NUVEM
Nove dividido por três menos um igual dois SIM - CALÇA
Oito dividido por um menos seis igual a quatro NÃO - PATO
Nove vezes um mais nove igual a um NÃO - FESTA
PATO
FESTA
TRILHA

Toefl Speaking Test:

I prefer news in the internet because is is my practice? …practice?...eh…for me I , I knew this is better?, the best?..........for me is more eh is more important.

Participant 18

SST L2:
Block 1
2
You hurt my arm
I have to do a course

3
I love that guy
I don't know what's train
I don't know what's point

4
The cow is black
I lost my key

5
I love the snow
I wanna a toy

6
I wanna buy a book
I hate rock

Block 2
2
The spoon is black

3
I have a date
The sky is black

4
I love my dog
My car is red

5
I love bird
I know that girl
I wanna go to the club

6
You lost him on the street

Block 3
2
The ball is blue
I don't know what is tool

3
I love bread
The sea is blue

4
It's a new year
I wanna know the king

5
I don't know what is flag
I love bad boy

6
I went to the farm
I don't know what is crowd

SST L1:
Block 1
2
Meu telhado quebrou
Eu vi aquela notícia

3
Eu não gosto de futebol
Eu comi abóbora

4
A carroça quebrou
Este é meu hóspede
Ele fez um decreto

5
Existem grandes amizades
Eu joguei a banana na lixeira
Eu comprei um bloco de cimento

6
Eu comprei um novo perfume
Eu olhei aquela revista

Block 2
2
Eu não tenho uma boa memória
Eu botei aquele envelope no correio

3
Eu gosto de estrela
Comprei uma nova mochila
Ele tentou fazer um suborno

4
Aquele homem foi exilado
Botei meu livro dentro do armário

5
O relógio está errado
Comprei um avental

6
Eu caí do beliche
Eu gosto do inverno
A estação mudou

Block 3
2
O tempo está nublado
Comprei uma blusa laranja

3
Estou tomando aquele remédio
Meu irmão caiu da cadeira
Meu avô comprou um pássaro

4
A lâmpada queimou
As pessoas precisam ter mais bondade

5
O planeta está sendo destruído
Botei novos peixes dentro do aquário

6
Eu não gosto de besouro
Tem um homem perdido na estrada
Aconteceu um desastre

OSpan L1:
Block 1
3

Dez dividido por dois menos três igual a dois?	SIM - CARTA
Dez dividido por dez menos um igual a dois?	NÃO - LENÇOL
Sete dividido por um mais dois igual a sete?	NÃO – TERRA

CARTA
LENÇOL
TERRA

5

Três dividido por um menos dois igual a três?	NÃO - PAPEL
Dois vezes um menos um igual a um?	SIM - AVÓ

Dez dividido por um mais três igual a treze? SIM - TINTA
Nove vezes dois mais um igual a dezoito? NÃO - GUERRA
Nove dividido por um menos sete igual a quatro? NÃO – CHUVA
PAPEL
AVÓ
GUERRA
CHUVA
LENÇO

3
Oito vezes quatro menos dois igual a trinta e dois? NÃO - FILA
Nove vezes três menos três igual a vinte e quatro? SIM - ÁGUA
Quatro dividido por um mais um igual a quatro? NÃO – MAÇÃ
FILA
ÁGUA
MAÇÃ

2
Dez dividido por um menos um igual a nove? SIM - FERRO
Oito vezes quatro mais dois igual a trinta e quatro? SIM – JORNAL
FERRO
JORNAL

Block 2
5
Seis vezes três mais dois igual a dezessete? NÃO - FEIRA
Seis dividido por três mais dois igual a cinco? NÃO - LAGO
Seis vezes dois menos três igual a dez? NÃO - FOGÃO
Oito dividido por dois mais quatro igual a dois? NÃO - LIXO
Oito dividido por dois menos um igual a três? SIM – DEDO
FEIRA
DEDO
LIXO

4
Nove dividido por um menos cinco igual a quatro? SIM - BALDE
Seis dividido por dois menos dois igual a dois? NÃO - LADRÃO
Sete vezes dois menos um igual a catorze? NÃO - ROCHA
Seis vezes dois menos dois igual a dez? SIM – PADRE
BALDE
ROCHA
PADRE

2
Dois vezes dois mais um igual a quatro? NÃO - JARDIM
Sete vezes um mais seis igual a treze? NÃO – LEITE
JARDIM
LEITE

4

Três dividido por um mais três igual a seis?	SIM - BRAÇO
Dez dividido por um mais um igual a dez?	NÃO - COBRA
Quatro vezes quatro mais um igual a dezessete?	SIM - FITA
Três vezes três menos um igual a oito?	SIM – IRMÃO

BRAÇO
COBRA
FITA
IRMÃO

Block 3

3

Três vezes um mais dois igual a dois?	NÃO - TELHA
Quatro dividido por dois mais um igual a seis?	NÃO - VINHO
Cinco dividido por cinco mais um igual a dois?	SIM – FOTO

TELHA
VINHO
FOTO

5

Dois vezes três mais um igual a quatro?	NÃO - MALA
Nove dividido por três menos dois igual a um?	SIM - BRUXA
Dez dividido por dois menos quatro igual a três?	NÃO - ÁLBUM
Cinco dividido por um mais quatro igual a nove?	SIM - DENTE
Dez vezes dois mais três igual a vinte e três?	SIM – VIDRO

MALA
BRUXA
VIDRO

2

Sete dividido por um mais seis igual a doze?	NÃO - TRILHA
Três vezes dois mais um igual a seis?	NÃO – FEIJÃO

TRILHA
FEIJÃO

4

Seis vezes quatro mais um igual a vinte e cinco?	SIM - NUVEM
Nove dividido por três menos um igual a dois?	SIM - CALÇA
Oito dividido por um menos seis igual a quatro?	NÃO - PATO
Nove vezes um mais nove igual a um?	NÃO – FESTA

CALÇA
PATO
FESTA

<u>Toefl Speaking Test:</u>

I prefer to get………… to get the news on the internet because I don't like to watch TV. I……………………………………I think that is very sick stay in front of TV and…………………that's it.

APPENDIX N

Instructions for the TOEFL iBT Speaking Test

Para esta tarefa você precisará de uma folha de papel e de uma caneta.

Você ouvirá um narrador que lhe perguntará sua opinião sobre um tópico familiar. Após ouvir a pergunta, um bip soará e você terá então 15 segundos para preparar sua resposta. Faça as anotações que achar necessárias na folha de papel. Você poderá usar essas anotações para responder à pergunta.

Ao final dos 15 segundos, você ouvirá uma gravação pedindo que você comece a responder. Então, outro bip indicará o momento exato em que você deverá começar a falar. Você terá 45 segundos após o bip para dar sua resposta.

Fale alto e claramente.
Seu teste será gravado.

Boa sorte!!!

APPENDIX O

Instructions for the Operation Span Test

Nesta tarefa você tentará memorizar palavras que você verá na tela do computador. Entre as palavras que serão apresentadas na tela, você terá que resolver operações matemáticas simples.
Você verá na tela uma equação seguida de uma palavra. Sua tarefa é ler a equação em voz alta e verificar se o resultado da mesma está ou não correto dizendo **SIM** ou **NÃO** no microfone. Imediatamente após dar sua resposta, você lerá a palavra também em voz alta. Você poderá pensar por alguns instantes na resposta, mas não poderá esperar para ler a palavra.

Vamos ver um exemplo:
(2 + 1) ÷ 3 = 1 ? GATO

Nesse caso você leria em voz alta: "Dois mais um, dividido por 3 é igual a um? Em seguida, você responderia **SIM** porque 1 é o resultado correto da equação. Imediatamente após dizer **SIM**, você leria em voz alta a palavra **GATO**. Você deve tentar memorizar esta palavra.

Você verá 3 blocos com 2, 3, 4 e/ou 5 pares de equações e palavras. Quando todos os pares de equações e palavras de um determinado conjunto forem apresentados, você verá uma tela com pontos de interrogação que indicarão o número de palavras que você viu naquele conjunto. Este será o sinal para você começar a dizer em voz alta as palavras que você conseguiu memorizar, respeitando a ordem em que elas apareceram na tela.

Em seguida, você verá outro conjunto de equações e palavras e repetirá os mesmos procedimentos até o fim do experimento.
Procure se concentrar na tarefa e prestar bastante atenção durante a apresentação das equações e das palavras, pois elas permanecerão por apenas alguns segundos na tela do computador.

Além de tentar memorizar a palavra apresentada após a equação, é muito importante que você também se esforce para acertar o resultado das equações.

Você terá um bloco completo de prática antes de começar os três blocos de teste.

Procure não tossir, hesitar, repetir-se e/ou interagir com o pesquisador. Seu teste será gravado.

APPENDIX P

Instructions for the Picture-naming Task

- ✓ Training Session:

Bem-vindo à Seção de Treinamento!!
Nesta seção você verá pares de figuras e palavras. A sua tarefa é nomear as figuras o mais rápido e corretamente possível, tentando ignorar as palavras. Por favor, fale alto e claramente. Tente não gaguejar, hesitar, corrigir-se ou repetir o que foi dito.

Pressione a barra de espaço para iniciar.

At the end of the training session: *A seção de treinamento terminou. Obrigada!*

- ✓ Control Condition:

Bem-vindo à primeira parte do experimento!!
Desta vez você verá somente figuras. Sua tarefa é nomeá-las o mais rápido e corretamente possível assim que aparecerem na tela. Por favor, fale alto e claramente. Tente não gaguejar, hesitar, corrigir-se ou repetir o que foi dito.

Pressione a barra de espaço para iniciar.

At the end of the control condition: *A primeira parte do experimento terminou. Obrigada!*

- ✓ Experimental Condition:

Bem-vindo à segunda parte do experimento!!
Agora você verá pares de figuras e palavras. Desta vez, as palavras serão apresentadas antes da figura, juntamente com a figura e após a apresentação da figura. A sua tarefa é nomear as figuras o mais rápido e corretamente possível, tentando ignorar as palavras. Por favor, fale alto e claramente. Tente não gaguejar, hesitar, corrigir-se ou repetir o que foi dito.

Pressione a barra de espaço para iniciar.

At the end of the experimental condition: *O experimento terminou. Obrigada por participar!*

APPENDIX Q

Instructions for the Semantic Categorization Task

✓ Experimental Session

Bem vindo à tarefa de Categorização Semântica!!

Nesta tarefa você verá uma palavra que representa uma categoria seguida de uma palavra que representa um objeto. Sua tarefa é dizer se esse objeto pertence ou não àquela categoria.
Por exemplo, você verá a categoria BEBIDA no centro da tela do computador. Em seguida, você verá a palavra CAFÉ também no centro da tela. Sua tarefa é dizer se CAFÉ é ou não uma bebida. Digite 1 se a resposta for SIM e 2 se a resposta for NÃO.

Pressione a barra de espaço para iniciar.

At the end of the experimental condition: *O experimento terminou. Obrigada por participar!*

✓ Training Session

Bem vindo à Seção de Treinamento!!

Nesta seção você verá *uma palavra que representa uma categoria seguida de uma palavra que representa um objeto. Sua tarefa é dizer se esse objeto pertence ou não àquela categoria.*
Por exemplo, você verá a categoria BEBIDA no centro da tela do computador. Em seguida, você verá a palavra CAFÉ também no centro da tela. Sua tarefa é dizer se CAFÉ é ou não uma bebida. Digite 1 se a resposta for SIM e 2 se a resposta for NÃO.

Pressione a barra de espaço para iniciar.

At the end of the training session: *A seção de treinamento terminou. Obrigada!*

APPENDIX R

Descriptive Statistics and Frequencies for measures of L2 Proficiency – PRO1, PRO2 and PRO3

Frequencies

Statistics
TOTCATEG

N	Valid	100
	Missing	0
Mean		49,44
Percentiles	25	45,00
	50	51,00
	75	55,00

TOTCATEG

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	30	2	2,0	2,0	2,0
	32	2	2,0	2,0	4,0
	35	1	1,0	1,0	5,0
	36	1	1,0	1,0	6,0
	37	2	2,0	2,0	8,0
	38	1	1,0	1,0	9,0
	40	2	2,0	2,0	11,0
	42	3	3,0	3,0	14,0
	43	3	3,0	3,0	17,0
	44	4	4,0	4,0	21,0
	45	5	5,0	5,0	26,0
	46	6	6,0	6,0	32,0
	47	4	4,0	4,0	36,0
	49	5	5,0	5,0	41,0
	50	5	5,0	5,0	46,0
	51	7	7,0	7,0	53,0
	52	10	10,0	10,0	63,0
	53	5	5,0	5,0	68,0
	54	6	6,0	6,0	74,0
	55	9	9,0	9,0	83,0
	56	7	7,0	7,0	90,0
	57	1	1,0	1,0	91,0
	58	3	3,0	3,0	94,0
	59	2	2,0	2,0	96,0
	60	4	4,0	4,0	100,0
	Total	100	100,0	100,0	

Frequencies

Statistics

PROFTOE

N	Valid	100
	Missing	0
Mean		2,6496
Percentiles	25	2,0000
	50	2,6700
	75	3,3300

PROFTOE

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1,00	5	5,0	5,0	5,0
	1,33	10	10,0	10,0	15,0
	1,67	7	7,0	7,0	22,0
	2,00	10	10,0	10,0	32,0
	2,33	13	13,0	13,0	45,0
	2,67	10	10,0	10,0	55,0
	3,00	10	10,0	10,0	65,0
	3,33	14	14,0	14,0	79,0
	3,67	8	8,0	8,0	87,0
	4,00	13	13,0	13,0	100,0
	Total	100	100,0	100,0	

Descriptives

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
TOTCATEG	100	30	60	49,44	6,91
Valid N (listwise)	100				

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
PROFTOE	100	1,00	4,00	2,6496	,9158
Valid N (listwise)	100				

Frequencies

Statistics

MEANZ

N	Valid	100
	Missing	0
Mean		-1.7231E-15
Percentiles	25	-,6034
	50	,1396
	75	,6966

MEANZ

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	-2,16	1	1,0	1,0	1,0
	-2,13	2	2,0	2,0	3,0
	-1,98	1	1,0	1,0	4,0
	-1,80	1	1,0	1,0	5,0
	-1,76	1	1,0	1,0	6,0
	-1,44	1	1,0	1,0	7,0
	-1,33	1	1,0	1,0	8,0
	-1,22	1	1,0	1,0	9,0
	-1,15	1	1,0	1,0	10,0
	-1,11	1	1,0	1,0	11,0
	-1,07	1	1,0	1,0	12,0
	-,97	1	1,0	1,0	13,0
	-,93	1	1,0	1,0	14,0
	-,86	1	1,0	1,0	15,0
	-,82	1	1,0	1,0	16,0
	-,75	1	1,0	1,0	17,0
	-,75	2	2,0	2,0	19,0
	-,71	1	1,0	1,0	20,0
	-,71	1	1,0	1,0	21,0
	-,71	1	1,0	1,0	22,0
	-,68	1	1,0	1,0	23,0
	-,64	1	1,0	1,0	24,0
	-,60	2	2,0	2,0	26,0
	-,57	1	1,0	1,0	27,0
	-,54	2	2,0	2,0	29,0
	-,53	1	1,0	1,0	30,0
	-,49	1	1,0	1,0	31,0
	-,46	1	1,0	1,0	32,0
	-,46	1	1,0	1,0	33,0
	-,45	1	1,0	1,0	34,0
	-,42	1	1,0	1,0	35,0
	-,42	1	1,0	1,0	36,0
	-,35	1	1,0	1,0	37,0
	-,31	1	1,0	1,0	38,0
	-,31	1	1,0	1,0	39,0
	-,24	1	1,0	1,0	40,0
	-,21	1	1,0	1,0	41,0
	-,17	1	1,0	1,0	42,0
	-,13	1	1,0	1,0	43,0
	-,06	1	1,0	1,0	44,0
	,01	2	2,0	2,0	46,0
	,05	1	1,0	1,0	47,0
	,05	1	1,0	1,0	48,0
	,08	1	1,0	1,0	49,0
	,12	1	1,0	1,0	50,0
	,16	1	1,0	1,0	51,0
	,16	1	1,0	1,0	52,0
	,20	2	2,0	2,0	54,0
	,23	1	1,0	1,0	55,0
	,23	2	2,0	2,0	57,0
	,24	1	1,0	1,0	58,0
	,34	1	1,0	1,0	59,0
	,34	2	2,0	2,0	61,0
	,41	1	1,0	1,0	62,0

	,44	1	1,0	1,0	63,0
	,48	1	1,0	1,0	64,0
	,49	1	1,0	1,0	65,0
	,52	1	1,0	1,0	66,0
	,56	3	3,0	3,0	69,0
	,56	1	1,0	1,0	70,0
	,59	3	3,0	3,0	73,0
	,67	1	1,0	1,0	74,0
	,67	1	1,0	1,0	75,0
	,71	1	1,0	1,0	76,0
	,74	1	1,0	1,0	77,0
	,77	2	2,0	2,0	79,0
	,77	1	1,0	1,0	80,0
	,81	1	1,0	1,0	81,0
	,81	2	2,0	2,0	83,0
	,85	2	2,0	2,0	85,0
	,85	1	1,0	1,0	86,0
	,89	1	1,0	1,0	87,0
	,99	1	1,0	1,0	88,0
	1,03	2	2,0	2,0	90,0
	1,14	1	1,0	1,0	91,0
	1,14	2	2,0	2,0	93,0
	1,21	2	2,0	2,0	95,0
	1,36	1	1,0	1,0	96,0
	1,43	2	2,0	2,0	98,0
	1,50	2	2,0	2,0	100,0
	Total	100	100,0	100,0	

APPENDIX S

Calculations for *SD* based on beta coefficients

L1 WMC X Proficiency level

Formulá => Y = a + b1*X + b2Z + b3*X*Z									
		WMC(X)		**a =**	0,04		-1 SD	Mean	+1 SD
	Low (-1SD)	Mean	High (+1SD)	**b1 =**	-0,376	x=	-0,83495	0	0,83495
Less Prof (-1SD)	0,7131	0,49789	0,282662	**b2 =**	-0,519	z=	-0,88226	0	0,88226
Mean Prof	0,3539	0,04	-0,27394	**b3 =**	-0,134				
More Prof (+1SD)	-0,0052	-0,4179	-0,83054						

L2 WMC X Proficiency level

Formulá => Y = a + b1*X + b2Z + b3*X*Z									
		WMC(X)		**a =**	-0,04		-1 SD	Mean	+1 SD
	Low (-1SD)	Mean	High (+1SD)	**b1 =**	-0,227	x=	-1	0	1
Less Prof (-1SD)	0,6837	0,3879	0,0921	**b2 =**	-0,485	z=	-0,88226	0	0,88226
Mean Prof	0,187	-0,04	-0,267	**b3 =**	0,078				
More Prof (+1SD)	-0,3097	-0,4679	-0,6261						

APPENDIX T

Repeated Measure ANOVA – post hoc analysis

Descriptive Statistics

	Mean	Std. Deviation	N
BLOCO1	931.94	163.36	100
BLOCO2	897.41	138.27	100
BLOCO3	861.51	134.00	100
BLOCO4	848.81	139.60	100
BLOCO5	820.90	143.89	100
BLOCO6	810.44	129.48	100

Within-Subjects Factors
Measure: MEASURE_1

BLOCK	Dependent Variable
1	BLOCO1
2	BLOCO2
3	BLOCO3
4	BLOCO4
5	BLOCO5
6	BLOCO6

Multivariate Tests

Effect		Value	F	Hypothesis df	Error df	Sig.	Eta Squared
BLOCK	Pillai's Trace	.566	24.823	5.000	95.000	.000	.566
	Wilks' Lambda	.434	24.823	5.000	95.000	.000	.566
	Hotelling's Trace	1.306	24.823	5.000	95.000	.000	.566
	Roy's Largest Root	1.306	24.823	5.000	95.000	.000	.566

a Exact statistic
b Design: Intercept Within Subjects Design: BLOCK

Mauchly's Test of Sphericity
Measure: MEASURE_1

	Mauchly's W	Approx. Chi-Square	df	Sig.	Epsilon		
Within Subjects Effect					Greenhouse-Geisser	Huynh-Feldt	Lower-bound
BLOCK	.416	85.201	14	.000	.744	.776	.200

Tests the null hypothesis that the error covariance matrix of the orthonormalized transformed dependent variables is proportional to an identity matrix.
a May be used to adjust the degrees of freedom for the averaged tests of significance. Corrected tests are displayed in the Tests of Within-Subjects Effects table.
b Design: Intercept Within Subjects Design: BLOCK

Tests of Within-Subjects Effects
Measure: MEASURE_1

Source		Type III Sum of Squares	df	Mean Square	F	Sig.	Eta Squared
BLOCK	Sphericity Assumed	1066716.815	5	213343.363	45.206	.000	.313
	Greenhouse-Geisser	1066716.815	3.719	286848.736	45.206	.000	.313
	Huynh-Feldt	1066716.815	3.882	274790.950	45.206	.000	.313
	Lower-bound	1066716.815	1.000	1066716.815	45.206	.000	.313
Error(BLOCK)	Sphericity Assumed	2336060.352	495	4719.314			
	Greenhouse-Geisser	2336060.352	368.156	6345.307			
	Huynh-Feldt	2336060.352	384.310	6078.580			
	Lower-bound	2336060.352	99.000	23596.569			

Tests of Within-Subjects Contrasts
Measure: MEASURE_1

Source	BLOCK	Type III Sum of Squares	df	Mean Square	F	Sig.	Eta Squared
BLOCK	Linear	1031487.247	1	1031487.247	123.131	.000	.554
	Quadratic	27617.067	1	27617.067	8.059	.005	.075
	Cubic	248.043	1	248.043	.054	.817	.001
	Order 4	233.743	1	233.743	.054	.816	.001
	Order 5	7130.715	1	7130.715	2.462	.120	.024
Error(BLOCK)	Linear	829335.139	99	8377.123			
	Quadratic	339264.064	99	3426.910			
	Cubic	454436.107	99	4590.264			
	Order 4	426315.793	99	4306.220			
	Order 5	286709.249	99	2896.053			

Tests of Within-Subjects Contrasts
Measure: MEASURE_1

Source	BLOCK	Type III Sum of Squares	df	Mean Square	F	Sig.	Eta Squared
BLOCK	Linear	1031487.247	1	1031487.247	123.131	.000	.554
	Quadratic	27617.067	1	27617.067	8.059	.005	.075
	Cubic	248.043	1	248.043	.054	.817	.001
	Order 4	233.743	1	233.743	.054	.816	.001
	Order 5	7130.715	1	7130.715	2.462	.120	.024
Error(BLOCK)	Linear	829335.139	99	8377.123			
	Quadratic	339264.064	99	3426.910			

	Cubic	454436.107	99	4590.264		
	Order 4	426315.793	99	4306.220		
	Order 5	286709.249	99	2896.053		

Tests of Within-Subjects Contrasts
Measure: MEASURE_1

Source	BLOCK	Type III Sum of Squares	df	Mean Square	F	Sig.	Eta Squared
BLOCK	Linear	1031487.247	1	1031487.247	123.131	.000	.554
	Quadratic	27617.067	1	27617.067	8.059	.005	.075
	Cubic	248.043	1	248.043	.054	.817	.001
	Order 4	233.743	1	233.743	.054	.816	.001
	Order 5	7130.715	1	7130.715	2.462	.120	.024
Error(BLOCK)	Linear	829335.139	99	8377.123			
	Quadratic	339264.064	99	3426.910			
	Cubic	454436.107	99	4590.264			
	Order 4	426315.793	99	4306.220			
	Order 5	286709.249	99	2896.053			

Tests of Between-Subjects Effects
Measure: MEASURE_1
Transformed Variable: Average

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Eta Squared
Intercept	445655740.335	1	445655740.335	4588.608	.000	.979
Error	9615099.498	99	97122.217			

BLOCK
Measure: MEASURE_1

	Mean	Std. Error	95% Confidence Interval	
BLOCK			Lower Bound	Upper Bound
1	931.940	16.336	899.525	964.355
2	897.410	13.827	869.975	924.845
3	861.510	13.400	834.922	888.098
4	848.810	13.960	821.111	876.509
5	820.900	14.389	792.348	849.452
6	810.440	12.948	784.749	836.131

Estimated Marginal Means

BLOCK
Measure: MEASURE_1

	Mean	Std. Error	95% Confidence Interval	
BLOCK			Lower Bound	Upper Bound
1	931.940	16.336	899.525	964.355
2	897.410	13.827	869.975	924.845
3	861.510	13.400	834.922	888.098
4	848.810	13.960	821.111	876.509
5	820.900	14.389	792.348	849.452
6	810.440	12.948	784.749	836.131

APPENDIX U

Multiple Regression – post hoc analysis

Descriptive Statistics

	Mean	Std. Deviation	N
Zscore(RT EXP) semantically related distractors -100ms	-4.8405724E-16	1.0000000	100
Zscore(SSTL2)	9.325873E-17	1.0000000	100
mean zscores for totcateg and proftoe	-1.5876E-15	.8823	100
L2ZBYPRO	.5102	1.0128	100

Correlations

		Zscore(RT EXP) semantically related distractors -100ms	Zscore(SSTL2)	mean zscores for totcateg and proftoe	L2ZBYPRO
Pearson Correlation	Zscore(RT EXP) semantically related distractors -100ms	1.000	-.452	-.566	.034
	Zscore(SSTL2)	-.452	1.000	.584	.317
	mean zscores for totcateg and proftoe	-.566	.584	1.000	-.063
	L2ZBYPRO	.034	.317	-.063	1.000
Sig. (1-tailed)	Zscore(RT EXP) semantically related distractors -100ms	.	.000	.000	.370
	Zscore(SSTL2)	.000	.	.000	.001
	mean zscores for	.000	.000	.	.266

	totcateg and proftoe				
	L2ZBYPRO	.370	.001	.266	.
N	Zscore(RTEXP) semantically related distractors -100ms	100	100	100	100
	Zscore(SSTL2)	100	100	100	100
	mean zscores for totcateg and proftoe	100	100	100	100
	L2ZBYPRO	100	100	100	100

Variables Entered/Removed

Model	Variables Entered	Variables Removed	Method
1	Zscore(SSTL2)	.	Enter
2	mean zscores for totcateg and proftoe	.	Enter
3	L2ZBYPRO	.	Enter

a All requested variables entered.
b Dependent Variable: Zscore(RTEXP) semantically related distractors -100ms

	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
Model					R Square Change	F Change	df1	df2	Sig. F Change
1	.452	.205	.196	.8964284	.205	25.198	1	98	.000
2	.585	.342	.329	.8192274	.138	20.341	1	97	.000
3	.589	.347	.327	.8203538	.005	.734	1	96	.394

Model Summary
a Predictors: (Constant), Zscore(SSTL2)
b Predictors: (Constant), Zscore(SSTL2), mean zscores for totcateg and proftoe
c Predictors: (Constant), Zscore(SSTL2), mean zscores for totcateg and proftoe, L2ZBYPRO

ANOVA

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	20.249	1	20.249	25.198	.000
	Residual	78.751	98	.804		
	Total	99.000	99			
2	Regression	33.900	2	16.950	25.256	.000
	Residual	65.100	97	.671		
	Total	99.000	99			
3	Regression	34.394	3	11.465	17.036	.000
	Residual	64.606	96	.673		
	Total	99.000	99			

a Predictors: (Constant), Zscore(SSTL2)
b Predictors: (Constant), Zscore(SSTL2), mean zscores for totcateg and proftoe
c Predictors: (Constant), Zscore(SSTL2), mean zscores for totcateg and proftoe, L2ZBYPRO
d Dependent Variable: Zscore(RTEXP) semantically related distractors -100ms

Coefficients

		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Correlations			Collinearity Statistics	
Model		B	Std. Error	Beta			Zero-order	Partial	Part	Tolerance	VIF
1	(Constant)	-4.419E-16	.090		.000	1.000					
	Zscore(SSTL2)	-.452	.090	-.452	-5.020	.000	-.452	-.452	-.452	1.000	1.000
2	(Constant)	-1.290E-15	.082		.000	1.000					
	Zscore(SSTL2)	-.185	.101	-.185	-1.824	.071	-.452	-.182	-.150	.659	1.518
	mean zscores for totcateg and proftoe	-.519	.115	-.458	-4.510	.000	-.566	-.416	-.371	.659	1.518
3	(Constant)	-3.964E-02	.094		-.421	.675					
	Zscore(SSTL2)	-.227	.113	-.227	-2.012	.047	-.452	-.201	-.166	.533	1.876
	mean zscores for totcateg and proftoe	-.485	.122	-.428	-3.987	.000	-.566	-.377	-.329	.590	1.694
	L2ZBYPRO	7.768E-02	.091	.079	.857	.394	.034	.087	.071	.806	1.241

a Dependent Variable: Zscore(RTEXP) semantically related distractors -100ms

Excluded Variables

		Beta In	t	Sig.	Partial Correlation	Collinearity Statistics		
Model						Tolerance	VIF	Minimum Tolerance
1	mean zscores for totcateg and proftoe	-.458	-4.510	.000	-.416	.659	1.518	.659
	L2ZBYPRO	.197	2.108	.038	.209	.899	1.112	.899
2	L2ZBYPRO	.079	.857	.394	.087	.806	1.241	.533

a Predictors in the Model: (Constant), Zscore(SSTL2)
b Predictors in the Model: (Constant), Zscore(SSTL2), mean zscores for totcateg and proftoe
c Dependent Variable: Zscore(RTEXP) semantically related distractors -100ms

Collinearity Diagnostics

		Eigenvalue	Condition Index	Variance Proportions			
Model	Dimension			(Constant)	Zscore(SSTL2)	mean zscores for totcateg and proftoe	L2ZBYPRO
1	1	1.000	1.000	1.00	.00		
	2	1.000	1.000	.00	1.00		
2	1	1.584	1.000	.00	.21	.21	
	2	1.000	1.259	1.00	.00	.00	
	3	.416	1.952	.00	.79	.79	
3	1	1.666	1.000	.04	.14	.10	.07
	2	1.409	1.087	.21	.03	.09	.15
	3	.646	1.606	.51	.08	.18	.27
	4	.279	2.446	.24	.75	.63	.52

a Dependent Variable: Zscore(RTEXP) semantically related distractors -100ms

APPENDIX V

Statistics - SPSS

RAW SCORES

Descriptive Statistics

		SSTL2	SSTL1	OSPAN	PROFTOE	TOTCATEG	rtexp semantically related distractors -100ms	RTCTR
N	Valid	100	100	100	100	100	100	100
	Missing	0	0	0	0	0	0	0
Mean		13.62	23.84	15.96	2.6496	49.44	851.05	877.10
Median		12.00	24.00	15.00	2.6700	51.00	856.50	895.50
Std. Deviation		7.53	8.24	8.68	.9158	6.91	137.60	166.54
Skewness		.787	.043	.432	-.132	-.870	.191	-.245
Std. Error of Skewness		.241	.241	.241	.241	.241	.241	.241
Kurtosis		.411	-.635	-.388	-1.098	.475	.901	-.579
Std. Error of Kurtosis		.478	.478	.478	.478	.478	.478	.478
Minimum		1	6	1	1.00	30	469	472
Maximum		38	42	40	4.00	60	1300	1216

Frequencies
SSTL2

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	1	1.0	1.0	1.0
	2	1	1.0	1.0	2.0
	3	3	3.0	3.0	5.0
	4	3	3.0	3.0	8.0
	5	2	2.0	2.0	10.0
	6	4	4.0	4.0	14.0
	7	10	10.0	10.0	24.0
	8	6	6.0	6.0	30.0
	9	4	4.0	4.0	34.0
	10	9	9.0	9.0	43.0
	11	6	6.0	6.0	49.0
	12	3	3.0	3.0	52.0
	13	6	6.0	6.0	58.0
	14	3	3.0	3.0	61.0
	15	2	2.0	2.0	63.0
	16	3	3.0	3.0	66.0
	17	4	4.0	4.0	70.0
	18	3	3.0	3.0	73.0
	19	4	4.0	4.0	77.0
	20	4	4.0	4.0	81.0
	21	4	4.0	4.0	85.0
	22	1	1.0	1.0	86.0
	23	2	2.0	2.0	88.0

	24	4	4.0	4.0	92.0
	25	4	4.0	4.0	96.0
	29	1	1.0	1.0	97.0
	32	1	1.0	1.0	98.0
	35	1	1.0	1.0	99.0
	38	1	1.0	1.0	100.0
	Total	100	100.0	100.0	

SSTL1

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	6	1	1.0	1.0	1.0
	7	2	2.0	2.0	3.0
	8	1	1.0	1.0	4.0
	10	1	1.0	1.0	5.0
	12	1	1.0	1.0	6.0
	13	2	2.0	2.0	8.0
	14	2	2.0	2.0	10.0
	15	7	7.0	7.0	17.0
	16	5	5.0	5.0	22.0
	17	3	3.0	3.0	25.0
	18	10	10.0	10.0	35.0
	19	2	2.0	2.0	37.0
	20	1	1.0	1.0	38.0
	21	1	1.0	1.0	39.0
	22	5	5.0	5.0	44.0
	23	3	3.0	3.0	47.0
	24	6	6.0	6.0	53.0
	25	3	3.0	3.0	56.0
	26	5	5.0	5.0	61.0
	27	3	3.0	3.0	64.0
	28	5	5.0	5.0	69.0
	29	3	3.0	3.0	72.0
	30	6	6.0	6.0	78.0
	31	4	4.0	4.0	82.0
	32	3	3.0	3.0	85.0
	33	2	2.0	2.0	87.0
	34	1	1.0	1.0	88.0
	35	4	4.0	4.0	92.0
	36	2	2.0	2.0	94.0
	38	2	2.0	2.0	96.0
	39	2	2.0	2.0	98.0
	41	1	1.0	1.0	99.0
	42	1	1.0	1.0	100.0
	Total	100	100.0	100.0	

OSPAN

		Frequency	Percent	Valid Percent	Cumulative Percent
	1	1	1.0	1.0	1.0
	2	2	2.0	2.0	3.0
	4	3	3.0	3.0	6.0
	5	9	9.0	9.0	15.0
	6	2	2.0	2.0	17.0
	7	3	3.0	3.0	20.0
	8	4	4.0	4.0	24.0
	9	1	1.0	1.0	25.0
	10	6	6.0	6.0	31.0
	11	1	1.0	1.0	32.0
	12	7	7.0	7.0	39.0
	13	4	4.0	4.0	43.0
	14	5	5.0	5.0	48.0
	15	3	3.0	3.0	51.0
	16	4	4.0	4.0	55.0
	17	4	4.0	4.0	59.0
	18	3	3.0	3.0	62.0
	19	5	5.0	5.0	67.0
	20	3	3.0	3.0	70.0
	21	6	6.0	6.0	76.0
	22	2	2.0	2.0	78.0
	24	3	3.0	3.0	81.0
	25	3	3.0	3.0	84.0
	26	2	2.0	2.0	86.0
	27	4	4.0	4.0	90.0
	28	3	3.0	3.0	93.0
	30	1	1.0	1.0	94.0
	31	2	2.0	2.0	96.0
	33	1	1.0	1.0	97.0
	34	1	1.0	1.0	98.0
	37	1	1.0	1.0	99.0
	40	1	1.0	1.0	100.0
	Total	100	100.0	100.0	

PROFTOE

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1.00	5	5.0	5.0	5.0
	1.33	10	10.0	10.0	15.0
	1.67	7	7.0	7.0	22.0
	2.00	10	10.0	10.0	32.0
	2.33	13	13.0	13.0	45.0
	2.67	10	10.0	10.0	55.0
	3.00	10	10.0	10.0	65.0
	3.33	14	14.0	14.0	79.0
	3.67	8	8.0	8.0	87.0
	4.00	13	13.0	13.0	100.0
	Total	100	100.0	100.0	

TOTCATEG

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	30	2	2.0	2.0	2.0
	32	2	2.0	2.0	4.0
	35	1	1.0	1.0	5.0
	36	1	1.0	1.0	6.0
	37	2	2.0	2.0	8.0
	38	1	1.0	1.0	9.0
	40	2	2.0	2.0	11.0
	42	3	3.0	3.0	14.0
	43	3	3.0	3.0	17.0
	44	4	4.0	4.0	21.0
	45	5	5.0	5.0	26.0
	46	6	6.0	6.0	32.0
	47	4	4.0	4.0	36.0
	49	5	5.0	5.0	41.0
	50	5	5.0	5.0	46.0
	51	7	7.0	7.0	53.0
	52	10	10.0	10.0	63.0
	53	5	5.0	5.0	68.0
	54	6	6.0	6.0	74.0
	55	9	9.0	9.0	83.0
	56	7	7.0	7.0	90.0
	57	1	1.0	1.0	91.0
	58	3	3.0	3.0	94.0
	59	2	2.0	2.0	96.0
	60	4	4.0	4.0	100.0
	Total	100	100.0	100.0	

RTexp

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	469	1	1.0	1.0	1.0
	516	1	1.0	1.0	2.0
	562	1	1.0	1.0	3.0
	618	1	1.0	1.0	4.0
	633	1	1.0	1.0	5.0
	659	1	1.0	1.0	6.0
	674	1	1.0	1.0	7.0
	676	1	1.0	1.0	8.0
	687	1	1.0	1.0	9.0
	689	1	1.0	1.0	10.0
	691	1	1.0	1.0	11.0
	700	1	1.0	1.0	12.0
	706	1	1.0	1.0	13.0
	709	1	1.0	1.0	14.0
	713	1	1.0	1.0	15.0
	720	1	1.0	1.0	16.0
	726	1	1.0	1.0	17.0
	727	1	1.0	1.0	18.0
	738	1	1.0	1.0	19.0
	739	1	1.0	1.0	20.0
	741	1	1.0	1.0	21.0
	744	1	1.0	1.0	22.0
	748	2	2.0	2.0	24.0
	750	1	1.0	1.0	25.0

	755	1	1.0	1.0	26.0
	758	1	1.0	1.0	27.0
	764	1	1.0	1.0	28.0
	767	1	1.0	1.0	29.0
	770	1	1.0	1.0	30.0
	778	1	1.0	1.0	31.0
	783	1	1.0	1.0	32.0
	792	1	1.0	1.0	33.0
	806	1	1.0	1.0	34.0
	811	1	1.0	1.0	35.0
	812	1	1.0	1.0	36.0
	813	1	1.0	1.0	37.0
	814	1	1.0	1.0	38.0
	820	1	1.0	1.0	39.0
	824	2	2.0	2.0	41.0
	826	1	1.0	1.0	42.0
	828	1	1.0	1.0	43.0
	835	2	2.0	2.0	45.0
	844	1	1.0	1.0	46.0
	846	1	1.0	1.0	47.0
	853	2	2.0	2.0	49.0
	856	1	1.0	1.0	50.0
	857	1	1.0	1.0	51.0
	858	1	1.0	1.0	52.0
	860	1	1.0	1.0	53.0
	862	2	2.0	2.0	55.0
	870	1	1.0	1.0	56.0
	871	1	1.0	1.0	57.0
	877	2	2.0	2.0	59.0
	880	1	1.0	1.0	60.0
	882	1	1.0	1.0	61.0
	884	1	1.0	1.0	62.0
	888	1	1.0	1.0	63.0
	889	1	1.0	1.0	64.0
	890	2	2.0	2.0	66.0
	892	2	2.0	2.0	68.0
	900	1	1.0	1.0	69.0
	906	1	1.0	1.0	70.0
	908	2	2.0	2.0	72.0
	909	1	1.0	1.0	73.0
	914	1	1.0	1.0	74.0
	918	1	1.0	1.0	75.0
	922	1	1.0	1.0	76.0
	935	1	1.0	1.0	77.0
	938	1	1.0	1.0	78.0
	944	1	1.0	1.0	79.0
	951	1	1.0	1.0	80.0
	955	1	1.0	1.0	81.0
	958	1	1.0	1.0	82.0
	961	1	1.0	1.0	83.0
	970	1	1.0	1.0	84.0
	972	1	1.0	1.0	85.0
	991	1	1.0	1.0	86.0
	994	1	1.0	1.0	87.0
	1006	1	1.0	1.0	88.0
	1019	1	1.0	1.0	89.0
	1021	1	1.0	1.0	90.0

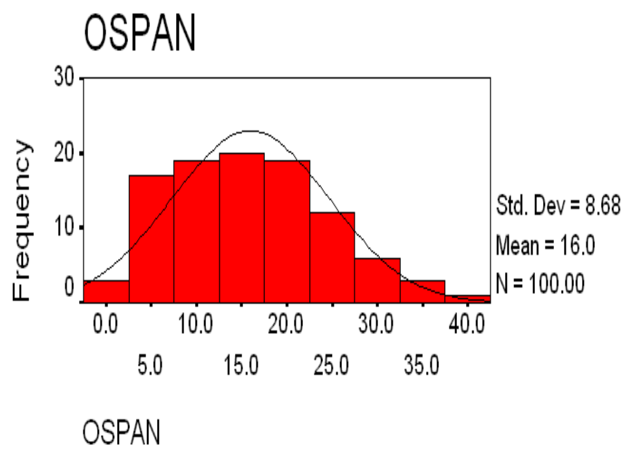
	1022	1	1.0	1.0	91.0
	1032	1	1.0	1.0	92.0
	1042	1	1.0	1.0	93.0
	1080	1	1.0	1.0	94.0
	1090	1	1.0	1.0	95.0
	1096	1	1.0	1.0	96.0
	1118	1	1.0	1.0	97.0
	1147	2	2.0	2.0	99.0
	1300	1	1.0	1.0	100.0
	Total	100	100.0	100.0	

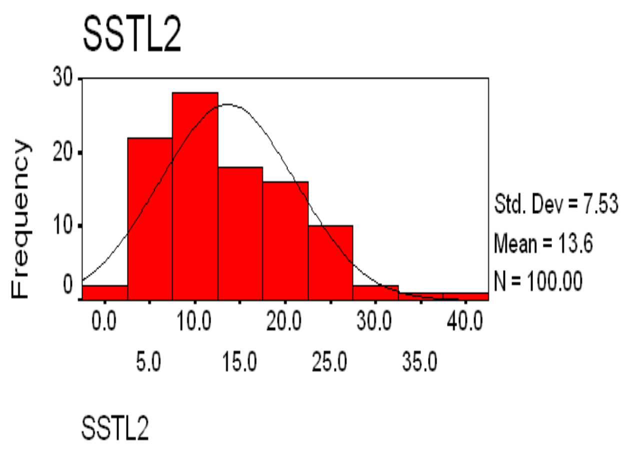
RTctr

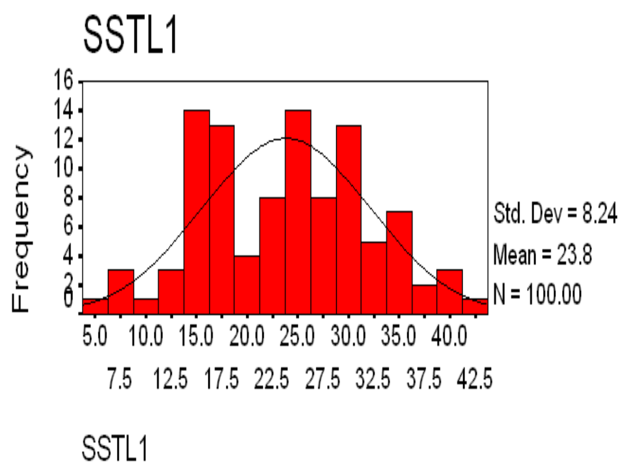
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	472	1	1.0	1.0	1.0
	503	1	1.0	1.0	2.0
	579	1	1.0	1.0	3.0
	585	1	1.0	1.0	4.0
	591	1	1.0	1.0	5.0
	592	1	1.0	1.0	6.0
	598	1	1.0	1.0	7.0
	607	1	1.0	1.0	8.0
	613	1	1.0	1.0	9.0
	633	1	1.0	1.0	10.0
	657	1	1.0	1.0	11.0
	664	1	1.0	1.0	12.0
	668	1	1.0	1.0	13.0
	669	1	1.0	1.0	14.0
	680	1	1.0	1.0	15.0
	684	1	1.0	1.0	16.0
	686	1	1.0	1.0	17.0
	688	1	1.0	1.0	18.0
	717	1	1.0	1.0	19.0
	725	1	1.0	1.0	20.0
	728	1	1.0	1.0	21.0
	729	1	1.0	1.0	22.0
	732	1	1.0	1.0	23.0
	747	1	1.0	1.0	24.0
	760	1	1.0	1.0	25.0
	762	1	1.0	1.0	26.0
	766	1	1.0	1.0	27.0
	781	1	1.0	1.0	28.0
	783	1	1.0	1.0	29.0
	785	1	1.0	1.0	30.0
	796	1	1.0	1.0	31.0
	799	1	1.0	1.0	32.0
	808	1	1.0	1.0	33.0
	809	1	1.0	1.0	34.0
	813	1	1.0	1.0	35.0
	818	1	1.0	1.0	36.0
	820	1	1.0	1.0	37.0
	824	1	1.0	1.0	38.0
	831	1	1.0	1.0	39.0
	836	1	1.0	1.0	40.0
	842	1	1.0	1.0	41.0
	861	1	1.0	1.0	42.0
	863	1	1.0	1.0	43.0

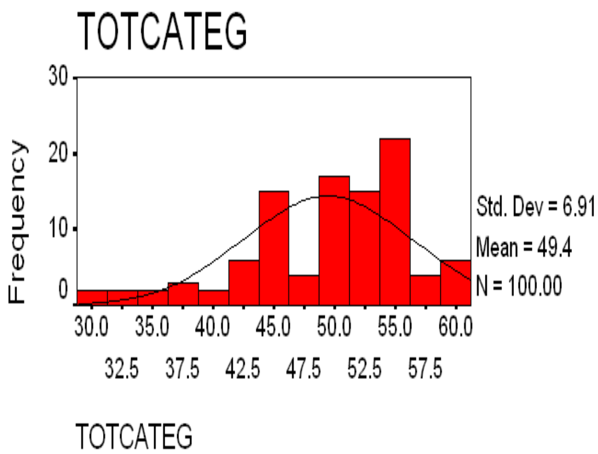
	872	1	1.0	1.0	44.0
	879	2	2.0	2.0	46.0
	885	1	1.0	1.0	47.0
	887	1	1.0	1.0	48.0
	890	2	2.0	2.0	50.0
	901	1	1.0	1.0	51.0
	905	1	1.0	1.0	52.0
	907	1	1.0	1.0	53.0
	910	1	1.0	1.0	54.0
	915	1	1.0	1.0	55.0
	917	1	1.0	1.0	56.0
	918	1	1.0	1.0	57.0
	922	1	1.0	1.0	58.0
	929	1	1.0	1.0	59.0
	931	1	1.0	1.0	60.0
	932	1	1.0	1.0	61.0
	936	1	1.0	1.0	62.0
	941	1	1.0	1.0	63.0
	946	1	1.0	1.0	64.0
	949	1	1.0	1.0	65.0
	950	1	1.0	1.0	66.0
	954	1	1.0	1.0	67.0
	955	1	1.0	1.0	68.0
	964	1	1.0	1.0	69.0
	966	1	1.0	1.0	70.0
	988	1	1.0	1.0	71.0
	990	1	1.0	1.0	72.0
	991	1	1.0	1.0	73.0
	993	1	1.0	1.0	74.0
	999	1	1.0	1.0	75.0
	1002	1	1.0	1.0	76.0
	1014	2	2.0	2.0	78.0
	1016	1	1.0	1.0	79.0
	1021	1	1.0	1.0	80.0
	1028	1	1.0	1.0	81.0
	1031	1	1.0	1.0	82.0
	1034	1	1.0	1.0	83.0
	1037	1	1.0	1.0	84.0
	1040	1	1.0	1.0	85.0
	1041	1	1.0	1.0	86.0
	1043	1	1.0	1.0	87.0
	1068	1	1.0	1.0	88.0
	1082	1	1.0	1.0	89.0
	1106	1	1.0	1.0	90.0
	1108	2	2.0	2.0	92.0
	1134	2	2.0	2.0	94.0
	1138	2	2.0	2.0	96.0
	1147	1	1.0	1.0	97.0
	1150	1	1.0	1.0	98.0
	1165	1	1.0	1.0	99.0
	1216	1	1.0	1.0	100.0
	Total	100	100.0	100.0	

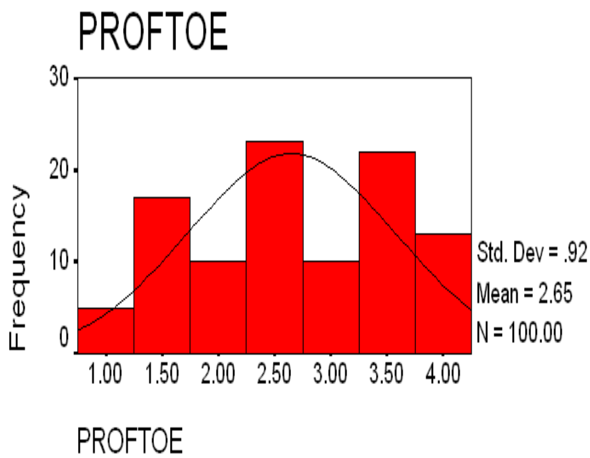
Histograms

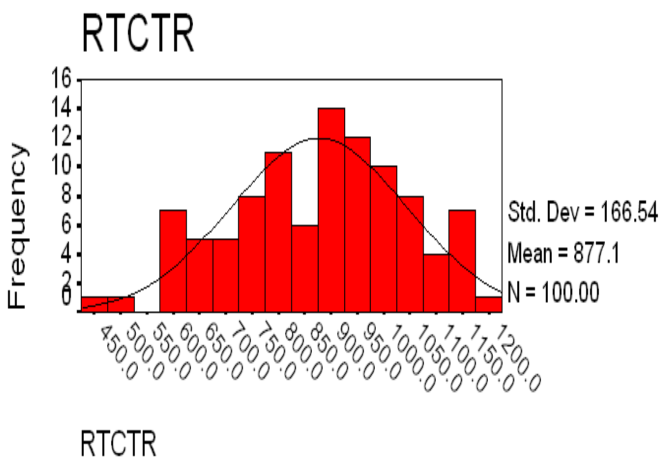

OSPAN
30
20
10
0
Frequency
0.0
10.0
20.0
30.0
40.0
5.0
15.0
25.0
35.0
Std. Dev = 8.68
Mean = 16.0
N = 100.00
OSPAN

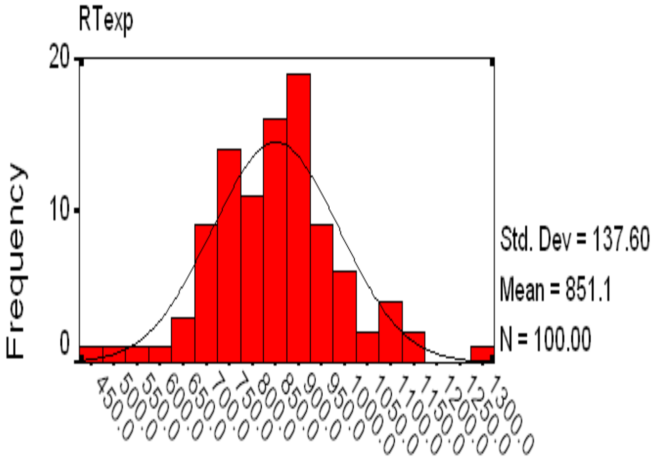

SSTL2
30
20
10
0
Frequency
0.0
10.0
20.0
30.0
40.0
5.0
15.0
25.0
35.0
Std. Dev = 7.53
Mean = 13.6
N = 100.00
SSTL2


SSTL1
16
14
12
10
8
6
4
2
0
Frequency
5.0
10.0
15.0
20.0
25.0
30.0
35.0
40.0
7.5
12.5
17.5
22.5
27.5
32.5
37.5
42.5
Std. Dev = 8.24
Mean = 23.8
N = 100.00
SSTL1


TOTCATEG
30
20
10
0
Frequency
Std. Dev = 6.91
Mean = 49.4
N = 100.00
30.0 35.0 40.0 45.0 50.0 55.0 60.0
32.5 37.5 42.5 47.5 52.5 57.5
TOTCATEG


PROFTOE
30
20
10
0
Frequency
Std. Dev = .92
Mean = 2.65
N = 100.00
1.00 1.50 2.00 2.50 3.00 3.50 4.00
PROFTOE


RTCTR
16
14
12
10
8
6
4
2
0
Frequency
Std. Dev = 166.54
Mean = 877.1
N = 100.00
450.0 500.0 550.0 600.0 650.0 700.0 750.0 800.0 850.0 900.0 950.0 1000.0 1050.0 1100.0 1150.0 1200.0
RTCTR



RTexp in milliseconds

Regression

Descriptive Statistics

	Mean	Std. Deviation	N
Zscore(RTEXP)	-4.8405724E-16	1,0000000	100
WMCL1Z	-9.7256E-16	,8349	100
mean zscores for totcateg and proftoe	-1.5876E-15	,8823	100
L1ZBYPRO	,3016	,7160	100

Correlations

		Zscore(RTEXP)	WMCL1Z	mean zscores for totcateg and proftoe	L1ZBYPRO
Pearson Correlation	Zscore(RTEXP)	1,000	-,507	-,566	-,006
	WMCL1Z	-,507	1,000	,414	,047
	mean zscores for totcateg and proftoe	-,566	,414	1,000	-,230
	L1ZBYPRO	-,006	,047	-,230	1,000
Sig. (1-tailed)	Zscore(RTEXP)	,	,000	,000	,478
	WMCL1Z	,000	,	,000	,320
	mean zscores for totcateg and proftoe	,000	,000	,	,011
	L1ZBYPRO	,478	,320	,011	,
N	Zscore(RTEXP)	100	100	100	100
	WMCL1Z	100	100	100	100
	mean zscores for totcateg and proftoe	100	100	100	100
	L1ZBYPRO	100	100	100	100

Variables Entered/Removed

Model	Variables Entered	Variables Removed	Method
1	mean zscores for totcateg and proftoe, WMCL1Z	,	Enter
2	L1ZBYPRO	,	Enter

a All requested variables entered.
b Dependent Variable: Zscore(RTEXP)

Model Summary

	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
Model					R Square Change	F Change	df1	df2	Sig. F Change
1	,640	,410	,398	,7758887	,410	33,725	2	97	,000
2	,647	,419	,400	,7742887	,008	1,401	1	96	,239

a Predictors: (Constant), mean zscores for totcateg and proftoe, WMCL1Z
b Predictors: (Constant), mean zscores for totcateg and proftoe, WMCL1Z, L1ZBYPRO

ANOVA

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	40,606	2	20,303	33,725	,000
	Residual	58,394	97	,602		
	Total	99,000	99			
2	Regression	41,446	3	13,815	23,044	,000
	Residual	57,554	96	,600		
	Total	99,000	99			

a Predictors: (Constant), mean zscores for totcateg and proftoe, WMCL1Z
b Predictors: (Constant), mean zscores for totcateg and proftoe, WMCL1Z, L1ZBYPRO
c Dependent Variable: Zscore(RTEXP)

Coefficients

		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Correlations			Collinearity Statistics	
Model		B	Std. Error	Beta			Zero-order	Partial	Part	Tolerance	VIF
1	(Constant)	-1.641E-15	,078		,000	1,000					
	WMCL1Z	-,395	,103	-,330	-3,853	,000	-,507	-,364	-,300	,829	1,206
	mean zscores for totcateg and proftoe	-,486	,097	-,429	-5,010	,000	-,566	-,453	-,391	,829	1,206
2	(Constan	4,039E-	,085		,477	,634					

	t)	02									
	WMCL1Z	-,376	,104	-,314	-3,621	,000	-,507	-,347	-,282	,808	1,238
	mean zscores for totcateg and proftoe	-,519	,101	-,458	-5,153	,000	-,566	-,465	-,401	,767	1,304
	L1ZBYPRO	-,134	,113	-,096	-1,184	,239	-,006	-,120	-,092	,923	1,084

a Dependent Variable: Zscore(RTEXP)

Excluded Variables

		Beta In	t	Sig.	Partial Correlation	Collinearity Statistics		
Model						Tolerance	VIF	Minimum Tolerance
1	L1ZBYPRO	-,096	-1,184	,239	-,120	,923	1,084	,767

a Predictors in the Model: (Constant), mean zscores for totcateg and proftoe, WMCL1Z
b Dependent Variable: Zscore(RTEXP)

Collinearity Diagnostics

		Eigenvalue	Condition Index	Variance Proportions			
Model	Dimension			(Constant)	WMCL1Z	mean zscores for totcateg and proftoe	L1ZBYPRO
1	1	1,414	1,000	,00	,29	,29	
	2	1,000	1,189	1,00	,00	,00	
	3	,586	1,552	,00	,71	,71	
2	1	1,501	1,000	,10	,10	,18	,15
	2	1,331	1,062	,19	,19	,09	,13
	3	,712	1,452	,44	,30	,18	,22
	4	,456	1,814	,27	,41	,55	,50

a Dependent Variable: Zscore(RTEXP)

Regression

Descriptive Statistics

	Mean	Std. Deviation	N
Zscore(RTEXP)	-4.8405724E-16	1,0000000	100
Zscore(SSTL2)	9.325873E-17	1,0000000	100
mean zscores for totcateg and proftoe	-1.5876E-15	,8823	100
L2ZBYPRO	,5102	1,0128	100

Correlations

		Zscore(RTEXP)	Zscore(SSTL2)	mean zscores for totcateg and proftoe	L2ZBYPRO
Pearson Correlation	Zscore(RTEXP)	1,000	-,452	-,566	,034
	Zscore(SSTL2)	-,452	1,000	,584	,317
	mean zscores for totcateg and proftoe	-,566	,584	1,000	-,063
	L2ZBYPRO	,034	,317	-,063	1,000
Sig. (1-tailed)	Zscore(RTEXP)	,	,000	,000	,370
	Zscore(SSTL2)	,000	,	,000	,001
	mean zscores for totcateg and proftoe	,000	,000	,	,266
	L2ZBYPRO	,370	,001	,266	,
N	Zscore(RTEXP)	100	100	100	100
	Zscore(SSTL2)	100	100	100	100
	mean zscores for totcateg and proftoe	100	100	100	100
	L2ZBYPRO	100	100	100	100

Variables Entered/Removed

Model	Variables Entered	Variables Removed	Method
1	mean zscores for totcateg and proftoe, Zscore(SSTL2)	,	Enter
2	L2ZBYPRO	,	Enter

a All requested variables entered.Model Summary

	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
Model					R Square Change	F Change	df1	df2	Sig. F Change
1	,585	,342	,329	,8192274	,342	25,256	2	97	,000
2	,589	,347	,327	,8203538	,005	,734	1	96	,394

a Predictors: (Constant), mean zscores for totcateg and proftoe, Zscore(SSTL2)
b Predictors: (Constant), mean zscores for totcateg and proftoe, Zscore(SSTL2), L2ZBYPRO

ANOVA

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	33,900	2	16,950	25,256	,000
	Residual	65,100	97	,671		
	Total	99,000	99			
2	Regression	34,394	3	11,465	17,036	,000
	Residual	64,606	96	,673		
	Total	99,000	99			

a Predictors: (Constant), mean zscores for totcateg and proftoe, Zscore(SSTL2)
b Predictors: (Constant), mean zscores for totcateg and proftoe, Zscore(SSTL2), L2ZBYPRO
c Dependent Variable: Zscore(RTEXP)

Coefficients

		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Correlations			Collinearity Statistics	
Model		B	Std. Error	Beta			Zero-order	Partial	Part	Tolerance	VIF
1	(Constant)	-1.290E-15	,082		,000	1,000					
	Zscore(SSTL2)	-,185	,101	-,185	-1,824	,071	-,452	-,182	-,150	,659	1,518
	mean zscores for totcateg and proftoe	-,519	,115	-,458	-4,510	,000	-,566	-,416	-,371	,659	1,518
2	(Constant)	-3.964E-02	,094		-,421	,675					
	Zscore(SS	-,227	,113	-,227	-	,047	-,452	-,201	-,166	,533	1,876

	TL2)				2,012						
	mean zscores for totcateg and proftoe	-,485	,122	-,428	-3,987	,000	-,566	-,377	-,329	,590	1,694
	L2ZBYPRO	7,768E-02	,091	,079	,857	,394	,034	,087	,071	,806	1,241

a Dependent Variable: Zscore(RTEXP)

Excluded Variables

		Beta In	t	Sig.	Partial Correlation	Collinearity Statistics		
Model						Tolerance	VIF	Minimum Tolerance
1	L2ZBYPRO	,079	,857	,394	,087	,806	1,241	,533

a Predictors in the Model: (Constant), mean zscores for totcateg and proftoe, Zscore(SSTL2)
b Dependent Variable: Zscore(RTEXP)

Collinearity Diagnostics

		Eigenvalue	Condition Index	Variance Proportions			
Model	Dimension			(Constant)	Zscore(SSTL2)	mean zscores for totcateg and proftoe	L2ZBYPRO
1	1	1,584	1,000	,00	,21	,21	
	2	1,000	1,259	1,00	,00	,00	
	3	,416	1,952	,00	,79	,79	
2	1	1,666	1,000	,04	,14	,10	,07
	2	1,409	1,087	,21	,03	,09	,15
	3	,646	1,606	,51	,08	,18	,27
	4	,279	2,446	,24	,75	,63	,52

a Dependent Variable: Zscore(RTEXP)
b Dependent Variable: Zscore(RTEXP)

Partial Correlation 1

Variable	Mean	Standard Dev	Cases
SSTL1	23,8400	8,2434	100
TOTCATEG	49,4400	6,9141	100
PROFTOE	2,6496	,9158	100

- - - P A R T I A L   C O R R E L A T I O N   C O E F F I C I E N T S - -

Zero Order Partials

	SSTL1	TOTCATEG	PROFTOE
SSTL1	1,0000	,4094	,2737
	(0)	(98)	(98)
	P= ,	P= ,000	P= ,006
TOTCATEG	,4094	1,0000	,5568
	(98)	(0)	(98)
	P= ,000	P= ,	P= ,000
PROFTOE	,2737	,5568	1,0000
	(98)	(98)	(0)
	P= ,006	P= ,000	P= ,

(Coefficient / (D.F.) / 2-tailed Significance)

" , " is printed if a coefficient cannot be computed

- - - P A R T I A L   C O R R E L A T I O N   C O E F F I C I E N T S - -

Controlling for.. PROFTOE

	SSTL1	TOTCATEG
SSTL1	1,0000	,3217
	(0)	(97)
	P= ,	P= ,001
TOTCATEG	,3217	1,0000
	(97)	(0)
	P= ,001	P= ,

(Coefficient / (D.F.) / 2-tailed Significance)

" , " is printed if a coefficient cannot be computed

Partial Correlation 2

```
Variable            Mean     Standard Dev     Cases

SSTL1            23,8400           8,2434       100
PROFTOE           2,6496            ,9158       100
TOTCATEG         49,4400           6,9141       100
```

```
- - -  P A R T I A L   C O R R E L A T I O N   C O E F F I C I E N T S
- -

Zero Order Partials

               SSTL1    PROFTOE   TOTCATEG

SSTL1         1,0000      ,2737      ,4094
             (    0)    (   98)    (   98)
             P= ,       P= ,006    P= ,000

PROFTOE        ,2737     1,0000      ,5568
             (   98)    (    0)    (   98)
             P= ,006    P= ,       P= ,000

TOTCATEG       ,4094      ,5568     1,0000
             (   98)    (   98)    (    0)
             P= ,000    P= ,000    P= ,

(Coefficient / (D.F.) / 2-tailed Significance)

" , " is printed if a coefficient cannot be computed
```

```
- - -  P A R T I A L   C O R R E L A T I O N   C O E F F I C I E N T S
- -

Controlling for..    TOTCATEG

               SSTL1    PROFTOE

SSTL1         1,0000      ,0604
             (    0)    (   97)
             P= ,       P= ,553

PROFTOE        ,0604     1,0000
             (   97)    (    0)
             P= ,553    P= ,

(Coefficient / (D.F.) / 2-tailed Significance)

" , " is printed if a coefficient cannot be computed
```

Partial Correlation 3

```
Variable            Mean      Standard Dev      Cases

SSTL2            13,6200            7,5315        100
TOTCATEG         49,4400            6,9141        100
PROFTOE           2,6496             ,9158        100


- - -  P A R T I A L   C O R R E L A T I O N   C O E F F I C I E N T S
- -

Zero Order Partials

               SSTL2   TOTCATEG    PROFTOE

SSTL2         1,0000      ,4925      ,5383
             (    0)    (   98)    (   98)
             P= ,       P= ,000    P= ,000

TOTCATEG       ,4925     1,0000      ,5568
             (   98)    (    0)    (   98)
             P= ,000    P= ,       P= ,000

PROFTOE        ,5383      ,5568     1,0000
             (   98)    (   98)    (    0)
             P= ,000    P= ,000    P= ,

(Coefficient / (D.F.) / 2-tailed Significance)

" , " is printed if a coefficient cannot be computed


- - -  P A R T I A L   C O R R E L A T I O N   C O E F F I C I E N T S
- -

Controlling for..    PROFTOE

               SSTL2   TOTCATEG

SSTL2         1,0000      ,2753
             (    0)    (   97)
             P= ,       P= ,006

TOTCATEG       ,2753     1,0000
             (   97)    (    0)
             P= ,006    P= ,

(Coefficient / (D.F.) / 2-tailed Significance)

" , " is printed if a coefficient cannot be computed
```

Partial Correlation 4

```
Variable            Mean     Standard Dev     Cases

SSTL2            13,6200           7,5315       100
PROFTOE           2,6496            ,9158       100
TOTCATEG         49,4400           6,9141       100

- - -  P A R T I A L   C O R R E L A T I O N   C O E F F I C I E N T S
- -

Zero Order Partials

               SSTL2    PROFTOE   TOTCATEG

SSTL2         1,0000      ,5383      ,4925
             (    0)    (   98)    (   98)
             P= ,       P= ,000    P= ,000

PROFTOE        ,5383     1,0000      ,5568
             (   98)    (    0)    (   98)
             P= ,000    P= ,       P= ,000

TOTCATEG       ,4925      ,5568     1,0000
             (   98)    (   98)    (    0)
             P= ,000    P= ,000    P= ,

(Coefficient / (D.F.) / 2-tailed Significance)

" , " is printed if a coefficient cannot be computed



- - -  P A R T I A L   C O R R E L A T I O N   C O E F F I C I E N T S
- -

Controlling for..    TOTCATEG

               SSTL2    PROFTOE

SSTL2         1,0000      ,3653
             (    0)    (   97)
             P= ,       P= ,000

PROFTOE        ,3653     1,0000
             (   97)    (    0)
             P= ,000    P= ,

(Coefficient / (D.F.) / 2-tailed Significance)

" , " is printed if a coefficient cannot be computed
```

Partial Correlation 5

Variable	Mean	Standard Dev	Cases
OSPAN	15,9600	8,6782	100
TOTCATEG	49,4400	6,9141	100
PROFTOE	2,6496	,9158	100

```
- - -  P A R T I A L   C O R R E L A T I O N   C O E F F I C I E N T S
- -

Zero Order Partials

               OSPAN   TOTCATEG    PROFTOE

OSPAN         1,0000      ,3378      ,1976
             (     0)    (    98)    (    98)
             P= ,        P= ,001    P= ,049

TOTCATEG       ,3378     1,0000      ,5568
             (    98)    (     0)    (    98)
             P= ,001    P= ,        P= ,000

PROFTOE        ,1976      ,5568     1,0000
             (    98)    (    98)    (     0)
             P= ,049    P= ,000    P= ,

(Coefficient / (D.F.) / 2-tailed Significance)

" , " is printed if a coefficient cannot be computed


- - -  P A R T I A L   C O R R E L A T I O N   C O E F F I C I E N T S
- -

Controlling for..    PROFTOE

               OSPAN   TOTCATEG

OSPAN         1,0000      ,2798
             (     0)    (    97)
             P= ,        P= ,005

TOTCATEG       ,2798     1,0000
             (    97)    (     0)
             P= ,005    P= ,

(Coefficient / (D.F.) / 2-tailed Significance)

" , " is printed if a coefficient cannot be computed
```

Partial Correlation 6

```
Variable            Mean     Standard Dev     Cases

OSPAN            15,9600           8,6782       100
PROFTOE           2,6496            ,9158       100
TOTCATEG         49,4400           6,9141       100
```

```
- - -  P A R T I A L   C O R R E L A T I O N   C O E F F I C I E N T S
- -

Zero Order Partials

               OSPAN    PROFTOE   TOTCATEG

OSPAN         1,0000      ,1976      ,3378
             (    0)    (   98)    (   98)
             P= ,       P= ,049    P= ,001

PROFTOE        ,1976     1,0000      ,5568
             (   98)    (    0)    (   98)
             P= ,049    P= ,       P= ,000

TOTCATEG       ,3378      ,5568     1,0000
             (   98)    (   98)    (    0)
             P= ,001    P= ,000    P= ,

(Coefficient / (D.F.) / 2-tailed Significance)

" , " is printed if a coefficient cannot be computed
```

```
- - -  P A R T I A L   C O R R E L A T I O N   C O E F F I C I E N T S
- -

Controlling for..    TOTCATEG

               OSPAN    PROFTOE

OSPAN         1,0000      ,0121
             (    0)    (   97)
             P= ,       P= ,905

PROFTOE        ,0121     1,0000
             (   97)    (    0)
             P= ,905    P= ,

(Coefficient / (D.F.) / 2-tailed Significance)

" , " is printed if a coefficient cannot be computed
```

Correlation zsstL2 X Meanz

Correlations

		mean zscores for totcateg and proftoe	Zscore(SSTL2)
mean zscores for totcateg and proftoe	Pearson Correlation	1.000	.584
	Sig. (2-tailed)	.	.000
	N	100	100
Zscore(SSTL2)	Pearson Correlation	.584	1.000
	Sig. (2-tailed)	.000	.
	N	100	100

** Correlation is significant at the 0.01 level (2-tailed).

ANOVA TASK ORDER

Within-Subjects Factors
Measure: MEASURE_1

CONDITIO	Dependent Variable
1	RTEXP
2	RTCTR

Between-Subjects Factors

		Value Label	N
TASKORDE	1	controlfirst	50
	2	experimentalfirst	50

Descriptive Statistics

	TASKORDE	Mean	Std. Deviation	N
RTEXP	controlfirst	823,16	143,07	50
	experimentalfirst	878,94	127,27	50
	Total	851,05	137,60	100
RTCTR	controlfirst	888,78	157,63	50
	experimentalfirst	865,42	175,82	50
	Total	877,10	166,54	100

Multivariate Tests

Effect		Value	F	Hypothesis df	Error df	Sig.
CONDITIO	Pillai's Trace	,037	3,813	1,000	98,000	,054
	Wilks' Lambda	,963	3,813	1,000	98,000	,054
	Hotelling's Trace	,039	3,813	1,000	98,000	,054
	Roy's Largest Root	,039	3,813	1,000	98,000	,054
CONDITIO * TASKORDE	Pillai's Trace	,082	8,798	1,000	98,000	,004
	Wilks' Lambda	,918	8,798	1,000	98,000	,004
	Hotelling's Trace	,090	8,798	1,000	98,000	,004
	Roy's Largest Root	,090	8,798	1,000	98,000	,004

a Exact statistic
b Design: Intercept+TASKORDE Within Subjects Design: CONDITIO

Mauchly's Test of Sphericity
Measure: MEASURE_1

	Mauchly's W	Approx. Chi-Square	df	Sig.	Epsilon		
Within Subjects Effect					Greenhouse-Geisser	Huynh-Feldt	Lower-bound
CONDITIO	1,000	,000	0	,	1,000	1,000	1,000

Tests the null hypothesis that the error covariance matrix of the orthonormalized transformed dependent variables is proportional to an identity matrix.
a May be used to adjust the degrees of freedom for the averaged tests of significance. Corrected tests are displayed in the Tests of Within-Subjects Effects table.
b Design: Intercept+TASKORDE Within Subjects Design: CONDITIO

Tests of Within-Subjects Effects
Measure: MEASURE_1

Source		Type III Sum of Squares	df	Mean Square	F	Sig.
CONDITIO	Sphericity Assumed	33930,125	1	33930,125	3,813	,054
	Greenhouse-Geisser	33930,125	1,000	33930,125	3,813	,054
	Huynh-Feldt	33930,125	1,000	33930,125	3,813	,054
	Lower-bound	33930,125	1,000	33930,125	3,813	,054
CONDITIO * TASKORDE	Sphericity Assumed	78289,245	1	78289,245	8,798	,004
	Greenhouse-Geisser	78289,245	1,000	78289,245	8,798	,004
	Huynh-Feldt	78289,245	1,000	78289,245	8,798	,004
	Lower-bound	78289,245	1,000	78289,245	8,798	,004
Error(CONDITIO)	Sphericity Assumed	872058,130	98	8898,552		
	Greenhouse-Geisser	872058,130	98,000	8898,552		
	Huynh-Feldt	872058,130	98,000	8898,552		
	Lower-bound	872058,130	98,000	8898,552		

Tests of Within-Subjects Contrasts
Measure: MEASURE_1

Source	CONDITIO	Type III Sum of Squares	df	Mean Square	F	Sig.
CONDITIO	Linear	33930,125	1	33930,125	3,813	,054
CONDITIO * TASKORDE	Linear	78289,245	1	78289,245	8,798	,004
Error(CONDITIO)	Linear	872058,130	98	8898,552		

Tests of Between-Subjects Effects
Measure: MEASURE_1
Transformed Variable: Average

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Intercept	149325121.125	1	149325121.125	4001,773	,000
TASKORDE	13138,205	1	13138,205	,352	,554
Error	3656844,170	98	37314,736		

ESTIMATED MARGINAL MEANS

1. TASKORDE
Measure: MEASURE_1

	Mean	Std. Error	95% Confidence Interval	
TASKORDE			Lower Bound	Upper Bound
controlfirst	855,970	19,317	817,636	894,304
experimentalfirst	872,180	19,317	833,846	910,514

2. CONDITIO
Measure: MEASURE_1

	Mean	Std. Error	95% Confidence Interval	
CONDITIO			Lower Bound	Upper Bound
1	851,050	13,540	824,181	877,919
2	877,100	16,697	843,964	910,236

3. TASKORDE * CONDITIO
Measure: MEASURE_1

		Mean	Std. Error	95% Confidence Interval	
TASKORDE	CONDITIO			Lower Bound	Upper Bound
controlfirst	1	823,160	19,148	785,161	861,159
	2	888,780	23,614	841,919	935,641
experimentalfirst	1	878,940	19,148	840,941	916,939
	2	865,420	23,614	818,559	912,281

ANCOVA

PRO1

Within-Subjects Factors
Measure: MEASURE_1

COND	Dependent Variable
1	RTEXP
2	RTCTR

Between-Subjects Factors

		Value Label	N
proficiency level based on totcateg	1	less proficient	26
	2	more proficient	26

Descriptive Statistics

	proficiency level based on totcateg	Mean	Std. Deviation	N
RTEXP	less proficient	938,23	133,81	26
	more proficient	775,77	102,30	26
	Total	857,00	143,65	52
RTCTR	less proficient	962,77	151,78	26
	more proficient	786,69	138,85	26
	Total	874,73	169,25	52

Multivariate Tests

Effect		Value	F	Hypothesis df	Error df	Sig.	Eta Squared	Noncent. Parameter	Observed Power
COND	Pillai's Trace	,071	3,742	1,000	49,000	,059	,071	3,742	,475
	Wilks' Lambda	,929	3,742	1,000	49,000	,059	,071	3,742	,475
	Hotelling's Trace	,076	3,742	1,000	49,000	,059	,071	3,742	,475
	Roy's Largest Root	,076	3,742	1,000	49,000	,059	,071	3,742	,475
COND * TASKORDE	Pillai's Trace	,055	2,841	1,000	49,000	,098	,055	2,841	,379
	Wilks' Lambda	,945	2,841	1,000	49,000	,098	,055	2,841	,379
	Hotelling's Trace	,058	2,841	1,000	49,000	,098	,055	2,841	,379
	Roy's Largest Root	,058	2,841	1,000	49,000	,098	,055	2,841	,379
COND * PRO1	Pillai's Trace	,009	,441	1,000	49,000	,510	,009	,441	,100
	Wilks' Lambda	,991	,441	1,000	49,000	,510	,009	,441	,100
	Hotelling's Trace	,009	,441	1,000	49,000	,510	,009	,441	,100
	Roy's Largest Root	,009	,441	1,000	49,000	,510	,009	,441	,100

a Computed using alpha = ,05

b Exact statistic
c Design: Intercept+TASKORDE+PRO1 Within Subjects Design: COND

Mauchly's Test of Sphericity
Measure: MEASURE_1

	Mauchly's W	Approx. Chi-Square	df	Sig.	Epsilon		
Within Subjects Effect					Greenhouse-Geisser	Huynh-Feldt	Lower-bound
COND	1,000	,000	0	,	1,000	1,000	1,000

Tests the null hypothesis that the error covariance matrix of the orthonormalized transformed dependent variables is proportional to an identity matrix.
a May be used to adjust the degrees of freedom for the averaged tests of significance. Corrected tests are displayed in the Tests of Within-Subjects Effects table.
b Design: Intercept+TASKORDE+PRO1 Within Subjects Design: COND

Tests of Within-Subjects Effects

Source		Type III Sum of Squares	df	Mean Square	F	Sig.	Eta Squared	Noncent. Parameter	Observed Power
COND	Sphericity Assumed	26915,314	1	26915,314	3,742	,059	,071	3,742	,475
	Greenhouse-Geisser	26915,314	1,000	26915,314	3,742	,059	,071	3,742	,475
	Huynh-Feldt	26915,314	1,000	26915,314	3,742	,059	,071	3,742	,475
	Lower-bound	26915,314	1,000	26915,314	3,742	,059	,071	3,742	,475
COND * TASKORDE	Sphericity Assumed	20434,911	1	20434,911	2,841	,098	,055	2,841	,379
	Greenhouse-Geisser	20434,911	1,000	20434,911	2,841	,098	,055	2,841	,379
	Huynh-Feldt	20434,911	1,000	20434,911	2,841	,098	,055	2,841	,379
	Lower-bound	20434,911	1,000	20434,911	2,841	,098	,055	2,841	,379
COND * PRO1	Sphericity Assumed	3168,757	1	3168,757	,441	,510	,009	,441	,100
	Greenhouse-Geisser	3168,757	1,000	3168,757	,441	,510	,009	,441	,100
	Huynh-Feldt	3168,757	1,000	3168,757	,441	,510	,009	,441	,100
	Lower-bound	3168,757	1,000	3168,757	,441	,510	,009	,441	,100
Error(COND)	Sphericity Assumed	352442,243	49	7192,699					
	Greenhouse-Geisser	352442,243	49,000	7192,699					
	Huynh-Feldt	352442,243	49,000	7192,699					
	Lower-bound	352442,243	49,000	7192,699					

Measure: MEASURE_1
a Computed using alpha = ,05

Source	COND	Type III Sum of Squares	df	Mean Square	F	Sig.	Eta Squared	Noncent. Parameter	Observed Power
COND	Linear	26915,314	1	26915,314	3,742	,059	,071	3,742	,475
COND * TASKORDE	Linear	20434,911	1	20434,911	2,841	,098	,055	2,841	,379

COND * PRO1	Linear	3168,757	1	3168,757	,441	,510	,009	,441	,100
Error(COND)	Linear	352442,243	49	7192,699					

Tests of Within-Subjects Contrasts
Measure: MEASURE_1
a Computed using alpha = ,05

Tests of Between-Subjects Effects
Measure: MEASURE_1
Transformed Variable: Average

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Eta Squared	Noncent. Parameter	Observed Power
Intercept	8618979,630	1	8618979,630	310,319	,000	,864	310,319	1,000
TASKORDE	33348,606	1	33348,606	1,201	,279	,024	1,201	,189
PRO1	776031,376	1	776031,376	27,940	,000	,363	27,940	,999
Error	1360953,624	49	27774,564					

a Computed using alpha = ,05

ESTIMATED MARGINAL MEANS

1. Grand Mean
Measure: MEASURE_1

Mean	Std. Error	95% Confidence Interval	
		Lower Bound	Upper Bound
865,865	16,342	833,025	898,706

a Evaluated at covariates appeared in the model: TASKORDE = 1,50.

2. COND
Measure: MEASURE_1

	Mean	Std. Error	95% Confidence Interval	
COND			Lower Bound	Upper Bound
1	857,000	16,675	823,491	890,509
2	874,731	19,860	834,821	914,640

a Evaluated at covariates appeared in the model: TASKORDE = 1,50.

3. proficiency level based on totcateg
Measure: MEASURE_1

	Mean	Std. Error	95% Confidence Interval	
proficiency level based on totcateg			Lower Bound	Upper Bound
less	953,288	23,251	906,564	1000,012

proficient				
more proficient	778,443	23,251	731,718	825,167

a Evaluated at covariates appeared in the model: TASKORDE = 1,50.

4. proficiency level based on totcateg * COND
Measure: MEASURE_1

		Mean	Std. Error	95% Confidence Interval	
proficiency level based on totcateg	COND			Lower Bound	Upper Bound
less proficient	1	938,836	23,724	891,161	986,512
	2	967,740	28,255	910,959	1024,521
more proficient	1	775,164	23,724	727,488	822,839
	2	781,722	28,255	724,940	838,503

a Evaluated at covariates appeared in the model: TASKORDE = 1,50.

PRO2

Within-Subjects Factors
Measure: MEASURE_1

COND	Dependent Variable
1	RTEXP
2	RTCTR

Between-Subjects Factors

		Value Label	N
proficiency level based on proftoe	1	less proficient	22
	2	more proficient	21

Descriptive Statistics

	proficiency level based on proftoe	Mean	Std. Deviation	N
RTEXP	less proficient	938,64	135,50	22
	more proficient	755,24	110,59	21
	Total	849,07	153,65	43
RTCTR	less proficient	963,82	151,18	22
	more proficient	779,19	146,59	21
	Total	873,65	174,30	43

Effect		Value	F	Hypothesis df	Error df	Sig.	Eta Squared	Noncent. Parameter	Observed Power
COND	Pillai's Trace	,067	2,860	1,000	40,000	,099	,067	2,860	,379
	Wilks' Lambda	,933	2,860	1,000	40,000	,099	,067	2,860	,379
	Hotelling's Trace	,072	2,860	1,000	40,000	,099	,067	2,860	,379
	Roy's Largest Root	,072	2,860	1,000	40,000	,099	,067	2,860	,379
COND * TASKORDE	Pillai's Trace	,045	1,906	1,000	40,000	,175	,045	1,906	,271
	Wilks' Lambda	,955	1,906	1,000	40,000	,175	,045	1,906	,271
	Hotelling's Trace	,048	1,906	1,000	40,000	,175	,045	1,906	,271
	Roy's Largest Root	,048	1,906	1,000	40,000	,175	,045	1,906	,271
COND * PRO2	Pillai's Trace	,004	,146	1,000	40,000	,704	,004	,146	,066
	Wilks' Lambda	,996	,146	1,000	40,000	,704	,004	,146	,066
	Hotelling's Trace	,004	,146	1,000	40,000	,704	,004	,146	,066
	Roy's Largest Root	,004	,146	1,000	40,000	,704	,004	,146	,066

Multivariate Tests
a Computed using alpha = ,05
b Exact statistic
c Design: Intercept+TASKORDE+PRO2 Within Subjects Design: COND

Mauchly's Test of Sphericity
Measure: MEASURE_1

	Mauchly's W	Approx. Chi-Square	df	Sig.	Epsilon		
Within Subjects Effect					Greenhouse-Geisser	Huynh-Feldt	Lower-bound
COND	1,000	,000	0	,	1,000	1,000	1,000

Tests the null hypothesis that the error covariance matrix of the orthonormalized transformed dependent variables is proportional to an identity matrix.
a May be used to adjust the degrees of freedom for the averaged tests of significance. Corrected tests are displayed in the Tests of Within-Subjects Effects table.
b Design: Intercept+TASKORDE+PRO2 Within Subjects Design: COND

Source		Type III Sum of Squares	df	Mean Square	F	Sig.	Eta Squared	Noncent. Parameter	Observed Power
COND	Sphericity Assumed	24371,314	1	24371,314	2,860	,099	,067	2,860	,379
	Greenhouse-Geisser	24371,314	1,000	24371,314	2,860	,099	,067	2,860	,379
	Huynh-Feldt	24371,314	1,000	24371,314	2,860	,099	,067	2,860	,379
	Lower-bound	24371,314	1,000	24371,314	2,860	,099	,067	2,860	,379
COND * TASKORDE	Sphericity Assumed	16241,136	1	16241,136	1,906	,175	,045	1,906	,271
	Greenhouse-Geisser	16241,136	1,000	16241,136	1,906	,175	,045	1,906	,271
	Huynh-Feldt	16241,136	1,000	16241,136	1,906	,175	,045	1,906	,271
	Lower-bound	16241,136	1,000	16241,136	1,906	,175	,045	1,906	,271
COND * PRO2	Sphericity Assumed	1246,432	1	1246,432	,146	,704	,004	,146	,066
	Greenhouse-Geisser	1246,432	1,000	1246,432	,146	,704	,004	,146	,066
	Huynh-Feldt	1246,432	1,000	1246,432	,146	,704	,004	,146	,066
	Lower-bound	1246,432	1,000	1246,432	,146	,704	,004	,146	,066
Error(COND)	Sphericity Assumed	340848,976	40	8521,224					
	Greenhouse-Geisser	340848,976	40,000	8521,224					
	Huynh-Feldt	340848,976	40,000	8521,224					
	Lower-bound	340848,976	40,000	8521,224					

Tests of Within-Subjects Effects
Measure: MEASURE_1
a Computed using alpha = ,05

Source	COND	Type III Sum of Squares	df	Mean Square	F	Sig.	Eta Squared	Noncent. Parameter	Observed Power
COND	Linear	24371,314	1	24371,314	2,860	,099	,067	2,860	,379
COND * TASKORDE	Linear	16241,136	1	16241,136	1,906	,175	,045	1,906	,271
COND * PRO2	Linear	1246,432	1	1246,432	,146	,704	,004	,146	,066
Error(COND)	Linear	340848,976	40	8521,224					

Tests of Within-Subjects Contrasts
Measure: MEASURE_1
a Computed using alpha = ,05

Tests of Between-Subjects Effects
Measure: MEASURE_1
Transformed Variable: Average

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Eta Squared	Noncent. Parameter	Observed Power
Intercept	7252998,593	1	7252998,593	262,093	,000	,868	262,093	1,000
TASKORDE	75906,988	1	75906,988	2,743	,106	,064	2,743	,366
PRO2	801167,011	1	801167,011	28,951	,000	,420	28,951	,999
Error	1106934,311	40	27673,358					

a Computed using alpha = ,05

ESTIMATED MARGINAL MEANS

1. Grand Mean
Measure: MEASURE_1

Mean	Std. Error	95% Confidence Interval	
		Lower Bound	Upper Bound
859,038	17,944	822,773	895,303

a Evaluated at covariates appeared in the model: TASKORDE = 1,51.

2. COND
Measure: MEASURE_1

	Mean	Std. Error	95% Confidence Interval	
COND			Lower Bound	Upper Bound
1	846,839	18,980	808,480	885,198
2	871,237	21,954	826,866	915,609

a Evaluated at covariates appeared in the model: TASKORDE = 1,51.

3. proficiency level based on proftoe
Measure: MEASURE_1

	Mean	Std. Error	95% Confidence Interval	
proficiency level			Lower Bound	Upper Bound

based on proftoe				
less proficient	958,895	25,502	907,353	1010,438
more proficient	759,181	26,123	706,384	811,978

a Evaluated at covariates appeared in the model: TASKORDE = 1,51.

4. proficiency level based on proftoe * COND
Measure: MEASURE_1

		Mean	Std. Error	95% Confidence Interval	
proficiency level based on proftoe	COND			Lower Bound	Upper Bound
less proficient	1	942,757	26,975	888,239	997,276
	2	975,033	31,203	911,969	1038,097
more proficient	1	750,921	27,631	695,076	806,766
	2	767,442	31,962	702,843	832,040

a Evaluated at covariates appeared in the model: TASKORDE = 1,51.

PRO3

Within-Subjects Factors
Measure: MEASURE_1

COND	Dependent Variable
1	RTEXP
2	RTCTR

Between-Subjects Factors

		Value Label	N
proficiency level based on mean zscores	1	less proficient	24
	2	more proficient	24

Descriptive Statistics

	proficiency level based on mean zscores	Mean	Std. Deviation	N
RTEXP	less proficient	956,29	130,29	24
	more proficient	771,29	111,18	24
	Total	863,79	151,97	48
RTCTR	less proficient	984,42	160,60	24
	more proficient	812,96	153,23	24
	Total	898,69	177,81	48

Effect		Value	F	Hypothesis df	Error df	Sig.	Eta Squared	Noncent. Parameter	Observed Power
COND	Pillai's Trace	,092	4,580	1,000	45,000	,038	,092	4,580	,553
	Wilks' Lambda	,908	4,580	1,000	45,000	,038	,092	4,580	,553
	Hotelling's Trace	,102	4,580	1,000	45,000	,038	,092	4,580	,553
	Roy's Largest Root	,102	4,580	1,000	45,000	,038	,092	4,580	,553
COND * TASKORDE	Pillai's Trace	,056	2,692	1,000	45,000	,108	,056	2,692	,362
	Wilks' Lambda	,944	2,692	1,000	45,000	,108	,056	2,692	,362
	Hotelling's Trace	,060	2,692	1,000	45,000	,108	,056	2,692	,362
	Roy's Largest Root	,060	2,692	1,000	45,000	,108	,056	2,692	,362
COND * PRO3	Pillai's Trace	,000	,007	1,000	45,000	,934	,000	,007	,051
	Wilks' Lambda	1,000	,007	1,000	45,000	,934	,000	,007	,051
	Hotelling's Trace	,000	,007	1,000	45,000	,934	,000	,007	,051
	Roy's Largest Root	,000	,007	1,000	45,000	,934	,000	,007	,051

Multivariate Tests
a Computed using alpha = ,05
b Exact statistic
c Design: Intercept+TASKORDE+PRO3 Within Subjects Design: COND

Mauchly's Test of Sphericity
Measure: MEASURE_1

	Mauchly's W	Approx. Chi-Square	df	Sig.	Epsilon		
Within Subjects Effect					Greenhouse-Geisser	Huynh-Feldt	Lower-bound
COND	1,000	,000	0	,	1,000	1,000	1,000

Tests the null hypothesis that the error covariance matrix of the orthonormalized transformed dependent variables is proportional to an identity matrix.
a May be used to adjust the degrees of freedom for the averaged tests of significance. Corrected tests are displayed in the Tests of Within-Subjects Effects table.
b Design: Intercept+TASKORDE+PRO3 Within Subjects Design: COND

Tests of Within-Subjects Effects
Measure: MEASURE_1

Source		Type III Sum of Squares	df	Mean Square	F	Sig.	Eta Squared	Noncent. Parameter	Observed Power
COND	Sphericity Assumed	38588,314	1	38588,314	4,580	,038	,092	4,580	,553
	Greenhouse-Geisser	38588,314	1,000	38588,314	4,580	,038	,092	4,580	,553
	Huynh-Feldt	38588,314	1,000	38588,314	4,580	,038	,092	4,580	,553
	Lower-bound	38588,314	1,000	38588,314	4,580	,038	,092	4,580	,553
COND * TASKORDE	Sphericity Assumed	22677,215	1	22677,215	2,692	,108	,056	2,692	,362
	Greenhouse-Geisser	22677,215	1,000	22677,215	2,692	,108	,056	2,692	,362
	Huynh-Feldt	22677,215	1,000	22677,215	2,692	,108	,056	2,692	,362
	Lower-bound	22677,215	1,000	22677,215	2,692	,108	,056	2,692	,362
COND * PRO3	Sphericity Assumed	57,881	1	57,881	,007	,934	,000	,007	,051
	Greenhouse-Geisser	57,881	1,000	57,881	,007	,934	,000	,007	,051
	Huynh-Feldt	57,881	1,000	57,881	,007	,934	,000	,007	,051
	Lower-bound	57,881	1,000	57,881	,007	,934	,000	,007	,051
Error(COND)	Sphericity Assumed	379141,765	45	8425,373					
	Greenhouse-Geisser	379141,765	45,000	8425,373					
	Huynh-Feldt	379141,765	45,000	8425,373					
	Lower-bound	379141,765	45,000	8425,373					

a Computed using alpha = ,05

Tests of Within-Subjects Contrasts

Source	COND	Type III Sum of Squares	df	Mean Square	F	Sig.	Eta Squared	Noncent. Parameter	Observed Power
COND	Linear	38588,314	1	38588,314	4,580	,038	,092	4,580	,553
COND * TASKORDE	Linear	22677,215	1	22677,215	2,692	,108	,056	2,692	,362
COND * PRO3	Linear	57,881	1	57,881	,007	,934	,000	,007	,051
Error(COND)	Linear	379141,765	45	8425,373					

Measure: MEASURE_1
a Computed using alpha = ,05

Tests of Between-Subjects Effects
Measure: MEASURE_1
Transformed Variable: Average

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Eta Squared	Noncent. Parameter	Observed Power
Intercept	8730137,915	1	8730137,915	294,931	,000	,868	294,931	1,000
TASKORDE	74156,615	1	74156,615	2,505	,120	,053	2,505	,341
PRO3	821406,615	1	821406,615	27,750	,000	,381	27,750	,999
Error	1332029,115	45	29600,647					

a Computed using alpha = ,05

ESTIMATED MARGINAL MEANS

1. Grand Mean
Measure: MEASURE_1

Mean	Std. Error	95% Confidence Interval	
		Lower Bound	Upper Bound
881,240	17,560	845,873	916,606

a Evaluated at covariates appeared in the model: TASKORDE = 1,50.

2. COND
Measure: MEASURE_1

	Mean	Std. Error	95% Confidence Interval	
COND			Lower Bound	Upper Bound
1	863,792	17,577	828,390	899,194
2	898,687	21,983	854,411	942,964

a Evaluated at covariates appeared in the model: TASKORDE = 1,50.

3. proficiency level based on mean zscores
Measure: MEASURE_1

	Mean	Std. Error	95% Confidence Interval	
proficiency level based on mean zscores			Lower Bound	Upper Bound
less proficient	975,052	25,010	924,680	1025,424
more proficient	787,427	25,010	737,055	837,799

a Evaluated at covariates appeared in the model: TASKORDE = 1,50.

4. proficiency level based on mean zscores * COND
Measure: MEASURE_1

		Mean	Std. Error	95% Confidence Interval	
proficiency level based on mean zscores	COND			Lower Bound	Upper Bound
less proficient	1	958,392	25,035	907,969	1008,814
	2	991,712	31,310	928,651	1054,774
more proficient	1	769,192	25,035	718,769	819,614
	2	805,662	31,310	742,601	868,724

a Evaluated at covariates appeared in the model: TASKORDE = 1,50.