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METU 2020

INVESTIGATIONS OF THE MIND AND BRAIN: ASSESSING BEHAVIORAL AND NEURAL PRIMING IN L2 MORPHOLOGY

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OCTOBER 2020

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A THESIS SUBMITTED TO
THE GRADUATE SCHOOL OF SOCIAL SCIENCES
OF
MIDDLE EAST TECHNICAL UNIVERSITY

BY

ORHAN DEMİR

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR
THE DEGREE OF DOCTOR OF PHILOSOPHY
IN
THE DEPARTMENT OF ENGLISH LANGUAGE TEACHING

OCTOBER 2020

Approval of the thesis:

INVESTIGATIONS OF THE MIND AND BRAIN: ASSESSING BEHAVIORAL AND NEURAL PRIMING IN L2 MORPHOLOGY

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ABSTRACT

INVESTIGATIONS OF THE MIND AND BRAIN: ASSESSING BEHAVIORAL AND NEURAL PRIMING IN L2 MORPHOLOGY

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Ph.D., English Language Teaching
Supervisor: Prof. Dr. Bilal Kırkıcı

October 2020, 244 pages

The main goal of this thesis was to investigate the temporal and spatial properties of early morphological processing in a second language (L2). For this purpose, a computer-based masked-priming lexical decision task was implemented, which was followed by a functional magnetic resonance imaging (fMRI) experiment with minimal differences in the data collection procedure. The first experiment was completed by 122 L2 learners of English (L1: Turkish) and the participants of the fMRI study were a subgroup of the former experiment (n. 49). Additionally, in order to test whether L2 early morphological processing was modulated by individual differences, a series of tasks was administered at the end of the first experiment to classify participants according to their level of overall proficiency, spelling accuracy and vocabulary size.

The results exhibited a morpho-orthographic decomposition pattern in L2 similar to the findings of the L1 literature. Overall proficiency was also found to be among the determining factors of visual word recognition in L2. As for the analyses of the fMRI data; unlike the L1 literature, left-frontal areas (BA6) were observed to be activated only in the processing of lexical items with links in the surface form but not in the meaning-based associations between primes and targets. Behavioral results laid emphasis on the significant effect of frequency and proficiency on the early stages of morphological processing. On the other hand, neural findings of this thesis referred to the hemodynamic reflections in L2 on the basis of the distinctive properties of morpheme types.

Keywords: morphological processing, priming, functional magnetic resonance imaging, individual differences, frequency of occurrence

ÖZ

ZİHİN VE BEYİN ARAŞTIRMALARI: İKİNCİ DİLDE BİÇİMBİLİMSEL HAZIRLAMANIN DAVRANIŞSAL VE SİNİRBİLİMSEL DEĞERLENDİRİLMESİ

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Tez Yöneticisi: Prof. Dr. Bilal Kırkıcı

Ekim 2020, 244 sayfa

Bu tezin temel amacı, ikinci dilde (D2) erken biçimbilimsel işlemlemenin zamansal ve uzamsal özelliklerini incelemektir. Bu amaçla, maskelenmiş hazırlama paradigmasının kullanıldığı bilgisayar temelli bir sözcüksel karar verme görevi gerçekleştirilmiş, ardından da içerik olarak ilk deneyle yüksek oranda örtüşen bir fonksiyonel manyetik rezonans görüntüleme (fMRI) deneyi uygulanmıştır. Ilk deneye anadili (D1) Türkçe olan 122 D2 İngilizce konuşucusu, ikinci çalışmaya ise ilk deneyin alt grubu olan 49 kişi katılmıştır. Bunun yanında, D2'de erken biçimbilimsel işlemlemede bireysel farklılıkların etkisini sınama maksadıyla katılımcıları genel yeterlik, imla yetkinliği ve sözcük bilgisine göre sınıflandıran bir dizi test ve görev ilk deneyi takiben tamamlanmıştır.

Sonuçlar, D1'e benzer şekilde D2'de biçimsel-ortografik bir ayrıştırma modeli ortaya koymuştur. Bunun yanında, D2'de görsel sözcük tanımlamada dilsel yeterliğin belirleyici unsurlardan biri olduğu görülmüştür. fMRI verileri D1 çalışmalarıyla karşılaştırıldığında ise,sol frontal bölgenin (BA 6) sadece biçim temelli ilişkilerin olduğu yapılarda etkinleştiği, anlamsal ilişki içeren hazırlama-hedef sözcük gruplarında bu etkinin söz konusu olmadığı gözlemlenmiştir. Davranışsal bulgular, bahsi geçen süreçte sözcük sıklığı ve genel dilsel yeterliğin önemine işaret ederken sinirbilimsel sonuçlar biçimbirim türlerinin hemodinamik yansımasını ön plana çıkarmıştır.

Anahtar Kelimeler: biçimbilimsel işlemleme, hazırlama, fonksiyonel manyetik rezonans görüntüleme, bireysel farklılıklar, sözcük sıklığı

To My Family

ACKNOWLEDGMENTS

First of all, I would like to express my gratitude to my supervisor, Prof. Dr. Bilal Kırkıcı for a vast number of things that would force me to write a separate piece of the same length as this thesis. Besides being a devoted advisor with endless support and a great supervisor with an exceptional intellectual profundity and commitment to scientific principles, he has also been the true model for his students as an honest person to shoulder responsibility for the community and the people around indiscriminately. His efforts to enable me to work under ideal conditions mean the world to me.

Secondly, I would like to thank Prof. Dr. Orhan Murat Koçak for his scientific and technical support whenever I was in desperate straits in the fMRI process as well as the perspective he ingeniously brought to my thesis. I will always remember his patience when I feel buried under the workload.

I owe a big thanks to Prof. Dr. Martina Gracanin-Yüksek because she has never hesitated to provide corrections to my thesis and other works even at the most difficult times. Working with her was the most meaningful part of being a research assistant.

I also thank Prof. Dr. Özgür Aydın and Assist. Prof. Dr. İpek Pınar Uzun for their constructive feedback, comments and suggestions that pointedly guided me to further studies.

Prof. Dr. Çiğdem Sağın Şimşek deserves a special thanks for encouraging her students to participate in my fMRI experiment, which had concerned me more than anything else. I really miss the days when I assisted her courses.

I am deeply indebted to Berkay Kayalı for his incredible help in the data collection process. I offer my regards to Mustafa Can Delikanlı and Emre Kale for their assistance at Bilkent UMRAM.

I feel extremely fortunate to have colleagues like Esra Ataman, Alper Kesici, Ozan Can Çağlar, Sinem Oruç, Samet Deniz, Gülden Taner and Mehmet Akkuş. It has always been a pleasure for me to work, study, discuss and chat with them. I would also like to thank Aziz, Mehtap, Volkan, Ömer, Gökçe and Oğuz for their everlasting friendship.

This thesis was supported by a METU research Project Grants (BAP-05-03-2017-001).

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LIST OF ABBREVIATIONS

BOLD	Blood Oxygenation Level Dependent
EEG	Electroencephalography
ELF	English as a Lingua Franca
ERP	Event-Related Potential
ESP	English for Specific Purposes
FLA	First Language Acquisition
fMRI	Functional Magnetic Resonance Imaging
LIFG	Left-Inferior Frontal Gyrus
LR	Lexical Representation
MEG	Magnetoencephalography
PET	Positron Emission Tomography
SLA	Second Language Acquisition
SOA	Stimulus Onset Asynchronies
SSH	Shallow Structure Hypothesis
TR	Repetition Time
WRAT-R	Wide Range Achievement Test Revisited

CHAPTER 1

INTRODUCTION

This thesis aimed to examine how second language (L2) learners process morphologically complex lexical items at the earlier stages of visual word recognition. In addition to the investigation of potential factors of reading complex words, it sought to identify the brain regions involved in L2 morphological processing. The first chapter provides background information regarding the need for a neuropsychological perspective in the L2 processing studies, a comparative look at the inquiries into morphological processing, the scope and significance of this thesis, as well as the research questions and the experimental paradigm.

1.1. A Psycholinguistic Approach to Second Language Acquisition

Many scholars consider the 1960s as the period of the introduction to second language acquisition (SLA)[1] studies with broader perspectives due to the groundbreaking Chomskyan theory (1957, 1965) and the discussions about the applicability of Chomsky's and his followers' assumptions to SLA contexts. On the other hand, the greatest increase in the number of rigorous SLA studies was observed in the 1980s. The probable reason for this surge was the political and social atmosphere in the world that accompanied globalization and the internalization of concepts such as English as a Lingua Franca (ELF) and English for Specific Purposes (ESP). The agenda behind the theoretical discussions about the status of English in communities where it is not acquired as the first language (L1) was the necessity to have a global culture- hence a global language. The immediate consequence of this necessity was

[1] Second language refers to all contexts of learning a further language than one's native language in this thesis. Therefore, second language acquisition is used as an umbrella term to address the fundamental questions of "how learners come to internalize the linguistic system of another language" (Van Patten & Benati, 2010; p. 2)

the focus on the nature of how a second language is learned and what variables play a role in this process. Besides, the debate about whether an L2 is located in a different area of the brain and activated by means of different mechanisms or whether it is the product of the same mechanisms that take place in first language acquisition (FLA) turned out to be an important source of motivation for second language researchers (Jegerski & VanPatten, 2014; VanPatten & Williams, 2015). As a natural consequence, investigations into the acquisition and use of an L2 in different contexts and with different purposes have led to an enormous pile of scientific output including studies covering different branches of linguistics ranging from phonology to pragmatics and different conditions, an example of which are the comparative studies on the effect of the acquisition of a further language before and after puberty (e.g. Hakuta et al., 2003; Granena & Long, 2013; Hartshorne et al., 2018).

As for the boundaries of L2 studies, hard as it is to identify the limits of this area of inquiry, researchers occupied with the landscape of SLA attempted to review the development of the field by dividing the SLA literature into certain broad areas. For instance, Macaro (2010) divided it into four broad areas:

- the acquisition of the rules system and the acquisition of vocabulary
- the development of language skills
- the beliefs that teachers and learners hold about second language learning
- the practice of teaching and learning (p. 9).

It is obvious that the way Macaro categorized SLA fails to account for the efforts to describe how people process L1 and L2 in real time. To explain how language users access mental rules and use them to encode and decode linguistic materials when they get to produce and comprehend language remains an inevitable duty for SLA scholars so that a deeper analysis of the nature of this phenomenon can be made. More specifically, it should be one of the major goals of SLA researchers to identify the processes that occur in linguistic activities at different levels. Correspondingly, the primary goal of the present study is to shed light on the fundamental properties of L2 processing at a certain level: the level of morphological processing.

1.2. Morphological Representation & Morphological Processing

As neatly described by Pollatsek and Treiman (2015), modern societies' inevitable need for reading accompanied a large body of research on the way people read and learn to read in their mother tongues and second languages. Dating back to Huey's publications on the psychology of reading at the beginning of the 20th century (1908, 1913), many attempts have been exerted to provide scientifically reliable findings on the nature and difficulties of reading in accordance with the dominant paradigms in the social sciences; namely, the behaviorist approach, which aimed to enhance learning by means of outer factors until the 1960s, and then the cognitive revolution, which paid attention to the internal complexities of human language. The cognitive revolution enabled researchers to investigate the reading process analytically. Different areas of language started to be investigated from different perspectives with the goal of gaining a better understanding of the nature of reading, accumulating a large body of research that ranged from spelling ability to the effect of discourse on how people interpret their reading. A division in the investigation of language areas has also been witnessed in language processing studies. Mainly concentrating on analyses at the levels of phonology, morphology and syntax, psycholinguists have made a remarkable effort to uncover the sorts of processes language users undergo and the strategies they benefit from when they read printed material. Along with the examination of the processing of sound and word groups, morphological processing turned out to attract a good deal of attention on account of its implicational power to answer some basic questions addressing language comprehension.

1.2.1. Theoretical Approaches to the Mental Lexicon

One point that makes morphological processing studies notable in theoretical debates on language comprehension is that they prove to be potential indicators of the features of the mental lexicon. When we read a sentence, we mostly try to understand it by combining the meanings of individual words. To do so, we retrieve information from the source that is claimed to accumulate the knowledge for words. This hypothetical center of information for words is called the 'mental lexicon'. It is assumed that there are entries stored for each word in this mental apparatus. To give an example, when we read the word *see*, we access information about its pronunciation, segmentation of meaningful units, distributional properties, meaning, and pragmatic features. By virtue of the well-accepted assumption that human memory is considerably limited, researchers seek an answer for how humans can hold such detailed information for thousands of words (Forster & Chambers, 1973). Central to this question is the endeavor to describe the organization of the mental lexicon.

It appears logical to argue that for a processor to work efficiently, it should incorporate only necessary entities in its hardware by the most cost-effective means. This bears a close resemblance to the internal organization of grammar. Chomsky's depiction of language as the perfect system of the optimal design (2005; p.2) entails the effective operation of thought systems (Conceptual-Intentional Interfaces) and speech systems (Sensory-Motor Interface), which draw heavily on mental representations. These representations are recognized as the semantic and phonetic components. The kernel area of grammar -morphosyntax- is the computational component of language, and the products of the computational system are mapped onto the semantic and phonetic components. It is proposed that the morphosyntactic mechanisms retrieve the necessary items from the mental lexicon to compute at the word and sentence level (Radford, 2009; p. 14). Such a fast and automatic process is only possible with a very well-organized system and optimal mechanisms and robust devices, so these criteria ought to be applicable to the source of these operations- the mental lexicon. Therefore, the organization of the mental lexicon is an important item on the agenda of morphologists.

Given that the fast operation of the steps described above is vital, the mental lexicon is supposed to contain the lexical items and their entries in such a way that they can be easily and swiftly accessed and processed. This assumption brings about a proposal regarding the storage of monomorphemic words: the lexical entries for each of these words are kept in our mental lexicon. One point of disagreement, however, remains with respect to lexical items with multiple subcategorization frames. Transitive verbs such as *eat*, *drink* or *read* are found to be acceptable under certain circumstances without complements as in *He is drinking too much these days*. The widely-accepted view on such 'exceptional' cases has been that for such verbs the mental lexicon includes two different lexical entries. Due to the limited number of these items, they do not pose a big problem for the optimal use of mental resources for the extraction of lexical items during morphosyntactic processing. The actual hot debate centers on the storage and representation of multimorphemic -morphologically complex- lexical items.

As Frost and Grainger (2000) put it, morphological factors are considered to be the determining issues for models of lexical organization. They come into play when attempts emerge to formulate how morphologically complex words are stored. As will be further discussed below, originally two models were put forward that radically differed from each other in their stance towards the incorporation of rules -keeping the associative components stable- in their simulation of the storage of complex words. Considering their explanatory power and the inextricable link between lexical storage, access and processing, I provide detailed information about these models in the following section.

1.2.2. Morphology in Visual Word Recognition

Along with the accumulated knowledge and recent developments in psychology and the neurosciences, the need for a reading model is evident. Such a model should be informative about reading from physical and neuropsychological perspectives. When we read printed words, the visual system works coordinately with the language processing mechanisms for an accurate interpretation. Therefore, the physical constituents of the whole process and its implicational effects (fixation, fovea, saccade and the like) on the process are of great importance. Secondly, a descriptive account of the way our mind works in order to assign meaning to a letter string when a word is perceived is essential for the purpose of establishing the explanatory power of a reading model. This thesis has the general aim of contributing to the formulation of the latter requirement of a potential model.

As was stated before, there is hardly any question as to the storage, access or retrieval of monomorphemic words: lexical entries are available for individual words and processed in a quite straightforward way unless there are any exceptional cases at the morpho-phonological level. On the other hand, whether or not morphologically complex words are decomposed into their morphological constituents has become one of the most controversial questions of language processing studies over the last 40 years. In other words, whether multimorphemic lexical items are treated like unanalyzed forms or they are separated into their stems and bound morphemes has existed as a trigger for a number of empirical studies testing various views touching upon the issue. Two radical accounts along with a number of hybrid models have so far been in competition, presenting sets of experimental evidence.

The initial hypotheses to uncover the underlying mechanisms of the processing of morphologically complex words focused on models to overcome mental storage load. In accordance with this concern, formulas have been produced to load the memory with the least quantity of linguistic items possible. Taft and Forster's Prefix Stripping Model (1975) was later attributed to being the pioneering work of *full decomposition* accounts of morphological processing. These accounts treat complex words differently from monomorphemic items in terms of the internal analysis. The memory is loaded with representations of simple words as chunks. These representations consist of entries regarding phonological, orthographic, morphological, semantic, and pragmatic properties of the relevant lexical items. They are purely memorized as a part of the language acquisition process, hence form the memorized part of language processing. Complex words are extracted from these lists by making use of the grammatical or semantic relationships. Such relationships are established during the process of lexical recognition at the morphological level; words are parsed into their constituent units via morphological decomposition. That is why it is essential that an internal analysis be performed to optimally constrain the limits of lexical storage. There is only one list of entries for *see*, *sees*, and *seen*, for example. This means we have access to the same list of entries for all these words when we read them. If the stem *see* is read, retrieving the knowledge of the stem is sufficient. However, when we get to process the complex words *sees* or *seen*, a second phase emerges. We reach the entry for the relevant stem and then apply morphological decomposition rules to assign the accurate meaning to these words. Correspondingly, the accurate comprehension of the word *sees* entails searching for the representation of the stem *see*, and applying the morphological rules, i.e. morphological analysis, to incorporate the grammatical function of the suffix *–s.* A limited number of grammatical functions of morphemes, i.e. rules, are learned (or acquired) at early stages of language acquisition and considered to constitute the learned part of language processing.

Various accounts in line with Taft and Forster's arguments came up for discussion, the principal characteristic of which is that they propose a morphological analysis of complex (multisyllabic) words, or the availability of *a prelexical left-to-right parsing mechanism* (Rastle, 2007). Instances of divergences among the rule-based models mark the beginning of the proposal of dual-route mechanisms- full form (Augmented Addressed Morphology Model by Caramazza, Laudana and Romani,

1988) or the competition between full form and morphological processing according to the familiarity of the lexical items (Morphology Race Model by Schreuder and Baayen, 1995)-, the availability of morphological representations at a prelexical or a supralexical level (Giraudo and Grainger, 2000), or the possible effect of the morphological relatedness on the formation of form-meaning networks by the associative memory (Plaut and Gonnerman, 2000). Among these debates, theoretical and empirical considerations as to what constitutes rules (the learned part) and representations (the memorized part) attracted a considerable amount of attention in the field.

Adopting the view that the processing mechanisms work more efficiently if each word is directly retrieved as a full-form instead of applying rules of some form, Butterworth (1983) asserted that there are lexical entries for each word, irrespective of morphological relatedness. He underlined the weaknesses of the ideas that

1. only base forms are listed, with inflectional and derivational compounds being computed online by rule, and

2. lexical representations make available morphemes rather than words for multimorphemic words

and arrived at the conclusion that “we are therefore left with the weaker evidence that all forms have their own LR (lexical representation, O.D.)” (p. 289). Butterworth’s *Full Listing Hypothesis* is considered both inspirational and encouraging for the connectionist approaches that eschew linguistic rules in lexical processing. Combining the basic features of Rumelhart’s (1977) review of the multiple processes accounts of lexical processing, Rumelhart and McClelland (1981, 1982) started to challenge the rule-based accounts by presenting alternative facilitative factors for visual letter and word recognition such as the contextual or orthographic associations among words at three levels: the feature level, the letter level, and the word level. Unlike the rule-based accounts, in connectionist models the view is maintained that a single associative mechanism in the form of an *associative memory* suffices to form the link between phonetic and semantic representations for the accurate comprehension and production of language.

It is possible to assume that these connectionist models do not need to draw a distinction between a mental lexicon and a grammar; associations stored in the associative memory are dedicated to the acquisition and use of language. These associations could be contextual enhancements, (McClelland & Rumelhart, 1981; Rumelhart & McCllelland, 1982) orthographic similarities or the impact of frequency. The strong relationships among words from these perspectives have statistical power and give rise to statistical learning mechanisms rather than the acquisition of grammatical rules. Therefore, no interference of morpho-syntactic analyses is observed in these simulations, so the words are perceived without being decomposed. For instance, there are three entries stored for the words *see*, *sees*, and *seen*. When we use or encounter the word *sees* we have direct access to it so that we can reach the word rapidly. The perceptional processes of the recognition of the word *sees* include its phonological connection with other words, the number of instances it is produced or comprehended, the contexts it is used and the like. However, it bypasses its grammatical relatedness to *see* or *seen*. In this sense, the same phonological association is established between other words and *seen* and *seed*.

Considering the insufficiencies of models that attempted to explain the vast expressive power of language solely on rules or connections, Pinker (1991, 1998) offered a hybrid model that implicates distinct cognitive mechanisms: an associative memory and symbol-manipulating rules. He suggested the Words and Rules Theory or the Dual-Mechanism Model by discussing the processing of regularly and irregularly inflected word forms and exhibited the failure of solely connections or rules to be able to account for the inconsistent linguistic behaviors of children and adults during the processing of such patterns. Pinker hence came up with the compromising idea he summarized as follows:

> Language maximizes the distinct advantages of words and rules by comprising both, each handled by a distinct psychological system. There is a lexicon of words for common or idiosyncratic entities; the psychological mechanism designed to handle it is simply a kind of memory. And there is a separate system of combinatorial grammatical rules for novel combinations of entities; the psychological mechanism designed to handle it is symbolic computation (1998, p. 4).

As exemplified above, in Taft and Forster’s rule-based account, it was hypothesized that there is a single entry in the mental lexicon for the words *see*, *sees*, and *seen*. On the other hand, the connectionist accounts stipulated that there should be separate entries for each of these words. However, Pinker and his collaborators (e.g., Pinker & Prince, 1991; Pinker & Ullman, 2002) put forth the application of rules for *sees* and the storage of *seen* in a so-called associative memory. Therefore, it is hypothesized that two lexical entries exist for the three word forms. In this model, the speaker resorts to two distinct mechanisms when he reads the words *sees* and *seen*.

The combinatorial mechanism establishes the grammatical connection between the base form *see* and the inflectional morpheme -*s* to assign present tense, which makes an accurate processing of the whole word possible. On the other hand, the word *seen* is not analyzed into its constituent morphemes *see* and -*en*, but is retrieved as a whole word, instead.

Pinker's highly influential *Words and Rules Theory* (1998) has been challenged from various aspects with revised models. Even though they weighed in with the dual mechanism model, Alegre and Gordon (1999), for example, challenged the criterion for the storage of the words in the associative memory; they postulated that there are threshold levels for the transfer of lexical items to keep them exempt from parsing. In other words, if a complex word is sufficiently frequent, it is retrieved as an unanalyzed form. Despite the falsifiability problem of the proposal in the lack of a precise formulation of the degree of frequency to climb over the threshold level, as a reaction to this argument, Pinker and Ullman (2002) restated their position by admitting that empirical evidence shows strong frequency effects for some regular and irregular forms. This argument pointed to the remarkable effect of frequency on linguistic processing - whether it was regarded as a determining factor in morphological analysis or not.

Another noteworthy challenge to Pinker's theory focused on the (non)decomposability of irregular past tense forms in English. In his Ph.D. dissertation, the focus of which was the computational efficiency of child grammar, Yang (2000) developed a critique of Pinker's implications for the non-compositionality of irregular forms by making the claim that Pinker was misled by the idiosyncrasy of irregular forms in English to make a generalization. In his Rules and Competition Model, he voiced the opinion that "the learning of an irregular verb is determined by the probability with which it is associated with its class, and the probability with which the class rule applies over the default -*d* rule" (p. 102), hence disagreeing with the claim that irregulars are always stored as chunks in the memory. Additionally, in line with Alegre and Gordon (1999), he attached importance to input frequency even if he did not single it out as the only crucial factor. Besides, some empirical findings such as those reported in Crepaldi et al. (2010) display the facilitative effects of the relatedness between irregular forms (e.g. *seen*) and their stems (e.g. *see*) on the reaction times of native speakers. The same effect was observed for regularly inflected forms (e.g. *watched*) and their stems (e.g. *watch*). It can hence be concluded from the findings obtained from children and adults that Pinker's arguments on the distinctive features of irregular forms are in need of deeper analyses and further tests on different conditions.

To summarize, three approaches are widely discussed in the morphological processing literature. On the one hand, the localists who are in favor of the rule-based accounts argue that we store stems and apply rules to retrieve complex words whereas connectionists explain the visual recognition of morphologically complex words depending on the statistical power of associations with other words. Hybrid models, on the other hand, advocated the applicability of both rules and representations taking into account the internal structure of lexical items. Another matter of debate related to the recognition of morphologically complex words is the engagement of orthographic similarity and semantic transparency in lexical processing to be discussed below.

1.2.3. Form and Meaning in Morphological Processing

Whether morphologically complex words are analyzed, i.e. decomposed into their constituent morpheme, in the course of processing or not has been discussed for a couple of decades. As was explained above, competing models have been presented that do or do not include a morphological decomposition component. Among the proponents of the rule-based accounts, the degrees of the magnitude of the effect of morphological, orthographic and semantic relatedness between the stems and complex words were at issue, as well.

As will be discussed in further detail in Chapter 2, there are empirical findings showing that when a morphologically complex word is encountered prior to its base form, this facilitates the reading of the second word; so, for example, when we read *see* after *sees*, this enables us to process the simple word *see* faster compared to an unrelated word (the *baseline*). It is possible to assume that this facilitation, referred to as *priming* (to be discussed later in this chapter), is thanks to the morphological relatedness between these two lexical items. That is to say, we analyze sees as *see* and *–s* by applying the morphological rule, so processing the same word (*see*) twice leads to faster recognition by re-activating the same stem. However, there are also alternative explanations. One of them is that we store and select words in the same location of our mental lexicon in accordance with the number of letters shared; correspondingly, it is maintained that the formal overlap between a complex word and its monomorphemic stem is the major cause of the facilitation when these two types of lexical items are processed, indirectly demonstrating formal decomposition in visual word recognition. The influence of the surface-form -the way that individuals process and encode the specific sequences of letters in written language- (McClung et al., 2012 p. 173) is taken as a critical construct in L1 lexical processing (e.g. Sibley et al., 2008), further languages (e.g. Heyer & Clahsen, 2015) and across languages considering the alphabetical characteristics of the first and second languages of individuals (e.g. Frost, 2005).

Another point emphasized in the literature is the role that lexical semantics plays in the process of reading. In a way similar to the letters shared by the complex words and their stems, *sees* and *see*, as an example, bear almost the same meaning. This way of thought renders the facilitation of the processing of a complex word possible after its recognition in a stem form due to the similarity in meaning. Imageability (Paivio, 1971), the number of semantic features (Pexman, 2012), associations between words (Balota et al., 2004), and lexical ambiguities (Beretta, Fiorentino and Poeppel, 2005) were accentuated to be among the foremost sources of meaning-based influence on lexical processing. Besides experiments on adult language users, the fundamental difference between first and second language processing is explained with reference to the relative dependence on lexical-semantic cues rather than the morpho-syntactic rules, which led to the formulation of the widely-debated Shallow-Structure Hypothesis (Clahsen & Felser, 2006), an overview of which is offered further below.

The arguments on the orthographic and semantic effect on morphological processing resulted in a more elaborate contrastive look at the facilitative elements in visual word recognition. Firstly, the need to dissect form and meaning from pure morphological effects arose. Complex words, by their natures, bear a formal and semantic connection with their stems. Therefore, detecting less effort in the processing of *sees* following its stem *see* cannot guarantee that this relative effortlessness occurred only on account of morphological factors. This quintessential overlap of form, meaning, and morphology needs to be eluded by the virtue of separating these links from each other on minimally different conditions. Thereupon, the claim that form facilitates the processing of *see* after *sees* is expected to exhaust other possibilities by making predictions on the existence of the same advantage of processing when *see* is encountered following *seed*. Along the same line, *look* should provide a similar convenience for the processing of *see* to that of *sees* if the effortlessness explained above stems purely from the meaning-based connection between the successive words. This perspective, coupled with further analyses on the sole and collective effects of potential factors of morphological processing, obviously increased the testability and explanatory power of the hypotheses in this field of inquiry.

Apart from the competition of potential factors in visual word recognition, the question whether morphological, orthographic and semantic factors intervene in reading concurrently or asynchronously has become another main topic of discussion in the reading literature. As stated above, there are empirical findings in support of the decomposition of morphologically complex words into their constituents and the possibility of the effect of form and meaning on this process. This bottom-up stimulus-driven word segmentation is put under scrutiny from the point of intervention of these above-mentioned factors at different phases of processing. That is to say, the point at which orthographic overlap and/or semantics begin to exert influence on the recognition of morphologically complex words and the question whether there is a phase of processing which is blind to orthographic or semantic influence are further issues that occupy the center of attention in morphological processing research.

As a matter of fact, it is indisputable that these factors enter into the organization of the mental representation and the lexical access to complex words in the final state (Marslen-Wilson et al., 1994; Diependeale et al., 2011). Even though no consensus has so far been reached regarding the decisive elements of this process, studies have displayed that semantically transparent or orthographically similar lexical items cause some facilitation in visual recognition. As for early morphological processing, the attempt to identify the mechanisms that are active at this phase is at the heart of the controversy. Rastle and her collaborators (2000, 2004, 2008) came up with the *form-before-meaning account*, in which it is claimed that the early stages of processing morphologically complex words are solely morphology-driven. In other words, only in later stages – maybe in the final stage- do we find orthographic overlap and semantic relatedness influencing the reading performance of language users. According to these researchers, as an example, being exposed to *sees* for a very short time – say 50 milliseconds - can facilitate the recognition of the stem *see* because the preceding word will have already been decomposed into its morphemes *see* and *-s* at the very first stage of the encounter and the stem will be reactivated when it is seen afterwards. Because of the absence of morphological relatedness, the same simulation would not be expected for *seed* or *look*, which are orthographically and semantically related to the stem *see*, respectively, if these words are not seen for a long-enough time. Although no widely-accepted counter-view against the above-mentioned account of early morphological processing was suggested for native language processing, there is an alternative hypothesis drawing the attention of researchers. The alternative hypothesis argued that when the semantic component of the morphological relatedness between two words is removed, the facilitative effect tends to decrease (Diependeale et al., 2005). The proponents of this latter argument compared the degree of facilitation of semantically transparent word pairs (e.g. farmer - FARM) with an opaque condition, in which a word contains a pseudo-morpheme and shares the same stem with the following monomorphemic lexical item (e.g., corner - CORN). The latter condition apparently does not provide a meaning-based facilitation but only a morpho-orthographic segmentation. This alternative view suggested that this early morpho-orthographic analysis can help the reader process the following word faster albeit at a significantly diminishing degree compared to a condition where the morpho-orthographic segmentation is coupled with a semantic effect. Furthermore, there are studies in nonnative processing that point to the possibility that purely orthographic overlap can produce facilitation in the processing of morphologically complex words (e.g. Heyer & Clahsen, 2015).

A good number of studies have recently yielded remarkable findings related to the very early stages of visual word recognition in different conditions; however, an agreement on what exactly determines the early processing of complex words has not been reached, especially in non-native morphological processing. Therefore, a deeper temporal look at morphological processing is essential.

1.2.4. Individual Differences in Morphological Processing

Drawing upon Perfetti and Hart's (2002) *Lexical Quality Hypothesis*, which maintains that reading effectively rests on the high quality lexical representation of orthographic, phonological, semantic and syntactic properties of individual words, researchers have shown a growing interest in the implications of individual differences in visual word recognition. Andrews (2010, 2012), along with her collaborators, traced what Perfetti referred to as *lexical experts* and *skilled readers* and implemented a series of experiments on the effects of individual differences on morphological processing. Apparently, the efforts to make contribution to the long-lasting debates on the reading wars (bottom-up versus top-down processes for effective reading) delivered by-products that brought a new insight into the early morphological processing literature. Andrews initially defended the idea that skilled readers vary in the extent to which they have developed the sub-branches of lexical representations, so readers could end up being skilled in spelling accuracy or vocabulary size depending on their state or lack of progress. An experiment conducted by Andrews and Lo (2013) revealed substantial findings about early morphological processing because it pointed out that form or meaning could play a role at the first stages of lexical retrieval “for some people” (p. 290). They postulated that people with higher spelling accuracy are associated with an ‘orthographic profile’ and this distinctive feature is manifested in the facilitation for the early retrieval of words sharing the same letters, to an extent irrespective of sematic transparency or morphological relatedness. In the same vein, language users with a larger vocabulary size are associated with a ‘semantic profile’ and are considered to undergo meaning-based influence in the early processing of complex words. Andrews and Lo's stance has been rather influential since this perspective attaches great importance to the variations among language users even if they are native speakers rather than taking an idealized look at this population.

Nonetheless, the number of studies addressing the potential modulation of early morphological processing by individual differences is rather scarce (but see Medeiros & Dunabeitia, 2016). Andrews and Lo's findings and conclusions are therefore still in need of triangulation with respect to the morphological structures they tested, their methodology, and analysis. As for non-native morphological processing, to the best of my knowledge, no study has gone beyond the inclusion of second language proficiency into the analyses as a factor or a covariate. Therefore, additional empirical findings on how individual differences may modulate (early) morphological processing are certain to make a huge contribution to the formation of reading models in L1 and L2.

1.2.5. The Neuropsychology of Morphological Processing

As language users, we perform certain mental activities in order to perceive or use the language. For instance, there are conscious and unconscious -or automatized-linguistic behaviors we exhibit when we read or interpret a sentence or a word; we assign meanings to items by means of the rules or associations we preserve. Detecting the patterns and commonalities of such mental processes in the course of language use is one of the goals of psycholinguists and uncovering the strategies language users adopt when they are faced with morphologically complex words constitutes one of the important goals in the field.

The field of psycholinguistics has been quite a productive and beneficial branch, with many groundbreaking findings and discoveries having been attained that led to the formation or revision of distinguished linguistic theories thanks to the elaborate tools of psycholinguistic research. Yet, as in all areas of scientific research, psycholinguistics bears some disadvantages that need to be overcome to reach falsifiable, reliable and generalizable conclusions with sufficient descriptive power. It deals with the characterization of an abstract concept: the mind. The investigation of such a hypothetical phenomenon does not necessarily reveal concrete findings. Psycholinguistic research enables us to have an indirect look at what happens in our mind so that we can only have implications about the properties of mental representations and operations. Specifically, language user's ultimate preferences on tests (e.g., grammaticality judgment tasks) and their reaction times as some linguistic structure unfolds (e.g. self-paced reading tasks) are the main sources of evaluation that let us have some ideas about the possible strategies they implement or the rules they abide by. That is to say, offline judgments and temporal description of language users' performance rarely allow researchers to fully understand mental processes; a third angle proves to be imperative. From this point of view, any picture of the representation and retrieval of morphologically complex words would be incomplete without a spatial look at these processes.

Decades after the interest in the identification of the locus of the language organ in the brain through inductive observations of the dead or of patients suffering from language pathologies such as aphasia, more sophisticated questions were raised concerning the existence and function of the human language faculty. It should be underlined that the advent of technological developments and more profound philosophical arguments concerning the properties of language mutually reinforced each other through the agency of empirical studies. Quite a few basic paradigm shifts in linguistics such as perceiving language as an abstract faculty rather than a physical organ, the evaluation of the relationship between language and intelligence, the consideration of bihemispheric foundations of language use compared to an irreplaceable role of the left hemisphere and a positive look at bilingualism – among others- occurred thanks to the conjugated movement of philosophical and empirical efforts. The more convenient it became to observe brain activities, the more scientifically-underpinned hypotheses were tested to shed light on the physical and psychological features of language, and vice versa. Therefore, characterizing the neural correlates of language processes became an inseparable component of linguistic inquiries.

As a sub-branch of cognitive neuroscience, neurolinguistics made its way for disclosing various higher brain functions with respect to when and by which neuron circuits linguistic operations are realized. Particularly, as summarized in Gwilliams and Marantz (2018), sensitivity to morphological structure was corroborated in a number of neurophysiological endeavors. Neuroimaging techniques such as magnetoencephalography (MEG) or non-invasive ways of measuring electrical activity of brain responses like electroencephalography (EEG) uncovered some common responses of participants when faced with complex words (e.g. Pylkkanen et al., 2004; Morris et al., 2008; Lehtonen et al., 2011; Cavalli et al., 2016). However, as in the behavioral experiments in psycholinguistics, these noteworthy contributions to the literature were also obtained as a result of time-based implications; the data stack was the product of the measures of temporal brain activations. Pulvermüller (2002) agreed that a much more fine-grained account of visual word recognition is possible with the incorporation of neuroimaging techniques that allow for visualizing brain activity on spatial scales. Considering the fact that positron emission tomography (PET) is invasive, functional magnetic resonance imaging (fMRI) remains to be the most suitable technique for uncovering the activation loci in the course of lexical processing.

Newman (2014) acknowledged that fMRI has many strengths; its first and foremost advantage is being a noninvasive technique to observe the living brain at work. It provides a level of neuroanatomical precision that is almost impossible to achieve with any other noninvasive technique (p. 178). To sketch out how fMRI functions, it measures when and how much the oxygen in the blood changes relative to different conditions. It is known that the brain cannot store energy; it is consumed and regenerated constantly, the main carrier of energy being oxygen (Bornkessel-Schlesewsky & Schlesewsky, 2009). When there is an increase in the oxygen level in the blood (referred to as BOLD) in a specific area of the brain, this fMRI signal is taken to indicate activation in the location of interest. Therefore, we can compare the activation levels in the brain when language users are exposed to different types of linguistic input and when they process the language – an example is the contrastive look at the processing of morphologically complex words versus monomorphemic words. Since earlier studies adopting an ERP paradigm (e.g. Münte et al., 1999; Rodriguez-Fornells et al., 2002; Lavric, Clapp and Rastle, 2007) manifested decomposition as increased brain activity, what remains to uncover is to identify the brain regions responsible for such reactions to complex words. Providing that time-wise inductions regarding the decomposition of (types of) morphologically complex words overlap with increased activity in certain regions of the brain in a consistent frequency, we can put forth assumptions on where the complex words are parsed in the brain and the neural correlates of the recognition of different types of morphemes in different conditions.

Although fMRI experiments produce the output of four dimensions - three spatial pictures along with a temporal output-, its power of temporal resolution is relatively low and so the results necessitate supplementary findings with behavioral studies focusing on the temporal changes in parallel. The present thesis, hence, aims to uncover the temporal and spatial reflections of the processing of morphologically complex words by running psycholinguistic and fMRI experiments to attempt to answer the same research questions.

fMRI is a relatively new technique that has been utilized in scientific inquiries since 1992 (Kwong et al., 1992). A handful of studies were implemented in morphological processing; however, the bulk of fMRI research aimed to uncover the ultimate state of the recognition of complex words by benefitting from unprimed or unmasked conditions (e.g. Henson, 2003; Fiorentino et al., 2015), the long-lag priming paradigm (e.g. Bozic et al., 2007) or a block-design fMRI experiment (e.g. Vannest, Polk and Lewis, 2005). These methodological alternatives did not yield valid results for early morphological processing, so the number of experiments addressing the activation loci the moment language users encounter complex words is scanty in both native and nonnative morphological processing. An important purpose of this thesis is therefore to contribute to the alleviation of this deficiency in the development of the spatial perspective of early morphological processing models.

A brief overview of the major debates in morphological processing has been provided above. In what follows, a discussion about how these arguments relate to the nature of visual word recognition in a second language (L2) will be presented.

1.3. L2 Morphological Processing

Whether L2 learners acquire and make use of the same grammatical rules as native speakers has been one of the major questions of second language theories. The most prominent accounts differ in the utilization of the same set of rules and strategies in L2 or the compensation of the deviations in L2 competence or use by means of non-grammatical sources. Namely, models adopting the Continuity Hypothesis (Pinker, 1990; Crain, 1991) or fundamental difference hypotheses (e.g. Schachter, 1989) formed the underlying rationale behind the theories aiming to account for the nature of second language acquisition covering the initial point up until the final stage. No specific model of morphological processing has yet been put forth; however, there are several hypotheses which draw upon this dichotomy of L2 theories.

The arguments for the availability of the same mental representations and the employment of the same mechanisms in L1 and L2 morphological processing were favored by some researchers. Never was the continuity in L2 claimed to be applicable unconditionally; nonetheless, a certain degree of convergence between native and nonnative speakers' performance in the recognition of morphologically complex words was supposed to lead to the potential attainment of nativelike L2 competence. A salient approach to morphological processing in L2 was that nativelike online integration of grammatical knowledge in the word-recognition process depended on the level of L2 proficiency. At least advanced L2 learners were observed to exhibit nativelike performance in lexical decision tasks for morphologically different types of words with respect to reaction times and accuracy rates (e.g. Feldman et al., 2009; Feldman et al., 2010; Diependaele et al., 2011) on certain conditions (e.g., opaque forms and semantically transparent word). To touch briefly on these studies, they showed a graded effect of facilitation considering the availability of information for words that follow morphologically complex lexical items. It was found that this graded effect applied not only to native but also to nonnative speakers. However, it must be noted that these types of convergences constituted "little evidence for two distinct mechanisms" (Feldman et al., 2010; p. 118) and were not regarded as the manifestation of paramount evidence to come up with a well-grounded model of the continuity of morphological processing in L2.

The Critical Period Hypothesis (Lenneberg, 1967) was another important claim that researchers of second language psycholinguistics referred to as a remarkable justification of deficiency in L2 grammatical processing. McDonald (2006) attributed late L2 learners' poor performance in judgment and reading span tasks to L1 effect, processing speed, and decoding ability, all of which correlated with age of acquisition beyond the critical period. Another age-related account of L2 processing was Ullman's Declarative - Procedural Model (2001), a neurobiologically motivated theory of SLA. The major claim of this theory is that particular genes play roles in the functioning of two memory systems: a procedural memory for implicit knowledge (associated with rules) and a declarative memory for explicit knowledge (associated with representations) of language. It is posited in this model that although knowledge in the declarative memory is learned and accessed easily and rapidly both in the L1 and in the L2, this is not true for what is stored in the procedural memory due to maturational constraints for L2 learners. Unlike the declarative memory, learning and consolidation in the procedural memory is only robust in early childhood. Correspondingly, as Ullman (2015) summarized, since L2 learners may begin the learning process in a later period of life, the functioning of the procedural memory declines and, hence, they depend more on the declarative memory. The unsuitability of the functional neuroanatomy of the declarative memory, which depends on the hippocampus and medial temporal lobe structures, in the substitution of the procedural memory, which is rooted in portions of the frontal cortex, turns out to be the major source of the poor performance in the acquisition and use of linguistic knowledge that is to be implicitly learned. As a reaction to this theoretical persuasion, Clahsen and Felser (2006) developed one of the most hotly-debated hypotheses of second language processing: the Shallow Structure Hypothesis. Incorporating the major characteristics of the Critical Period Hypothesis and the predictions of the Declarative - Procedural Model for the learning and processing of an L2, they revised Ullman's holistic view of rules and representations to make predictions regarding the online usage of L2 grammatical knowledge depending on the availability of the non-structural information the relevant structures contain. Clahsen and Felser claimed that L2 learners show nativelike performance patterns in the processing of structures if they have the opportunity to make use of lexical or semantic cues; otherwise, it is unlikely to observe qualitatively similar linguistic behaviors. As a salient example, Kırkıcı and Clahsen (2013) yielded a remarkable distinction between the recognition of inflected and derived word forms; unlike Feldman (2010), they found that L2 learners showed a similar performance to L1 speakers in the early processing of derived words but they were found to be slower on inflected words. This significant difference was attributed to the introduction of meaning in derivational morphemes in contrast to form-based changes in inflectional morphemes. It was asserted that this fundamental difference is not affected by L1 or proficiency but late L2 acquisition selectively modulates grammatical processing (Clahsen & Felser, 2018).

Individual differences have aroused substantial interest among SLA researchers for decades and this interest has accumulated a good number of inquiries. Research has dwelled on many issues ranging from personal (e.g., beliefs, motivation, attitudes) to cognitive (e.g., learning styles, metacognitive strategies, intelligence) aspects of individual differences. The overwhelming majority of this line of research has focused on the output of the second language learning process, while the effect of individual differences on the online integration of linguistic knowledge into the comprehension/production process has largely been neglected. It is undeniably a considerable progress starting from the perception of individual differences as "noise" or meaningless phenomena to their addition into analyses; nevertheless, leaving aside proficiency, which has practically proved to be a default variable of SLA studies, there is still only one variable of this kind with descriptive adequacy that was deeply investigated in L2 psycholinguistics: working memory (short term memory utilized in online processing) in syntactic processing (e.g., Havik et al., 2009; Sagarra & Herschensohn, 2010; Reichle et al., 2016). As for the examination of variation across individuals in the use of morphological information in L2 processing, to the best of my knowledge, no study has gone beyond the examination of the modulation of visual word recognition by the age of onset of acquisition and language proficiency. An obvious reason for this is that L2 morphological processing is a relatively new area of research and there are still unanswered questions on the very basic nature of this process. Another possible reason is the scantiness of experiments in L1 morphological processing to seek an insight in a contrastive model into philosophical, empirical, and methodological debates. It is expected that taking an initial step in exploring the impact of individual factors – in addition to proficiency - on L2 processing can shed light on and help explain the controversial results obtained in L2 early morphological processing studies.

As for the neuroimaging of L2 morphological processing, the importance of a meticulous description of visual word recognition via behavioral and neurological evidence was already addressed above. Besides, following brain processes in milliseconds is needed for testing hypotheses on morphological processing, but inferences solely based on the interpretation of time-based data of morphological processing tend to mislead researchers, especially in L2 studies. Bosch & Leminen (2018) emphasize the deficiency of time- based experimental measures and the vitality of spatial reasoning of L2 reading by stating that similarities in behavioral responses by native and non-native speakers do not entail the same underlying neural computation mechanisms. Correspondingly, no matter how many ERP studies were conducted in both L1 and L2 morphological processing and how great the temporal resolution of this method, as was criticized by Clahsen (2016), they provide a rough indication of the brain areas involved in the decomposition of complex words. That is to say, considering the fact that output-oriented offline results and time-based evidence obtained from online tasks do not guarantee a consistent and generalizable assessment of L2 early morphological processing, conducting neuroimaging studies is essential for testing and formulating models. As a matter of fact, fMRI studies have not been in demand even when the method became applicable and the devices available possibly out of the difficulty of recruiting participants and gaining access to funding and so the number of studies is not sufficient to constitute a spatial view of decomposition. Nevertheless, some patters seem to be emerging (Ullman, 2015; p. 148), which will be summarized in the literature review below. Further research is definitely needed so that complementary contributions to the philosophical and empirical debates on morphological processing can be provided.

1.4. The Scope and Significance of This Thesis

Exploring the early phase of the processing of morphologically complex words by L2 learners and the factors that come into play in this process is the ultimate goal of this thesis. As explained above, many models have been presented to simulate how people behave when they encounter complex words. Even if the debates are still in progress, empirical studies helped the researchers grasp a somehow generalizable view on L1 morphological processing: morpho-orthographic information navigates us in the early stages; then we make use of semantic and lexical information to comprehend multimorphemic items. This is by all means not the absolute conclusion; yet, the amount of research in line with this form-then-meaning argument increases and strengthens this idea year by year. For this reason, the need for testing all the potential factors of this area of research is not so urgently articulated among L1 researchers; however, controversial results in L2 processing lay emphasis on conducting further studies by adopting alternative perspectives. In accordance with this purpose, I seek to provide a new insight into the morphological processing literature with the framework to be explained below.

First of all, the studies conducted in this research area have taken as the morphological focus either one or two morpheme types (e.g. regular vs. irregular; inflectional vs. derivational) and have attempted to come up with hypotheses that they claimed could account for the rest of fundamentally different structures, as well. Theoretical debates concerning the functions and semantic properties of bound morpheme categories (e.g. Anderson, 1992; Pinker & Ullman, 2002) indirectly imply a reflection of the relevant distinctions in language use. Another issue is the testing conditions in sensitive tasks measuring reaction times in milliseconds. As Speed et al. (2018) stated, "the use of diverse samples is a pillar of modern science" (p. 191). A more diverse sample of observations related to a research question undoubtedly increase the ecological validity of findings and conclusions by leaving (almost) no room for alternative interpretations or confusions. Moreover, previous studies indicated that experimental conditions could provide challenging results for the well-accepted implications referring to the task-induced effects (e.g. Marelli et al. (2013)) or inconsistent findings based on methodological paradigms (e.g. Marslen-Wilson et al. (1994)). To date, this issue has been indirectly assessed only by means of behavioral methods in the morphological processing literature. Comparing testing conditions in a behavioral and neuropsychological experiment utilizing same materials is still a significant need for the accurate portrayal of L2 morphological processing. Considering these facts, making generalizations across types of morphological structures of different nature is likely to problematic. Therefore, I designed experiments by which I could test how L2 learners process three basic types of morphological structures at very early stages of recognition: derivational morphemes, regular inflectional morphemes, and irregularly-inflected lexical items. All participants were presented with complex words including each of these types of structures. The present study was – to the best of my knowledge- the first to employ such a design. Complex words were used including the productive derivational morpheme *-al*, the productive past participle regular inflectional morpheme *-ed* and the realizations of irregularly-inflected past participle items.

Secondly, this thesis features experiments testing the impact of individual differences in L2 early morphological processing. It is well-known that L2 speakers vary hugely compared to L1 users due to many reasons which are not within the scope of this thesis. In parallel with this, along with proficiency, the analysis of individual differences carries the potential of resolving the aforementioned uncertainty regarding the initial determinants of selective reactions by L2 speakers in the recognition of complex words. With this purpose in mind, the participants tested as part of the present study were divided into categories according to their spelling accuracy and vocabulary knowledge. As regards proficiency, the theoretical disagreements about its definition pose a serious problem for its identification. In Lado's (1961) definition, proficiency covers the intersection between language elements and language skills. Failure in the identification of such a well-emphasized construct can hinder the scientific value of the interpretation of results. Assessment of such a multicomponent phenomenon is further complicated by differences in learning contexts (classroom contexts vs research contexts) and the linguistic environment (foreign language vs second language vs bilingual language vs heritage language and the like). At this point, the feasibility problem comes into play: setting the ratio between the available resources and the required resources (Bachman & Palmer, 1996; p. 35). One possibility to overcome this handicap is the abstraction of the level of proficiency away from their performance in tests covering all the language elements and skills (Leclerq et al., 2014; p.11). This option is rarely favored as it puts the effect of fatigue at stake. Another alternative involves the assessment of certain language elements such as grammar and vocabulary as well as a couple of skills – mostly reading and writing- and accepting the risk of treating the scores obtained as representative for the overall proficiency. A third way preferred in psycholinguistic research in recent years on account of practical considerations is self-assessment: participants are asked to evaluate their own competence in language elements and skills on a Likert Scale. This method is also disadvantageous as it presupposes that all participants and the researcher own the same knowledge and perception about what constitutes proficiency and the participants make an objective assessment of their level. In order to minimize the drawbacks of these methods, I chose to incorporate the scores of a standardized test and participants' self-rating of their proficiency into the evaluation phase. In addition, participants were administered a linguistic background questionnaire to elicit information about the frequency of the use of L2 in daily life and the extent of learning and using L2 in a naturalistic context. These were also considered as constituent elements of proficiency in certain proportions so that a valid determination of the overall proficiency could be succeeded.

Thirdly, running an fMRI experiment following the traditional behavioral lexical decision task that I describe in the following part served two important purposes. As I stated above, the controversy in time-course of morphological processing could be resolved with alternative views on certain phases of experiments- an important one of them being the measurement of performance. However, the literature on the neuroimaging of L2 morphological processing with a spatial look at the phenomena does yield few if any inferences to grasp the brain activities correlating with the reaction to complex words by L2 speakers. That is why the increase in fMRI experiments keeps the considerable potential of disentangling the obscurity and coming up with an explanatorily powerful account of this process. A circumstantial contribution of the implementation of an fMRI experiment is the examination of the impact of testing condition on the processing patterns of L2 speakers. Previous studies signaled the variation of reactions and processing patterns when participants are asked to complete reading tasks with the identical content under different conditions. Unlike the former inquiries, this thesis compares L2 speakers' performance in the recognition of complex words with two different methodological paradigms by keeping all the other variables identical.

In the light of the research gaps that I sketched out throughout the chapter, the research questions of this thesis are as follows:

1. Do L2 speakers decompose morphologically complex words at an early phase of recognition? Do their processing patterns vary according to types of morphological structures?

2. Do L2 speakers' early morphological processing patterns correlate with the hemodynamic brain response patterns?

3. To what extent do individual differences modulate the processing patterns of L2 speakers?

4. To what extent do testing conditions have an impact on the early processing of morphologically complex words by L2 speakers?

On the purpose of uncovering the early processing patterns of L2 speakers, the first step is to decide on the ideal method to obtain the most accurate findings. The final part of this chapter gives brief information about the method adopted in this inquiry named masked priming.

1.5. Choosing the Best Experimental Paradigm: Visual Masked Priming

Testing whether L2 learners decompose morphologically complex words can be achieved by means of indirect measures. Even though roughly comparing participants' reaction times to complex and simple lexical items are unlikely to be informative, a contrastive evaluation of the facilitation effect between two stimuli is mostly informative. Here I refer to the phenomenon called *priming*. Priming addresses the condition in which prior exposure to a linguistic structure either facilitates or interferes with a speakers' subsequent linguistic behaviors (Trofimovich & McDonough, 2011). Like in all other branches of psychology and education, priming is one of the most frequently used paradigms in (various sub-branches of) psycholinguistics. Considering the case specific to morphological processing; the logic works this way: usually two stimuli are presented. The first one is referred to as the prime and the following as the target. The researcher measures response times to targets. Priming emerges when the response time to the target is faster compared to a baseline (Forster et al., 2003; p. 2). The direct comparison of the possible effect of related and unrelated words is possible in the priming method by keeping the target word the same and manipulating the prime items. Correspondingly, if L2 speakers react faster when they see the word *see* preceded by *sees* relative to an unrelated word such as *corn*, we can infer a priming effect that could be attributed to orthographic, semantic, morphological relatedness or the combination of all or some of them. However, controlled manipulation of primes can help researchers exhaust the possibilities to the desired degree.

Since the focus of this thesis is L2 early morphological processing, the conscious perception of the prime and the possible interference of episodic memory between the prime and target are supposed to be minimized. In other words, the goal of delving into automatic early morphological processing can be achieved by making the participants unaware of the prime. The technique that taps into this unconscious, automatized processing is *masked priming*. Forster et al. (2003) claim that the presence of a forward mask prior to the prime, short prime durations and the immediate arrival of the target right after the prime with no intervening materials can rule out confounding factors – namely retroactive effects. Masked priming is the ideal paradigm to fulfill all these requirements. The prime word is typically preceded by hashes or stars to make it invisible (i.e., to *mask* it) and the short presentation of this word (usually between 30 ms. and 70 ms.) is immediately followed by the presentation of a target word in this technique. Following the presentation of the target word, the participants are required to make a lexical decision (word/non-word). That is why a sufficient amount of time (500 ms. to 1000 ms.) is allocated to the visibility of the target word so that participants can make decisions regarding the availability of the target in the inventory of the language in question. In the light of the pivotal advantages of this procedure, both behavioral and neuroimaging experiments conducted in this thesis were run under the guise of lexical decision tasks adopting the masked priming paradigm.

CHAPTER 2

LITERATURE REVIEW

The ultimate goal of this thesis is to shed light on the nature of L2 morphological processing. It investigates early morphological processing from multiple perspectives to make a feasible contribution to this primary target. Because many L2 processing models intend to explain why and how L2 differs from L1 processing, they naturally trace back to L1 accounts. This chapter begins with the presentation of the major tenets of L1 morphological processing models and proceeds with empirical evidence for and against each model. The second major part of this chapter focuses on alternative and/or complementary approaches to account for early morphological processing underlined in the Introduction chapter: assessments of individual differences and neural correlates. The final part of this chapter deals with the implications of processing models in L2 as well as experimental studies testing their applicability.

2.1. Approaches to Morphological Processing in L1

It was briefly discussed in the Introduction that morphological processing models centered on the trade-off relating to the human cognitive processing capacity: the brain could either hold the specific rules to apply them under every suitable circumstance or it could hold the items with specific connections for access with an optimal speed. This junction ended up with models describing how people recognize morphologically complex words by taking a position in either side of the camps. Yet, the deficiency of absolute success in modelling morphological processing from such radical perspectives introduced hybrid models that advocate the storage of whole words when the rules are not applicable or available. These models emerged from different sources: philosophical debates, empirical evidence, or simulations of reading. The first part of this chapter provides background information about these approaches as well as selected works that test or draw upon them.

2.1.1. Rule-Based Approaches to Morphological Processing

The point of departure of rule-based approaches to morphological processing is the assumption for the applicability of productive feature of language to the internal structure of lexical items. The combinatorial power of language has generally been animated in the formation of novel sentences with frequent lexical items or structural loops to compose extraordinarily long sentences or uninterpretable texts out of hardly irrelevant sentences. Productivity can also exhibit its characteristic feature in the combination of morphemes to compose words. Rule-based accounts – the most well-accepted ones according to Milin et al. (2017; p. 7) - do hereby differ from other accounts because they argue that combinatorial rules for the formation of morphologically complex words are represented in the mental lexicon and retrieved from this source throughout the process of word recognition.

Murrell and Morton (1974) compared the degree of facilitation of pre-training – which is now termed as priming – with a morphologically related morpheme (cars - CAR) to pre-training with an orthographically related word to an equal extent (card - CAR). Their analyses of participants' performance in latency and accuracy displayed the facilitation for morphologically related items but not for those with only orthographic relation. They attributed this difference to the increase in the frequency of lexical items as a result of the addition of a morpheme which they called "morpheme- frequency effect". It is quite a reasonable interpretation taking into account the debates of the relevant period; the recognition system was thought to incorporate a sole determinant to map form and meaning: frequency. Leaving aside the focus of evaluation and methodological issues (number of participants – sensitivity of the measurement techniques), this study made way for elaborated investigations of the processing of complex words by means of the priming concept.

Taft and Forster (1975) conducted the seminal work to pinpoint morphological decomposition. Their focus was nonce words with or without prefixes. Assuming that it takes longer to process morphologically complex words relative to simple words they compared the reaction times to nonce words in which a real prefix was removed (e.g. (re)juvenate) and nonce words in which a pseudo suffix was removed (e.g. (re)pertoire). The faster responses to the latter case were taken as the evidence of morphological decomposition prior to lexical access: "the increased latency for real stem non-words represents the time taken to check the contents of the lexical entry to determine whether the stem can stand alone (p. 641)." A further experiment in the same study tested the processing of nonce words with real and pseudo-prefix. This experiment yielded the faster reaction times in the second case as well (e.g. depertoire took faster to process than dejuvenate) due to the extra time for pre-lexical analysis when the participants were faced with potentially complex words. These findings led them to the assertion that complex words were initially parsed into their constituent elements and then interpreted holistically - coined as Prefix Stripping Model.

These two studies are of great importance on account of their impact on the further inquiry of morphological processing from two aspects: determination of the most appropriate method and the most relevant research question to investigate how people recognize complex words. A growing body of literature predominantly aimed to test whether morphologically complex words are processed holistically or analytically, and to do this, utilized the priming paradigm in lexical decision tasks by accepting accuracy, reaction times, electrophysiological brain responses or hemodynamic measures as the indicators of the parsing process. Below I provide information about the improvement of the model succeeding Taft and Forster's (1975) above-mentioned assumptions through its current version.

2.1.1.1. Marslen-Wilson et al. (1994)

Marslen-Wilson and his colleagues aimed to reveal the primary unit of lexical representation that is a central area of language processing. Their preferred path to the answer was to decrease the number of possibilities out of two outstanding candidates: morpheme-based organization or the perception of phonetic words as the primary units of representations. It was assumed that the detection of insensitivity to morphological properties of words would rule out the morpheme-based accounts. To test whether morphological rules are activated in lexical processing and what other factors (semantic and phonology) play a role in the recognition of morphologically complex words, they conducted six experiments on derivationally complex words and prefixed forms. Cross-modal priming technique was utilized in the experiments: the participants were exposed to the prime words aurally which was immediately followed by the presentation of targets as printed words.

The first three experiments focused on the priming effect of phonetic overlap and semantic transparency on the processing of derivationally complex words. In the first experiment, prime-target pairs consisted of morphologically related and phonetically transparent (e.g. delightful-delight), morphologically related pairs with different phonetic realizations (e.g. tension-tense) and morphologically unrelated but phonetically transparent (e.g. tinsel-tin) items. Hearing the primes, participants were shown the target words for 200 milliseconds and given 3 seconds to decide whether the sequence of letters on the screen were real words or not. Reaction times to different conditions displayed the clear priming effect of morphology. No priming was yielded on conditions that prime and target were morphologically unrelated. Observing the priming effect in morphologically related words raised the possibility of the emergence of facilitation due to semantic relatedness. Second and third experiments were implemented to dissociate the effect of semantic from morphology. In the second experiment, priming effects for transparent pairs (morphologically and semantically related e.g. predictable - predict) were contrasted with opaque pairs (involving a derivational morpheme but without any meaning-based relatedness e.g. authority - author). The same design was followed in the following experiment with the increase in the number and type of items. The results in both experiments confirmed priming effects in transparent pairs; however, in the lack of meaning-based relevance –in opaque pairs- there was no significant priming, so it was postulated that semantic relatedness could produce priming unlike morphological or phonological associations. The final three experiments were intended to examine Taft and Forster's (1975) Prefix Stripping Model with the design used in the second and third experiments – comparing the priming effect when there was a transparent derivational prefix (e.g. insincere - sincere) with opaque pairs (e.g. restrain - strain). A consistent finding was observed in these experiments as well with respect to the lack of priming in opaque pairs. Regarding the absence of facilitation in semantic opacity, the authors equated participants' treatment of these pairs with the way they would process monomorphemic (unanalyzed) forms and emphasized the important role played by semantic factors.

This research proved to be of substantial importance on account of the elaborate method of separating the conjoined effects of form and meaning from morphology to grasp an idea of their graded effects along with the noteworthy findings that initiated a discussion about lexical access under various circumstances. Nonetheless, they avoided making use of inflectional morphemes and justified this choice by stating that "derived forms are separately represented in memory from their stems". With these findings, such a rationale would necessarily follow the prediction that this distinctive feature of derived forms entailed priming in derivationally complex forms unlike inflected forms, which had already been falsified by Lukatela et al. (1982). Furthermore, applying the same procedure in Hebrew - a non-concatenative language- Frost et al. (1997) found priming effects on morphologically related prime-target pairs regardless of the semantic relatedness, which implied the typological sensitivity of the results obtained in this research. On the other hand, applying a cross-modal priming technique precluded gaining insight about early morphological processing.

2.1.1.2. Rastle et al. (2000)

Two experiments were run by Rastle and the other researchers with the overall goal of examining automatic and unconscious strategies employed by language users when they read morphologically complex words. The experiments targeted the identification of the source of priming at the initial phase of reading at varying duration of the exposure to the prime. To this end, they ran lexical decision tasks by means of masked priming technique. They intended to determine the independent effects of morphology, semantics and orthography at different stages of reading complex words by considering Marslen-Wilson et al.’s (1994) conclusion as regards the determining effect of meaning on the cross-modal priming paradigm by which the prime was fully perceptible. They manipulated the information given in the primes and prime-exposure durations. Five conditions were contrasted with three stimulus onset asynchronies (SOA): 43 ms (when the prime was invisible), 72 ms (when the prime could be visible) and 230 ms (when the prime can be detected but it is presented too briefly to benefit from (non)linguistic strategies). The conditions were:

a.) morphologically, semantically and orthographically related primes and targets- namely transparent pairs (e.g. departure-DEPART)
b.) opaque prime and targets (e.g. department-DEPART)
c.) only semantically related primes and targets (e.g. cello-VIOLIN)
d.) only orthographically related primes and targets (e.g. electrode-ELECT)
e.) identical primes and targets (e.g. cape-CAPE)

What they found out was the clear effect of morphology in all SOAs: transparent and opaque pairs produced priming in all SOAs, not significantly different from identity pairs. Semantically related pairs produced priming only when SOA was 230 ms, which was the indicator of a serial “form-then-meaning” account. In other words, morpho-orthographic information was utilized even when primes could not be perceived, hence, at a very early stage of processing, whereas it was only possible to integrate semantic information into the process when the participants were able to detect the primes, namely at a later stage of processing.

Rastle et al. (2000) interpreted the findings as supporting the classical localist approaches, which claimed that instances of relatedness between items are represented through interconnected lexical nodes- as it is in the morphologically related primes and targets- thereby facilitation occurs in the recognition of the latter words. On the other hand, the failure to yield priming by purely orthographically or semantically related pairs was regarded as a challenge to the connectionist approaches that favored (nearly) equivalent priming effects for each types of overlap between primes and targets (i.e. orthographic, semantic, and morphological).

2.1.1.3. Longtin et al. (2003)

The applicability of the conclusions reached by the two seminal studies explained above (Marslen-Wilson et al., 1994; Rastle et al., 2000) were tested by Longtin and her colleagues in a different language, French. This research examined the role of semantic transparency and opaque conditions in the processing of simple and complex words. Arguing that some of the opaque pairs in Rastle et al. (2000) were problematic in the sense that when the stem was stripped, the residuals were not actually suffixes (e.g. cardiac-CAR), they proposed the notion of pseudo-derivation which consist of pseudo-roots and pseudo-affixes (e.g. baguette (little stick)-BAGUE (ring)). They compared the priming effects in the pseudo-derived pairs in addition to transparent (e.g. gaufrette (wafer)-GAUFRE (waffle)), opaque (fauvette (warbler)-FAUVE (wild cat)) and orthographic (e.g. abricot (apricot)-ABRI (shelter)) pairs. The first experiment was a lexical decision task with the masked priming design (SOA: 46 ms). In the second experiment, the same materials and design were used in an auditory cross-modal priming paradigm. The results reflected the contradiction yielded in Marslen-Wilson et al. (1994) and Rastle et al. (2000); morphological relatedness led to facilitation in the masked priming paradigm in three conditions (transparent, pseudo-derived, and opaque pairs) unlike orthographic prime-target sets. Therefore, early priming was again found to be blind to semantic effects. As for the cross-modal priming experiment, only semantically related primes facilitated the processing of targets, hence, the influence of meaning as the determining factor of the ultimate interpretation of morphologically complex words.

Putting a special emphasis on the priming effects found in pseudo-derived words, the researchers claimed that early processing of derived words was not a consequence of the relationship between primes and targets in the mental lexicon because neither roots nor morphemes were argued to have any organic link with the actual word to be recognized. Correspondingly, the results turned out to be an important reservation about the Stem Reactivation Account (Feldman et al., 2002).

Apart from the conceptual debates regarding the (non)distinctive properties of pseudo-derived items from opaque pairs, the results confirmed the insights put forth by Frost (1997) and Boudelaa & Marslen-Wilson (2001; 2005) in a non-concatenative language – Hebrew-, improved by Rastle et al. (2000) in English –a concatenative language- similar to French regarding the nature of initial reading of complex words. Pre-lexical affix stripping process was observed in typologically different languages that indicated an automatic decomposition independent of the semantic effect.

2.1.1.4. Rastle et al. (2004)

As a reaction to the conceptual debates concerning the similar priming effects in orthographic and opaque items referred to in Rastle et al. (2000) and Longtin et al. (2003); Rastle and her colleagues started with the characterization of these types of prime-target relationships. They argued that unlike semantically transparent pairs, the degree of facilitation in opaque items was not significantly higher than those produced by orthographically related pairs even though priming effects were observed in semantically opaque conditions relative to unrelated baseline pairs in such studies as Feldman (2000) and Rastle et al. (2000). Therefore, it would not be possible to come up with a meaning-independent morpho-orthographic decomposition account in early processing.

Starting from the imprecise and contradictory findings in the assessment of opaque condition, they drew a distinction between opaque and orthographic items; opaque items are taken to have an etymologically morphological relationship and orthographic items are supposed to consist of etymologically, semantically as well as morphologically unrelated pairs. That is why the prime-target pairs such as corner-CORN had previously been included in the item sets of orthographic condition on account of the ignorance of morphological relatedness but such pairs were assessed in the list of opaque condition in this research. On the basis of this theoretical decision, researchers conducted a lexical decision task by utilizing a masked priming technique (SOA: 42 ms.). Facilitation effects of three conditions were compared: transparent pairs (e.g. cleaner-CLEAN), opaque items (e.g. corner-CORN), and only orthographically related prime-target pairs (e.g. brothel-BROTH). In comparison with the previous studies mentioned above, the results were quite straightforward: there was no significant difference between the priming effects in transparent and opaque conditions, furthermore, priming in both of these conditions distinguished statistically from that of orthographic condition.

In the light of the findings that displayed equivalent facilitation in transparent and opaque conditions, they argued that the obligatory component of information that is immediately integrated in reading is morpho-orthographic and it is independent of semantic relatedness. This account obviously posed as a counter to meaning-based localist accounts (e.g. Marslen-Wilson et al., 1994) and distributed-connectionist approaches laying a great emphasis on the semantic relationship during the setup of links among lexical components (e.g. Berent et al., 1999).

2.1.1.5. Longtin & Meunier (2005)

Another research examining the role of semantic and orthographic factors in early morphological processing was implemented by Longtin and Meunier. Their study differed from the previous ones in that they tested whether morphologically complex pseudo-words primed their roots compared to non-morphological pseudo-words. They assumed that obtaining such a priming effect would weaken Full Listing Hypothesis (Butterworh, 1983) -which interpreted facilitation as an activation from the complex word to the root- because searching for a link between a pseudo-word and the root would lead to a failure. Likewise, it would provide a counter argument to the prelexical (Cole, Segui and Taft, 1997) or supralexical (Giraudo & Grainger, 2000; 2001) accounts since the activation of whole word representations would be impossible for pseudo-words in order to retrieve the morphological information. Furthermore, they investigated priming effects in interpretable or non-interpretable combinations of a morpheme and a root to test the meaning (in)dependence in early visual word recognition from a different viewpoint. To do this, they applied the masked priming paradigm by administering a lexical decision task (SOA: 47 ms).

The analyses of reaction times supported the decomposition model because participants' reaction times to an existing target word (e.g. RAPIDE) was faster when it followed a morphological pseudo-word (e.g. rapidifier) compared to a non-morphological pseudo-word (e.g. rapiduit), which produced no priming. This was in line with the previous accounts that argued against the facilitation of processing due to the formal overlap. Secondly, priming was equally yielded when an existing target word (e.g. RAPIDE) followed a morphological pseudo-word (e.g. rapidifier) and an existing morphologically complex word (e.g. rapidement). This finding was significant since it was considered to be a challenge to hypotheses given above because facilitation in the recognition of the target word did not require a link between two genuine words represented in the mental lexicon. Thirdly, when the priming effect of interpretable pseudo-words (e.g. rapidifier-RAPIDE) was compared to non-interpretable ones (e.g. sportation-SPORT), the result was not statistical so no interference of the meaning-based root-suffix combination was reflected at early stages of morphological processing. Therefore, this study is quite remarkable because it provided evidence for the early morphological decomposition model by revealing its applicability to the non-existing and non-interpretable words.

2.1.1.6. Crepaldi et al. (2010)

Referring to the findings of previous studies implying an initial morpho-orthographic decomposition and access to a meaning-bearing stem only with longer stimuli, Crepaldi and his colleagues raised the issue of how irregularly inflected words were processed. They emphasized the importance of such an evaluation by stating that such words could not be extracted by means of a simple orthographic analysis, as it was the case for derived and regularly inflected words. Rastle et al. (2004, 2008) predicted that language users could not immediately decompose these words so they could not prime their stems. As a matter of fact, this assumption had been tested before Crepaldi et al. (2010); however, they were problematic with respect to the matching of irregular items with orthographic primes. A slot-based coding scheme had been used by Pastizzo & Feldman (2002) and Kielar, Joanise and Hare (2008), therefore, no orthographic overlap was assumed for such prime-target pairs as ate-EAT. The comparison of priming produced by these pairs with words that did not share any letters (e.g. low-EAT) possibly resulted in questionable conclusions. To overcome this problem, slot-based coding scheme was supplemented with a spatial coding scheme by which the number of letters shared by primes and targets were also taken into consideration. They implemented two experiments by using masked priming technique (SOA: 42 ms.) to seek whether irregular forms primed their stems. The first experiment included target words each of which were paired with three different prime types in three lists. These types were irregularly inflected words with orthographic relatedness (e.g. fell-FALL), only orthographically related words (e.g. full-FALL) and unrelated baselines (e.g. hope-FALL). The analyses revealed priming obtained only in irregularly inflected prime-target pairs.

Although the results were quite straightforward, with a deeper look at the irregular forms used in the experiment the researchers realized a sort of tendency to cluster in sub-regularity. Statistical regularities in prime-target pairs were taken into consideration (e.g. extracting one of two consecutive vowels for the past tense form of verbs such as meet, bleed, feed and breed, or changing the final –d to a –t for verbs like spend, send, lend and bend). They speculated that this kind of orthographic regularity between present-past alternations was sufficient for early visual word recognition. In other words, early morpho-orthographic decomposition model could be the product of a pure formal overlap with consistent changes in letters reflecting semantic or functional differences between primes and targets. This proposal was checked with a second experiment in which orthographically related items shared the same sub-regularities (e.g. book-BAKE) found in irregularly inflected words (e.g. took-TAKE). The same experimental procedures were followed to find out that pseudo-inflected word pairs did not speed up the processing whereas the priming effect yielded by irregularly inflected was repeated. As a result, the orthographic pattern characterized for the irregular words and their stems did not produce priming when prime and target were not genuinely related.

The results were difficult to reconcile with Rastle and her colleagues' (2000) proposal that an orthographically identifiable stem needed to be shared for the reactivation of a stem following affix stripping. No stem was identifiable to decompose in such pairs as fell-FALL, nonetheless, they were significantly facilitative. On the basis of these findings, the researchers postulated that there was an intermediate level of morphological priming between morpho-orthographic segmentation level that was responsible for the types of priming that were provided above and the semantic system which was activated when the prime was fully visible: lemma level. Drawing upon the model incorporating a lemma level in the recognition of complex words by Taft

(2003, 2004), Crepaldi and the other researchers argued that, as distinct from derivationally and inflectionally complex words which activate their stems at the morpho-orthographic segmentation level, irregular inflections as well as their base forms (e.g. fell or fall) activate their stems (e.g. fall) at the lemma level. According to this model, there are no lemmas for orthographic regularities at this level. That is why formal overlaps do not cause any activation at this level by permitting savings of the processing mechanisms and speeding up the recognition of the target words.

This study was considered to be very remarkable in that it considerably contributed to the shaping of the morpho-orthographic decomposition model. Additionally, priming effect found in the irregularly inflected words proved to be challenging for the proponents of other rule-based models such as Yang's (2000) Rules and Competition Model which claimed that irregular verbs form their past tense versions by means of phonological rules, and dual mechanism models that adopted the view that irregular verbs are stored and accessed as full-form representations in the mental lexicon.

2.1.1.7. Lazaro et al. (2015)

Lazaro and his colleagues' research sought to identify the role of stems in the recognition of complex words. In consequence of previous studies, a stem reactivation model following the affix stripping had been assumed. This model explained the facilitation of the recognition of a target word following a morphologically related complex word by the early decomposition of the prime (e.g. cleaner is decomposed into clean and -er). In this sense, the target word (e.g. clean) is processed for the second time, thus, a facilitative effect arises. This study questioned the absolute must status of stems in the morphological decomposition by comparing two conditions:

a.) the effect of a suffix as a prime on complex words (e.g. ero-COCINERO (-er-COOKER)) in comparison with the effect of an unrelated suffix (e.g. ista-COCINERO (-ist-COOKER))
b.) the effect of a suffix as a prime on pseudo-complex words (e.g. eza-CERVEZA (in-BEER)) in comparison with the effect of an unrelated suffix (e.g. ista-CERVEZA)
c.) the effect of formal overlap between a prime and a target which do not share any morphological unit (e.g. bro-CEREBRO (BRAIN)) in comparison with the effect of unrelated letter strings (e.g. din-CEREBRO)

A masked priming lexical decision task was administered (SOA: 66 ms.). The results showed that condition a and condition b produced similar priming effects whereas there was no acceleration in the reaction to the target words in condition c. This means that a real suffix and a pseudo-suffix displayed similar facilitation.

The results had two substantial implications. Firstly, it supported the early pre-lexical decomposition hypothesis blind to semantic effects (Rastle et al. 2004) because there was no semantic relatedness between eza-CERVEZA type pairs, however, the priming effect was not different than ero-COCINERO type pairs. More importantly, Lazaro and his colleagues provided evidence for this hypothesis regardless of whether the target word comprised a stem or not. Such an evaluation became possible because this study distinguished from the previous ones in that when the pseudo-complex words were stripped off their pseudo-morphemes, there were no stems remaining. For example, Rastle et al. (2004) tested the priming effect in primes for the opaque condition which consisted of real words and existing morphemes in English such as *corn* + *-er*. However, the items for condition b in this study included existing morphemes in Spanish and when they were removed from the target words what remained were letter strings with no lexical representations. To exemplify, considering the evidence for affix stripping by which *–eza* primes *CERVEZA*, we are left with a non-word *CERV* but this fact does not preclude the priming effect. In conclusion, the results were in line with the view that language users initially process complex words by means of morpo-orthographic segmentation and disregard the pure semantic or formal factors just as they do not pay attention to the availability of a real stem.

2.1.1.8. An Overall Assessment of the Rule-Based Approaches

The first part of this chapter provides an overview and selective empirical works regarding the decomposition model in early morphological processing in L1. It is evidently a data-driven model improved by means of the collective efforts some of which were presented above. At this juncture, it is necessary to state that not all of the findings unarguably supported the claim that language users immediately resort to the morpho-orthographic information to process complex words.

One of the most notable studies with challenging findings was implemented by Diependeale et al. (2005). They conducted a masked-priming lexical decision task by using a bulk of the items in Longtin et al. (2003), and the results exhibited priming effects in both opaque and transparent prime-target sets, but the magnitude was bigger in the transparent condition. Although the study put forth the need for the revision in the decomposition model, it can be argued that exposure-duration produced divergent results. While the primes remained on the screen for 46 ms. during the whole experiment in Longtin et al. (2003), Diependeale and his colleagues preferred to present primes in three different SOAs: 13 ms., 40 ms., and 67 ms. I propose that a 13ms. prime duration is a rather debatable choice because it is in need of being tested with respect to even a subconscious perception and processing, whereas 67 ms. could result in the conscious recognition. On the other hand, Dunabeitia et al. (2011) found priming effects in not only transparent and opaque but also in orthographic primes when the experimental items in Rastle et al. (2004) were manipulated in a transposed-letter priming study. Leaving aside assigning a cross-case same-different task which forced participants to focus on the formal properties of words, the results could be attributed to the presentation of primes (at least) twice; they were seen along with the hashes for 1 second and then displayed alone for 50 ms. Correspondingly, both task-induced effects and the duration of the primes raised questions about the internal validity of results. Another research that apparently created task-induced effects on the results was Marelli et al. (2013). They conducted an eye-tracking experiment with the masked-priming design to show that priming effect was only produced in transparent pairs. However, the target word was presented with a one-digit number and participants were asked questions about either the word or the number. No rationale in such a modification in the task was suggested. Nonetheless, this change accompanied with a considerably distracting process, which is arguably a confounding factor.

To summarize, although a couple of studies came up with claims for the revision of its basic tenets, a majority of the experiments conducted with a rule-based view yielded consistent results to shape a decomposition model. They reached a conclusion that complex words go through a morpho-orthographic decomposition process at the very early stages of recognition. This process is blind to meaning-based influence. It is not purely orthographic, either. Yet, it is still a morpho-orthographic decomposition process due to the inextricable morpheme-grapheme link. Moreover, it does not necessitate a real stem or a transparent relationship between the morpheme and its root.

The second part of the literature on L1 morphological processing starts with the essentials of the connectionist approach and the much-debated processing accounts adopting the principles of this approach.

2.1.2. Connectionist Approaches to Morphological Processing

The connectionist perspective dates back to the philosophical debates on the human understanding between the rationalists and empiricists in the 17th and 18th centuries. In contrast with the rationalist view that is built on the power of generalizable rules, Pinker (1999; p. 89) is of the opinion that the modern connectionist paradigm acquired the top currency with David Hume's ideas in his seminal work *An Enquiry Concerning Human Understanding* (1748) summarized as the power of the mind to connect things that are experienced together or that have a similar appearance. This argument was supported by other empiricists such as John Locke (1689) who laid emphasis on the arbitrariness found between words and the meanings assigned by them. Drawing on these cornerstones of empiricism and adding a mathematical model to account for the source of associations in detail, connectionist model emerged to represent human cognition including the learning and use of language.

Many hypotheses were suggested to explain the complexity of reading by referring to the properties of cognitive and perceptual processes underlying this automatized language skill. So far, I have provided the basic assumptions of rule-based approaches. What rule-based approaches have in common with the connectionist approaches of reading is that they both adopt the view that a single mechanism is at work for the processing of all types of morphological structures. What distinguishes these approaches from each other is that the single mechanism refers to the activation of morphological, orthographic or semantic properties of words –or lexical nodes in the connectionist jargon- that correspond to one representation in the mental lexicon for the rule-based approach. On the other hand, the single mechanism is the representation of diverse nodes for diverse representations that could form a facilitative or inhibitory links from the connectionist perspectives. This distinction is eventuated in splitting the models of word recognition into two broad areas: the localist perspective which argues for the existence of one node (lexical item) for one representation and the distributed perspective that takes a stand with the availability of various nodes for each representation to connect links among them. The abovementioned morpho-orthographic decomposition model is the leading account of the localist, rule-based single mechanism perspective of visual word recognition. Below I provide basic information about the most influential model adopting the connectionist view -Interactive Activation Model- and the competing frameworks to describe the linguistic processing from a distributed, connectionist single-mechanism perspective.

2.1.2.1. Interactive Activation Model

The attempts to simulate word recognition through associative links rather than the context-free application of rules started with the criticism of the Chomskyan linguistics in the late 60s. It is accepted among the contemporary proponents of this approach that the first inquiries came up with oversimplifying simulations with "toy lexicon (Norris, 2013, p. 517)" to explain the process with no more than four-letter words. Such fundamental limitations were also true of Morton's hotly debated Logogen Model (1969). With a special emphasis on the semantic and contextual information, Morton requires the activation of a vast number of units named *logogens* for the recognition of spoken or written language. The words are retrieved by means of the logogens that contain semantic and orthographic information about the relevant lexical items. According to this model, the logogens need to accumulate enough information to reach a threshold so that response (recognition or production of words) is possible. This refers to the effect of word frequency and the role of context for the interaction of the Cognitive System to produce semantic information with the Logogen System and derive the relevant semantic information for the production/comprehension of phonological output. Despite being an influential attempt at the time, Morton's Logogen Model was criticized mainly for two reasons. It constrained the model within the very basic phonological and semantic features so ignored the distributional (syntactic) and functional (pragmatic) complexities that should take part in the theorization of language comprehension and production. In addition, it assumed that there were counting devices – logogens- to decide whether a certain word crossed a certain threshold level for its recognition but this threshold level that was peculiar to each particular word was underspecified, hence, inconvenient for testing.

As Norris agrees (2013), along with the development of computational models, more accurate simulations with explicit descriptions and tangible predictions were offered. Interactive Activation Model is regarded as a cornerstone for the transition from the abstract "box and arrow" models to the identification of networks to incorporate mental representations and processing mechanisms by means of mathematical formulae. The model was grounded in the word superiority effect, a phenomenon which roughly postulates that letters are identified faster and more accurately when they are presented as a part of real words compared to their addition to non-words (Reicher, 1969; Wheeler, 1970). The advantages of letter recognition in real words (semantic value, pronounceability, orthographic regularity, and distributional properties of words unlike non-word letter strings) are assumed to be reflections of the activation of multiple nodes in the neural network at semantic, orthographic and word levels of representation. Each node at these levels is considered to carry mutually exclusive hypotheses in competition with the others to be activated. As put by McClelland (1979), these nodes could work to inhibit or activate the other nodes depending on the consistency of the stimulus with the stored information. For example, when the letter *b* is recognized, the nodes for the orthographic representation activate nodes at the word level with the same initial letter such as *bake, book* or *bite* and inhibit others with another initial letter (e.g. *cake, cook* or *cite*). Likewise, when a language user reads a word such as movie, the nodes for the feature representation will activate the nodes at the word level with sematic relationship (e.g. *director, script* or *camera*) and prevent nodes for irrelevant words (e.g. *fruit, water* or *car*) from being activated. This flow of information is bidirectional to add weight to the activation of sufficient nodes for the recognition of lexical items (Rastle, 2007). The proponents of Coltheart et al.'s (1977) neighborhood size account made an important contribution to the model by claiming that words with the large neighborhood size (based initially on Coltheart et al.'s measure of neighborhood density, subsequently on Levenshtein's (1965) distance algorithm) are recognized later than words with small neighborhood size because of the competition of outnumbering nodes to be activated. Adopting Coltheart and others' definition which says that neighborhood size for a word is the number of other words that can be created by changing one letter, Andrews (1989) administered lexical decision and naming tasks with words and non-words with various neighborhood sizes. The results yielded facilitation in words with fewer neighbors to enable the researcher to conclude that "the more neighbors a word has, the greater the probability that the target unit the target unit would be subject to the effects of this inhibitory mechanism so that the consequence would be interfering effects of large neighborhoods. (p. 803)".

2.1.2.2. Parallel Distributed Processing

Alternative theories within the pioneering Interactive Activation framework were developed. Parallel Distributed Processing system by Rumelhart, Hinton, and McClelland (1986) was presented to explain the acquisition and use of lexical knowledge in line with the abovementioned theoretical framework. The theoreticians came up with an explicit model of reading by regarding this language skill as "a computer program that accepts as input letter strings and produce as output some form of phonological representation" (Coltheart et al., 1993, p. 590). A well-known instantiation of this view is Seidenberg and McClelland's (1989) triangle model. Challenging the broad claims of dual-route models incorporating two procedures (lexical route and mapping sound to letter procedures) as a necessity of skilled reading aloud (e.g. Coltheart 1978, 1985), Seidenberg and McClelland postulated that a model of one single-route can provide a satisfactory explanation for reading. The units (or nodes) of orthographic representations are computed and converted into phonological representations with a three-step feeding network. Orthographic units, phonological units, and hidden units that they claim mediate the computation of the other two units are connected to each other and carry weights for the activation of nodes. As put by Seidenberg (2007), these hidden units are entitled to train the network for the formation of underlying representations of input codes, hence, going one step beyond the associations to generalizations to be learned. Their architecture of the single-route parallel-distributed system had a simulation with a task-oriented design such as providing an account for reading words and non-words, performing lexical decision tasks, development of lexical or phonological dyslexia. To concretize their model, they simulated a training with a 2900 monosyllabic-word corpus. A trial consisted of the selection of an input, computation of its phonological output and comparison of the output with the target by means of a learning algorithm. The algorithm is based on experience, that is, frequency. Correspondences between spelling and sound turn into statistical regularities to be learned and applied easily, such as pronouncing initial b as /b/ after the computation of words *bear, beat, bat, boring.* Such implicit regularities are picked up and encoded into the weights of the nodes for activation when the following words share similar patterns. Seidenberg (2007) exemplifies this argument with the faster activation of words such as *gave* or *sale* after only one exposure to the word *save* due to the common phonological output that will have already been activated by the time target words are encountered. The Seidenberg and McClelland's

(1989) triangle model was rather outstanding in the sense that it sought insights for the attainment of the cognitive sub-skills underlying reading aloud. However, two important weaknesses should be highlighted: their model was presented with an oversimplified training simulation that included only monosyllabic and simple words. It did not have a concrete argument regarding the contrastive processing of morphologically complex words. Secondly, their model put all its emphasis on the phonological and orthographic features of words as determining factors of the activation of subsequent items with no deeper look at the potential power of semantics.

2.1.2.3. Dual Route Cascaded Model

Coltheart et al.'s (2001) simulation of visual word recognition and reading aloud –called Dual Route Cascaded Model- was actually a comprehensive extension of the Interactive Activation Model to take into account the nodes for the phonological representations responsible for translating letter strings to sounds in the course of reading aloud. This model fundamentally proposed that there are lexical and non-lexical routes for the flow of information at different levels of nodes that are responsible for meaning-based and orthographic and phonological representations. The crucial claim of the model that differentiates it from the other dual-route models (e.g. Patterson & Shewell, 1987; Paap & Noel, 1991; Behrmann & Bub, 1992) is that although the bidirectional nature in the activation of nodes at different levels of representation (to provide semantic, phonological or orthographic information) is also applicable in this model, semantic or phonological information does not play a critical role in reaching the threshold level for visual word recognition. In other words, the lack of activation in the nodes for semantic or phonological representation does not block the recognition of a word if there is sufficient activation in the non-lexical grapheme-to-phoneme conversion route. This view drew upon Coltheart and Coltheart's (1997) research, which found qualitative similarities of the performance of reading printed words by patients suffering from phonological or semantic damage to those of healthy language users. Therefore, the Dual-Route Cascaded Model was characterized by dependence on the formal overlap among the nodes for the lexical representations.

2.1.2.4. Spatial Coding Model

Davis (2010) took a critical look at the literature including various computational models of visual word recognition starting with the original Interactive Activation framework and propounded a considerable discrepancy between the theories and empirical evidence. He attributed the failure of the models that accounted for the findings in masked form priming experiments to the way of defining the nodes for orthographic representations by context-dependent orthographic input coding schemes. He proposed the context-free spatial coding schemes for orthographic representations that calculate the grades of activation for letters according to their positions within words. Patterns of activation are identified relative to the ordering of letters such as the existence for quite different spatial coding schemes for the letters *o, p, s,* and *t* for the words *stop* and *post* unlike the similarity of schemes for *pots* and *post*. He claimed that such a matching calculation could account for the priming effect for top-STOP but not for top-POST pairs and even for the priming after non-words such as jugde-JUDGE due to the toleration of minor changes in the position of letters.

2.1.2.5. Naïve Discrimative Learning Model

Baayen's (2011) model that touches upon the comprehension and processing of lexical items was inspired by Wagner and Rescorla's (1972) influential human learning framework, which basically says that if there are strong enough associations between conditioned stimuli and the unconditioned stimuli, the latter is predicted and analyzed successfully, hence, the emergence of learning. The strength between these ensuing stimuli is determined according to the weights of association calculated by possible combinations. Wagner and Rescorla defined their two-layer model as supervised learning, the most important feature of which is the adaptation of the subsequent predictions based on the previous feedback to improve accuracy. This referred to the incremental learning possibilities by the development of more direct associations between cues (conditioned stimuli) and outcomes (processing of the unconditioned stimuli) with more exposure. Evert and Arppe (2015) list these possibilities termed as the Rescorla-Wagner equations as follows:

- No change if a cue is not present in the input.
- Strength increases if the cue and outcome co-occur.
- Strength decreases if the cue occurs without the outcome-

- If outcome can already be predicted well (based on all input cues), adjustments become smaller. (p. 6)

Baayen (2011) adjusted these fundamental principles of this domain-general learning model to modelling language comprehension and processing. The model is naïve in the sense that it computes cue-outcome associations for every individual word, so there are certain threshold levels of activation via the strengths of association for each lexical items. The distinctive feature of this model compared to the previous ones is its discriminative side, which claims that the activation of the cues for an outcome relies on how well the cue discriminates other potential outcomes. That is to say learning depends on "discrimination measures that take into account how often a cue is "unfaithful' (Milin et al., (2017) p. 12)" to other lexical items. This directly requires the revision of traditional calculation of the co-occurrence frequencies of input and output to consider the occurrence of cues in contexts where it has nothing to do with the outcome. This roughly builds on the decrease of the strength of activation for a cue when it is exposed in the undesired contexts. Baayen et al. (2011) modelled this framework with two or three letter words (bigrams or trigrams) that formed the representations. The model did not draw a distinction between stems, words, or (types of) affixes. The representations with the discriminative power were called lexomes. The researchers provided an account of the facilitation in orthographically or phonologically related words by means of the discriminative power of the trigrams/triphones in such pairs as pastor – PAST. Two noteworthy claims are made accordingly. No morpheme-based attention is paid to the internal structure of lexical items, therefore, no morphological decomposition is argued to occur. Furthermore, the facilitation is expected not to occur by decomposition while reading but to be learned by means of the strength of associations.

2.1.2.6. An Overall Assessment of the Connectionist Approaches

The connectionist models described above show a stark contrast to the rule-based approaches from the theoretical and methodological perspectives. They theoretically differ in the components of the process they prioritize. Rule-based approaches offer a context-free, localist, single-route model of the early process of visual word recognition in which the morpho-orthographic properties of words are initially taken into consideration. On the other hand, connectionist approaches mostly suggest a distributed process activated with associations among nodes by means of multiple routes among the representations in which internal structures of words –apart from their orthographic and phonological properties- are disregarded, therefore, no distinction is drawn between monomorphemic and complex words. They methodologically differ in the way the proponents of these models shape their theories. Rule-based approaches are transformed via emerging empirical evidence (the transition period starting with Murrel and Morton (1974) and the current state of the model by Lazaro et al. (2015)). In this sense, it is possible to put forth a linear development of a rule-based morphological processing model. However, connectionist models can only be considered alternative simulations with no empirical background to claim that they reflect what is actually going on in the human mind; neither were various models with some sort of modifications offered by falsifying the former ones with objective measures.

As Gaskell (2007) agrees, connectionist models have vitalized the views paying considerable attention to statistical language learning and processing with well-grounded mathematical analyses. Nonetheless, there are noteworthy weaknesses in common with the models adopting the connectionist views. These weaknesses are summarized below:

- The most important deficiency they bear is the lack of empirical data to take the models beyond the basic simulations. No matter how elaborate the simulations are, they mostly failed to be supported by robust evidence displaying the linguistic behavior of language users.
- The simulations were evidently inspired by inquiries on basic visual object recognition. That is to say, essential properties of the internal structures of words were usually ignored in the simulations that compute letters to sounds or vice versa. To my best knowledge, one model recognized the role meaning-based associations play in lexical processing (Harm and Seidenberg (2004) model- the computation of lexical semantics) but the morphological properties were not given weight to the recognition of words in any of the well-debated connectionist models. Therefore, such models proved to be incapable of accounting for the different priming effects in sees-SEE, seen-SEE, or corner-CORN pairs compared to seed-SEE pairs evidenced by Crepaldi et al. (2010).
- The context-dependent nature of the connectionist models was an obstacle to make generalizable predictions on the interaction among words. As put by

Norris (2013), "it is almost impossible for theorists to be sure how their models will behave" (p. 518).

- The connectionist models did not provide an analytical look at the temporal dynamics of lexical processing. Unlike rule-based views that different sorts of information were considered at certain stages of visual word recognition, the connectionist models did not create distinct hypotheses for the initial and final states of lexical processing.

The diametrically opposite approaches to lexical processing resulted in the introduction of hybrid, dual mechanism models that accepted the roles of both rules and associations in the recognition of (complex) words. The Words and Rules Theory is considered the most challenging effort to explain how complex words are processed by offering two systems in two locations in the brain for the combinatorial rules and idiosyncratic entities.

2.1.3. The Words and Rules Theory

The Words and Rules Theory adopting a dual-mechanism system dates back to the early 90s when the debates on the power of reading models began to be escalated with the accumulation of empirical evidence for the rule-based models on one side, and the complicated simulations with strong mathematical foundations in line with the Interactive Activation framework on the other. Pinker and his collaborators' efforts to form a compromise between the rule-based and connectionist approaches were rooted in the lack of descriptive power of these competing models in that period. Pinker and Prince (1991) supposed that a hybrid model could explain findings of various studies (e.g. Pinker & Prince, 1988 vs. Prasada et al., 1990) displaying discrepancies in the behaviors of language users towards different types of words. This model basically consisted of a mental grammar to benefit from rules for morphological decomposition and mental lexicon to store the associations for the connections among the related lexical forms.

As it was summarized above, initial studies on the processing of morphologically complex words revealed the effect of morphology and orthography on the faster recognition of words. The standpoint of 90s was the absolute necessity of both morphological and orthographic relatedness for priming. As for the connectionist models, they sought to associate words in the same contexts for priming via nodes incorporating phonological or orthographic representations. Such a theoretical polarization incapacitated both approaches to provide a contrastive insight into the recognition of regularly and irregularly inflected forms. Rule-based approaches' argument for the decomposition of the complex forms into their morphemes was rather applicable for regularly inflected past tense forms such as *watched* (-ed rule is automatically applied to the stem). However, it was not possible for the localists to argue that irregularly inflected forms are also parsed into their constituent units as they cannot be decomposed into their stems and morphemes (e.g. *took* cannot be analyzed as two distinct morphemes including *take* and the past tense morpheme). As for the connectionist views, they came up with relatively decent explanations for the processing of irregularly inflected forms within the context of their stems (e.g. *take* is followed by *took* in priming studies) by means of letter-based or phoneme-based associations. Yet, the same logic did not apply to the regularly inflected forms given the findings showing the advantage of morphological relationship for the priming effect compared to pure orthographic or phonologic overlap (e.g. Marslen-Wilson et al. (1994)).

In consideration of the inadequacy of radical views, Pinker and Prince (1994) proposed the full-fledged theorized version of their previous publications (e.g. Pinker & Prince, 1988, 1991; Pinker, 1991) by incorporating the strong sides of the localist and connectionist views. They specifically examined the psychology of inflections in English by elucidating that "the regular process seems to be the very essence of the symbol-manipulating, algorithmic approach to language underlying most theories of grammar, whereas the irregular process seems to involve a quite different kind of memory-driven processing (p. 230-1)". Therefore, the process is modular and two different systems are needed for the computation of such structurally different elements of language.

The Words and Rules Theory stipulated the functioning of two distinct mechanisms for the online integration of rules or representations depending on the structural properties of input. One of these mechanisms is the mental grammar by which language users conduct combinatorial operations such as forming complex words out of stems and morphemes. Language users keep the rules in the mental grammar and apply them to all members of a group of words that hold the same feature. Therefore, to form a grammatical sentence carrying a finished past action or state meaning, the default procedure is to add the –ed morpheme at the end of the verb of the relevant sentence irrespective of the content of the predicate. A backward reading assumes that a similar default procedure is applied when a verb carrying the past tense meaning is perceived. Namely, the past form (e.g. watched) is split into its stem (e.g. watch) and past tense morpheme (-ed) in agreement with the rule-based approaches (e.g. Rastle et al., 2000). The default and swift realization of, say past tense, rules disencumber the lexicon from containing separate lexical entries for the bare and inflected forms of verbs, thereby, contributes to the efficient functioning of the memory system during real time language use. However, it should be noted that morphologically complex words with exceptionally high frequency can sometimes hurdle the parsing threshold and be processed like a simple word.

Apart from playing a supplementary role in the functioning of mental grammar by keeping entries for the bare forms of regular words, the mental lexicon is the second mechanism of Pinker and Prince's model that is treated as *repository of pure unpredictability*. In other words, lexical items that turn out to be unpredictable for the mental grammar are assumed to be stored in the mental lexicon in addition to the morphologically simple words. The only difference between the way simple words and irregularly inflected verbs is the additional past tense feature incorporated into the sets of information for the lexical entries of the irregular forms. Accordingly, unlike regular forms, irregularly inflected past forms of verbs happen to be outside of the coverage zone of the "add –ed at the end of the bare form" rule –hence being unpredictable- and they are stored separately in the mental lexicon and functions of memory. Pinker & Ullman (2002) explicitly described the process as follows:

> A stored inflected form of a verb blocks the application of the rule to that verb (e.g. brought pre-empts bringed). Elsewhere (by default) the rule applies: it concatenates -ed with the symbol 'V', and thus can inflect any word categorized as a verb. (p. 456)

The fact that no rules are exploited in the production and comprehension of irregularly inflected forms entail that the relatedness between bare and past forms of the irregular verbs manifests itself not in the rules but in the associations. From this point of view, the Words and Rules Theory can be considered an unquestioned extension of the classical connectionist approaches to morphological processing described above. Yet, a remarkable distinction is drawn in that whereas the connectionist approaches rely heavily on the associations established by means of orthographic or phonological relatedness among lexical items, as Kırkıcı (2005) highlighted, whole words are connected to whole words and constituents of words (e.g. onset, code, rime) are connected to those of others in Pinker and Prince's model (p.

43). This means that a sort of rote memory is required for irregular past tense forms by establishing connections with neither the first, second, or any sounds or letters in the bare and inflected forms but –as the key phrase in Pinker and Prince (1994; p. 231)- with associations or analogies between unanalyzed *existing forms* in a full-listing fashion (e.g. bring-brought, know–known, ring-rang).

As the authors admitted, the Words and Rules Theory is actually not a brand-new look at the language use (1994; p. 233). There are generative linguists coming up with further proposals for the unpredictable language usages. For instance, Aronoff (1976) and Lieber (1980) claimed that a second mechanism located in the memory was required for the efficient computation of less systematic parts of grammar later coined as "redundancy rules" (Ritchie et al., 1992). Moreover, researchers adopting the generative perspectives provided empirical evidence for the activation of distinct mechanisms to process regular and irregular forms. Stanners et al. (1979) conducted a lexical decision task in which participants saw regular or irregular past tense forms of verbs for 1500 milliseconds after they made decisions on the bare forms of the same verbs in the previous trials of the same experiment session. The results showed that participants' reactions were significantly faster for the irregular verbs than the regular verbs. The researchers interpreted these findings as the evidence of rule-application for the regular verbs even if the stems were separated from the past form by several minutes whereas such a relatedness was not the case for the irregular verbs and their stems, hence the inapplicability of the operation of a lexical memory according to a unitary principle. Kempley and Morton (1982) also yielded similar findings in an auditory word detection task in noise. Notwithstanding, the Words and Rules Theory drew considerable attention and was hotly debated for more than a decade following its presentation as a full-fledged theory. I suppose that this was partly due to its explicit (testable, falsifiable) way of argumentation; as I mentioned above some voices were raised among the generativists against the all-inclusive views towards the symbol-manipulator mechanisms, however, no scholars had proposed such a well-depicted model of language processing with a dual-route aspect before. Correspondingly, empirical evidence was sought to argue for the psychological reality of Pinker and Prince's dualist approach (e.g. Longworth et al., 2005; Stockall & Marantz, 2006) to reveal findings in line with the proposals of the relevant theory. Additionally, a neurolinguistics perspective was developed by Ullman (2001a, 2001b) who underlined the importance of memory systems which were separately assigned the computation of distinct linguistic structures. More importantly (for this dissertation), Ullman made further claims regarding the application of his model to L2 that ended up with a new model on its own touching upon the fundamental differences between L1 and L2 acquisition and processing. (Detailed information on Ullman's model is provided in the second part of this chapter)

It is well-accepted that the Words and Rules Theory righteously occupied an important position in the morphological processing literature due to its stance aiming to embrace general constraints on word formation and instances staying out of bounds. Still, its popularity has decreased in recent years. It is possible to speculate on two reasons for this disfavor. Firstly, no other structures except past tense forms in English were tested to support/undermine the claims of the theory leading to a triangulation problem. Secondly, robust empirical data for the decomposability of irregular past tense were revealed to considerably discredit the descriptive power of the Words and Rules Theory as stated above (e.g. Crepaldi et al., 2010). Therefore, endeavors to explain the nature of morphological processing continued with alternative accounts putting individual features of language users at forefront.

2.1.4. Individual differences in Morphological Processing

There is a consensus among those investigating properties of first language acquisition that certain variations such as language aptitude, the length and quality of access to the target language, intellectual inheritance can affect the speed of acquisition; however, hardly any difference plays a significant role in the steps and ultimate status of the language acquisition process among the healthy language learners (Johnson & Newport, 1989; Crain & Thornton, 1998; Hickok et al., 1998). As for the processing of language, the effects of only a couple of potential factors like working memory and reading speed were deeply analyzed especially as regards the interpretation of sentences. It is not possible to describe attempts to uncover individual differences intervening in morphological processing as an inquiry with theoretical depth or empirical abundance. Apart from Perfetti and Hart's (2002) *Lexical Quality Hypothesis* and studies targeting the philosophical debates on the reading wars, which I mentioned in the Introduction, several studies proved to have a noteworthy impact on the general outlook on the features of morphological processing, especially on the priming effects of semantic and formal overlap. Below is a summary of the most relevant studies concerning this issue.

2.1.4.1. Burt & Tate (2002)

Considering the fundamental questions addressing to the acquisition and development of reading, recent interest in spelling made way for investigations into the organization of orthographic knowledge and its effect on the spelling ability. The researchers ran three experiments in order to assess how spelling accuracy affects visual word recognition and leads to comparative priming manipulations.

The target population was university students in Australia. The first experiment included two tests: spelling words to dictation and a lexical decision task. The experimental items consisted of 48 words which were 8 letters in length and 41 words selected from a database named WRAT-R (Wide Range Achievement Test Revisited, Jastak & Wilkinson, 1984). Each word was pronounced by an Australian native speaker twice and participants wrote down their spellings. A traditional lexical decision task including the same experimental items in the prior task was taken approximately one hour later. The items appeared on the screen for 500 ms. following a warning signal (+). The results showed no correlation between the performance of participants in the spelling production task and their speed in the lexical decision task. That is, common orthographic knowledge of participants rather than their spelling or verbal ability was found to underlie their visual word recognition. A new group of students were recruited for the second experiment, the goal of which was to assess the same issues in the first experiment by means of a spelling recognition task and another lexical decision task in which the items appeared on the screen for only 200 ms. 50 test words and 50 fillers with 8 to 10 letters were utilized in the spelling recognition task. The results supported the findings in the former experiment; the latency and accuracy advantage for the items spelled correctly by the participants applied to the new tasks and conditions in the latter one, as well. The third experiment sought to check the effect of the orthographic knowledge on the spelling accuracy after a certain period of time. A masked priming task (SOA: 80 ms.) was conducted to compare identity and form priming effects for the correctly and incorrectly spelled items in the dictation task that was implemented at least one week before. The dictation task that followed the same procedure in the first experiment. Similar findings were yielded again regarding the facilitatory effect of orthographic knowledge on the reaction times and accuracy of words regardless of the time elapsed between the time when the input was exposed and it was put to use online or offline. Moreover, the fact that low frequency words caused the most difficulty in spelling and online recognition in all of the tasks strengthened the claim on the primary effect of the knowledge of words on lexical processing.

The results basically pointed out that reading ability depended on the spelling accuracy more than other factors such as verbal ability or working memory. Such a direct relationship led to theoretical implications on the organization of lexicon. The findings were in line with the single-lexicon models (e.g. Allport & Funnell, 1981; Behrmann & Bub, 1992) which assumes that only one lexical entry is sufficient for reading and spelling as it embraces knowledge of both compared to the dual-lexicon views (e.g. Henderson & Chard, 1980; Bruck & Waters, 1988; Joshi & Aaron, 1991) that defend the necessity of separate lexica for input (reading) and output (spelling).

2.1.4.2. Yap et al. (2009)

This research mainly addressed to the role of individual differences in the interaction between semantic priming and frequency that were manipulated in four lexical decision experiments. It was hypothesized that readers with less lexical integrity (small vocabulary size) reflected the joined effects of semantic priming and lexical frequency on visual word recognition tasks more significantly than other readers.

The participants were university students from different universities with varying levels of vocabulary knowledge. The first and second experiments were administered to those studying at the Washington University and were classified as individuals with very high vocabulary knowledge. Both experiments featured non-words. The former one had (orthographically and phonologically) legal non-words (e.g. FLIRP) whereas the latter one included pseudohomophonic non-words (e.g. BRANE). Pseudohomophonic words, relative to the legal non-words- are considered to exaggerate the magnitude of prime-target associative strength and word frequency due to the difficulty in their discrimination from real words (p. 5). The third and fourth experiments were replications of the first two experiments targeting students at the University of Albany, who represented typical readers. Each experiment included (semantically) related and unrelated words (e.g. solo-ALONE, slippery-WINE) and non-words (e.g. brane- DOCISION, aforde-BREEF) with high or low frequency. Masked priming lexical decision tasks were administered (SOA: 150 ms.). Prior to the experiments, participants completed the vocabulary subscale of Shipley Institute of Living Scale (Shipley, 1940). Statistical analyses displayed a significant emphasis of vocabulary knowledge of participants on the interaction of semantic priming and frequency: as it was predicted, the magnitude of the semantic priming effect for participants with less vocabulary knowledge were bigger than the others especially with the low-frequent words. On the other hand, the performance of participants with bigger vocabulary size revealed no interaction but the additive effects of semantic priming and frequency; larger semantic priming effects were observed as the frequency of lexical items increased.

Apart from underlining the critical role of individual differences on the relationship between meaning and frequency within the context of morphological processing, this study came up for discussion Plautt and Booth's (2000) single non-linear morphological processing mechanism and Sternberg's (1969) multiple independent stages framework. The researchers argued that there exist feedforward and feedback pathways between the lexical items and the semantic system; however, the mechanism is selectively operational according to the lexical integrity (for the participants with higher vocabulary size as reflected in the additive effects of semantic relatedness and frequency). Correspondingly, with reference to the applicability of Stolz and Neely's (1995) findings concerning the influence of contextual cues on the stimulus quality, they put forward an alternative model of the retrieval of prime in which the relevant feedback for the semantic relatedness is not automatic but operational only when it is necessary.

2.1.4.3. Andrews & Hersch (2010)

Referring to Perfetti's (1992) description of spelling as the best index of lexical quality, Andrews and Hersch (2010) compared the role of spelling accuracy and reading proficiency in masked form priming among university students. It had been assumed that sensitivity to neighbor primes, which differ only one letter from the target in various positions such as *bontrast-CONTRAST* or *clam-CALM*, provides remarkable evidence for the effect of form in lexical processing. Nevertheless, Forster and Taft (1994) argued that the facilitatory effect of orthographic priming is limited to the targets in low-density regions of lexical space- in other words, those with fewer neighbors (low N) in contrast with the lexical items with a good number of minimal pairs (high N). Considering this argument, the first experiment aimed to seek evidence for the masked form priming by the individual and neighborhood variations. 97 undergraduate students were administered six tests to measure their written language proficiency (reading comprehension, reading speed, spelling dictation, spelling recognition, vocabulary, and reading span). Following the identification of individual differences in reading, a masked priming task (SOA: 50 ms.) including 80 orthographically related prime-target pairs was implemented. The critical items were orthographic neighbors that contained four letters (e.g. jury-FURY), differing according to being in a low or high density. The analyses in which individual differences were entered as covariates in the masked form priming of high and low N words came up with an absolutely novel finding: better spellers' reaction to unrelated pairs (e.g. knee- FURY) were faster relative to the related ones whereas the expected facilitation was found in the poor-speller group.

Experiment 2 was conducted to replicate the results of the former priming task and to dive more into the potential effects of different neighbor primes. Unlike the first experiment, five letter words with partial prime were utilized that had one non-alphabetic symbol (e.g. t#ble- TABLE). These partial–prime words were also separated into two groups: unambiguous partial-prime words with only one possible replacement (cr#wd - CROWD) and ambiguous partial-prime words with the potential activation of more than one neighbor (e.g. #rown-CROWN/ DROWN/ FROWN/ GROWN). 123 participants took the masked form priming task with the same design as the former task. Even though it was found that less priming (in both directions- inhibitory or facilitative) were yielded in ambiguous partial-prime words relative to the unambiguous pairs, the results overall confirmed the findings that better spelling led to the inhibition and poorer spelling resulted in facilitation for the processing of neighbor primes.

The researchers speculated that written language proficiency elicits the good spelling and precise representations of lexical items as well as their neighbors; correspondingly, bearing all the neighbors in mind possibly leads to the competition of the target with the potential targets for the related prime. In other words, such a superiority in reading could have an adverse effect on the orthographic priming.

2.1.4.4. Andrews & Lo (2012)

As a continuation of Andrews and Hersch (2010) with a reference to Perfetti and Hart's (2002) Lexical Quality Hypothesis, 100 university students who were measured on the skills of reading, spelling and vocabulary knowledge were administered masked priming lexical decision tasks (SOA: 50 ms). The goal was to investigate the effects of letter identity and letter order on the lexical decision so the effect of one-letter-different neighborhood primes (e.g. snag-SNUG) was compared to transposed letter pairs (e.g. salb - SLAB) in words and non-word primes along with the addition of individual differences into analyses as covariates. Correspondingly, 60 experimental stimuli of quadruplets were prepared with a stable target and a transposed letter prime (e.g. colt - CLOT), a neighbor prime (e.g. plot - CLOT) and an unrelated prime (e.g. gine - CLOT). To test the lexical competition, an equal number of primes were real words and nonwords. In line with the hypothesis that lexical competition is greater for words than non-word primes, the results displayed parallelism with those of Andrews and Hersch (2010): orthographic effects of lexical decision were observed to be modulated by individual differences and higher lexical quality were found to indicate stronger lexical competition. To be more specific, those who were identified as lexically qualified (with overall higher scores on the reading, spelling and vocabulary tests) showed faster reactions to non-word primes as there were fewer potential competitors. Yet, the harshness of the competition among real words affected these qualified participants more than less qualified once; hence, better readers were inhibited in their reaction times to the real words. Therefore, for the better readers, the positive correlation for the nonword primes and the negative correlation for the real word primes were repeated in this study not only in neighborhood primes but also in transposed letter pairs. Moreover, the researchers interpreted the results from a broader perspective touching upon the applicability of the Interactive Activation Model due to the critical role of the connections and competitions among the lexical items in the real time accurate selection and processing.

2.1.4.5. Andrews & Lo (2013)

The researchers supposed that contradictory findings in the previous research on morphological processing- especially relative strengths of priming for transparent, opaque and orthographic items- necessitated a new look at the evaluation of language users' reactions based on individual variations. The relatively constant findings obtained by previous studies summarized above raised the question of the generalizability of the modulating role of individual differences to the semantic and formal relatedness interfering in morphological processing. For this purpose, it was hypothesized that there were potential independent effects of vocabulary size and spelling ability on the reading of opaque or transparent word pairs, in particular, vocabulary scores were predicted to correlate with semantic coherence (Perfetti, 2007) whereas additional boost would be yielded in opaque and orthographically related word pairs for the good spellers.

After being assessed on three written language proficiency tests (a test of vocabulary, a dictation test, and a spelling recognition task) in addition to a general proficiency test, 100 undergraduate students participated in a masked priming lexical decision task (SOA: 50 ms). The task contained 90 experimental stimuli of three conditions in equal number – transparent (e.g. cleaner - CLEAN), opaque (e.g. corner - CORN) and form (e.g. pulpit - PULP) pairs. The overall results did not support the form-then-meaning accounts (e.g. Rastle 2000, 2004): both transparent and opaque pairs produced priming; however, the effect was significantly smaller in the latter condition and it did not significantly differ than the effect yielded in orthographically related pairs. As for the linear mixed analyses considering individual variations, it was revealed that the magnitude of priming was found not to vary depending on the overall proficiency level of the participants but be modulated according to individual differences regarding spelling and vocabulary. When the performance of individuals on the transparent pairs was analyzed, the researchers displayed the superiority of those with higher vocabulary size indicating the modulation of semantic priming in line with the vocabulary knowledge. On the other hand, participants whose performance on spelling tests surpassed their scores on the vocabulary tests produced significantly stronger priming for form and opaque than transparent pairs.

The fact that some skilled readers showed the graded effects of transparency whereas the others were equally faster at their reactions to both transparent and opaque items made it difficult to reach a compromise with the form-first models. Besides, multiple route models (e.g. Kuperman et al., 2009; Plaut & Gonnerman, 2000; Baayen et al., 2011) have not created a simulation in the same direction with the findings of this study; what is worse, Parallel Distributed Processing made some implications with an opposite pattern regarding the effect of individual differences among skilled readers. As for the lexical quality account of reading, the authors assumed that the results were most consistent with this approach as it identified skilled reading with a bottom-up precise orthographic representations of lexical forms and provided both context-free (e.g. Andrews, 2012) and naturalistic evidence (Ashby et al., 2005; Kuperman & Van Dyke, 2011) concerning its assumptions.

2.1.4.6. Bhide et al. (2014)

This study intended to test the hypothesis developed as a result of the robust findings by Andrews and Hersch (2010) from a developmental perspective. Namely, to map a general developmental course of form priming, it tested whether the negative effect of lexical precision (significant inhibitory priming for high neighbor primes) underlies developmental differences in written language proficiency or variations in vocabulary growth. The rationale was simply that as the new words were acquired, the neighbors of the primes would increase and lead to the suspense in the reactions, thus inhibition in processing. That is why an increase was expected in the inhibition as the age of language users increased.

37 adults, 26 adolescents and 38 children from universities or schools in Washington were recruited to take part in a masked priming lexical decision task (SOA: 66.66 ms). The lexical decision task included three prime types: repetition, form, and unrelated varied by orthographic neighborhood size (high N and low N). Additionally, a neighbor knowledge test was administered in order to measure children's and adolescents' knowledge of the neighbors of the stimuli utilized in the first experiment. The participants conducted another lexical decision task in which minimal pairs of the former experiments' targets (words and legal non-words) were presented. The neighbor knowledge test displayed a slight difference in the knowledge of neighbor size of the target words by children (9.38 out of 13.06) and adolescents (9.98 out of 13.06). Both groups were considered to be informed of relatively high neighbor size but the slight difference remarkably correlated with the age of participants. As for the analyses of the reaction time to the orthographically related word pairs, there was no effect of written vocabulary growth. The interaction between neighbor knowledge, neighbor size and the form/repetition priming was non-significant Nevertheless, a significant effect of age was observed: for high N targets, priming decreased with age. Actually, only adults produced a small inhibitory priming for orthographically related prime-target pairs.

Claiming that written vocabulary knowledge is not related to the developmental differences in priming, Bhide et al. were of the opinion that a modification to Andrews and Hersch's (2010) lexical precision mechanism was needed. This revision included a new angle that justified facilitation of form priming in children by referring to the lack of precision of orthographic representations in this group. In other words, the new model depended on the spelling ability in adults and age-related factors in children.

2.1.4.7. Medeiros & Dunabeitia (2016)

Another study on the effect of individual differences in the processing of morphologically complex words was conducted by Medeiros and Dunabeitia (2016) with a specific focus on the reading speed. With reference to Diependeale et al.'s (2009) hybrid model that divides morphological processing into two routes (morpho-orthographic and morpho-semantic segmentation), the researchers postulated that effective use of these routes depended on the reading strategy of each individual. In particular, faster reading was associated with bigger reliance on semantic profiles of lexical items but slower reading was thought to enhance the utilization of orthographic information.

130 native Spanish speakers completed a masked suffix priming lexical decision experiment (SOA: 50 ms). The test included prime-target pairs in Spanish that either share the same suffix (e.g. herrero-BASURERO) or that end with different morphological endings. In addition, pseudo-word pairs for both groups were created with the same logic (e.g. butenlez-SOGOSTEZ). A second lexical decision task that contained only monomorphemic words was administered to classify participants according to their reading speed. When all the participants were analyzed as one group, the results showed a significant suffix priming no matter how small it was. On the other hand, analyses of variance demonstrated that it was significantly larger for the slow readers than fast readers (for which no priming effect was found).

Even though the experiment presented supportive evidence for the role of form and meaning in morphologically complex words and emphasized the importance of individual differences in morphological processing, it provided noteworthy counter-evidence against Dunaebitia et al. (2014) which related fast reading to an orthographic profile rather than a semantic superiority. Taking this controversy into account, the authors referred to another study (Hargreaves et al., 2012) which revealed that the magnitude of semantic information decreased among the fast readers. Correspondingly, a compromise was proposed with a generalization that pointed to the overreliance on both lexical (meaning-based) and sub-lexical (morpho-orthographic) information as a direct result of the increase in the reading speed. Therefore, it was argued that participants needed to sacrifice one route for the sake of the fast recognition on masked suffix priming conditions.

2.1.5. Neuroimaging of Morphological Processing

The inconsequential attempts to come up with a clear picture of the reading pattern for morphologically complex words in real time engendered alternative looks at the field of inquiry. A very remarkable modification in the quest for how people process complex words was the ideational shift to spatial output as the dependent variable of the reading activity instead of the inferences related to the response time. In other words, the identification of the magnitude of the activation in certain areas of the brain was thought to disentangle the controversial results and generalizations produced according to the participants' temporal reactions to the complex lexical items. Even though functional neuroimaging techniques have enhanced our understanding of how language processes are implemented in the human brain, for this moment, it is hard to claim that the expectations have been entirely fulfilled. There are ongoing debates and unresolved issues related to the localization of the subcomponents of language including morphology. One factor is claimed to be non-removable nature of the confounding factors such as task demands, noise, and reservations for the participation in a neurocognitive experiment. More importantly, there is still an insufficient number of studies conducted with similar procedures as the products of the same rationale. That is why very few studies remain to make comparisons and inductions. Nevertheless, being a relatively new field without an established methodology neuroimaging research has steadily gained ground in the last two decades. An important indicator of the progress made so far is the implementation of the studies in L2 morphological processing, which implies the noteworthy development of a neural reading pattern in L1 studies to the extent that researchers were entitled to make comparison between the neuroimaging of L1 and L2 morphological processing. The next part presents the most representative studies on the neuropsychology of reading complex words in L1.

2.1.5.1. Ullman et al. (1997)

The study specifically focused on the above-mentioned long lasting debate between the symbol-manipulating and associative approaches to cognitive processing of morphologically complex words in the human brain. The researchers stipulated that the applicability of the dualist model (Rules and Representations; Pinker, 1991) to the neurocognitive investigations depended on the existence of two different patterns of activation for the processing of regularly and irregularly inflected forms. On the other hand, no neural differentiation would be observed when participants read these types of lexical items. As it was stated beforehand, Ullman extended Pinker's model by providing a neurocognitive perspective. He did so referring to the findings from two types of patients. One displayed itself in general declarative memory impairments as a conclusion of more errors in the formation of irregular forms in Alzheimer's disease with the traits in the temporal-parietal system. The other was obtained from significantly more errors in the production of regular past tense forms in English by the patients of Parkinson's disease as an indicator of the deficiency in the procedural system resulting in the less activation of frontal/basal ganglia.

To test this claim in a functional neuroimaging study, they asked five participants to silently repeat the past tense form of regular and irregular verbs displayed on the screen in an fMRI study. The words were displayed for 20 seconds following another 20 second-fixation period. The scans were obtained with TR sequences of 2 seconds. The analyses supported Ullman's previous assertions regarding distinct mechanisms for regular and irregular forms: while posterior regions were found to subserve the production of the past tense forms of irregulars while frontal cortex and basal ganglia were thought to play a significant role to form regularly inflected verbs.

There are absolutely many points to approach critically with respect to the methodological choices made by the researchers to test their hypothesis. Firstly, the number of participants were arguably insufficient to make a powerful generalization. Second, it did not give a clear answer concerning the decomposition of the complex words because participants did not need to analyze past tense forms of verbs into their constituent morphemes. Third, it was not a masked-priming study so the participants made use of linguistic knowledge as well as episodic memory and predictions based on various kinds of information. Moreover, only whole brain analysis was run even though there were predictions about special locations in the brain that were previously proposed by the researchers. This should have necessitated region of interest analysis. Most importantly, participants were asked to produce past tense forms of verbs silently and it was assumed – with no data- that they made correct productions so that MR scans could be taken into consideration. In spite of all these methodological deficiencies, it was a pioneering examination of morphological processing to inspire many others with methodological elaborations.

2.1.5.2. Beretta et al. (2003)

Beretta and others aimed to answer the same research question that Ullman et al. (1997) put forward. In addition to the problems I mentioned above, they argued that the findings should be treated with caution because of the inherent confounds of English regular inflections. It was assumed that regular inflection in English is the most frequent verb type so the observed activation could be associated with the frequency effect. Besides, irregular inflection involves somewhat regular changes in stems like a block design so the activation could indicate between-block strategies rather than distinct mental representations for the bare and past tense forms. The researchers planned to overcome this problem by examining German, which they claimed unproblematic with these confounds.

An event-related fMRI study was implemented in which eight native speakers of German participated. The test included nouns and verbs of regular and irregular classes and the task was to silently pluralize nouns and past tense form of verbs. To check whether participants knew the appropriate forms they were asked to do the same task loudly immediately after the experiment. The data were acquired with TR sequences of 2 seconds. The analyses of MR data yielded overall greater activation for irregulars than regular forms of both nouns and verbs. Being exposed to regular forms exhibited greater lateralization to the left hemisphere while reading irregulars led to the almost equal activation of both hemisphere- even with a slight trend towards right hemisphere lateralization. Furthermore, the magnitude of activation was always greater for irregulars compared to the regular forms.

The authors' speculation regarding this finding was that there existed effects of facilitation in regulars resulting in less work and less activation when the regularly inflected words were processed. Overall, the results were consistent with the duality models and previous findings in Ullman et al. (1997) although many of the above-mentioned methodological handicaps were maintained.

2.1.5.3. Vannest et al. (2005)

This was another study to test the neurological validity of the dual-route model. It differed from the previous ones in that Vannest and others looked for additional evidence for the model by utilizing derivationally suffixed forms. They presupposed that there are decomposable (e.g. –ness, -less, -able) and non-decomposable (e.g. –ity, -ation) derivational morphemes in English and expected to identify distinct neural correlates for words inflected with these different types of suffixes.

A self-paced block-design memory-encoding task was administered to 15 native speakers of English. The task contained 100 decomposable and 100 non-decomposable derivationally suffixed words in addition to 100 inflectionally suffixed lexical items. Viewing blocks of 50 words for 2 seconds, participants were asked to remember them as well as possible and choose the words they encountered in the block in a 10-item recognition test. MR scans were acquired with TR sequences of only 300 milliseconds. Behavioral results did not display any significant difference in the memory performance among any of the conditions. As for the results of the MR data, subject-by-subject region of interest analysis and group region of interest analysis were run for the Broca's area which was associated with the decomposition and the basal ganglia which was considered to be activated as a result of whole-word analysis. The results revealed a main effect of suffixed word condition; overall, decomposable items activated more voxels than the non-decomposable whole-words. There were significant increases in activity in Broca's area when participants encountered decomposable words (inflected or derived) compared to derivationally suffixed words with non-decomposable morphemes (-ity and -ation).

It should be accepted that the results were quite robust; given the findings of previous studies there emerges a very clear picture of the neuropsychological reality of the dual mechanism in language processing. However, in addition to the caveats in Ullman (1997) and Beretta (2003), task effect remains to be a potential confounding factor in this research. Putting an effort to remember up to 50 words definitely leads to a remarkable cognitive load and possibly determines differences in participants' performance based on their working memory capacity that was not taken into consideration in the analysis.

2.1.5.4. Devlin et al. (2004)

Empirical evidence at the neural level systems was searched for an answer to the theoretical debate on the existence of a separate system called morphology in this study. Considering the literature which they argued revealed a graded priming patterns according to the strength of semantic and formal relatedness, the researchers assumed that morphology is a pure convergence of form and meaning rather than a separate form of linguistic information. They hypothesized that because morphological information could be abstracted from meaning and form, brain regions that were sensitive to morphology would overlap with those sensitive to orthographic and/or semantic structure.

An event-related fMRI study with a traditional visual masked-priming paradigm (SOA: 33 ms.) was designed with four conditions: (i) transparent (e.g. cleaner - CLEAN), (ii) orthographic (e.g. tenable - TEN), (iii) semantically-related (e.g. mirror - LOOK), (iv) unrelated (e.g. ceremony - PICK) prime and target pairs. Twelve native speakers of English participated in the experiment in which they completed a lexical decision task for 28 items on each condition. A total of 132 brain volumes of 3-second-TR sequences were collected for each participant. Both whole-brain analysis and region-of-interest analysis were run by calculating the mean percent BOLD signal change per condition (related vs unrelated).

Behavioral data yielded significant main effects of priming for transparent and orthographic pairs. No effects of meaning or interaction between form and meaning were observed albeit a very small facilitation effect. Responses were significantly faster to visually related items relative to those that did not. These findings were interpreted as the non-existence of the indication of morphology beyond form and meaning. As for the MR analysis, semantic processing was associated with significant activations in left temporal gyrus whereas left occipito-temporal cortex was remarkably active when participants processed orthographically-related lexical items. Most significantly, an overlap of the activation of these two regions were detected as a result of the sensitivity to morphological relatedness. Data obtained from both behavioral and neural paradigms enabled the researchers to conclude that the results were consistent with their initial hypothesis that morphology is a product of the combination of orthographic and semantic information, so it is not a distinct linguistic level involved in the production or comprehension of language.

The researchers followed the traditional methodology of investigations into the early stages of morphological processing to identify its neural correlates and this absolutely proved to be a major step forward. Nonetheless, two important points should be raised concerning the practical and theoretical adequacy of their generalizations. There is not a widely-accepted conclusion to be drawn from the literature characterized by the graded effects of semantic and orthographic relatedness.

Robust findings were gained with respect to the equal priming effects for transparent and opaque word pairs although no priming was produced for semantic or orthographic relatedness (Rastle et al., 2000). In connection with this argument, it would be easier to differentiate the effect of form and meaning by adding the opaque condition (e.g. corner - CORN) in the experiment so that the dissociated effect of morphology could be tested.

2.1.5.5. Gold & Rastle (2007)

Unlike Devlin et al. (2004), Gold and Rastle's pre-admission is that early morphological processing is blind to semantic effects and they looked for evidence of such a non-semantic decomposition process at the neural level. They collected fMRI data of a lexical decision task employing a masked priming paradigm, (SOA: 30 ms.) the design of which included the opaque condition (e.g. corner - CORN) in addition to those of Devlin et al. (2004). There were 48 prime-target pairs for each condition as the stimuli of the experiment. 18 volunteers completed the task, however, 2 of them were excluded from the analysis because of excessive movement in both directions during the task. An event-related design with four runs with 48 targets was employed (TR: 2 seconds).

Planned comparisons of the behavioral data revealed that there were significant priming effects of morphological and pseudo-morphological word pairs compared to those of semantic and orthographic relatedness. Therefore, mere overlap in form or meaning could not explain the priming patterns observed in the experiment. The analysis of fMRI data provided a profound implication concerning the types of information involved in early stages of morphological processing. It did not show any overlap in the locations activated in consequence of priming produced by morphological and semantic relatedness; on the other hand, two out of three regions activated in morphological priming were also activated as a result of orthographic priming. These areas were left posterior fusiform gyrus and left posterior middle occipital gyrus.

As stated by the authors, this was the first study to support the evidence of early morpho-orthographic decomposition stage by means of functional neuroanatomic evidence. Three brain regions activated in morphological priming were all left-lateralized in certain regions of this lobe to be consistently upheld by the studies that followed.

2.1.5.6. Meinzer et al. (2009)

An alternative to the direct comparison of inflectional and derivational or decomposable and non-decomposable morphemes was suggested because of the necessity for the manipulation of the internal structure of complex words while keeping their external properties constant. They maintained that if decomposable words of different complexity were compared by means of behavioral and neural data this would make way for the description of a graded pattern of morphological processing. The reading pattern of German nouns with high and low complexity was examined in an fMRI study. The nouns included the same suffix, thus the same surface structure. However, they differed in the number of steps followed for their final form; there were nouns such as '*Deutung* (interpretation)' which were derived in only a single step (converting from a verb into a noun) and they were classified as 1-step derivation. On the other hand, there were also nouns such as '*Milderung* (mitigation)', they were derived in two steps as their roots were originally adjective (adjective – verb - noun), hence being classified as 2-step derivation.

Matching all the potential confounds (word-class, suffix, word-frequency, family-size, number of letters and syllables) the researchers employed a lexical decision task administered to 24 native speakers of German. A total number of 72 words (36 words in each group) were used. Additionally, pronounceable and unpronounceable letter strings with no meaning were included in the experiment. A block-design lexical decision task was employed (TR: 3 seconds) in which participants were instructed to detect pronounceable but senseless non-words.

The results showed that participants detected the pseudo-word targets with a high accuracy rate (95%) and two classes of words (1 & 2-step derivation) were rated equally complex by a different participant group. Besides, MR analyses displayed different levels of activation for 1-step derivation and 2-step derivation items. Specifically, a significant difference in the activation level was observed in the left inferior frontal gyrus and middle as well as superior gyri as a reaction to reading nouns of 2-step derivation items compared to the processing of 1-step derivation group.

The authors commented on the results stating that "the brain computes the degree of a word's complexity" (p. 1968). With that being said, the drawbacks of the aforesaid task in a block-design study should be mentioned. An attention was remarkably paid to eliminate the effect of potential factors in processing. However, the findings obtained in such a research provided cues only about the end-state of the reading process involving the employment of both linguistic information as well as episodic memory and processing strategies. Therefore, converging results by means of an optimized method serving the purpose of the enquiry is considered necessary.

2.1.5.7. Bick et al. (2011)

The long-lasting debate about the (non)existence of morphology as an independent element of language was addressed in this fMRI experiment and tested in Hebrew. The researchers justified their choice of language on the basis of the argument that languages differ in their morphological structure and such a language-dependent effect could play an important role in morphological processing. They claimed that as opposed to languages with impoverished morphology those with a rich morphological content like Hebrew could signify a clearer and graded sensitivity to morphological manipulations in the reading patterns for complex lexical items. The goal of this study was to support their earlier findings (Bick et al., 2008) obtained in an explicit behavioral study demonstrating the independence of morphological processing via research implicitly looking at the neural networks of the reading process for complex words. Moreover, referring to what was revealed in a masked-priming fMRI study in English (Gold & Rastle, 2007), the second goal was to make a comparison to test their argument for the role of morphological richness at the early stages of processing.

A masked-priming lexical decision task (SOA: 33 ms.) was taken by twenty native speakers of Hebrew. 160 target words were matched with primes on five conditions in five sets according to (i) morphological and semantic relatedness, (ii) morphological relatedness with no similarity in meaning, which was peculiar to Hebrew among a few others, (iii) orthographic relatedness, (iv) only semantic relatedness, and (v) unrelated status between the primes and targets. Because of the need for the reasonable length of an imaging experiment, only100 non-words were also added to the stimuli; therefore, the probability of pushing “yes” and “no” buttons for equal times could not be achieved.

Behavioral results displayed no main effect of condition in reaction times to target words. Imaging results did not show any difference between the activation levels in certain regions (particularly middle temporal gyrus, left central sulcus, and left superior parietal lobe) on semantic or orthographic conditions compared to the unrelated condition. These regions were the most activated locations when the primes were semantically or orthographically related to the target words. Then, activation levels of the processing of morphologically related (condition i and ii) and morphologically unrelated (condition iii, iv, and v) prime target pairs were contrasted. A significantly decreased fMRI signal implying increased activity was found in the left inferior frontal gyrus, left inferior parietal lobe, and the angular gyrus. Therefore, it was argued that a network corresponding to morphological activity dissociated from form or meaning was identified. Moreover, together with their former research, they came up with a broad generalization that "implicit and explicit processes involve networks that overlap" (p. 9).

2.1.5.8. Bozic et al. (2013)

This study focused on the mechanisms and parallel neural networks engaged in spoken word recognition. In agreement with previous body of research (Marslen-Wilson & Tyler, 2007; Beeman, 2005; Tyler et al., 2005; Binder et al., 2000), the authors supposed that two complementary systems with different functional roles work together for the auditory comprehension of language. According to this argument, grammatical computations are supported by the left hemispheric frontotemporal system; meanwhile, a bi-hemispheric system is associated with the mapping of sound to meaning and general perceptual demands. Their initial work concerning this two-legged mechanism concentrated primarily on the recognition of inflected forms, which supported this argument exhibiting selective activation of the left-lateralized decompositional system (Bozic et al., 2010). The alleged lack of compositionality in derivationally suffixed words (Matthews, 1991) lied behind a follow-up study asking whether derivationally complex words exhibit the same neurocognitive characteristics as regular inflected forms; i.e., whether they are decomposed by means of the above-mentioned joint mechanisms.

All the methodological preferences made in Bozic et al., 2010 were adopted in this study excluding the type of morphemes. Correspondingly, 6 conditions were created with 40 words in each group: (i) transparent and productive (e.g. player), (ii) transparent but non-productive (e.g. warmth), (iii) opaque and productive (e.g. archer), (iv) opaque but non-productive (e.g. breadth), (v) orthographically-related (e.g. scandal), and morphologically simple (e.g. giraffe) words constituted the stimuli of the experiment. 18 native speakers of English participated in a gap detection task. Short silent gaps were inserted between 60 fillers (20% of the whole stimuli) and the participants were instructed to quickly and accurately decide whether words contained a silent gap using a button box.

No main effect of condition was observed in error rates. Region of interest analysis was conducted for the MR data and bilateral frontotemporal regions were selected. The results did not display any evidence for the selective engagement of the left hemisphere; instead, bilateral activation was revealed as a consequence of the competition between the words and their stems irrespective of the conditions. That is, reading all stimulus classes led to the activation of bilateral temporal areas, left frontal gyrus, and bilateral anterior cingulate. Morphologically complex stimuli did not display left-lateralized activation as was observed in Bozic et al., 2010. Therefore, unlike inflections, general perceptual systems in a bihemispheric model was considered to be at work for the comprehension of derived words as a result of their interaction with the meaning of the stem attached.

2.1.5.9. Neuroimaging Studies with Alternative Paradigms

To examine the neural networks engaged in morphological processing, a considerable number of studies were implemented by adopting alternative research paradigms to fMRI. A short summary of the remarkable findings of selective studies are provided in this part of the chapter.

Laine et al. (1999) were among the first researchers to question whether the left-lateralization of the production of language could extend to input processing, particularly morphological processing, as well. They conducted a positron emission tomography (PET) study on the production of English past tense. Participants were asked to memorize words which were either monomorphemic or case-inflected, which was followed by a recognition memory test. The analyses suggested significant increases of activation in Broca’s area (in the left inferior frontal lobe) and weaker activations in the right hemisphere. The results were considered to be robust evidence for the determining role of the Broca’s areas and adjacent regions in the processing of regularly inflected words.

Rastle et al. (2015) tested the above-mentioned claims made by Crepaldi et al. (2010) addressing to the differential magnitude of priming in regular and irregular forms. A masked priming study (SOA: 40 ms.) sought to gain findings via brain potentials and it was designed in the context of an event-related potentials (ERP) paradigm. Target words were paired with either regularly inflected third-person inflected forms (e.g. stirs - STIR) or irregularly inflected past tense form (e.g. bent - BEND) to serve as primes. 32 university students participated in the lexical decision task. First temporal window of ERP (up to 250 ms. post target onset) showed significant priming for regularly inflected prime-target pairs. Moreover, earlier onset and greater magnitude for the regular inflections were observed in the N400 modulation. In other words, different time courses for regular and irregular inflectional priming were yielded via ERP analyses, which fully supported Crepaldi et al.'s (2010) claims.

Fruchter and Marantz (2015) sought evidence for the validity of the temporally-differentiated perspective of Crepaldi et al.'s (2010) model in the neuro-cognitive system by implementing a magnetoencephalography (MEG) study. The model roughly suggested a three-step process for the recognition of complex words; initial decomposition, subsequent lookup of the morphemes (at the lemma level), and final evaluation of the well-formedness of lexical items. Furthermore, inspired by another model of morphological processing supporting a huge effect of lexical frequencies of the family members of a stem, semantic coherence, surface and stem frequency (Moscoso del Prado Martín et al., 2004), the researchers manipulated the stimuli accordingly. A visual lexical decision task with simultaneous MEG recordings was administered to twelve native speakers of English. Target stimuli were 200 derivationally suffixed words and 200 non-words. Behavioral analyses confirmed the role of the derivational family entropy (family members of the stem), semantic coherence and surface as well as stem frequency as they significantly modulated reaction times to target words. Likewise, MEG analyses presented a full-fledged picture of the functions of these independent variables in lexical processing. Additionally, derivational family entropy was observed to facilitate left temporal activity earlier than the other factors (beginning around 240 ms.) while surface and stem frequency was found to be effective later (at around 430-450 ms. of the recognition) to be followed by semantic coherence. The findings were quite robust and demonstrated as empirical support for the notions concerning temporal properties (Crepaldi et al., 2010) and variables producing an effect on visual word recognition (Moscoso del Prado Martín et al., 2004).

Gwilliams and Marants (2018) tested two hypotheses addressing to the decomposition of internally different types of complex words. Although both hypotheses agree that truly complex words (e.g. farmer) are decomposed into their constituent morphemes and winter-type words, i.e. those containing a string sequence that matches a suffix with a potential stem and bearing no relationship in terms of meaning and structure, are processed as chunks, they make different predictions about excursion-type words that contain a string sequence that matches a suffix and behave in line with the functions of the relevant suffix (e.g. excursion as a de-verbal noun). First hypothesis claims that *excurse* can be generated as it obeys the morpho-syntactic rules enforced by the suffix *–ion*; however, the second hypothesis suggests that decomposition for excursion-type words is impossible because such a word as *excurse* never occurs in a context. It was predicted by the researchers that if the first hypothesis was the case, an activity in the fusiform gyrus at around 170 ms. (M170) would be observed in a MEG study as it was in truly complex words. 24 native speakers of English participated in a visual lexical-decision task designed with four experimental conditions: (i) truly complex words (e.g. builder), (ii) pseudo-complex words (e.g. corner), (iii) winter type, and (iv) excursion-type words were utilized. MEG analyses supported the first hypothesis; no significant difference was found in the level of activity in fusiform gyrus at M170 between the processing of truly complex words and excursion type items. The results implied the computation of words as visually complex entities if they obey the morpho-syntactic rules regardless of their independence of the attached suffixes.

2.1.6. A General Evaluation of L1 Morphological Processing

A selective group of studies out of the comprehensive literature on L1 morphological processing was presented in the first part of this chapter. It is possible to argue that converging evidence was found with respect to the major questions in this field of inquiry. I present these questions and the most updated answers in the light of the above-cited findings.

a.) What is the most explanatorily powerful approach to morphological processing in L1?

It is still hard to reach an ultimate conclusion because of inconsistent results, different perspectives improved to interpret findings, and the lack of a standard methodology. Nonetheless, two factors highlighted the advantages of one-route models adopting serial processing (form-then-meaning) accounts (e.g. Taft & Forster, 1975): they are relatively straightforward, hence easy to test (falsifiability issue), and empirical findings mostly fit with these accounts.

b.) Does morphology play an independent role in the mental representation and processing of morphologically complex words?

Yes. A good number of online studies employing various experimental paradigms confirmed that a graded effect of form and meaning is available at different stages of processing; however, observing initial stages of reading complex words exhibited decomposition pattern blind to orthographic or semantic properties. Further support was obtained in studies examining neural correlates of various stages of morphological processing. In other words, morphology- theoretically and empirically- is not the sum of form and meaning in L1.

c.) Do different types of affixes have different processing patterns in L1?

Probably. There is not robust evidence showing non-decomposition for irregularly-inflected words unlike regulars. Besides, in line with the theoretical debates about the fundamental differences between derivations and inflections (e.g. Matthews, 1991; Anderson, 1992) recent imaging studies came up with contrasts in brain responses to these types of morphemes. However, a full-fledged processing model to compare such frequent types of morphemes (derivational, regular, and irregular) is yet to be proposed.

d.) Can individual differences account for how morphologically complex words are processed in L1?

To a certain extent. Along with other factors, it was seen that individual differences such as vocabulary size and spelling accuracy could modulate whether and how complex words are decomposed into their morphemes. Rather than the overall proficiency level, their individual differences turned out to be a remarkable phenomenon to describe the reading pattern of L1 speakers.

e.) Is there a parallelism between the behavioral data and brain responses to morphologically complex words in L1?

To a great extent. A couple of studies suggested that there were subtle illusions of the surface form by which our behaviors were affected, so inconsistencies were irresistible because our brain was strikingly sensitive to internal structures of lexical items. Yet, these can still be considered exceptional experiments, given a huge number of studies providing converging behavioral and imaging data about the decomposition of complex words under certain circumstances.

2.2. Morphological Processing in L2

Broadly speaking, a *de facto* hierarchy in the investigations into the features of SLA have emerged in the last decades. The first step in the formulation of a hypothesis has been to question whether there is a natural convergence or divergence between learning a native language and a second language. Well-known theories were grounded by the orientation of scholars towards this very first question. This has been the case in the inquiry of morphological processing in L2, as well. The difference is that other branches of SLA focusing mostly on the acquisition of grammatical structures had a relatively clear picture of the linguistic behaviors of native speakers and mostly undisputed descriptions of their performance. However, as it was stated above, many different perspectives to explain how native speakers read complex words are available. Correspondingly, describing the processing of complex words in L2 compared to L1 is very challenging. Therefore, adopting and building on an L1 processing model is inevitable. Reviewing the literature, it can be argued that a majority of studies in L2 presupposed the validity of above-stated one-route serial processing models (Taft & Forster, 1975) or the neurocognitive account of the declarative/procedural dichotomy (Ullman, 2001b). Leaving aside the implications of L1 models in L2, Shallow Structure Hypothesis (SSH) (Clahsen & Felser, 2006) eventuated as the sole L2 processing hypothesis in its own right.

2.2.1. Shallow Structure Hypothesis

Doing a (quasi)meta-analysis of several studies on the processing of morphological and syntactic structures in L1 and L2, Clahsen and Felser (2006) reached a conclusion regarding the distinct type of information being employed in real time by L1 and L2 speakers. It was indisputably one of the most influential papers of SLA studies and has been thenceforth very hotly debated. Albeit its huge impact and recognition level, as the authors admitted, it was criticized for the lack of clarity in its arguments and predictions about certain components of SLA. A need emerged to clarify some misunderstandings and refine the hypothesis, hence the publication of a revised version (Clahsen & Felser, 2018). The summary of the model given below is based on the latter publication describing the SSH.

Different models were proposed to account for the real time processing differences in L1 and L2 (e.g. Paradis, 1994; MacWhinney, 1997; Segalowitz, 2003). These models sought to justify such differences in real-time performance on account of the domain-general learning mechanisms such as a shortage of computational resources or failure in automatization in comprehension and production. The distinctive feature of the SSH was that it claimed that L1 and L2 speakers hold the same processing mechanisms and computational resources but L2 speakers cannot build abstract morpho-syntactic representations in real time. Proficient L2ers try to compensate for this handicap by heavily exploiting semantic, pragmatic, probabilistic or surface-level information. In other words, sensitivity to non-grammatical and reduced reliance on morpho-syntactic information were considered to characterize L2 grammatical processing.

The crucial confusion with the SSH was the ambiguity in the claims of the model regarding the basic nature of L1/L2 difference; they spoke of the fundamental and qualitative differences, at the same time, mentioned shallower and less detailed integration of grammatical representations in L2. This choice of wording in the keynote article of this model (Clahsen & Felser, 2006) was corrected in the successive publication (Clahsen & Felser, 2018) clearly stating that "a black-and-white picture was not intended… the SSH posits gradual L1/L2 differences" (p. 3). Moreover, Clahsen and Felser did not make a precise claim about the (absence of) L1 influence in L2 processing; studies exhibited no difference in L2 processing among participants from typologically different L1 backgrounds (e.g. Marinis et al., 2005; Sato & Felser, 2010, Gerth et al., 2017). Correspondingly, although they assumed that L1 effect is limited than what has been postulated in L2 literature, no interlanguage influence was unwarranted. The authors also needed to clarify their speculation about the final state of L2: although the SSH has strong arguments about the inefficient use of grammatical information in L2 processing, the model did not claim that L2ers could never develop native-like morpho-syntactic processing abilities. According to this model, being a native-like would be possible on condition that increased exposure was provided for increased automatization and entrenchment of grammatical processing routines (p. 6). Another point to be updated in the revised version of the model dealt with L1/L2 differences in processing time-course. Recent studies exhibited delays in the predicted effects of grammatical constraints in L2 compared to L1. (Felser & Cunnings, 2012 as an example of syntactic processing in L2; Clahsen et al., 2013 on morphological processing). Thus, the characteristic features of the SSH was updated as "sensitivity to non-grammatical and reduced and delayed reliance on morpho-syntactic information". Lastly, although the impact of age of acquisition was crucially acknowledged and a large number of participants from different age of acquisition groups were tested in online experiments, the SSH could not specify how and when grammatical processing would be non-nativelike.

The SSH inspired numerous psycholinguistic research in L2 morphology and syntax that tested its premises through well-designed experiments. So far, the studies have largely supported the model, some contradictory findings notwithstanding. I hereby present the most representative L2 morphological processing studies that shaped, improved, and challenged the model.

2.2.1.1. Silva & Clahsen (2008)

To examine how L2 processing differs from L1 processing of different morphological structures, four masked-priming experiments were administered to adult native and L2 speakers of English.

The first experiment focused on the processing of regular past tense forms in English in a lexical decision task (SOA: 60 ms). There were 21 participants in each of three groups: Chinese L2ers of English, German L2ers of English and the control group of natives. As the former L1 studies displayed, native participants produced full priming for the regularly inflected past tense forms. However, L2ers did not show any priming effect for the regular forms. Taking into account the facilitatory effect of identity primes, the results could not be attributed to giving slower reactions in L2. In addition, no difference was found in the priming patterns of L2 groups.

Experiment 2 was a revised version of the first experiment in accordance with an aim of the researchers: to test the results against shorter SOAs and L2ers with different backgrounds. In parallel, two revisions were made; SOA was reduced to 30 milliseconds and an additional 21 Japanese L2ers of English participated in the experiment with the same procedure and materials used in the former one. Repetition priming effects were observed in both L1 and L2 groups, but morphological condition produced facilitatory effects for only native participants.

Experiment 3 was realized in order to test the priming effects of derivationally inflected words in L2. The only methodological difference between Experiment 1 and 3 was accordingly the content of the morphology condition. Productive and transparent deadjectival word forms with the derivational morpheme *–ness* were utilized in the morphology condition. Three groups of participants took part in the experiment; 24 Chinese and 24 German L2ers of English as well as 24 native subjects. The results were consistent for the control group; they produced full priming in the third experiment, as well. As for the L2ers, a partial priming effect for the morphologically related pairs was yielded.

The final experiment examined whether the priming effect found in the former experiment was peculiar to a specific suffix and the results could be replicated for another deadjectival suffix *–ity*. Except the morphology condition in the item set of the third experiment, all the other testing conditions were kept constant. The priming effects in the morphology condition were quite similar to those of Experiment 3 for both L1 and L2 groups (full priming for the natives and partial priming for the L2ers).

The results were claimed to fully support the SSH. A clear difference between the L1/L2 priming patterns was observed. On the one hand, native participants showed a full priming effect irrespective of the type of morphemes, which could not be explained by the pure incorporation of form and meaning. They decomposed words into their constituent morphemes. On the other hand, L2ers never produced full priming for the morphologically-related pairs. They made less use of grammatical information and this shortage was asymmetrical depending on the type of morphemes. They made more use of morphological representations for derived forms possibly due to the creation of new lexemes in derivationally-suffixed words in comparison with the pure combinatorial processes in regularly-inflected words.

2.2.1.2. Neubauer & Clahsen (2009)

In this study, three experimental techniques were employed to compare L1/L2 morphological processing of regular and irregular participle forms in German. The pool of participants was 40 advanced L2ers of German with Polish as their L1 and 66 native speakers.

An offline acceptability judgment task was used to compare the ratings of unusual noncanonical words – denominal verbs in this case- that could be legitimately formed by means of regular (e.g. befliegt (flied)) or irregular (e.g. befliegen (flew)) inflection in contrast with underived words with irregular roots that could only end up with the irregular suffix *–n*. L1 participants' ratings were as expected: they rated –n endings for underived words as very natural but found the regular inflection (*-t* endings) more acceptable for denominal verbs. In other words, they relied on morphological representations wherever it became possible. L2ers were indecisive in the denominal cases, but they gave higher ratings for the *–n* suffix endings for underived words. This means although L2ers were not so strongly affected by the morphological structure as L1 users, they were not found to be blind to such grammatical information.

The second experiment was a visual lexical decision task. It aimed to identify potential frequency effects in recognizing morphologically complex words in L2. It was a modified version of Clahsen et al. (1997), which showed the effect of frequency on irregular but not for regular participles as an indicator of decomposition for regular and lexical storage for irregular forms in L1. 30 L1 and 31 L2 participants completed a lexical decision task in which regular and irregular words were manipulated based on their frequency. Lexical items remained on the screen until a response was received or disappeared after 2 seconds providing no decision was made. The results exhibited a replication of the previous research for the L1 group: shorter reaction times for high-frequency irregular forms but no significant difference for the regular participles. However, an overall effect of frequency was yielded across types of morphemes (regular and irregular) for the L2 group.

The motivation for the implementation of the third experiment was the need for the evaluation of the role of morphological decomposition in real time processing of regular and irregular forms. A masked priming experiment (60 ms) was implemented within a lexical decision task completed by 39 L1 and 39 L2 speakers of German. Similar priming patterns (partial priming) were produced for irregular forms. However, in the case of regulars, a full priming effect was observed in the L1 group while there was no priming in the reaction times of L2 speakers.

To summarize, nativelike performance was observed in the L2 group for irregular forms unlike regulars. In line with SSH, L2 performance was considered to rely on memorization of simple and inflected words rather than morphological decomposition.

2.2.1.3. Clahsen & Neubauer (2010)

This study sought to provide evidence for the surface frequency effects in the processing of derivationally suffixed words in L2 German. The phenomenon that the researchers examined was the productive and transparent –*ung* nominalization to form feminine noun out of a verbal stem (e.g. gründen (to found) – Gründung (foundation)). The research consisted of two experiments differing in the methodological paradigms adopted.

The first experiment was an unprimed visual lexical decision task in which experimental items (derived nouns) were manipulated according to their surface frequency. 30 L1 and 31 advanced L2 users of German (L1: Polish) participated in the experiment. The stimulus disappeared if a response was received; otherwise, they remained on the screen for 2 seconds. The results displayed a significant surface frequency effect for both groups; larger priming and smaller error rates for high frequency words were observed. a between-group comparison of the effect size exhibited larger effects in the L2 group.

The second experiment was a masked-priming lexical decision task (SOA: 60 ms.) designed to examine the priming effect of derived nouns in the absence of the conscious recognition of the derived nouns. The researchers followed the same procedures in the preparation of experimental items as in the former experiment except matching experimental items in their surface form frequency. 33 L1 and 33 advanced L2 users of German (L1: Polish) who did not complete the unprimed lexical decision task took part in the second experiment. L1 users showed a similar reading pattern to that of the first experiment; a full priming effect was yielded. However, unlike the first experiment, there was no priming effect in the reaction times of the L2 group.

In addition to the benefits of a research design utilizing different methodologies to make a realistic evaluation of findings, this study exhibited an overestimation of the frequency effects in real time processing. It was once again emphasized that L2ers perform differently from L1 users due to the ineffective use of the procedural systems to process unfolding grammatical entities.

2.2.1.4. Clahsen et al. (2013)

To provide insights into the role of processing speed and precise time course of accessing different kinds of information in L2 processing, behavioral and eye-movement experiments were implemented.

Experiment 1 was a masked-priming lexical decision task testing groups of advanced Arabic learners of English on the regular past tense forms. It had two versions: the first version was a standard masked-priming task modelling Silva and Clahsen (2008) in all aspects of methodology (items, procedure, and analysis). 21 L1 and 20 advanced L2 users of English (L1: Arabic) participated in the standard experiment. The results exhibited full priming for the L1 group but no priming for the L2 participants; in other words, replicated the findings in Silva and Clahsen (2008).

The second version made use of the same lexical items in the morphology condition but, unlike the standard design, a blank screen appeared at the offset of primes for 200 milliseconds to be followed by targets. The goal was to examine the potential effect of the extra time for the processing of the prime (complex words). A new group of participants with the same profile (20 participants in each group) completed this delayed masked priming lexical decision task. The analyses did not present any difference in the processing of inflected words between the standard and delayed priming tasks in L1 and L2 (full priming in L1 & no priming in L2).

Experiment 2 and 3 dealt with the offline and online sensitivity of L2ers to constraints against inflected forms inside derived words. By and large, they were adaptations of Cunnings and Clahsen's (2007) L1 research to the L2 context for the direct comparison of findings. As Cunnings and Clahsen (2007) showed, L1 users of English singular rather than plural base nouns to add derivational suffixes (e.g. ratless vs. ratsless) and find derived irregular plurals more acceptable than regular plurals (e.g. liceless vs. ratsless). Experiment 2 was an offline acceptability judgment task taken by 25 advanced Dutch learners of English. Participants were asked to rate the acceptability of short sentences with derived nouns in plural or singular forms of regular and irregular base forms as exemplified above. Comparison of the ratings of L2ers to those of L1 participants in Cunnings and Clahsen (2007) did not exhibit any significant difference in the preferences of both groups.

Experiment 3 tested online L2 sensitivity to the above-mentioned constraints via eye-movement measures. Participants saw the same types of derived forms as in Experiment 2 in paragraphs and were instructed to read these paragraphs to themselves at their normal pace. Reading time measures were calculated for the derived word regions (derived words and half a letter space either side). Planned comparisons displayed different reading time patterns for L1 and L2ers; elevated reading times for unacceptable forms in the L1 group were not replicated.

Taken together, the experiments made two important suggestions. Firstly, inefficiency of the extra time in Experiment 1 implied that slowed L2 processing did not cause fundamental L1/L2 differences. Secondly, albeit equivalence in later analyses of morphological constraints in offline tasks, eye-movement experiments confirmed the hypothesis that "the L2 comprehension system employs real-time grammatical information less than the L1 system" (p. 26).

2.2.1.5. Kırkıcı & Clahsen (2013)

To confirm the previous hypothesis concerning whether derivational and inflectional morphemes behave differently in L2 (Silva & Clahsen, 2008), the researchers argued that previous findings needed testing against different linguistic structures in different target languages. This study compared the processing patterns of derivational and inflectional morphemes in L2 Turkish - which is not a Indo-European language such as English - by focusing on two frequent, productive and transparent suffixes (aorist verb inflection *–Ar* as in kurar (establishes) and deadjectival nominalization *–lIk* as in körlük (e.g. blindness)). Two online experiments were conducted for this purpose.

The main experiment looked for evidence for the priming effect of morphological relatedness between primes and targets. It was a masked-priming lexical decision task (SOA: 50 ms.). An equal number of derivationally and inflectionally-suffixed word pairs (15 items with *–Ar* and 15 items with *–lIk* morpheme) were tested against identity and unrelated type pairs. 32 L1 and 32 highly proficient L2 users of Turkish with a variety of L1 backgrounds were tested. Significant priming effects for the derived nouns with *–lIk* suffix were found for both groups whereas only L1 group produced such an effect for the inflected verbs with *–Ar* suffix.

The main experiment was complemented by a follow-up task to check the role of orthographic relatedness between morphologically related primes and targets in the priming effect obtained in the first experiment. The researchers followed the same methodological procedures by replacing the (morphologically) related condition with orthographic relatedness that did not allow any semantic or morphological connection between primes and targets. 28 L1 and 28 L2 users of Turkish who took part in the first experiment completed the lexical decision task. The analyses displayed a similar pattern in both groups: no priming effect of orthographic overlap at such a short SOA.

The results supported previous arguments and findings indicating clear contrast between L1 and L2 morphological processing across different target languages irrespective of L1 backgrounds. Moreover, the study contributed to the theoretical debates about the outputs of derivational and inflectional processes (e.g. Stump, 2001). It basically confirmed that when primes and targets share lexical entries - as in the case of derivationally related words – there is a convergence between L1 and L2 processing. Otherwise, i.e. when the output of an inflectional process is a feature-form pairing rather than a new lexical entry, morphological decomposition is activated in L1 but not in L2.

2.2.1.6. Heyer & Clahsen (2015)

The main motivation of this study was the signs of orthographic priming in L2ers obtained in previous studies (to be covered later in this chapter e.g. Feldman et al., 2010; Diependeale et al., 2011). It was argued that L2 processing might be influenced by the surface form of words. Given that previous findings suggested a priming effect for derivationally-suffixed words in L2, this study compared priming effects between derivationally and orthographically related prime-target pairs.

In a masked-priming lexical decision task with two SOAs (33 and 67 ms.), reaction times to morphologically and orthographically related pairs were measured against the unrelated condition. 50 L1 and 49 advanced L2 users of English participated in the experiment. In parallel with previous research (Silva & Clahsen, 2008; Kırkıcı & Clahsen, 2013), priming effect for derived pairs were observed in both groups. However, only L2 participants exhibited a facilitatory effect of orthographic overlap with both short and long SOAs.

Two arguments of the SSH were strongly supported by this research. Priming in derived words confirmed the similarity in L1 and L2 processing when grammatical analyses were not required. No effect of SOAs, on the other hand, agreed with the hypothesis that L2 processing is not simply delayed. More importantly, it claimed to resolve the *suspicion* of the effect of orthography in L2 processing. Nonetheless, given the number of previous and following studies with contradictory findings, further research is essential for the depiction of a clear picture of the issue.

2.2.1.7. Jacob et al. (2017)

Another study to compare how derived and inflected words are processed in L2 was conducted in German. Its significance arose from its originality in the sense that it contained the first experiment to directly compare derivational and inflectional suffixes because participants made their lexical decisions on the same target words.

A masked-priming task (SOA: 50 ms.) was taken by 40 L1 and 36 advanced L2 users of German (L1: Russian). Three conditions made way for the preparation of the item lists accordingly: morphology, semantic, and orthography. Morphologically related items consisted of 28 infinitival targets (e.g. ändern ‘to change’) preceded by

–ung nominalization as derived primes (e.g. Änderung '(the) change') or the past participle as inflected primes (e.g. geändert 'changed'). Data analyses provided consistent results with former experiments to strengthen assumptions of the SSH; no facilitatory effects of meaning or form were found in this study, too. Moreover, a significant priming effect for derived nouns were observed in both groups, which was not the case for inflected forms given that these types of primes facilitated only the L1 performance.

2.2.2. The Words and Rules Theory in L2 Morphological Processing

As Kırkıcı (2005) stated, if a dual-mechanism model is meant to carry universal validity it should come up with parallel assumptions for the acquisition and processing of a second language (p. 79). To this end, the Words and Rules Theory has not been established as an L2 model but its theoretical claims and predictions of L1 processing have been tested by means of direct or indirect L1/L2 comparisons. However, psycholinguistic and neurolinguistics attempts- though in a limited number- to extend the model to L2 processing have not arrived at uniform conclusions. The model has concordantly fallen into disfavor among L2 researchers and theorists in the last years. Below are the most representative studies that examined the applicability of the implications of the model in L2 processing.

2.2.2.1. Birdsong & Flege (2001)

This study addressed to the effect of the age of arrival in the L2 context and age at testing on L2 adaptation to the regular-irregular distinction. The researchers tested how participants reacted in a multiple-choice sentence completion task. The gaps in each sentence involved a past tense form or a plural noun manipulated according to regular-irregular (e.g. helped vs swam) and high frequent-low frequent (e.g. dogs vs knuckles) conditions. 60 L2 learners of English (L1: Korean (n. 30) and Spanish (n.30)) completed the sentence completion task on a computer which recorded the responses out of five alternatives and reaction times. Participants were equally divided into three subgroups based on two categories: their ages at the time of testing (between the ages of 16-26, 21-31, and 26-36) and their ages of arrival in the United States (between the ages of 6-10, 11-15, and 16-20).

Accuracy rates were identified and compared on the basis of the two conditions given above. The results showed that participants' judgments on the regular forms were not influenced by frequency. Both L1 Spanish and L1 Korean groups did not perform significantly better on high frequent items. On the other hand, significant differences were obtained between accuracy scores on high frequent and low frequent irregular forms for both L1 groups. However, a main effect of age at testing was found in irregular forms – not in regulars- contrary to what was expected by Ullman (2001b). As for the analyses of reaction times, they were not reported in detail and researchers informed us only about the consistency of the reaction time data with the accuracy rates.

In short, the results have largely supported the dual mechanism models. As it was predicted by the proponents of the Words and Rules Theory, regulars were found to be insensitive to frequency as they were analyzed into their constituents whereas surface frequency influenced the processing of irregulars because they were memorized by means of associative links.

2.2.2.2. Kırkıcı (2002)

This study also aimed to investigate how different groups of L2ers process regular and irregular forms with reference to Zobl's (1998) positive correlation between proficiency and employment of rule-based mechanisms in L2. The researcher designed a sentence completion task by making use of stimuli developed by Ullman (1999), Ullman & Gopnik (1999), and van der Lely & Ullman (2001). 49 advanced and less advanced L2ers of English (L1: Turkish) in a formal learning context participated in the task. Participants were instructed to write the past tense of 56 regular and irregular verbs in total that were grouped according to frequency (high vs low frequency) and authenticity (genuine vs novel).

The analyses indicated that frequency effect was evident for both advanced and less advanced participants in irregular items. Both groups were more successful in their production of high frequency items and avoided their overregularization more often. More remarkably, a similar frequency effect was seen in regular forms; high frequency items were used significantly more accurately. Additionally, they showed a considerable tendency to irregularize (e.g. brush – brash, bring - brang) regular forms compared to native adult or child subjects.

The results did not fully support the Words and Rules Theory considering the sensitivity to frequency in regular forms. Nevertheless, as it was expected, findings regarding irregulars signified full-form storage for irregular forms because participants resorted to their associative memory whenever it was possible. Moreover, in contrast with Zobl's (1998) claims, both groups benefitted from rules when the memory was not so helpful by means of either overregularization or irregularization.

2.2.2.3. Murphy (2004)

Murphy conducted another offline study to demonstrate how beginner users of L2 treat regular and irregular forms. He designed a writing task in which participants were asked to produce past tense forms of nonexistent words in English. The experimental items were prepared in a three-point scale (prototypical, intermediate, and distant) displaying phonological similarity to real regular (e.g. spling bearing prototypical similarity to cling, sling, fling) and irregular verbs (e.g. smeeb with intermediate similarity to beam, cream, gleam) in the target language. The task was completed by 20 beginner L2ers of English (L1: various) whose length of residence in England was not longer than 6 months.

As the theory anticipated, participants applied the past tense rule for regular nonce words significantly more often than irregular nonce words. Furthermore, an analysis of their performance of irregular nonce words yielded the effect of similarity to the real worlds in that overregularization increased as the phonological resemblance decreased. As for the regular nonce words, the results were quite unexpected; phonological similarity had clearly influenced the use of regular forms, albeit in the opposite direction for regular nonce words. In other words, phonological similarity to real verbs led to the avoidance of regularization. Therefore, the study ended up with a question mark for such a sharp regular-irregular distinction in L2 processing. The non-supportive findings concerning independence and priority of the computational procedure for regular forms called upon revisions about the predictions of dual-mechanism models in L2.

2.2.2.4. Kırkıcı (2005)

Kırkıcı conducted a complementary study to his previous findings (Kırkıcı, 2002) that shed doubts on the validity of the dual-mechanism models in L2. With the same goals as was stated in the former research, this inquiry benefitted from an online and an offline measure. 6 L1, 24 advanced and 22 intermediate level of L2 users of English (L1: Turkish) took part in both experiments.

Kırkıcı firstly administered an unprimed lexical decision task in which the items appeared on the screen for 600 milliseconds. Participants' reaction times as well as responses were measured. Experimental items were 52 inflected verbs divided into two groups (regular vs irregular) each of which had two sub-groups (high frequent vs low frequent). Each group and sub-group had equal number of items. The results displayed a moderate – not significant though – effect of frequency only on the L1 groups' reaction times to irregulars. Given the small number of participants, the lack of statistical significance was not considered counter-evidence for the Words and Rules Theory. Surprisingly, no effect of frequency was observed in the high proficiency L2 group in their reaction times to either regular or irregular verbs. On the other hand, both regularity and frequency conditions affected reaction times given by the low proficiency groups.

L2 results obviously did not fit the predictions of the dual-mechanism models or connectionist accounts. In agreement with Beck (1997), Kırkıcı attributed his findings to the influence of instructed and explicit L2 acquisition referring to the sessions dedicated to the memorization of the past tense forms of verbs. Interestingly, this study provided supportive findings of Zobl's (1998) above-mentioned claims about proficiency unlike Kırkıcı (2002) which turned out to largely uphold the Words and Rules Theory.

The offline experiment was an elicited production task in which the same participants were asked to answer questions by compounding nouns (e.g. *What do you call a person who eats mice?*) in written forms. The rationale was to test if there was a differential treatment of regular and irregular forms within compound nouns and if there was an effect of proficiency. The stimuli consisted of 25 nouns (14 regular plural nouns and 11 irregular plural nouns with various features). As expected, L1 group never pluralized regular nouns within compounds, which was not the case for the irregulars. Separate analysis of L2 groups also yielded that L2ers made the regular-irregular distinction. A deeper look revealed that high proficiency group rarely pluralized regulars (13,9%) but often preferred the plural forms of irregulars (64,6%) with a significant difference. The same trend was valid for the low frequency group with higher percentages (59,4% regular, 72,7% irregular) and a significant difference. Therefore, the offline results fully supported the model at issue. Additionally, group comparisons exhibited significant effect of proficiency and strengthened the claims related to the employment of rules as a result of the overall linguistic improvement.

2.2.2.5. Hahne et al. (2006)

Behavioral and ERP experiments were implemented to manifest additional evidence from various sources about how regulars and irregulars are processed by L2ers. Two elicited production tasks were supplemented by two ERP experiments in German participle inflection and plural nouns. 18 advanced L2ers of German (L1: Russian) participated in all the experiments.

As it was explained before, past participle formation in German is possible with the addition of *–t* suffix to regular verbs and *–n* suffix to irregular verbs. In the experiment, a typical nonce word production task was conducted. Participants were asked to form the past participle forms of nonce verbs given in the infinitive simple past tense form in a sentence. They were presented 40 sentences in total with four experimental conditions: i.) close similarity to regulars, ii.) mixed inflectional pattern, iii.) close similarity to irregulars, and iv.) non-rhyming irregular nonce verbs. The results displayed a strong tendency to use regular *–t* suffix for all types of nonce verbs compared to the *–n* participle that was hardly ever applied. The results agreed with the anticipations of dualist models and Clahsen (1997) that obtained parallel results with native speakers of German.

In the first supplementary ERP experiment, participants were asked to read sentences word by word on a computer screen. The sentences included four types of verbs: i.) regular participles, ii.) incorrect regular participles, iii.) irregular participles, and iv.) incorrect irregular participles. Each word was presented for 700 milliseconds in yellow letters. After 10 sentences, a probe sentence was presented in red letters and the task was to decide if it was a repetition of one of the previously presented 10 sentences. ERP data also showed a clear regular-irregular distinction; whereas irregularization yielded an evident centrally distributed negativity (between 450- 600 ms.), regularization manifested itself in a small parietal positivity (between 600 – 1000 ms.).

The second behavioral experiment focused on the pluralization of nouns in German. German has a zero plural form and four overt plural suffixes (*-e, -er, -(e)n,* and *-s*). This experiment compared the application of the least frequent and productive suffix *–en* (presented as irregular suffix in the study) to the most frequent and productive one *–s* (referred to as the regular suffix) in nonce words. It was an offline acceptability judgment task in which participants were asked to rate sentences including monosyllabic items in two conditions: (i) similarity to the existing irregular forms, and (ii) non-rhyming with irregular nouns in German. The results showed that–n endings were rated higher for the nonce words rhyming with genuine irregular nouns in German, but –s suffix got the higher ratings when there was not such a similarity. This kind of dissociation was interpreted as indicative of the parallelism with previous studies (e.g. Marcus et al., 1995) supporting the dualist models in L1.

The second ERP experiment had a similar design differing in that the sentences were presented auditorily and probe sentences emerged after eight sentences following a warning tone. They decided if they had listened to the probe sentences before. Sentences included a total number of 96 critical items forming correct and incorrect plural nouns with regular and irregular suffix. Significant results were found in the analysis of morphological violations: regularizations elicited a late positivity which was identified as a P600, but a clear negativity was yielded in in both early and late occurring electro waves in N400-like waveforms for the irregularizations. The results were considered as a reflection of the validity of the Words and Rules Theory in L2 due to the similarities of findings to L1 experiments employing the same methodology (Weyerts et al., 1997; Lück et al., 2001).

In brief, very contradictory findings have been obtained in the attempts to relate the claims of the leading dual-mechanism model, the Words and Rules Theory- to L2 morphological processing. The majority of the results pointed out L1/L2 differences (with notable exceptions such as Hahne et al., 2006) but it was obviously impossible to go one step beyond to identify potential variables of L2 processing (e.g. proficiency, frequency, learning environment and the like) that were alleged to play roles in L2 acquisition.

2.2.3. Similar Priming Patterns in L1 and L2 Processing

L2 morphological processing literature incorporates a set of empirical research that proposed the idea that the same principles are activated in L1 and L2 processing to a similar degree in the sense that both groups employ procedural and declarative memory on the relevant conditions in the same vein (cf. Hahne et al., 2006). In other words, it is asserted that language determines the course of L1 and L2 morphological processing irrespective of form or meaning if the rules are applicable. Associative links are as frequent for L2ers as they are for native speakers. Qualitative and quantitative differences of processing among L2ers are attributed to the level of proficiency with a positive correlation. The results have not been conclusive to reach a full-fledged hypothesis, yet, these studies have been considerably debatable among the psycholinguistics community as a result of the contradictory findings with the evidence provided by the SSH proponents although similar methodologies were exploited. Short summaries of the most peculiar research maintaining the above-stated suggestions are provided below.

2.2.3.1. Feldman et al. (2010)

To compare the recognition of regular and irregular verb forms in L1 and L2 English, the authors conducted two experiments employing different priming paradigms. Primes were regular past tense forms (e.g. helped- HELP) or two types of irregular past tense forms that differed in preserving the length of the prime (e.g.fell – FALL vs teach- TAUGHT). The experimental group held Serbian as L1 that constituted a specific focus on the effect of such a highly inflected language with a systematic correspondence between phonemes and graphemes compared to the frequently investigated languages such as German or English.

The first experiment was a masked-priming lexical decision task (48 ms.). 53 L1 and 148 L2 participants rating themselves as "overall good in English" completed the task, which included orthographically related and completely unrelated prime-target pairs in addition to three types of inflection as the morphology condition. In contrast with previous studies, no interaction between prime and verb type was observed in the L1 group. As for the L2 group, although facilitation in regular inflection was significant relative to the unrelated condition, comparing sub-groups of the morphology condition in terms of the magnitudes of facilitation did not yield significant results. An analysis including only a sub-group of the least proficient participants replicated Silva and Clahsen (2008) with no facilitation in regulars, this did not generalize to high proficiency group or overall comparisons of L1 and L2 groups. In short, no fundamental L1/L2 differences in facilitation across inflected forms were observed.

Seeing no significant differences between the facilitations in morphology and orthography conditions, the authors needed to circumscribe the contribution of formal overlap yielded in the first experiment. A cross-modal priming experiment that was conceived to be "semantically attuned and less dominated by word form similarity" (p. 128) was conducted in which primes were auditory and targets were presented visually. Except the presentation of the primes, all other aspects of the experiments were identical. 45 L1 and 99 L2 participants (with the same self- ratings as in Experiment 1) were employed. L1 speakers showed a morphological facilitation and orthographic inhibition related to the unrelated conditions, but the interaction between the verb type (regular vs. two types of irregular forms) and prime failed to reach significance, once again. Orthographic inhibition was not the case in the L2 group but morphological facilitation was found. Moreover, there was an interaction between verb types and prime, with only regular forms having fully reliable facilitation effect.

The results were obviously striking. They provided evidence for the decomposition of regular forms in a second language irrespective of the priming paradigms. The absence of the priming effect across regular and irregular conditions posed a substantial challenge to dual-mechanism models of morphological processing as well as the claims of the SSH referring to the use of non-grammatical information for regular forms. Moreover, except for regulars, the tendency to attach considerable importance to proficiency was disputed.

2.2.3.2. Diependeale et al. (2011)

To account for how potential L1/L2 processing disparities, another study involving three psycholinguistic experiments was conducted. It aimed to provide a detailed test of differences within the L2 group so participants were classified according to age of acquisition, age of relative proficiency, comprehension and reading skills, and length of exposure to the L2. 65 L1 participants and two groups of L2 users of English were tested in three experiments: 66 Spanish and 65 Dutch learners. Priming in transparent and opaque conditions were measured against formal overlap. As opposed to previous studies (e.g. Silva & Clahsen, 2008), experimental items were not limited to a particular suffix.

The first experiment was meant to be a baseline to verify the findings of L1 literature regarding the significant priming in transparent and opaque items compared to orthographic relatedness and a weak advantage of transparent pairs over opaque ones. A masked-priming experiment (SOA: 53 ms.) displayed a convergence with earlier findings: significant priming was produced for transparent and opaque conditions but not for the form condition relative to unrelated pairs. However, when the magnitude of priming was compared, the results were partially unexpected: significantly larger facilitation was observed for transparent items than the opaque pairs, but no significant difference was found in the comparison of opaque and form conditions. The results supported the debatable meta-analyses provided in Feldman et al., 2009 and Rastle & Davis, 2010. Nonetheless, the baseline for the following experiments was limited to the significant morphological effects with both transparent and opaque items.

Spanish learners of English participated in the second experiment that was identical to the former task. Participants were reported as highly proficient leaners of English. The statistical analyses exhibited a similar priming pattern to that of the first experiment. Priming effects were seen in the transparent and opaque conditions. Yet, there were remarkable divergences, as well. There was a significant priming effect in the form condition. Moreover, no significant differences were observed in the comparisons of priming effects for either transparent and opaque conditions or opaque and orthographic conditions.

The final experiment comprised the same methodological aspects except the participants. Dutch L2 learners of English with a later age of acquisition (11,92 years) and less exposure (7,18 hours per week) to English than the Spanish participants (7,8 and 11,99 respectively). The results replicated the graded priming pattern; facilitation effect was biggest in the transparent condition and smallest in the orthographically related pairs with the intermediate effect in the opaque condition. Again, no differences between the comparisons of transparent and opaque, or opaque and form conditions were yielded. Furthermore, orthographic relatedness produced a priming effect in this experiment, too.

This study displayed a similar priming pattern to a similar extent in L1 and L2 although divergences were still available in lower levels of L2 proficiency. In this sense, a developmental pattern in L2 processing was put forth with a general assumption that processing in L2 was determined by linguistic information as opposed to the SSH. Besides, it suggested a greater reliance on the formal aspects of the language in L2 processing, which was tested and verified by Heyer and Clahsen (2015) as explained above. Also, it could be induced that the absence of the difference in priming effect between transparent and opaque items addressed to the indifference to meaning at the early stages of processing, hence the applicability of form-then-meaning account in L2.

2.2.3.3. Coughlin & Tremblay (2014)

The researchers referred to the inconsistent findings and inductions in L2 morphological processing and aimed to contribute to the literature in the decomposition of inflections in L2 and the effect of proficiency. It examined the decomposition of verbs with the first-person-plural affix *–ons* in French (e.g. donnons (we give)) by L1 and English L2 users of French to eliminate L1 effect since English does not have a counterpart of the relevant morpheme. The mean score of the L2 proficiency test reflected an intermediate level (23.8 out of 45) ranging from advanced (37) to elementary (11).

30 L1 and 30 English learners of French participated in a masked-priming word-naming task (SOA: 50 ms.). They were instructed to read aloud the target words that remained on the screen for 750 milliseconds. In addition to the above-stated morphological condition, four prime types were presented; identity, orthographically related, semantically related, and unrelated. The results showed full morphological priming for both groups. Analyzing L2 group's performance based on the proficiency level displayed an increase in the priming effect as a consequence of an increase in proficiency. Another similarity in L1 and L2 groups was seen in the orthographic condition; partial priming effects (relative to the unrelated condition) was found in both groups. Unlike morphological priming, it was not modulated by proficiency. Lastly, no semantic priming effect was revealed in L1 or L2.

The results turned out to support the claim that L2 learners employ the same (linguistic) mechanisms to process regular inflectional morphology in contrast with the SSH. It was also suggested that there was a positive correlation between morphological priming and overall proficiency. Besides, structural differences between L1 and L2 were considered not to play a major role in L2 processing.

2.2.3.4. Foote (2015)

Foote aimed to examine the role of type of inflection and proficiency in L2 processing. The second goal was to expand the L2 morphological processing research to a morphologically rich language like Spanish. For this purpose, 20 L1 and 40 L2 users of Spanish (L1: English), who were equally classified as advanced or intermediate learners, were recruited to take part in two experiments.

Two masked-priming lexical decision tasks (SOA: 50 ms.) were completed by L1 and L2 participants. Both tasks contained 5 conditions: (i) morphology, (ii) form,

(iii) meaning, (iv) identity, and (iv) unrelated. Tasks differed only in the content of the morphology conditions. Task 1 involved third-person singular inflection of present tense forms (e.g. cante – CANTA (he sings – TO SING)), and feminine forms of adjectives (e.g. tonto – TONTA (silly-fem - SILLY)) were utilized in Task 2. Lexical decision tasks were followed by supplementary semantic rating tasks in order to verify the assumption that prime-target pairs in the third condition (meaning) were semantically related. Participants were asked to rate in a five-point likert scale how related the pairs in the third and fifth (unrelated) condition were.

Analyses of the semantic rating tasks agreed with the judgments of the researchers in terms of (un)relatedness; participants rated items of the meaning condition rather positively and unrelated pairs negatively. Advanced learners' judgments were very similar to those of natives although participants in the intermediate group showed a relatively smaller magnitude of difference between related and unrelated pairs.

The results from the lexical decision tasks displayed a similar pattern on accuracy: intermediate learners were significantly less accurate whereas no difference was found between native and advanced participants. The results were replicated in the second task, which exhibited no effect of the type of inflection. As for the response times, only a significant effect of prime type was observed with no interactions. Orthographically and semantically related prime-target pairs did not yield any significant facilitation; on the other hand, morphologically related items produced full priming. The results did not differ in tasks and participant groups; hence no effect of proficiency, L1, or type of inflection.

In sum, the results proved to be supportive of the assumption that L2 learners benefit from the same representations and strategies in morphological processing as L1 users; nevertheless, the absence of facilitation in the form condition and a developmental pattern was remarkably suggestive considering the claims of the seminal works (e.g. Diependeale et al. (2011).

2.2.4. Neuropsychology of L2 Morphological Processing

As stated above, L2 studies from various perspectives tended to build their hypotheses on solid L1 bases. The goal has mostly been to converge on the L1 performance that reflected well-defined grammatical or processing rules. Due to the absence of consensus in all aspects of the process, this has not been the case for morphological processing, yet. This unfortunate state of the research area has manifested itself with even more disadvantages in the investigations into the neuroimaging of L2 morphological processing. Nevertheless, L1 literature of a very limited number of studies with appropriate methodology provided some hints regarding the location of morphology and activated areas on a temporal basis. These findings enabled L2 researchers to make comparisons even though we are still far away from gaining ground on L1 outcomes. As might be expected, there are not plentiful neuroimaging studies that specifically focused on this area of inquiry taken together these handicaps. Indeed, reviews covering the L2 products in such a new area did not lay any emphasis on the studies on morphology (e.g. Kovelman et al., 2008; Sabourin, 2014; Van de Putte, 2018). Below is a report of studies with substantial contributions to the relevant literature.

2.2.4.1. Lehtonen et al. (2009)

The underlying pre-assumption of this study was the opposing view with respect to the universality of lexical processing. Referring to the previous studies on the processing cost of inflected nouns in Finnish and Swedish (Ahlsen, 1994; Lehtonen & Laine, 2003), the researchers concluded that Finnish inflected nouns were decomposed into constituent morphemes, which was not true for their counterparts in Swedish. Classifying these two languages as structurally different in this sense, they examined whether neural evidence for differential representations of inflected words could be obtained from participants with a high command of both languages.

16 participants (L1: Finnish, L2: Swedish), who were considered bilingual because they acquired both languages before starting school, were recruited in an unprimed lexical decision task. The materials consisted of inflected and monomorphemic nouns in both languages, and nonce words. The task was completed in two sessions divided according to the language of the content; Finnish and Swedish tasks. Correspondingly, participants were instructed to make their decisions regarding the availability of the letter strings displayed on the screen in the certain language of the session. The maximum response time was 2 seconds. Along with the scans of neural correlates (TR: 3 seconds), response times to items were measured in a block-design fMRI experiment. It included 34 task blocks spanning for 30 seconds in each session.

The error rate criterion of 15% was not exceeded by any participants with a mean accuracy rate of 97,3%. No difference between the performance in language-based sessions was reported. On the other hand, significant main effects of language and morphological structure were found in the analysis of reaction times. It was shown that Finnish words received longer reaction times than Swedish words; besides, overall reaction times to inflected nouns were longer than simple words. What is more, no difference was seen in the reaction times to inflected nouns and monomorphemic words in Swedish. These findings were presented as evidence for the processing cost in Finnish inflected nouns unlike those in Swedish.

As for the fMRI results, whole-brain analysis reflected the behavioral differences in the brain activation. No significant activations were found for the processing of inflected nouns in Swedish compared to monomorphemic words in the same language. Conversely, left-inferior cortex (BA 44) exhibited more activation as a reaction to Finnish inflected nouns than other complex or simple lexical items in Finnish and Swedish. Region of interest analysis replicated the same neural patterns with specific activation peaks for left fusiform gyrus, left-inferior frontal gyrus, and anterior insula.

The study suggested that structural differences between languages were elicited in the behavioral data and diversified magnitudes of brain activations within the same individuals holding both languages. The inferences should be approached cautiously from the standpoint of L2 morphological processing literature out of two reasons. The study defined itself as an examination of bilingualism, which was assumed to be different from a typical L2 study in many ways. It also did not adopt a standard methodology of morphological processing which aimed to separate morphology from the linguistic (e.g. phonology, orthography, and semantics) and non-linguistic (e.g. episodic memory, domain-general information processing strategies) confounding factors. Nevertheless, it proved to be of significance because it confirmed previous neuropsychological L1 findings and aimed to compare brain activation patterns in two languages in the most controlled way possible.

2.2.4.2. Pliatsikas et al. (2014a)

In extended versions of the Declarative Procedural Model, Ullman recognized the role of cerebellum in grammatical processing as a part of the procedural network (2004). Neurolinguistic studies on healthy and aphasic populations provided supportive evidence in L1 processing (e.g. De Smet et al., 2013; Marvel & Desmond, 2012). Ullman also claimed that although late L2 acquisition could be detrimental to proceduralization, it would be possible to reach native-like competence as a result of naturalistic exposure and experience in L2 rather than classroom practice. This study aimed to reveal structural changes in the brain in parallel with the activation of procedural network in L2. As most of the studies on the dualist model did, the phenomenon examined by the researchers was the regular-irregular distinction.

22 L1 and 17 advanced L2 users of English (L1: Greek) who resided in the UK for an average of four years participated in a masked-priming lexical decision task (SOA: 35 ms.). Experimental items were regular and irregular past tense forms of verbs and unrelated prime-target pairs as the baseline. Along with the response time measures, whole-brain images were acquired with TR sequences of 2,020 milliseconds. Whole-brain analysis was run to check if there was an increase in the grey matter located in the cerebellum reflecting the application of grammatical rules.

The groups did not differ in terms of accuracy rates. No information was provided about the facilitatory effect of the regular and irregular conditions but correlations between the reaction times to these two conditions and grey matter volume in the cerebellum were established. No significant correlation was observed in the analysis of the L1 group. As for the L2 group, the results showed only a negative correlation for the regular condition but no other significant correlation was found for the other conditions (irregular, regular unrelated, irregular unrelated). The reactions to regular pairs were faster; therefore, the decrease in the reaction times was attributed to the utilization of linguistic rules. Correspondingly, the application of rules correlated with the increase in the grey matter, hence a negative correlation between a possible priming effect and grey matter volume in the cerebellum. Moreover, adding years of residence in the UK as a regressor into the analysis revealed that naturalistic exposure positively correlated with the grey matter volume in the posterior left putamen.

The findings suggested that learning a second language requires a structural reorganization, therefore, affects the structure of the cerebellum. They also highlighted the importance of naturalistic data on the exploitation of procedural network. Yet, it was noted as a guidance to future studies that limitations in the range and amount of naturalistic exposure did not permit a stronger effect.

2.2.4.3. Pliatsikas et al. (2014b)

The absence of any brain-based research on the claims of the dual-route models about the regular-irregular distinction was underscored and presented as the prominent motivation for an fMRI study in L2. This study aimed to test whether the proposed distinction has its neural equivalents in L1 and late L2 learners of English. It differed from the previous studies explained above in that it directly focused on the activations in the brain regions that Ullman (2004) argued underlay the processing of regular inflection, namely the LIFG, basal ganglia and the cerebellum.

The participant group recruited in Pliatsikas et al. (2014a) participated in this experiment, too. L2 participants were advanced and late learners of English (mean age of onset of acquisition: 7 years 7 months). A masked-priming lexical decision task (SOA: 33 ms.) was prepared with four conditions: regular related (e.g. played – PLAY), regular unrelated (e.g. fork - PLAY), irregular related (e.g. kept -KEEP), and irregular unrelated (e.g. fork - KEEP) prime-target pairs were used as experimental items. Together with the accuracy and response time data, MR scans were collected with TR sequences of 2 seconds.

Both groups reached above 95% accuracy rate with no significant difference. Similarities were also seen in the analyses of reaction times because a main effect of prime type was observed in both groups showing that participants were faster in both regular and irregular pairs relative to the unrelated prime-target conditions. As for the region of interest analyses for the processing of regular inflection, no significant difference was found between the L1 and L2 groups with respect to the activation levels of the areas under investigations. Comparisons of related and unrelated regular morphology conditions yielded the activation; correspondingly, involvement of left inferior frontal gyrus in the decomposition of regularly inflected words in both L1 and L2 users. Therefore, the hypothesis that proceduralization would be available to proficient L2 users was supported by means of behavioral and neural evidence.

2.2.4.4. De Grauwe et al. (2014)

This was, to my best knowledge, the first study to investigate the neural correlates of the processing of derived words in L2 that utilized fMRI technology. Because the behavioral evidence for holistic or decompositional processing of derived words is quite mixed, this study was expected to shed new light on the recognition of such lexical items in late L2ers. Another aspect of the originality of the study was that unlike all other behavioral and neural studies on the processing of derivations, it was claimed to involve the first experiment using unmasked priming paradigm.

18 L1 and 21 highly proficient L2 users of Dutch (L1: German) participated in a lexical decision task. Two types of prefix verbs; i.e. particle verbs (e.g. meenemen (take along)) and prefixed verbs (e.g. omvatten (enclose)), served as targets of experimental items. Half of them occurred in the primed condition preceded by their stems, the other half on the unprimed condition on which targets were preceded by their stems after four to six intervening stimuli so that a potential repetition suppression effect could be determined. The stimulus appeared on the screen for 2 seconds or until a response was received in a block-design fMRI study with TR sequences of 2110 milliseconds.

Only accuracy rates were reported in the behavioral results revealing that the task was more demanding for L2ers. They made more errors (5,2%) than native controls (1,5%). Additionally, they made fewer errors to the primed than unprimed complex words. Two types of analyses were run for the fMRI data: whole-brain analyses, and region-of interest analyses of the Broadmann Area 44,45, and 47 that constituted most parts of the left-inferior frontal gyrus (LIFG) gray matter. The results showed that LIFG was less activated for the primed than unprimed complex words in the L2 group whereas no significant difference was observed in the native participants. In agreement with the previous studies on inflections (e.g. Tyler et al, 2005; Lehtonen et al., 2006; Meinzer et al., 2009; Vannest et al., 2011; Bozic et al., 2013), whole-brain analyses also displayed the involvement of left or bilateral posterior superior temporal gyrus or superior temporal sulcus in the processing of derived verbs in both L1 and L2.

The results clearly displayed a repetition suppression effect in LIFG for L2 processing of derivationally complex words. Additionally, considering the activation of above-stated other areas associated with phonology supported the morpho-phonological processing accounts. On the other hand, parallel activation patterns in both derivations and inflections posed a remarkable challenge to dual-mechanism models as well as the SSH.

2.2.5. A General Evaluation of L2 Morphological Processing

The second part of this chapter covered the salient studies investigating how complex words are recognized by L2 users. Unlike L1 literature, it is not possible to argue that decisive arguments were presented or indisputable conclusions were reached. As it was done above, major questions are presented to attempt to provide the most updated answers given what the studies have found out.

a.) What is the most explanatorily powerful approach to morphological processing in L2?

It is not even reasonable to attempt to give a satisfying answer to this question because of a practical reason. Only one hypothesis seems to have attained the complete status of being a model in L2 processing (the Shallow Structure Hypothesis). Although no alternative model is yet to be proposed, the literature abounds with findings going counter to the predictions of the SSH.

b.) Does morphology play an independent role in the mental representation and processing of morphologically complex words in L2?

It is unknown. Several studies revealed decomposition pattern at the initial stages of lexical recognition without any priming effects of orthography or semantics. Other studies, however, claimed to reach the signs of the determining effect of orthography in the facilitation of lexical processing in L2. On the other hand, some researchers assumed that pure grammatical analyses are to a great extent replaced with semantic or non-linguistic surface-level information in real time L2 processing. All accounts were followed by supportive and non-supportive empirical evidence.

c.) Do different types of affixes have different processing patterns in L1?

The results are totally mixed except irregulars. Similar to the L1 literature, a clear regular-irregular distinction was observed in behavioral tasks. However, derived-inflected distinction proposed by the SSH referring to the lack of grammatical information in derivationally complex words was undermined by other behavioral studies as well as neuroimaging findings that displayed the activation of the same areas in the brain as a consequence of the priming effect in these types of morphemes. Furthermore, the claims about the sensitivity to frequency in L2 morphological processing remains to be doubtful.

d.) Can individual differences account for how morphologically complex words are processed in L2?

We have no idea as to the effect of individual differences in L2 morphological processing on account of the absence of any empirical evidence. It is only known that proficiency level modulates the processing pattern regardless of the morpheme types. Notwithstanding, two caveats should be stated: there exist a limited number of studies exhibiting the same reading patterns for high and low proficiency groups, and no neuroimaging data to verify this assumption have been provided, yet.

e.) Is there a parallelism between the behavioral data and brain responses to morphologically complex words in L1?

As of this moment, the answer is no. Even if counter-evidence is ignored to conclude that there is a main effect of morpheme type in behavioral tasks, most of the studies that examined the neural responses to the reading of derivations and inflections displayed the activations of the same regions, especially LIFG grey matter. Correspondingly, speaking of a discrepancy between behavioral and neural evidence makes sense. Yet, it should be emphasized that the number of neuroimaging studies in this field is quite scarce. In addition, any neuropsychological research directly comparing morpheme types has not been implemented, yet.

CHAPTER 3

ASSESSING BEHAVIORAL PRIMING IN L2 MORPHOLOGY

This chapter reports the findings of the first experiment addressing the L2 morphological processing pattern and its determinants in the light of the behavioral data. It begins with the presentation of the rationale behind (another) priming experiment in L2, which is followed by the relevant research questions and methodological details concerning the research design and materials preparation. Then, the results are discussed with reference to previous research.

3.1. Another Study in L2 Morphological Processing

As was summarized in the second chapter, the picture depicted regarding morphological processing is getting blurred in the transition from the scope of L1 to L2 research. It is possible to mention some well-agreed issues in the L1 literature such as the evident role of morphology, the impact of individual factors and the *form-then-meaning* account in lexical processing. On the other hand, there is little consensus in the debates surrounding the recognition of morphologically complex words in L2. Leaving aside the neural investigations, it is hard to attribute the aforementioned disagreements to the scarcity of the number of behavioral experiments considering the fact that only the most representative studies were presented in the review of the literature of this thesis. The endeavors fading into obscurity entailed the assessment of the research area from various perspectives to be supported by empirical evidence.

The experiments implemented in this thesis aim to identify the magnitude of the effect of three potential factors in L2 morphological processing to contribute to the formation of a model that could clarify the discrepancies among the proponents of different L2 accounts. First of all, it is argued that testing the most frequent morpheme types (regular inflections, irregular inflections, and derivations) under the same testing conditions could enable the most accurate comparison possible. In this way, robust evidence is likely to be presented regarding whether different processing patterns are found in L2 based on the morpheme types. Secondly, individual differences are well worth the attention, especially after they were found to modulate L1 morphological processing patterns (e.g. Andrews & Lo, 2012). That is why this thesis considers individual differences a significant candidate for the development of a perspective to account for why a good number of previous L2 morphological processing studies ended up with a pure confusion. In parallel with this insight, the most relevant individual differences to visual word recognition are included as separate variables in the evaluation of the L2ers' performance. Lastly, incorporating a time-course priming experiment and hemodynamic responses to the same input can make way for the disentanglement of the muddle about not only the temporal and neural accounts of L2 morphological processing but the debatable effect of the testing conditions on the reaction times to morphologically complex words, as well.

A behavioral and a neural priming experiment were conducted to provide evidence about the extent to which the variables listed above could modulate L2 morphological processing. This chapter reports the behavioral experiment so the research questions fully or partially specific to the first experiment are repeated below:

- Do L2 speakers decompose morphologically complex words at an early phase of recognition? Do their processing patterns vary according to types of morphological structures?
- Do L2 speakers' early morphological processing patterns correlate with the hemodynamic brain response patterns?
- To what extent do individual differences modulate the processing patterns of L2 speakers?

3.2. Experimental Methodology

A masked-priming visual lexical decision task was implemented in order to measure participants' reactions to monomorphemic words following certain types of morphologically complex lexical items. The task was to discriminate between existing and nonce words in L2 English that appeared on a computer screen by pressing the appropriate button on a response box as fast and accurate as possible. As in the previous studies that adopted the same methodological paradigm, reaction times (RT) to words (targets) appearing immediately after other lexical items (primes) were considered to be suggestive as to the lexical processing depending on the degree of relatedness (ranging from fully transparent to unrelated) between prime-target pairs.

A masked-priming design was preferred because of its advantage in ruling out retroactive effects[2]. The lexical decision task was followed by a series of follow-up paper-and-pencil tests to make sure that participants had a good command of the meaning and morphological properties of primes and targets. Besides, standardized tests were administered in order to determine participants' levels of overall L2 proficiency and spelling accuracy, as well as vocabulary knowledge size in English. In this part of the chapter, detailed information is provided about the content of each task utilized in the behavioral assessment of L2 morphological processing.

3.2.1. The Lexical Decision Task: Materials and Design

An equal number of 24 prime-target pairs were prepared for six conditions of the masked-priming experiment as given below:

a.) morphological relatedness by means of derivational inflection: The suffix –al was utilized for the preparation of the derivationally-related primes. It is relatively productive in both of its functions: forming nouns from verbs (e.g. refusal, arrival) and forming adjectives from nouns (e.g. personal, national) but fully satisfying in terms of the predictability criterion (Carstairs-McCarty, 2002; pp. 51-53, 88). Due to the relatively larger extent of the orthographic change in many of the complex words derived from the first function of this suffix (e.g. survival, denial), all the primes used were adjectives derived from a monomorphemic noun (e.g. magical – MAGIC, herbal - HERB). [3]

b.) morphological relatedness by means of regular inflection: The past tense morpheme –ed, which is fully productive, was used to form primes of this group. All the items derived from monomorphemic stems with past tense meaning (e.g. offered – OFFER, helped - HELP).

c.) morphological relatedness by means of irregular inflection: Irregular English verbs in the past participle form that were inflected out of monomorphemic stems were used to form primes of this condition (e.g. taught– TEACH, broken - BREAK). Because the number of shared letters between primes and targets is assumed to matter in the visual word recognition process, irregular verbs

[2] See Chapter 1.5 for detailed information about masked-priming paradigm.

[3] See Appendix A for the experimental items, fillers and nonce words.

with no formal overlap (e.g. was/were – BE, went - GO) were not included in this list regardless of how frequent they are.

d.) semantic relatedness: In order to test whether any possible priming effect is caused by a pure meaning-based relationship between primes and targets, prime-target pairs which are neither morphologically nor orthographically but only semantically related[4] formed experimental items of this condition (e.g. picture – PHOTO, rule - LAW).

e.) orthographic relatedness: To test the claim that early lexical processing is solely form-driven (e.g. Heyer & Clahsen, 2015), prime-target pairs holding formal associations with no morphological or semantic relatedness were included in the experiment (e.g. grammar – GRAM, wild - WILL).

f.) opaque condition (pseudo-morphological relatedness): Due to the fact that dissecting semantic relatedness from morphologically-related conditions is impossible in English, the final condition was created in order to test whether any possible decomposition pattern was blind to the semantic effect. It consisted of primes including potential morphemes in English and their suppositional roots as targets with no meaning-based associations (e.g. irony – IRON, corner - CORN).

As a sub-component of each condition, an unrelated condition included the same primes that appeared before the targets of the items of the six conditions given above. Unrelated primes did not share any semantic, orthographic or morphological relationship with their targets. Neither did they include any letters in the same positions with their targets (e.g. abrupt - MAGIC). In addition, a list of identity primes, in which the prime-target pairs were identical (e.g. magic - MAGIC), was also employed. These baselines were created to enable the researcher to compare the extent of the facilitation in the recognition of targets on relevant conditions. Below is a table summarizing the content of the experimental conditions and their identity and unrelated counterparts.

Given the evident effect of frequency, length, and formal overlap between lexical items in the course of visual recognition, the matching of primes and targets in the sub-

[4] Semantic (un)relatedness in the 4th, 5th and 6th conditions as well as in the fillers was determined by means of a technique called latency semantic analysis (LSA) that analyzes conceptual relationships between lexical items. A user-friendly interface was brought into use in the website http://lsa.colorado.edu/.

Table 1: The Stimulus Set of the Lexical Decision Task

Condition	Prime	Target	Unrelated	Identity
Derivational	normal	NORM	year	norm
Regular Inflectional	died	DIE	hat	die
Irregular	flown	FLY	sour	fly
Semantic	movie	FILM	plane	film
Orthographic	truth	TOOTH	lemon	tooth
Opaque	country	COUNT	register	count

groups of the experimental conditions is essential. Correspondingly, the matching criteria determined by Jacob et al. (2018) were adopted in this study.

a.) Two analyses of variance (ANOVAs) showed that types of prime-target pairs with morphological relatedness (derivational, regular inflectional and irregular) were matched in length and frequency of occurrence as given in Table 2.

b.) Separate ANOVAs revealed that unrelated primes of morphological relatedness conditions were matched with their targets in length and word form frequency. Table 3 and 4 provide descriptive and inferential information about these items.

Table 2: Mean Length and Frequency in Morphological Relatedness

Condition	Length	Frequency (per million)
Derivational	6,96	39,67
Regular Inflectional	6,41	35,63
Irregular	6,47	33,38
p value	,318	,864

Table 3: Mean Length of Unrelated Primes and Targets in Morphological Relatedness

Condition	Prime	Target	Significance
Derivational	4,67	4,79	,746
Regular Inflectional	4,7	4,75	,898
Irregular	5,08	5,16	,857

Table 4: Mean Frequency of Unrelated Primes and Targets in Morphological Relatedness

Condition	Prime	Target	Significance
Derivational	74,6	71,3	,867
Regular Inflectional	39,5	37,1	,816
Irregular	28,4	29,1	,913

c.) Semantically related primes and their unrelated counterparts were matched in length and word form frequency. As Tables 5 and 6 display, the same matching was observed for overlap and opaque conditions.

Table 5: Mean Length of Related and Unrelated Primes in Semantic, Overlap and Opaque Conditions

Condition	Related	Unrelated	Significance
Semantic	6,75	6,63	,790
Overlap	6,33	6,46	,749
Opaque	6,92	6,79	,679

Table 6: Mean Frequency of Related and Unrelated Primes in Semantic, Overlap and Opaque Conditions

Condition	Related	Unrelated	Significance
Semantic	35,2	34,9	,986
Overlap	34,2	36,4	,854
Opaque	34,3	40,8	,678

d.) Mean length and word form frequency of primes in morphological relatedness (the combination of derivational, regular inflectional and irregular) (6,6 and 36,2 per million, respectively) were observed to match with those of primes in semantic, overlap, and opaque conditions by means of separate ANOVAs as shown in Table 7.

Table 7: Mean Length and Frequency of Primes in Semantic, Overlap and Opaque Conditions

Condition	Length	vs. Morphology	Frequency	vs. Morphology
Semantic	6,75	,596	35,17	,909
Overlap	6,33	,341	34,17	,835
Opaque	6,92	,203	34,25	,867

e.) Mean length and word form frequency of targets in morphological relatedness conditions (the combination of derivational, regular inflectional and irregular) (4,9 and 47,5 per million, respectively) were matched with those of targets in semantic, overlap, and opaque conditions by means of separate ANOVAs as shown in Table 8.

Table 8: Mean Length and Frequency of Targets in Semantic, Overlap and Opaque Conditions

Condition	Length	vs. Morphology	Frequency	vs. Morphology
Semantic	5,13	,349	46,25	,932
Overlap	4,75	,967	45,46	,766
Opaque	4,42	,904	42,67	,787

f.) Orthographically related prime-target pairs were matched with morphologically related items with respect to absolute [$t(94) = 0{,}918$ $p = .677$] and spatial [$t(94) = 1{,}132$ $p = .261$] overlap.

For the purpose of keeping participants naïve with respect to the ultimate goals of the task, twice as many filler items as experimental items (n. 288) were added to form the ultimate number of the prime-target pairs of the task in each list (n. 432). Out of the 288 fillers, 72 pairs contained a real word as a target while the target words in the rest of the items (n. 216) were nonce words[5] to keep the number of "Yes" and "No" responses equal. In parallel with the items of the morphological relatedness conditions, half of the fillers had adjective-noun pairs as primes and targets, and the other half with verb-verb pairs. Primes of these groups were matched with one another in length [t(34) =,000 p= 1] and word form frequency [t(34) =,058 p=,954], so were their targets [t(34) = -,294 p =.771 and t(34) =,178 p=.860 respectively]. Half of the fillers with "Yes" response (n. 36) and 36 of the targets with "No" response were followed by a genuine word in English as a prime whereas the rest of the filler items (n. 216) had fake words in their primes. Therefore, both primes and targets in the whole experiment list had equal number of genuine and nonce words. Nonce words that were employed as primes or targets were in line with the orthographic and phonological rules of the target language, so they were considered to be potential English words.

In order for the participants to encounter each target only once, three lists were prepared in a Latin square design. The lists were pseudo-randomized owing to two considerations: to hinder semantic or formal associations among the targets and following primes for at least three consecutive prime-target pairs, and not to present more than three experimental items of the same condition in a row. Therefore, each list contained 144 experimental and 288 filler items. Each list was reversed to eliminate possible fatigue effects, hence a total number of six lists.

3.2.2. Participants

A total of 122 (73 female and 49 male) L2ers of English participated in the behavioral experiment. 10 of the participants were invited to take only the lexical decision task in the piloting stage whereas the rest (n. 112) of those in the participant pool additionally completed the follow-up tasks and placement tests for the identification of overall proficiency in English and individual differences. They were all students at various departments of Middle East Technical University in the Ankara campus at the time of testing. Their ages ranged from 18 to 26 with an average number of 20,7 (SD: 1,42). According to their ratings in the Language Background Questionnaire[6] that they completed prior to the lexical decision task, participants' mean score of overall use of L2 (English) in daily life was declared to be 32,1 percent,

[5] Nonce words were obtained via ARC Nonword Database. For detailed information about the website of the database: http://www.cogsci.mq.edu.au/research/resources/nwdb/nwdb.html
[6] See Appendix B.

hence less frequent than their L1. As summarized in the table below, separate looks at language skills enabled the researcher to observe such a high gap in the allocation of the use of English to four skills, as well.

Table 9: Participants' Use of English in Daily Life

Language Skill	Average	SD	Min.	Max.
Speaking	19%	11%	1%	65%
Listening	33%	12%	10%	75%
Writing	41%	23%	5%	95%
Reading	46%	19%	5%	95%
Overall	32,1%	12%	6%	70%

Participants unexceptionally stated that their onset of exposure to English started at school whereas they all started to learn Turkish from birth. No participant lived in a country with a majority of native English speakers for more than 5 months. In addition, none of the participants reported themselves as bilingual. They participated in the tasks in exchange for a small fee or course credit.

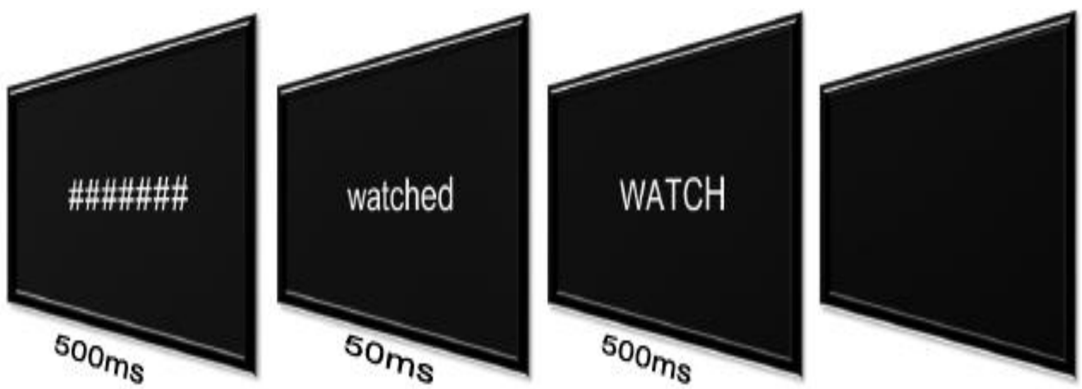
3.2.3. Procedure

As was previously mentioned, a masked-priming visual lexical decision task was administered to L2ers of English. As for the presentation of the stimulus, each item set started with a blank screen that appeared for 500 milliseconds (ms). The blank screen was followed by masks of hash symbols (#) for another 500 ms. The number of (#) signs corresponded to the number of letters in primes that appeared for 50 ms, in other words, the SOA of the lexical decision task was 50 ms because this length of exposure for the prime words was used in a number of seminal experiments in the L1 (Andrews & Hersch, 2010; Andrews & Lo, 2012, 2013; Medeiros & Dunabeitia, 2016) and L2 literature (e.g. Kırkıcı & Clahsen, 2013; Coughlin & Tremblay, 2014; Foote, 2015; Jacob et al., 2017). Immediately after the primes, targets stayed on the screen for 500 ms. in a different case than the primes in order to eliminate the possibility of visual facilitation. See Figure 1 for a scheme of the masked priming paradigm utilized in the behavioral task.

All the visual items were presented at the center of the screen in white letters against a black background in Courier New 18-point size. E-Prime Psychological Software Version 2 (Schneider, Eschman & Zuccolotto, 2002) enabled the researcher to control the experiment and a Logitech gamepad was used for the collection of responses. The experiment was implemented by means of an ASUS laptop with a 15,6-inch monitor.

Before the experiment, participants were informed about their rights to abort the task whenever they wanted to. They were asked to fill out and sign a consent form to declare that they participated in all steps of the experiment on a voluntary basis. They were also asked to state their dominant hands, which would correspond with the "YES" button for each participant. After that, the researcher requested that participants decide as quickly and accurately as possible whether the words they would see on the screen were real words in English or not by pressing either the left or the right button on the gamepad in accordance with their dominant hands. The same instruction visually appeared on the screen in the introductory stage of the task, as well.

Figure 1: Representation of the Masked Priming Paradigm of the Lexical Decision Task



The lexical decision task started with a 10-item practice session to familiarize participants with what was expected in the experiment and to check whether they recognized the primes. At the end of the practice session, they were asked to put a tick on the words that they had encountered so far. It was observed that no participants checked more than one out of 5 prime items, which made the researcher sure that they had not recognized the primes. Before the beginning of the experimental session, they were reminded of the requirements of the task once again and initiated the task when they were ready. One break was given in the middle of the experiment (following question number 216) as a precaution against fatigue and attentional handicaps. Participants were randomly assigned to one of the six lists. The experiment was administered in a quiet room and lasted no more than 20 minutes. When they completed the experiment, participants were asked to orally describe the task and to predict the goal of the study. No participant was able to detect the prime or guess why they were requested to participate in this experiment.

After the lexical decision task, two paper-and-pencil follow-up tasks[7] were completed by the participants to make sure that they had already known the morphologically complex words used in the experiment. The first task contained bare forms of regular and irregular verbs included in the behavioral experiment. Participants were asked to write the past participle forms of each verb given. As for the primes of derivationally complex words, participants took a multiple-choice test to identify the alternatives that were closest in meaning to the bare forms (excluding *–al* morpheme) of these items. Three choices were provided for each item; one of which was considerably related, another one being completely unrelated and the third one with moderate relatedness[8]. Whether or not completing the fMRI experiment, participants were not informed about the overall goal of the experiment until both the behavioral and the neural task were finalized.

An interval of at least two weeks was given before the supplementary tests were administered in order to identify participants' proficiency level as well as to detect individual differences among them with respect to spelling accuracy and vocabulary size. Below, details about the content and development of these tests are provided.

3.2.4. Supplementary Tests

3.2.4.1. Overall Proficiency in L2

As was discussed in the first chapter[9], the accurate identification of proficiency in L2 poses striking challenges due to conceptual and practical concerns. For the purpose of attaining the highest accuracy, all the available sources were utilized to

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[7] See Appendix C.

[8] Scores of relatedness were obtained via LSA that was utilized for the preparation of semantic condition for consistency.

[9] See 1.4.

contribute in the decision phase. Correspondingly, the following formula was considered in the classification of participants according to their level of proficiency:
[(50x Standardized Test Scores) + (50x Self Ratings)]/100 + Bonus for Living Abroad]

i. Participants completed a 40-question standardized multiple-choice cloze test[10] developed by Ionin and Montrul (2010) and used in many studies including Ionin et al. (2011;2012), who reported it as highly reliable (p. 126). The test was a sentence completion task in which every seventh word -except the first sentence- was removed and replaced with three choices. Every correct choice amounted to 1.25 points to reach a maximum score of 50 and the wrong answers were not penalized. The test lasted approximately 15 minutes.

ii. In the Language Background Questionnaire described above, participants were asked to rate their overall proficiency in English as well as their qualification in four language skills on a 9-point likert scale. The sum of the ratings with a maximum score of 45 was proportioned to 30. Plus, the percentage that they stated about the extent of the daily use of English was taken into account with a maximum score of 10. Another 10 points were added to reach 50 on the basis of their self-ratings regarding how comfortable they felt understanding and using English in their daily lives.

iii. Participants were asked to state if and for how long they had ever been abroad. An extra 3 points were added to the sum of (i) and (ii) if they had lived in an English-speaking country for more than 6 months and 1 point if they had lived in other Western European (e.g. Germany, Belgium) or North American (e.g. Canada) countries where English is widely used.

Calculating an overall score out of 100 for each participant was followed by the operation to convert the obtained continuous variable into a categorical one. The median-split technique was run to observe that participants with an overall score above 74 were considered "high proficient" (n. 52) and those with or below 74 were classified as "low proficient" (n. 60).

[10] See Appendix D.

3.2.4.2. Vocabulary Size Test

Considering the previously mentioned L1 studies that sought to correlate vocabulary knowledge with semantic and morphological processing, a supplementary test to measure the vocabulary size of the participants was administered in order to test the same possibility in L2 processing. A multiple-choice vocabulary size test[11] created by Nation (2004) and further developed by Nation and Beglar (2007; p. 9-13) was adopted and implemented. It was designed to measure L1 and L2 written receptive vocabulary size in English. Its original version contained 140 questions with 14 sets of 10 items, each of which belonged to a 1000-word family. The sets ranged from the most frequent 1st 1000 to the 14th 1000 word families in English with gradual decrease in the level of frequency. It was discrete, selective and relatively context independent (Nation, 2007). Empirical evidence was provided regarding its validity and reliability to utilize in L1 and L2 contexts (Beglar, 2010). A more recent version that included 200 questions with 20 sets of 10 items – addressing the first 20.000 word family in English – was adapted in a way to make it completely context-free by removing the sentences where the unknown words were mentioned. The rationale was to create an analogous condition to masked priming paradigm in which participants made lexical decisions on isolated lexical items. Two sets of 100 words were created in a balanced way concerning the frequency of items in each word family. Two forms were reported to have been tested for their equivalence (Nation, 2007). Participants were randomly administered to the versions of the test[12]. The test lasted at most 25 minutes.

Participants were divided into two groups according to their scores on the vocabulary size test as a result of a median split technique, which revealed that those scoring above 51 were in the high vocabulary size group (n. 52) and participants scoring 51 or below were classified in the low vocabulary size group (n. 60).

3.2.4.3. Spelling Recognition Task

Proposals associating spelling ability with orthographic and morphological processing in L1 made way for a further task in this thesis to test its applicability in

[11] The test is freely available on Paul Nation's web page (www.victoria.ac.nz/lals/about/staff/paul-nation#paul_nation_vocabulary_resources_downloads).
[12] See Appendix E.

L2. For this purpose, a spelling recognition task[13] was administered in which participants were asked to circle the words that they thought were incorrectly spelled. The task was created and developed by Andrews and her collaborators, who administered it in many L1 morphological processing studies including Andrews & Hersch, (2010) and Andrews & Lo (2012, 2013), as discussed in Chapter 2. It consisted of 88 words that are highly frequent with a mean score of 32,27 per 1 million in the CELEX database; therefore, the absence of lexical knowledge about the items was quite unlikely to emerge as a confounding factor. Only correct responses were taken into account to calculate the scores. Participants completed the task right after the vocabulary size test in approximately 10 minutes.

The median split technique was run to form two categories based on the spelling ability of participants considering participants' performance on this task. It showed that those with a score above 77 out of 100 (n. 54) turned out to have a high spelling ability while the rest who scored 77 or below were assumed to have a low spelling ability (n. 58).

3.3. Results

Before the implementation of descriptive and inferential analyses, data cleaning was conducted in accordance with the methodological orientation of previous seminal studies in morphological processing (e.g. Diependeale et al., 2011; Silva & Clahsen, 2008). Eight basic steps as given below were systematically taken in both behavioral tasks (i.e. in the lexical decision task and the analysis of reaction times in the neural experiment described in the following chapter) to obtain a homogenized and normally distributed dataset for the following phases of analyses.

- Filler items were deleted from the dataset.
- It was planned that participants who incorrectly responded to more than one fifth of the items would be completely removed from the analysis. However, there was no participant whose accuracy rate for the experimental items was below 80 percent.
- Experimental items which received an average accuracy rate below 60 percent were eliminated from the subsequent processes. As a result of this, three prime

[13] See Appendix F.

target pairs (i.e. brother, deposit, broth – BROTH with 36% accuracy; stubborn, mineral, stub – STUB with 37% accuracy; attitude, property, stance – STANCE with 57% accuracy) were excluded from the analysis.

- Inaccurate answers (“No” responses to the real words) were removed from the data file.
- Responses that exceeded 2000 milliseconds were excluded from the analysis.
- It was planned that if the mean RTs of any of the participants or experimental items exceeded or were smaller than the sum or extraction of the mean reaction time (753 ms.) and the twofold of the standard deviation value (228 ms.) of the remaining items (i.e. longer than1209 ms. or shorter than 259 ms.), they would be deleted from the dataset. Item-based and individual-based analyses showed that
    i. there was no item with an RT below 259 ms.
    ii. there was no participant whose mean RT exceeded 1209 ms.
    iii. there was no item the mean RT of which exceeded 1209 ms.

Therefore, no item or participant was completely removed from the subsequent analyses.

- Individual responses that exceeded 1209 ms. were removed from the dataset.
- Following the identification of the mean response times of each individual along with the standard deviations, each response that exceeded the sum or extraction of the mean reaction times and the twofold of the standard deviation values was deleted. The reason for this additional step was to delete extremely slow or fast reaction times on an individual basis. The whole process resulted in the loss of 13% (n. 2069 out of 16128) of the experimental dataset.

Data cleaning was followed by a descriptive look at the magnitude of the priming of the abovementioned six conditions. The first analysis did not take individual differences into consideration. In other words, all the data collected from 112 participants were evaluated with no classification based on proficiency, vocabulary size or spelling ability. As Table 10 revealed, comparisons of the reaction times to related, unrelated and identity pairs of each condition showed that participants responded rather faster to morphologically-related prime-target pairs (derivational, regular inflectional, irregular inflectional, and opaque conditions) relative to semantic or orthographical relatedness.

Table 10 also showed that no priming[14] was produced in the semantic condition at all (F_1(1,111)=-.0093, p=.992; F_2(1,111)=.014, p=.875). Even though participants were faster in their responses to the targets following orthographically-related primes

Table 10: Mean RTs (in milliseconds) and Error Rates (in percentages) in the Lexical Decision Task

	Derivation		Regular Inflection	
	RTs	Errors	RTs	Errors
Related	712	3,7	690	3,9
Unrelated	730	4,3	707	4,6
Identity	709	3,7	688	3,8
Difference[15]	18		17	

	Irregular Inflection		Opaque	
	RTs	Errors	RTs	Errors
Related	702	3,6	727	4,7
Unrelated	723	4,9	744	5,4
Identity	696	3,5	722	3,1
Difference	21		17	

	Semantic		Orthographic	
	RTs	Errors	RTs	Errors
Related	741	4,6	722	4,1
Unrelated	740	5,5	731	4,9
Identity	724	3,4	714	3,9
Difference	-1		9	

compared to the unrelated ones, the magnitude of priming was too small (9 ms.) to be significant (F_1(1,111)=.391, p=.132; F_2(1,111)=.282, p=.154). As for the prime-target pairs with morphological relatedness, separate ANOVAs revealed that they produced full priming [F_1(1,111)=6,014, p=.002; F_2(1,111)=8,913, p=.002 for the derivational primes, F_1(1,111)=5,417, p=.004; F_2(1,111)=7,306, p=.002 for the regularly-inflected primes, F_1(1,111)=6,691, p=.001; F_2(1,111)=5,977, p=.004 for the irregularly-inflected primes, and F_1(1,111)=4,048, p=.012; F_2(1,111)=7,130, p=.004 for the opaque primes].

[14] In this thesis, priming refers to a significant difference between the facilitatory effect of a related prime relative to an unrelated prime. Full priming, on the other hand, additionally requires the same level of facilitation as an identity prime.

[15] Difference refers to the subtraction of the RTs in the unrelated condition from the related.

Reaching such robust statistical evidence regarding the facilitatory effect of morphology in visual word recognition in contrast to meaning or formal overlap made deeper analyses based on the group differences critical. In other words, it turned out to be essential to uncover the possible determining factors of the morphological priming in this specific participant pool. Table 11 displays a comparative look at the descriptive analysis of the above-mentioned priming effects by taking the classification of participants according to their proficiency level or individual differences into consideration. Whereas major differences were observed in the magnitude of priming between high proficient and low proficient participants in the morphology-related conditions, it was definitely not the case in comparisons as regards vocabulary size or spelling ability. This indicates that participants' reading pattern of morphologically complex words differ only with respect to their level of proficiency in English. Separate ANOVAs comparing high proficient and low proficient participants verified that the differences in Table 11 in the four morphological conditions were significant [F(1,111)=2,941, p=.014 for the derivational primes, F(1,111)=2,448, p=.016 for the regularly-inflected primes, F(1,111)=2,212, p=.028 for the irregularly-inflected primes, and F(1,111)=3,903, p<.001 for the opaque primes], but not in the orthographic (F(1,111)=,660, p=.511) or semantic (F(1,111)=-,803, p=.423) conditions. On the other hand, the comparison of the high and low vocabulary size groups via separate ANOVAs did not yield any differences in any of the six conditions [F(1,111)=,417, p=.618 for the derivational primes, F(1,111)=,981, p=.329 for the regularly-inflected primes, F(1,111)=-,346, p=.730 for the irregularly-inflected primes, F(1,111)=1,547, p=.125 for the opaque primes, F(1,111)=-,518, p=.615 for the orthographically-related primes, and F(1,111)=,183, p=.815 for the semantically-related primes]. Likewise, separate ANOVAs run for the comparisons based on spelling did not provide any significant difference between the priming effect among high and low spelling ability groups [F(1,111)=,920, p=.329 for the derivational primes, F(1,111)=,788, p=.432 for the regularly-inflected primes, F(1,111)=,084, p=.934 for the irregularly-inflected primes, F(1,111)=1,581, p=.117 for the opaque primes, F(1,111)=,008, p=.993 for the orthographically-related primes, and F(1,111)=-,160, p=.873 for the semantically-related primes].

In order to test whether different groups of participants behaved in a parallel way depending on the type of input, it was necessary to check for interactions among within-subject (type of prime-target pairs) and between-subject (groups based on proficiency and individual differences) variables on the priming-induced conditions. To begin with, a repeated-measures (RM) ANOVA with a 4 (prime types: derivational, regular, irregular, and opaque)x 3(groups based on the level of proficiency, vocabulary size, and spelling ability)x 2 (priming effect: relatedness vs. unrelatedness) was run to observe no interaction between variables. Subsequent RM ANOVAs that included between-subject factors into analyses separately did not display any interaction between these independent variables and type of primes and relatedness, either.

The only significant interaction was between relatedness and proficiency (F_1(1,111)=18,775, p=.000; F_2(1,111)=13,803, p=.000), which supported the previous finding that the magnitude of priming produced by the participants changed in accordance with their level of proficiency.

Table 11: A Within-Subjects Contrastive Look at the Priming Patterns (in milliseconds)

Comparison of the Groups based on Proficiency Level						
	Derivation	Regular	Irregular	Opaque	Semantic	Orthography
High[16]	39	29	35	25	9	12
Low	-3	5	7	9	-11	-3
Difference	42	24	28	16	20	15
Comparison of the Groups based on Vocabulary Size						
	Derivation	Regular	Irregular	Opaque	Semantic	Orthography
High[17]	16	16	27	15	-3	5
Low	20	13	18	19	1	13
Difference	-4	3	9	-4	-4	-8
Comparison of the Groups based on the Spelling Ability						
	Derivation	Regular	Irregular	Opaque	Semantic	Orthography
High[18]	17	13	21	15	4	5
Low	18	18	16	17	-3	11
Difference	-1	-5	5	-2	7	-6

[16] High refers to the highly proficient participants while low refers to the low proficiency group in line with the statistical analysis described in 3.2.4.1.
[17] High refers to the high vocabulary size group while low refers to the low vocabulary size group in line with the statistical analysis described in 3.2.4.2.

[18] High refers to the high spelling ability group while low refers to the low spelling ability group in line with the statistical analysis described in 3.2.4.3.

3.4. Discussion

The focus of this chapter was the examination of the visual recognition of morphologically complex words and its potential determinants in L2 from a behavioral perspective. For this purpose, a masked-priming experiment was conducted to observe three remarkable findings stated below:

- The error analysis revealed that participants completed the experiment with an overall high accuracy rate to compare with native speakers of English.
- Significant priming was produced in four types of morphological-relatedness: derivationally, inflectionally - regular and irregular -, and opaque prime-target pairs were processed faster than their unrelated counterparts.
- Analyzing priming patterns on the basis of the individual differences displayed a proficiency-based figure to emerge as a determining factor not only in the production of priming in a specific group but also in the magnitude of priming.

3.4.1. Reviewing the Experiment with Regard to the Literature

To briefly summarize, the results obtained from the experiment did not show a complete correspondence with previous L2 morphological processing models or hypotheses for two fundamental reasons. First, the findings supported serial models of processing owing to the absence of attention to semantic or orthographic information at early stages of visual recognition. Secondly, this experiment revealed that L2ers could make optimal use of morphological information in the course of visual word recognition irrespective of the type of morphemes they were exposed to (cf. Silva & Clahsen, 2008; Neubauer & Clahsen, 2009 among others[19]) without any facilitation provided solely by semantic or orthographic information (cf. Heyer & Clahsen, 2015). The third point of discrepancy was that priming effect was found not only in regular conditions but also in irregularly-inflected prime-target pairs (cf. Feldman et al., 2010[20]) to which it was not plausible to attribute an associative account due to the absence of priming in well-matched orthography or semantic conditions with respect to the length, frequency or meaning-based associations (cf. Zobl, 1998; Birdsong &

[19] See Chapter 2.2.1.

[20] See Chapter 2.2.3.

Flege, 2001; Murphy, 2004 and the like[21]). Below is presented a detailed comparative look at the applicability of previous assumptions in the light of the outcomes of this experiment.

Considering the fact that not only morphological but opaque and semantic primes as well were matched in certain aspects such as length and frequency called Clahsen and Felser's (2006) assumption about the surface-form frequency effect in question. Their account failed to predict priming and/or the absence of priming in all conditions except the processing of derived nouns. A direct implication of the surface-form frequency effect was to observe the same priming effect in the orthography condition, which was not the case at all. Primes in the orthography condition were well-known words but participants evidently did not decompose them into their potential stems (e.g. freeze - FREE) possibly because they had morphologically nothing to do with such targets. This finding was also in contradiction with Heyer and Clahsen's (2015) proposal that L2 processing was purely orthographic. Moreover, the SSH argument about the use of lexico-semantic information is considered to be controversial due to the fact that semantically-related prime-target pairs - which were very highly frequent, too- did not produce any priming effect whereas opaque relatedness (e.g. brother - BROTH) was quite facilitatory in the reading process. Taking all of these issues into account, the SSH account of L2 morphological processing is viewed as an 'overselective' approach overlooking L2ers' receptive power to compute grammatical information under certain circumstances. Likewise, the proponents of the Words and Rules Theory did not come up with a felicitous anticipation for the participants' commeasurable reaction to regular and irregular forms with no requirement for the manipulation of experimental items in terms of the lexical frequency or the onset of acquisition (e.g. Birdsong & Flege, 2001; Kırkıcı, 2002). To put it another way, they drew a clear distinction between regular and irregular forms in L2 and estimated different strategies to process these prime types, which would be reflected in the reading latencies under the same testing condition. Nonetheless, both irregular and regular primes proved to facilitate the reading of their stems and this was not attributable to the perception of irregulars as chunks due to the fact that there was no priming only based on the surface-form frequency exemplified

[21] See Chapter 2.2.2.

by no priming effect in the orthography condition. Correspondingly, frequency did not seem to be the sole source of strong enough semantic associations to facilitate targets. Moreover, as it was stated above, participants' onset of L2 acquisition were quite similar, so the results could not necessarily arise from such a factor.

The above-stated findings of this thesis entailed accounting for how the facilitative power of irregulars equated with such decomposable forms as regulars or derivationally inflected forms. What was observed in this experiment indicated the validity of Crepaldi et al. (2010)'s arguments[22] in L2 regarding the availability of the intermediate level between morpho-orthographic and semantic systems in which primes – either regularly or irregularly inflected- were fully visible rather than Rastle et al.'s (2000, 2004) affix-stripping hypothesis.[23] It is worth noting in here that this argument could be raised only for high frequency words because, as it is explained in detail below, the researcher argues that high frequency of occurrence has discrepant effects in L1 and L2; it is likely to result in the full-form storage in L1 whereas L2ers treat them analytically via decomposition. Further studies with the same methodology that manipulate the level of frequency will definitely supplement this argument.

As for the accounts maintaining congruent processing patterns in L1 and L2[24], significant divergences were evident although they agreed with what was observed in this experiment about the developmental pattern for the approximation to L1 processing. Observations indicating no difference in the magnitude of priming between regular and irregular forms (Feldman et al., 2010), and no effect of proficiency on the processing of certain types of morphemes (Foote, 2015) were somewhat contradictory. Nonetheless, it can be argued that the most consistent implications with the present experiment were made by those adopting a continuity view in L2 morphological processing (in particular, Diependeale et al. 2011 and Coughlin & Tremblay, 2014).

3.4.2. Speculations and Implications

This masked-priming experiment was implemented and evaluated by means of the same methodological paradigm as previous L2 morphological processing studies

[22] See Chapter 2.1.1.6.

[23] See 2.1.1.4.

[24] See Chapter 2.3.3.

that were considered to be seminal works of this field of inquiry; however, the results dramatically differed especially from the proponents of the Shallow Structure Hypothesis (SSH) and the Words and Rules Theory (WRT). Most importantly, the findings yielded an ‘indiscriminate’ morpho-phonological decomposition account in L2. In other words, the assumption that different types of morphemes are accessed and processed by the help of different mechanisms was strikingly challenged by the comparable magnitude of priming produced for the derivational, regularly and irregularly inflectional relatedness (18 ms.,17 ms. and 21 ms. respectively) by the same participants on the same testing conditions in the experiment. As it was stated before, experimental items were matched in length and frequency as well as the level of semantic association. Accordingly, an implication stemming from the reaction times to one type of prime-target pairs is expected to apply to the other, as well. The prevailing logic adopted in the literature assumed a morphological decomposition account as a result of facilitatory effect of morphological information independent of meaning and formal overlap; therefore, such an account proved to be eligible for derivational and regular conditions in this experiment because all the morphological conditions displayed such a facilitatory effect. In this case, it is reasonable to speculate on such a divergence from previous accounts by referring to a methodological preference favored in this study: items (primes and targets) were matched in frequency but unlike previous studies, they were intentionally selected out of the high frequency members of their types in all conditions.

The reason for this choice was the emphasis to be placed on the unquestioned foresight with regard to the putative parallelism of the effect of frequency – which was considered to be the most salient factor to determine the usefulness of a lexical item (Koprowski, 2005) - on L1 and L2 acquisition processes. It is widely accepted that fundamental differences exist between the nature of L1 and L2 acquisition – hence parsing and processing (Fodor, 1998a;1998b)- and they are taken into consideration in many aspects of L2 investigations ranging from the plausible accuracy rate (e.g. Longtin et al., 2003 vs. Heyer & Clahsen, 2015) to the SOA of the prime or presentation of the target (e.g. Crepaldi et al., 2010 vs. Silva & Clahsen, 2008). Nonetheless, to the best knowledge of the researcher, the need for a similar adaptation concerning the possibly different effect of frequency on L1 and L2 contexts has been neglected. As several studies displayed, the researchers need to address to the differential threshold frequency levels for the storage – i.e. full listing- and internalization –i.e. morphological decomposition- of lexical items in the L1 and L2 performances (e.g. Duyck et al., 2008; Martinez & Murphy, 2011; Crossley et al., 2014; Kartal & Sarıgül; 2017). Crossley et al., 2014, for instance, argues that L2 learners – unlike natives- move toward the production of words with higher frequency values as they become more proficient in English (p. 324). Moreover, Ellis's (2002) conclusion following a long empiricist discussion on the frequency effects in L2 learning was that "higher frequency words get more activation from the same evidence than do low-frequency words (p. 151)". In the light of such arguments, the author of this thesis is of the opinion that evaluations of the frequency levels with respect to the analyses of structural properties of words should be unique; high frequencies of occurrence based on L1 input could imply that such items are processed purely holistically by natives; however, it is unlikely to be the case for L2ers because – as it was found out in this experiment- such frequent items are presumably decomposed into their constituent elements by the latter group especially in explicit learning contexts. For this reason, high frequent primes and targets were preferred. As Table 12 displays, primes utilized in this experiment are evidently more frequent than those used in previous studies that presented empirical evidence for the SSH and the WRT as well as those arguing for a similar processing pattern for L1 and L2.

It should be noted that there is an obvious need for empirical research in the frequency effect in lexical processing by manipulating frequency levels to identify the boundaries of holistic and analytic recognition in L1 and L2. Although it is fairly reasonable to postulate that the same lexical items are treated differently by L1 and L2 groups, a concrete and precise indication is absolutely required. In particular, since Larsen-Freeman (1975) emphasized the importance of frequency as a crucial variable in the acquisition of morphemes in L2, its idiosyncratic effect has been widely investigated by researchers with various perspectives (e.g. Ellis & Schmidt, 1997; Goldschneider & DeKeyser, 2001; Arnon & Snider, 2010; Durrant & Doherty, 2010; Gardner & Davies, 2007; Year & Gondon, 2009); however, sufficient empirical evidence does not exist regarding the contrastive effect of frequency on morphological processing.

Table 12: Mean Frequency of Primes (per million) in the Experimental Items of this Study and the Seminal Works of the SSH

	Derivational	Regular	Irregular
This Study	39	36	33
Silva & Clahsen (2008)[25]	18	4	
Clahsen & Neubauer (2010)[26]	17		
Kırkıcı & Clahsen (2013)[27]	14	26	
Zobl (1998)		13	15
Feldman et al. (2010)		24	26

[25] To obtain consistent results, the calculations of the frequency in this thesis, Silva & Clahsen (2008), Zobl (1998) and Feldman et al. (2010) were made by means of the CELEX database (http://celex.mpi.nl/).

[26] The calculation of the frequency was based on the German version of the CELEX database.

[27] Turkish National Corpus (https://www.tnc.org.tr/) was utilized for the identification of the frequency level of primes.

CHAPTER 4

ASSESSING NEURAL PRIMING IN L2 MORPHOLOGY

This chapter provides information about the second experiment of this thesis, seeking further evidence regarding the distinctive properties of L2 morphological processing from a brain-based perspective. Moreover, by establishing parallelisms with the former experiment in the content and procedures, the researcher reports whether testing condition is an independent factor in the representation and processing of morphologically complex words in L2. The chapter covers the reason for the implementation of a second experiment, the relevant research questions of the thesis, methodological details, analyses of behavioral and neural data, as well as the discussion of the findings.

4.1. A Complementary Experiment in L2 Morphological Processing

The main reason for the implementation of a brain-based priming experiment in an L2 context is the need for the abundance of similar experiments to have a more concrete insight into the neural blueprint of L2 morphological processing. As the literature review put forward, the number of L1 research studies increases along with the accumulation of consistent results for the identification of brain regions activated to fulfill the lexical decomposition task. Arguments proposed in the light of the initial studies were upheld with minor modifications[28]. On the other hand, there are very few attempts to observe and speculate on the spatiotemporal features of visual word recognition in L2. The lack of neural experiments could be partially ascribed to the practical concerns about the implementation of such demanding inquiries; furthermore, inconclusive theoretical debates on the characteristics of the recognition of morphologically complex words in L2 and their impact on the methodological concerns are apparently the source of a strong disincentive. Considering the arguments

[28] See Chapter 2.1.5.

that were made by means of the results of the behavioral data of this thesis, a follow-up experiment stands out as a must because the results did not fit with previous hypotheses of the well-discussed models and the researcher supposed that this divergence grew out of the methodological preferences in picking up the highly frequent primes and targets. Thereby, the second experiment of this thesis provided not only behavioral evidence to check the findings of the former experiment but neural findings so that considerable contributions to the endeavors to uncover activation patterns in L2 lexical processing were intended, as well.

The second major source of motivation to conduct an fMRI experiment is the quest for the potential effect of testing conditions on visual word recognition in L2. Whether participants display different lexical processing patterns based on the situation they are positioned in was tested by few studies such as Marelli et al. (2013). However, the fact that they preferred different SOAs in two lexical decision tasks adopting different methodological paradigms resulted in a confounding variable, so it was quite problematic to hypothesize about the independent role of these two testing conditions (computer-based vs. eye-tracking lexical decision tasks). Furthermore, both methodological paradigms observed participants' indirect reactions to lexical items, hence, produced behavioral data. It was problematic because testing conditions of experiments were expected to share as many properties as possible so that a direct comparison of their influence in participants' linguistic behaviors could be possible. To overcome these two problems, a neural experiment sharing the same materials and methodology but observing participants' reading patterns from different perspectives was required.

The above-stated reasons entailed implementing an fMRI study in parallel with the previous masked-priming lexical decision experiment reported in Chapter 3. This experiment aims to directly answer two research questions that are repeated below:

- Do L2 speakers' early morphological processing patterns correlate with the hemodynamic brain response patterns?
- To what extent do testing conditions have an impact on the early processing of morphologically complex words by L2 speakers?

It also intends to provide complementary evidence for two research questions in coordination with the behavioral experiment of this thesis. These questions are:

- Do L2 speakers decompose morphologically complex words at an early phase of recognition? Do their processing patterns vary according to types of morphological structures?
- To what extent do individual differences modulate the processing patterns of L2 speakers?

4.2. Experimental Methodology

With the intent of a direct comparison of the findings to the previous experiment, the researcher planned to make as few revisions as possible to the methodological design adopted in the former study. The practically required changes were in the number of participants, fillers, testing sessions and the intervals between the presentation of lexical items. This part of the chapter is assigned to the rationale behind the adaptations in the design and implementation of the neural priming experiment.

4.2.1. The Second Lexical Decision Task: Materials and Design

All the experimental items of the computer-based lexical decision task (n. 144 per list) were utilized in this experiment. Correspondingly, methodological preferences and matching criteria with regard to the frequency, length, and semantic association between primes and targets were completely preserved. As for the fillers, half of them were removed from the list in order not to put a healthy data collection process in an MR machine at risk; a session including the settlement of the participant, practice and localization as well as the lexical decision task was expected to last around half an hour. Therefore, 144 fillers, which consisted of non-existing primes and targets, were included in this experiment. When the unused pairs were removed from the lists, the researcher made small adaptations so that

i.) three consecutive experimental or filler prime-target pairs were not presented.

ii.) orthographic or meaning-based associations among the targets and following primes were hindered for at least three pairs in a row.

In order to discriminate brain activity among different types of stimuli in two aspects (i.e. fillers vs. experimental stimuli, types of conditions [regular, irregular, derivational, opaque, orthographic, and semantic]) and acquire a truly active BOLD signal because “the BOLD response takes approximately 2 seconds to start to rise after stimulation, 6 to 8 seconds to peak, and does not return to baseline until 12 to 20 seconds after stimulation (Newman, 2014; p.155)", an event-related fMRI design was prepared. Stimuli were presented with 4, 6 or 8 second-intervals in an unsystematic way to prevent participants from responding in a mechanical way. The same configurational preferences regarding the appearance of items on the screen (e.g. font size, background color, layout) were preserved.

Considering the drawbacks about the duration of a testing session, five experimental sessions lasting five to six minutes were prepared. They were followed by a five-minute-anatomical imaging session for the comparison of the brain activations in a resting state with those in the visual word recognition task. Each experimental session consisted of 55 to 60 prime-target pairs. Because of the possible inconsistent transmission of signals at the initial phases of the records, a blank screen appeared for 20 seconds at the beginning of these sessions. Below is a figure representing the adapted version of the masked-priming lexical decision task.

Figure 2: Representation of the Masked Priming Paradigm of the Neural Experiment

Behavioral data were acquired by means of the same experimental software utilized in the first experiment. As for the acquisition of MR data, SIEMENS MAGNETOM TrioTim Syngo MR B17 was employed (TA: 5:34, Voxel size: 3.0×3.0×3.0 mm, 100 % phase resolution, mode: inplane, series: interleaved) with repetition time (TR) sequences of 2 seconds.

4.2.2. Participants

Out of practical concerns (participants' inhibitions, availability of the required apparatus, and financial limitations), a subset of the participant pool who were recruited in the former experiment completed the second experiment. 49 of the participants who completed the lexical decision task and the supplementary tests (n.112) were invited to the fMRI experiment. The first four participants were recruited in the piloting process. The primary concern in the selection of the members of such a sub-group was the representativeness of the whole participant group; therefore, a similar profile to the behavioral experiment was generated. Below is a table comparing the mean values of participant profiles in the former and latter experiment.

Table 13: A Contrastive Look at the Participant Profiles

	Experiment1	Experiment2
Number	122	49
Age	20,7 (1,42)	21,1 (1,94)
Use of English	32,1%	30,7%
Proficiency[29]	46,5% high - 53,5% low	46,8% high – 53,2% low
Vocabulary	46,5% high - 53,5% low	45,7% high – 54,3% low
Spelling	48,2% high – 51,8% low	47,8% high – 52,2% low

4.2.3. Procedure

Participants who were found eligible were invited to the research center designed for fMRI and brain-based psychological investigations at Bilkent University-UMRAM[30]. Reading a check-list of warnings about physical disorders and medical illnesses or status that could risk being in an MR device, participants were asked to sign a consent form and informed about the hazardous clothes and accessories in an MR room. They were reminded about the experimental task: deciding whether the letter strings they would see on the MR screen were real words in English or not as accurately and fast as possible. A two button fiber optic response pad was customized to represent "Yes" responses on the right-hand and "No" responses on the left-hand.

[29] See Chapter 3.2.4. to check by what criteria participants were classified.

[30] UMRAM: National Magnetic Resonance Research Center. For detailed information: http://umram.bilkent.edu.tr/index.php/tr/

Following the practice session containing 10 questions, participants completed the task with five breaks at the end of each session. The researcher communicated with the participants during these breaks in case any experimental or health problems should occur. The whole process lasted about 40 minutes.

At the end of task, participants were asked to predict the researchers' goal to administer these experiments. No accurate or relevant idea was expressed about the purpose of the tasks, none of the participants reported any observations or suspicions of an extra item between hashes and targets, either. All the participants employed in any of the tasks conducted in this thesis were informed about the purpose of the behavioral and neural priming tasks when the fMRI data collection process was finalized. A small payment or course credit was provided in return for their participation.

4.3. Results

This section of the chapter gives detailed information about the data analysis procedures and reports the findings from descriptive and inferential aspects. The first part covers behavioral findings – analyses of the reaction times and accuracy rates of participants' performance. A detailed look at the fMRI data to find a possible hemodynamic brain response pattern in L2 morphological processing follows.

4.3.1. Analyses of the Behavioral Data

The researcher followed the same steps adopted in the former lexical decision task in order to work on a cleaned and normalized dataset[31]. Applying the same criteria in removing particular experimental items and participants led to the loss of 12% responses (782 out of 6480) in total. Remarkable details in this process are as given below.

- No participant was completely removed out of the dataset due to the violation of accuracy or reading span criteria.
- The same prime-target pairs in the experimental items (brother, deposit, broth – BROTH with 40% accuracy; stubborn, mineral, stub – STUB with 42% accuracy; attitude, property, stance – STANCE with 58% accuracy) that were

[31] See Chapter 3.3

deleted in the first experiment were removed again, even though there was a small positive difference in the participants' accuracy rates.

- Overall, participants responded more slowly in this experiment (mean RT: 801 ms.).
- No response was excluded from the analysis out of too fast responses.
- No prime-target pair was completely deleted because it was responded too slowly or too fast.

Descriptive analyses of the behavioral data for possible priming patterns in the neural experiment revealed quite a similar picture to those of the first lexical decision task. Although remarkably longer response times were observed in all items including fillers, checking the magnitude of priming based on conditions indicated the same model that was found in the former task. That is to say, participants were faster in targets following morphologically-related primes (derivational, regular or irregular inflection, and opaque) whereas no priming was produced in morphologically-unrelated (semantic and orthographic) conditions. Additionally, margins between related and unrelated conditions were found to be comparatively bigger whereas identity conditions were almost identically close to the related conditions. Below is given a table comparing each condition.

Separate ANOVAs showed that full priming was produced in derivational ($F_1(1,44)$=3,939, p=.018; $F_2(1,44)$=5,008, p=.011), regularly-inflected ($F_1(1,44)$=528, p=.021; $F_2(1,44)$=2,615, p=.017), irregularly-inflected ($F_1(1,44)$=3,353, p=.011; $F_2(1,44)$=2,849, p=.016) and opaque ($F_1(1,44)$=4,088, p=.017; $F_2(1,44)$=2,571, p=.019) conditions. On the other hand, no priming was observed in semantic or orthographic conditions [($F_1(1,44)$=,148, p=.862; $F_2(1,44)$=-.210, p=.892), and ($F_1(1,44)$=,293, p=.746; $F_2(1,44)$=.243, p=.819), respectively]. That is to say, initial analyses robustly displayed the same processing pattern emerging in both experiments based on the behavioral indicators.

In line with the first experiment, the following step in the analysis of the behavioral data was the group-based comparison of participants' performance. Groups were identified by running the median-split technique as it was implemented in the first experiment. Separate ANOVAs turned out to reveal that significant differences were seen only between high and low proficiency participants (n. 25 - 20) for the four conditions that produced priming effect – namely derivational, regular, irregular, and opaque – [($F(1,43)$=2,933, p=.023), ($F(1,43)$=3,173, p=.003), ($F(1,43)$=2,482, p=.017), (F(1,43)=2,716, p=.009) respectively], which was definitely not the case for the classification of individuals depending on their vocabulary size (n. 23 - 22) [(F(1,43)=-,063, p=.950), (F(1,43)=1,592, p=.119), (F(1,43)=-,058, p=.954), (F(1,43)=-,445 p=.658) respectively], or spelling accuracy (n. 25 - 20) [(F(1,43)=-,056, p=.955), (F(1,43)=1,698, p=.197), (F(1,43)=,437, p=.664), (F(1,43)=1,201 p=.236) respectively]. Furthermore, similar to the former experiment, the only interaction was found between the proficiency as a between-subject factor and relatedness (related vs. unrelated) (F_1(1,44)=22,336 p=.000; F_2(1,44)=19,055, p=.000). It should be noted that a marginally significant interaction was also observed between proficiency and type (derivational, regular, irregular, and opaque) but only in the by-participant analysis (F_1(1,44)=2,922 p=.064; F_2(1,44)=.1,397, p=.102).

To summarize the findings out of the analyses of the behavioral data, the second experiment obviously supported the hypotheses made on the basis of the previously conducted computer-based masked priming experiment. In other words, the argument that when morphologically complex lexical items are frequent enough for proficient L2ers, they are processed combinatorially was upheld in the follow-up experiment. Proficiency was once again found to be a significant factor in the processing pattern for the visual word recognition in L2 whereas knowledge about the meaning of lexical items or their orthographic properties were observed not to determine the online decomposition of complex words in their own rights. Moreover, it was also shown that participants displayed almost the same performance under quite different testing conditions unlike Marelli et al. (2013). The next part of the chapter reports neural findings of the second masked priming experiment and provides an account for the extent of correlations between temporal and spatial reactions to the complex lexical items in L2.

4.3.2. Analyses of the fMRI Data

For the purpose of identifying whether and where there was an activation in the brain in parallel with the recognition of morphologically complex words, the first step that followed the acquisition of fMRI data was preprocessing. In Ashby’s (2011) words, “preprocessing includes all transformations that are needed to prepare the data for the more interesting task-related analyses” (p. 41). The main goal of this process is to minimize systematic but non-task-related sources of variability (e.g. moving the head) that could suddenly change the BOLD response from each spatial positions. The

Table 14: Mean RTs and Error Rates in the Behavioral Data

	Derivation		Regular Inflection	
	RTs	Errors	RTs	Errors
Related	784	3,4	751	2,7
Unrelated	810	4,1	774	3
Identity	775	3	746	2,6
Difference	26		23	
	Irregular Inflection		Opaque	
	RTs	Errors	RTs	Errors
Related	770	3,3	803	3,9
Unrelated	793	3,7	822	4,5
Identity	762	3	796	4
Difference	23		19	
	Semantic		Orthographic	
	RTs	Errors	RTs	Errors
Related	816	5,1	806	4,5
Unrelated	822	4,9	801	4,8
Identity	782	4	773	3,8
Difference	6		-5	

initial preprocessing steps followed in this experiment were those typically suggested (Ashby, 2011) and adopted in seminal fMRI studies (e.g. Gavrilescu et al., 2002; Ashburner & Friston, 2007; Klein et al., 2009). All the statistical operations on the fMRI data were run through SPM 12 (Statistical Parameter Mapping, http://www.fil.ion.ucl.ac.uk/spm) implemented in Matlab (Mathworks Inc., Sherborn, MA, USA). Below is the step by step account of how the fMRI dataset was preprocessed.

- The data acquired in DICOM format in the MR scanner were transformed into the image (img, single file – nii - NIfTI) files to work on the SPM. Then, because the first 20 seconds provided no task-related input due to the risk of inconsistent signals, the first 10 scans recording these BOLD signals of each session were deleted.

- The data were realigned in order that movement artefacts would be minimized. This step is crucial because as Ashby (2011) stated, when a subject moves his/her head, activations will be recorded in different voxels than they should (p. 52). That is why the scans of all participants are expected to be realigned according to a representative one. When the dataset was estimated and resliced at this stage of preprocessing, the smoothing kernel was 2 millimeters (mm) and the separation between the points sampled in the reference image was 4 mm.
- Coregistration was the next important step because it serves to align functional (task-related) and structural (anatomical) images. Considering the scans with 2-second-TRs, the spatial resolution of the functional data was naturally low in this experiment unlike the anatomical scans that provided scans with TRs of 8,6 seconds- hence smaller voxel sizes and high resolution. By coregistering these two types of scans, the functional data were enhanced with respect to spatial resolution. The dataset was coregistered by means of estimation and reslicing. The average distances between sampled points in functional and structural scans were 4 and 2 mm, and histogram smoothing was 7 & 7 mm as typically preferred in fMRI studies.
- Coregistration was followed by segmentation because classifying distinct tissue types in an MR image (grey matter, white matter, and cerebro-spinal fluid) was a necessity for the intense and high quality images (Clarke et al., 1995). Segmentation was applied by means of high-resolution T1-weighted (structural) images. SPM12 standardly combined spatial normalization, bias field correction, and tissue segmentation (smoothness: 0 mm, sampling distance: 3 mm).
- A huge difficulty emerges in the identification of brain regions in a group of participants when the differences in the sizes and shapes of individual brains are taken into consideration. According to Ashby (2011), the best alternative to deal with this problem is to “register the structural scan of each subject separately to some standard brain where the coordinates of all major brain structures have already been identified and published in an atlas” (p. 64). This process, namely normalization, was applied for each participant so that the

coordinates of significantly activated clusters could be determined accurately. The dataset was normalized and written with the standard bounding box values (2x3 double: -78, -112, -70 mm, and 78, 76, 85 mm) and 3x3x3 mm voxel sizes.

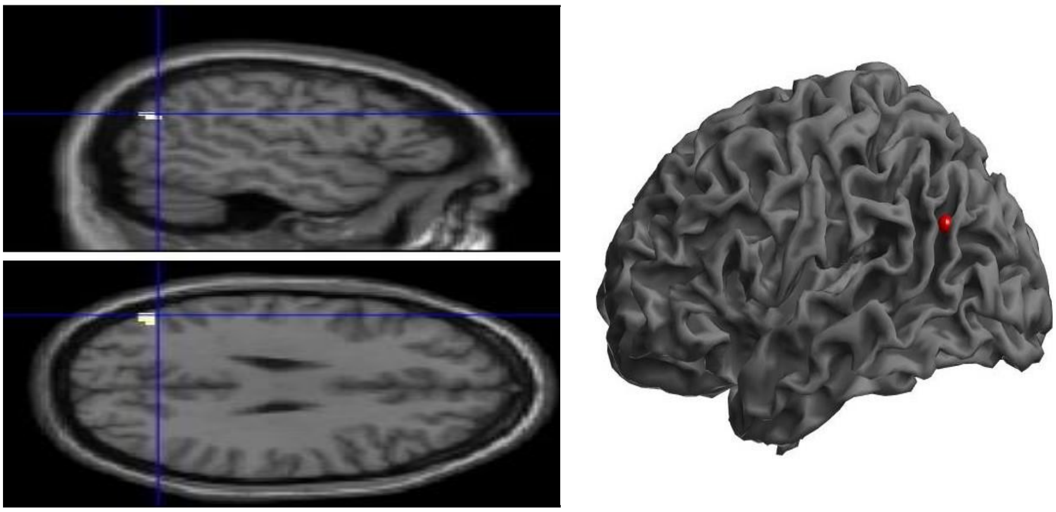
- After the data were normalized, voxels were smoothed by replacing BOLD value in each of them with a weighted sum of BOLD responses in neighboring voxels. Thanks to smoothing, the noise was reduced so that signal-to-noise ratio increased – hence the changes in the task-related BOLD responses. Ashby (2011) assumed that smoothing made the distribution of the BOLD responses more normal and made the data more likely to satisfy the assumptions of the statistical models that would be applied in individual and group analyses. Full Width at Half Maximum (FWHM), that is, the amount of smoothing that occurred in each direction was 12x12x12 mm.
- MR scans corresponding to the items that were not taken into analysis of the behavioral data because of too slow or inaccurate responses were excluded from the individual and group analyses of the fMRI dataset, as well.

After the dataset was preprocessed, individual analyses for six types of relatedness between primes and targets (derivational, regular inflection, irregular inflection, opaque, orthographic, and semantic) were run. Specific preprocessed images were identified that corresponded to the TRs taken when the input in the relevant types was presented to the participants in each of the five sessions. Images were classified and analyzed in three conditions (related, unrelated, and identity) and the task-related activations were detected for each of these conditions by taking the other two conditions as baselines (e.g. Identity: 1 0 0, Related: 0 1 0, Unrelated: 0 0 1). The same operation was conducted for all participants systematically so that files combining five sessions of each participant according to the conditions (con.img files) were prepared in six types of relatedness for group analyses.

Following the methodological orientation in the analyses of the behavioral data, the first step in the group analyses was to run separate one-way ANOVAs within subjects for the six conditions by taking all participants (n. 45) as one group. Below is the report of the neural regions involved in the processing of related conditions for each of the relevant types of relatedness relative to the unrelated conditions.

a.) Derivational Relatedness: Significant activations were observed to emerge in the left angular gyrus of the parietal cortex (Broadmann Area [BA] 39) when the participants' performances on the derivationally related (e.g. magical - MAGIC) and unrelated (e.g. abrupt - MAGIC) prime-target stimuli were compared (height threshold T: 4.4785, p < .05 FWE, MNI coordinates: -48, -67, 26).[32]

Figure 3: Representations of the region (Left angular gyrus) with significant prime-target difference (p < .05) in the derivational related-unrelated condition



b.) Regular Relatedness: Left frontal cortex (BA 6) was found to be activated when target words followed regularly-inflected prime items (e.g. offered - OFFER) compared to unrelated ones (e.g. rainy - OFFER). Figure 4 displays the location of the activation at a significant level (height threshold T: 4.4713, p < .05 FWE, MNI coordinates: -24, -4, 71).

c.) Irregular Relatedness: The comparison of irregular prime-target pairs to the unrelated ones differed from the results of other types of contrastive analyses in that two activated areas were observed and they were both in the right hemisphere. Irregularly-inflected primes facilitated the recognition of targets (e.g. taught - TEACH) relative to the presentation of unrelated primes before the same targets (e.g. flower - BREAK), which was also reflected outside the Broadmann areas but near the center of the brain – in the caudate nucleus of the basal ganglia (MNI coordinates: 18, 17, 20) and in the thalamus (MNI coordinates: 21, -28, 14) at a significant level (height

[32] In order to identify the activated Broadmann areas and specific brain regions, the researcher utilized a software which shows the locations and the anatomical names of the relevant areas via templates such as the automated anatomical labeling atlas. For futher information about the tool: http://www.nitrc.org/projects/mricron.

threshold T: 4.5258, $p < .05$ FWE). See Figure 5 that represents the location of the activated areas.

Figure 4: Representations of the region (Left frontal cortex) with significant prime-target difference ($p < .05$) in the regular related-unrelated condition

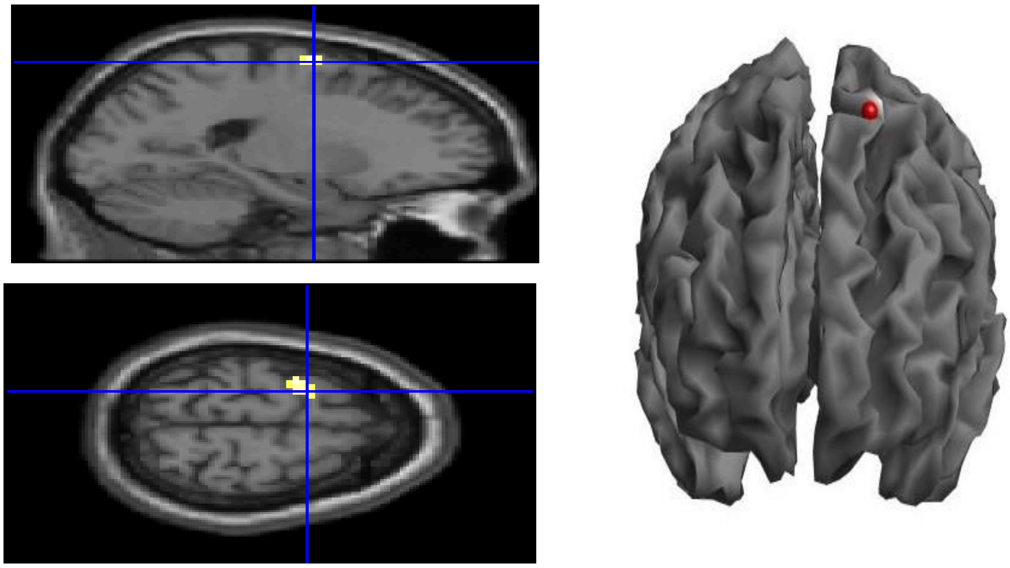
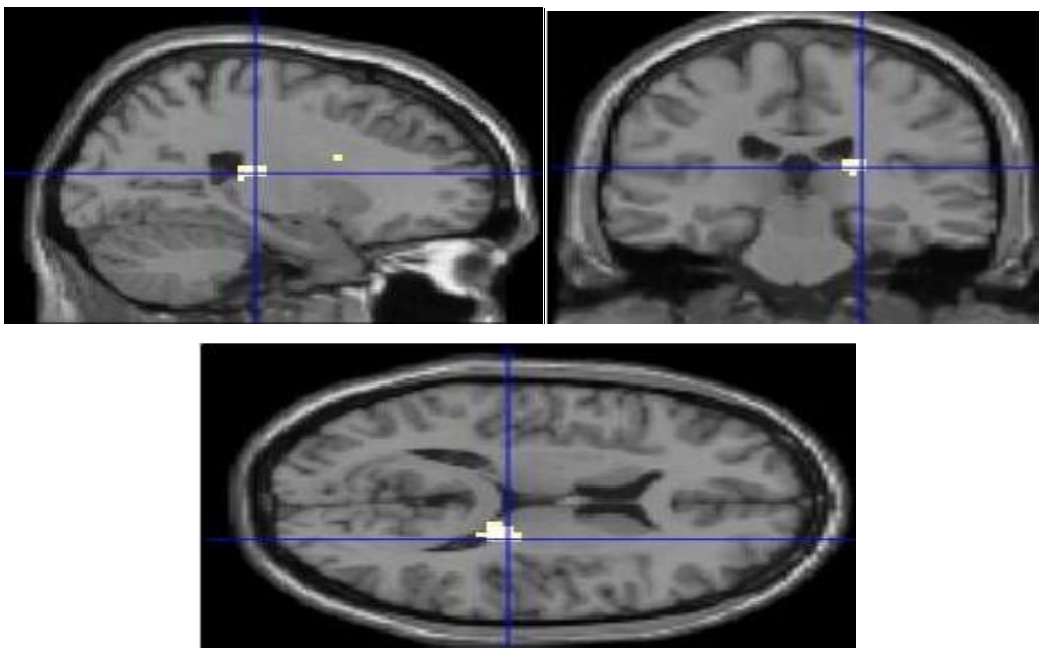
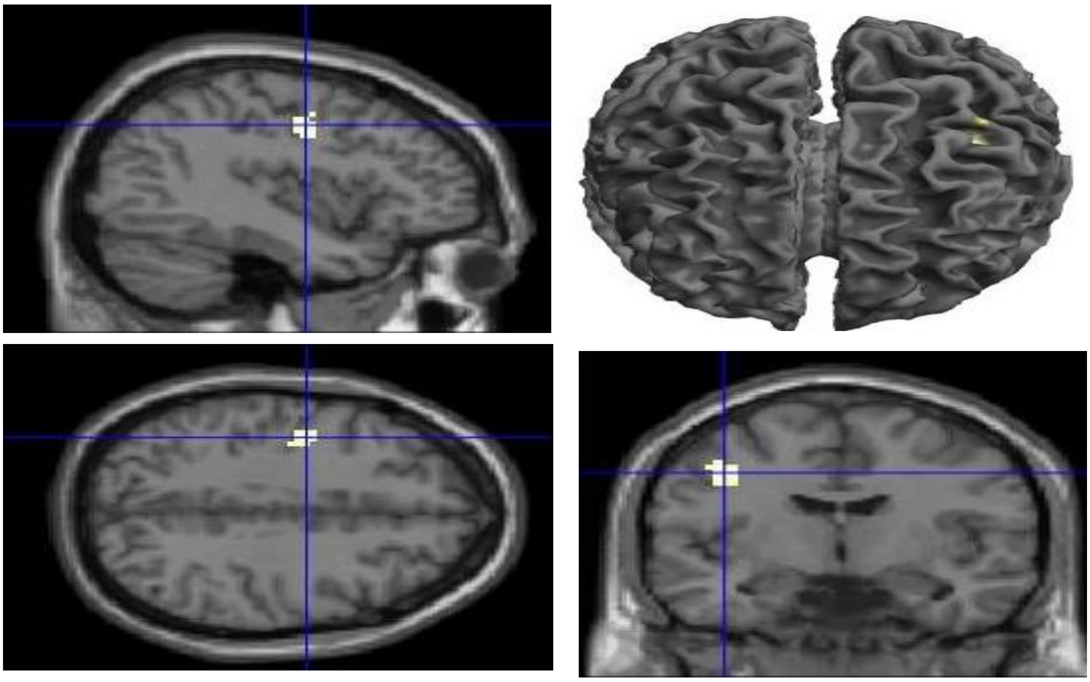


Figure 5: Representations of the regions with significant prime-target difference ($p < .05$) in the irregular related-unrelated condition



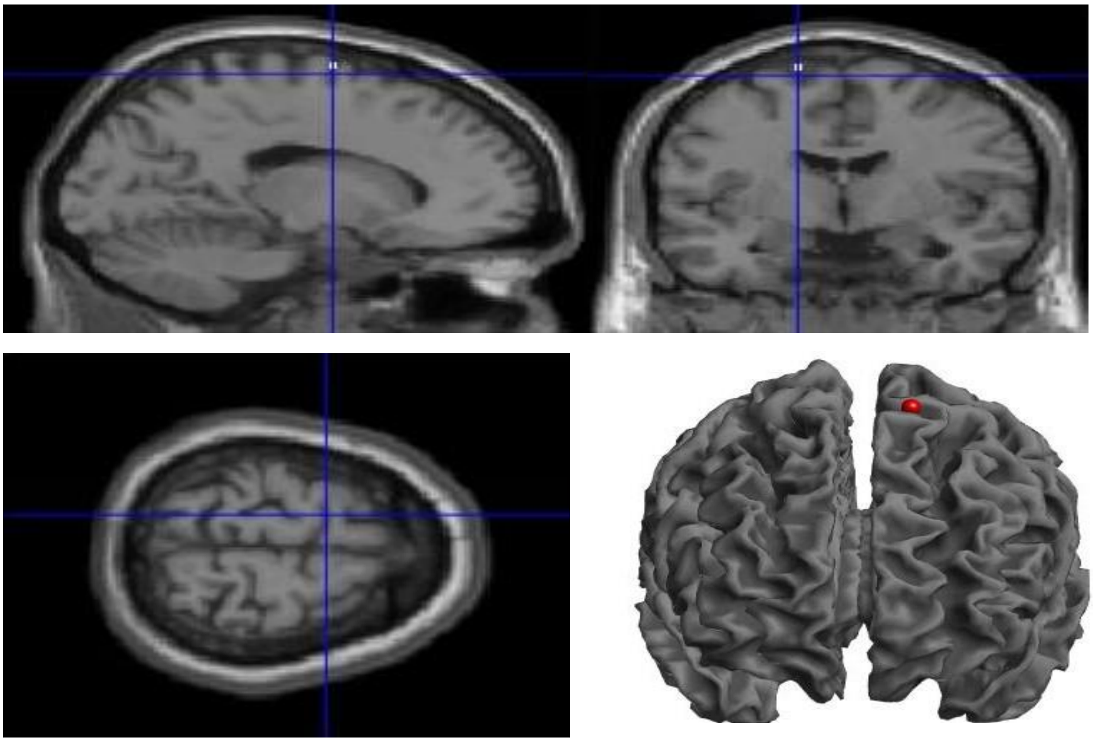
d.) Opaque Relatedness: Similar to the regular relatedness, it was found out that BA 6 – left frontal cortex - was the location that was activated during the recognition of the target preceded by an opaque prime (e.g. irony - IRON) but not in the processing of unrelated prime and target pairs (e.g. alarm - IRON). Specifically, as displayed in Figure 6, precentral gyrus was assumed to significantly reflect the facilitative effect of this type of relatedness on the reading of the lexical items (height threshold T: 4.5016, $p < .05$ FWE, MNI coordinates: -36, -7, 38).

Figure 6: Representations of the region (Precentral gyrus) with significant prime-target difference ($p < .05$) in the opaque related-unrelated condition



e.) Orthographic Relatedness: No supra-threshold clusters were observed at a significant level through a contrastive look at the facilitative effect of related orthographic condition (e.g. grammar - GRAM) against the prime-target pairs of the unrelated condition of the same type (e.g. festival - GRAM). However, when the p-value was set to .08 and the height threshold was accordingly decreased to 4.3109 mm, the results displayed the activation of BA 6 in parallel with the regular and opaque relatedness. To put it specifically, the results implied the selective activation of the left frontal superior gyrus as a reaction to the formal overlap- albeit below the conventionally-accepted level of significance (MNI coordinates: -15, -4, 74).

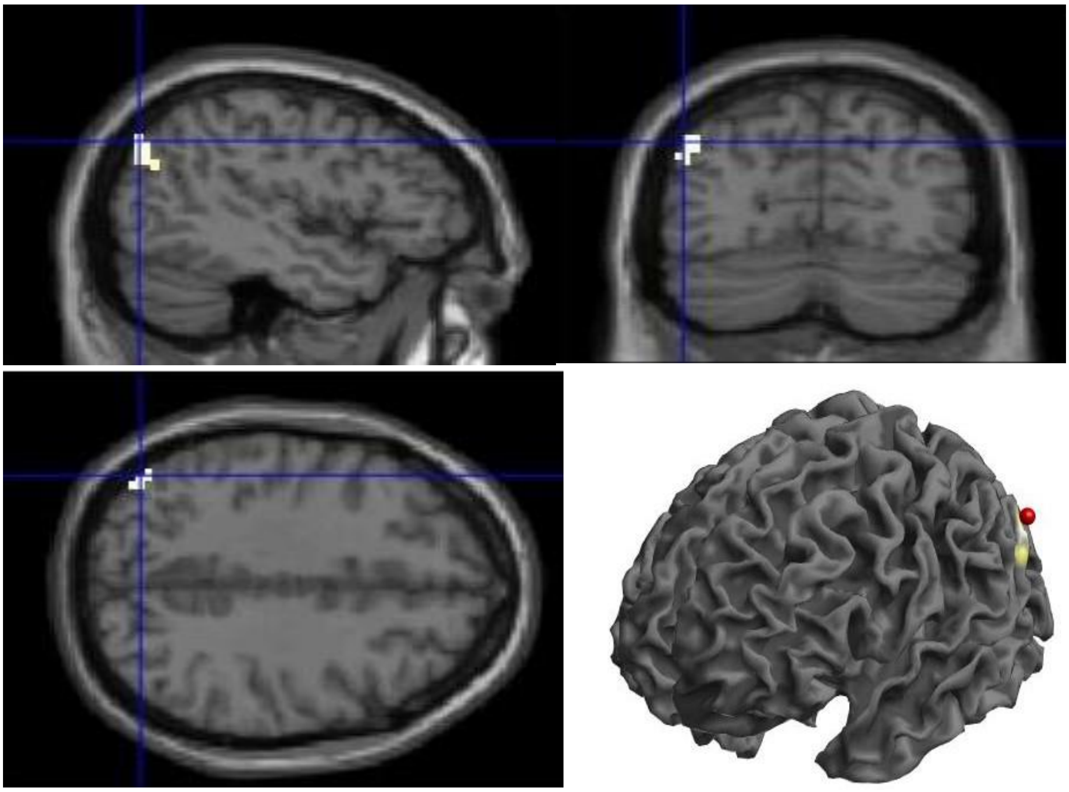
Figure 7: Representations of the region (Left frontal superior gyrus) with prime-target difference (p < .08) in the orthographic related-unrelated condition



f.) Semantic Relatedness: No area was detected with distinctive activation in the semantically-related prime-target pairs at a significant level, either. When the researcher gradually reset the values of family wise error and the height threshold to .09 and 4.2777 mm, remarkable similarities were observed in the activation pattern to the derivational type of relatedness. In other words, BA 39- left angular gyrus of the parietal cortex was observed for semantic processing when the semantic relatedness (e.g. picture - PHOTO) was contrasted with the unrelated pairs (e.g. journey - PHOTO) although it did not reach statistical significance (MNI coordinates: -45, -73, 41).

The final step of the fMRI data analysis was to compare participants' performance based on three ways of classification: overall proficiency, vocabulary size, and spelling ability. The 2nd level two sample t-test provided no supra-threshold clusters (when p value was set to .05 and .10) in any of the six types of relatedness conditions when participants were divided into two groups according to their lexical or orthographic knowledge. That is, no distinctive and significant brain activations reflected the (dis)advantage of knowledge about vocabulary or spelling during the

Figure 8: Representations of the region (Left angular gyrus) with prime-target difference ($p < .09$) in the semantic related-unrelated condition



early stages of visual word recognition. As for the t-test results of the high and low proficiency groups, no brain region was reported to be activated in the semantic and orthographic conditions – even when p value was set to .10- unlike the other four conditions. In derivational, regular and opaque relatedness, the areas reported in the whole-group analyses above were found to be activated in the high proficiency group in contrast with the less proficient participants. In other words, BA 39 in the derivational relatedness and BA 6 in the regular and opaque types of relatedness exhibited significant involvement in the processing of relevant lexical items in the former group but not the latter one ($p < .05$). The recognition of irregularly-inflected prime-target pairs partially differed in that unlike the whole-group analysis, only basal ganglia (MNI coordinates: 18, 17, 20) displayed a significant group-based difference

($p < .05$) whereas thalamus (MNI coordinates: 21, -28, 14) was observed to be involved in the high proficiency group when the p-value was set to .07.

4.4. Discussion

The main goal of the fMRI experiment was to identify the spatiotemporal dynamics of the early stages of visual word recognition as well as the triangulation of the time-induced behavioral conclusions of the former experiment. The results drawn from the analysis of reaction times and selective brain activation patterns can be summarized as follows:

- Behavioral analyses exhibited a replication of the results of the first masked-priming lexical decision task. That is to say, the morphologically-related four conditions (derivational, regular, irregular, and opaque) produced priming just exactly the same way the first experiment did. On the other hand, no facilitative effect of orthography or semantics were observed in this experiment per se, either.
- Overall proficiency but not vocabulary size or spelling ability was found to be the only individual difference that could modulate visual word recognition irrespective of the testing conditions.
- Different regions were associated with the processing of six types of relatedness; however, a BA-based assessment enabled the researcher to put forth a certain pattern of activation: derivational and semantic relatedness correlated with BA 39 whereas regular, opaque and orthographic facilitation involved BA 6. Two regions of activation were identified in the recognition of irregular forms in the right hemisphere.

A close look at the fMRI data in combination with the previous findings of this dissertation yields a suggestive picture of L2 morphological processing pattern. First of all, a remarkably high correlation between the findings of two experiments enabled the researcher to come up with an empirically strengthened account. In other words, the argument that L2ers display a native-like performance and pattern in the processing of morphologically complex words when the lexical items are frequent enough to process was validated and triangulated by means of two different methodological paradigms. The counter-argument associating high frequency with the storage and retrieval of unanalyzed forms for L2 users was challenged again owing to the lack of facilitation in the highly frequent orthographic and semantic prime-target pairs.

Secondly, in agreement with the former experiment, proficiency rather than vocabulary knowledge or spelling ability turned out to modulate L2 visual word recognition. The results imply that L2 processing models from a developmental perspective apparently entail highlighting the importance of overall proficiency for the purpose of attaining optimal correspondence with the native reading models. Consequently, examining the consistent results in these experiments put forward two determinants in the decomposition of complex words in L2: proficiency and frequency.

Behavioral findings of this thesis also yielded insights concerning the debatable effect of testing conditions on the recognition of complex words. As stated above, Marelli et al.'s (2013) methodological preferences were considered problematic mainly because they used different SOAs in tasks. When the procedures were retained in the fMRI experiment including the SOA (50 ms.) and items, an absolute convergence of the reaction times to prime-target pairs was found between the computer-based and brain-based lexical decision tasks. That is, unlike Marelli et al. (2013) testing conditions did not create any significant differences in the performance of participants. It should hereby be noted that this argument needs additional empirical support covering other possible SOAs, test environments of morphological processing such as PET and MEG studies as well as alternative non-invasive ways of investigations. In short, due to the inadequate number of experiments regarding this issue, further studies are expected to challenge these findings as the researcher did for Marelli et al (2013)'s study.

Regarding the interpretation of the results of brain activations that synchronized priming at the standard level of significance, several theoretical implications are possible to make in spite of the scarcity of previous work to come up with precise conclusions. Primarily, identifying the activated areas in the thalamus and the basal ganglia of the right hemisphere as a result of the recognition of irregularly inflected forms whereas other types of priming (regular inflection, derivation and opaque) occurred in the left hemisphere suggested a bi-hemispheric model of lexical processing. Rather than the traditional perspective hypothetically locating language in the left hemisphere by disregarding the types and levels of processing (Hickok & Poeppel, 2004), this study supported the hypothesis that both hemispheres are engaged in the comprehension of linguistic input (e.g. Taylor & Regard, Bozic et al., 2013; Tremblay & Dick, 2016). As Tremblay & Dick (2016) stated, the classical model is not built upon modern macroscopical neuroanatomy (p. 66), so it is supposed to be updated in harmony with the evolution of the researchers' knowledge about the brain anatomy for a couple of decades. Correspondingly, even though the studies have not put forward a consistent and reliable account so far partly because of the methodological and theoretical divergences, this study propounded mounting evidence for the involvement of both hemispheres in the linguistic operations.

The analyses of the behavioral and neural data of the irregular items made way for the debates on the psycholinguistic properties of these forms, as well. Observing a facilitative effect of the irregular primes once again confirmed the applicability of the hypothesis in L1 regarding the decomposition of morphologically complex lexical items irrespective of their regularity (Leminen et al., 2019; p. 18) to L2. In keeping with the recent evidence supporting this claim in L1 morphological processing in various languages (e.g. Kireev et al., 2015; Klimovich-Gray et al., 2017; Slioussar et al., 2014), obtaining consistent results exhibiting the decomposability of irregulars across testing conditions challenge the approach that irregular forms are stored in the memory as chunks. Besides, it was seen that irregulars were the only types to reveal two areas of activation which were not in similar regions or hemisphere to those of other types of relatedness. This observation is notably associated with Crepaldi et al.'s (2010) interpretation of their behavioral data obtained by means of the same experimental paradigm (masked-priming lexical decision) with a similar SOA (42 ms.). An association with their finding is possible because they speculated that irregulars are decomposed with an additional fundamentally different mechanism emphasizing an intermediate level between the morpho-orthographic segmentation and the semantic system (lemma level). Accordingly, pinpointing distinctive regions for the recognition of irregular forms possibly highlights not only the validity of Crepaldi's (2010) assertion concerning the above-mentioned unique property of irregulars but also its location in the brain. As for the specific regions observed to be activated in the processing of irregular forms, Ullman's (2015) arguments about the involvement of basal ganglia in procedural learning (p. 148) also espoused the theoretical views favoring the decomposability of irregular forms. Furthermore, it was considered a hint for the neural reflection of morpho-orthographic segmentation due to the role of basal ganglia in grammatical processing. On the other hand, Llano (2015) stated that the clinical literature exhibited the role of thalamus in lexical selection and a model of the neurobiology of language should point to the function of thalamus in the mapping of semantic information to lexical units (pp. 106-110). Given Crepaldi et al.'s (2010) postulations in reference to the operation of semantic systems in the second level of the processing of irregular forms – the lemma level- the findings of this thesis proved to be highly meaningful because two regions that were activated as a reaction to the recognition of irregulars served functions in the idiosyncratic reading of such lexical forms. In this regard, new studies presenting region of interest (ROI) analyses with a specific focus on certain regions for each type of morpheme such as Pliatsikas (2014a) are expected to lead to a decisive conclusion.

The results also inferred that the examination of the exact brain regions reacting to the decomposition of complex words partially supported previous arguments along with several modifications required. On the one hand, the assertion that LIFG plays the central role in morphological processing for both inflected and derived forms (e.g. Ullman, 2004; Bozic et al., 2007; Sabourin, 2014) did not turn out to be completely compatible with the findings of this experiment. As explained above, this fMRI experiment identified the increases in the activation level in the left frontal cortex (BA6) for the production of regular and opaque priming; however, unlike De Greuwe et al., 2014, left angular gyrus (BA39- outside the traditional Broca area) was observed to be the only area with significant activation as a reaction to the processing of derived forms. Moreover, the right hemisphere was involved in the reading of irregularly inflected lexical items. Along with other experimental studies (e.g. Morris et al., 2007; Bozic et al., 2013; Schuster et al., 2018) which did not observe the reaction of the LIFG in the processing of complex forms, the results corroborated the quest for a bi-hemispheric task-based model considering the properties of types of morphemes. On the other hand, the significant LIFG activations in the regular and opaque forms agreed with the other studies (e.g. Lehtonen et al., 2009; Pliatsikas et al., 2014b; Prehn et al., 2018) about the central role of the left frontal gyrus in the surface form-related structures (in Anderson's (1992) classification). In other words, limited though they are, the absolute consensus in the literature implies the role of the traditional Broca area in the new model underway.

Lastly, as stated in the previous section, alternative looks at the fMRI data displayed theoretically suggestive implications even in the absence of conventionally-accepted level of significance. Similar to the derived forms, marginally significant activation was observed in BA39 on the semantic condition. Likewise, BA6 was involved in the processing of orthographic forms as it was on the regular and opaque conditions albeit at an unsatisfactory level of statistical significance. This conjunction is presumably beyond a coincidence; rather, it has a bearing on the putative split between derived and inflected forms (Matthews, 1991; Anderson, 1992) considering the parallelisms between the output of orthographic and regular forms on the one hand, and between the semantic and derived forms on the other hand. In this sense, in addition to the empirical support of Kırkıcı & Clahsen (2013) via behavioral evidence for the theoretical distinction between the inflectional and derivational processes, this study exhibited neural indicators in the same vein.

CHAPTER 5

CONCLUSION

The final chapter presents the concluding remarks about the goals and outcomes of this thesis. It begins with a brief summary of the findings and continues with an overall discussion by providing implications obtained by means of two experimental studies. The next part proceeds to report the limitations of this study and finalizes the chapter with reference to the suggestions for further investigations.

5.1. Overall Conclusions

This thesis evolved out of the long and inconsequential debates on the distinctive and identical features of L1 and L2 morphological processing. Taking advantage of the relatively consistent results regarding the L1 side over the last decades, it aimed to test whether L2ers employ the same processing strategies while reading morphologically complex words. In particular, this thesis tested whether L2ers decompose morphologically complex lexical items at an early and almost unconscious phase of reading as well as what factors could play a significant role in this process. In addition, recent improvements in technological facilities for the identification of the task-based activation of certain brain regions motivated the researcher to implement a follow-up fMRI study. The specific purpose of the latter study was to detect the neural correlates of the L2 decomposition process in comparison to L1 processing. The maximum level of correspondence between these two experiments also made it possible to check the potential effect of testing conditions in L2 visual word recognition.

The analyses of the first experiment indicated a native-like morphological processing pattern; while morphologically complex (genuine or pseudo) words were found to be parsed into their constituent morphemes, semantic or orthographic information did not lead to the facilitation of the recognition of target words in their own rights. The apparent discrepancy between these results and earlier studies was attributed to the high level of frequency of lexical items in this study with a rationale that did not link high frequency with holistic reading in L2. Besides, among the factors that were considered to have a role in L1 morphological processing, it was proficiency that had a main effect in the recognition of the morphologically-related word pairs in L2.

The fMRI experiments yielded two types of findings. On the one hand, the behavioral results of the masked-priming lexical decision task were in complete agreement with those of the former experiment and so verified the above-mentioned conclusions. On the other hand, the neural findings revealed that derived and inflected forms activated different brain regions in L2, hence the suggestion that the theoretical distinction between these main types of morphemes manifested itself in L2 by means of the magnetic levels of the blood oxygen in different locations in the brain. Furthermore, the widely-accepted role of the LIFG in L1 morphological processing was observed to be limited to grammatically motivated inflections in L2 due to the fact that left angular areas were involved in the meaning-driven derived morphemes, instead. Indirect evidence supporting this interpretation was found with a second look at the statistically non-significant fMRI data of the orthographic and semantic conditions. Orthographic relatedness between the primes and targets actually yielded a remarkable magnitude of activation in the region where the significant involvement was found for the inflections. A similar convergence was also detected between the semantic and derivational conditions. Therefore, the hypothetical differences in the functional properties of morphemes obtained its neural underpinnings in this experiment. Moreover, identifying two regions activated as a reaction to the priming effect on the irregularly inflected condition upheld the previous suggestions for the unique processing model of irregularities through a two-step mechanism.

5.2. General Discussion

The results of this thesis were found to be at variance with the estimations of the major morphological processing models available. The experiments did not support the connectionist views on account of the correspondence of the findings with the basic tenets of the serial models of visual word recognition rather than the parallel processing accounts. That is, unlike morphology, yielding no behavioral or neural sign for the efficient role of the orthographic or semantic information while reading complex words undermined the models that predicted the intervention of such hypothetical factors at early stages of lexical processing. Neither the computer-based lexical decision task nor the fMRI experiment displayed any significant level of facilitation in the recognition of words when the participants had to employ only orthographic or semantic information. Although it does not entail the elimination of form and meaning in lexical processing, the study necessitated a revision of the connectionist models from the temporal perspectives to come up with distinct accounts that specify the reading phenomenon based on the time-based phases of the process.

The results converged with the localist approaches of the serial models in the sense that distinct types of information were retrieved during reading. However, compared to the hotly-debated hypotheses of visual word recognition in L2, the findings of this thesis differed from those of earlier behavioral and brain-based experiments in that no distinctions in the reaction to the morpheme types were observed regarding the priming effect. The results turned out to diverge from the predictions of the Words and Rules Theory because they did not distinguish between regular and irregular forms, hence providing evidence against the view that irregulars are stored as full forms unlike regulars. Likewise, the findings were challenging for the Shallow Structure Hypothesis due to the occurrence of similar levels of facilitation in the derivational and inflectional prime-target pairs.

On the other hand, reviewing the studies that implied a continuity model in L2 with respect to the use of grammatical information in language processing, notable instances of discrepancy between the previous literature and this study were observed. Observing no distinction in terms of the regularity of the morphemes for combinatorial reading (cf. Feldman et al., 2010) or the absence of the orthographic priming effect (cf. Diepenedeale et al., 2011) were unforeseen by the proponents of a nativelike grammatical processing pattern in L2. Nevertheless, asserting a development model depending on the level of proficiency to fully utilize grammatical information in real-time language use was upheld in two experiments with consistent findings.

It was essential to account for the considerable disagreement between the results of this thesis and the previous literature. The incongruity of the findings to such a large extent implied a primary difference in L1 and L2 with respect to the correlation of the frequency with decomposition. The analyses referred to the speculation that highly frequent complex words were separated into their constituent elements resulting in a faster recognition by L2 participants although no facilitation was found in highly frequent orthographic or semantic relatedness. The L1 literature did not allege that such an advantage was the case for the native speakers. Therefore, the presence of frequency as a core element of L2 morphological processing turns out to be the most feasible explanation of the contradiction with the former studies. Besides, as it was stated in several studies, proficiency steps forward as the determinant factor of the potential between variables rather than vocabulary knowledge or spelling accuracy.

The scarcity of fMRI studies drawing on the priming paradigm signifies that further studies serve on the formation of a model of L2 neurobiology, not on the criticism or falsification of the prior endeavor. In view of the widely acclaimed views on the location of linguistic knowledge in the L1 brain, the findings only partially supported the claim that LIFG is involved in the use of grammatical information. Although significant magnitudes of activation in the abovementioned region were yielded for the regular relatedness, priming was produced for derived and irregular conditions with the involvement of different areas. This distinction refers to the hemodynamic reflection of the unique properties of morphemes in the course of reading complex words even though it did not make a time-based difference. Moreover, Crepaldi et al. (2010)'s two phased argument about the decomposition of irregulars found its neural basis in L2 because it was detected that two distinct areas in the brain – distant from the left frontal cortex- were activated as a result of the priming effect in the irregular condition. The results suggested that irregulars are processed quite differently than the regular suffixes; however, this difference cannot be attributed to the storage of irregularly inflected lexical items as full forms owing to the facilitative effect for the activation of their stems. As for the deeper analyses of the orthographic and semantic conditions, which did not produce any priming effect or brain activations according to the standardized values, it was noticed that formal overlap produced the activations of the same regions as the regular condition and the meaning-based associations between primes and targets proved to involve the areas in common with the derived relatedness. Accordingly, the results affirmed the hypothesis that offered a split between inflected and derived forms regarding their links with the surface forms of the words and their meanings.

5.3. Implications of the Findings

The results summarized above came up with substantial implications from theoretical and developmental perspectives of L2 grammatical processing. A notable inference out of the results of the experiments is the need for a revision of the L2 visual word recognition models. Overall, the findings imply that modelling how L2ers process grammatical structures requires a multi-faceted approach rather than making predictions based on a representative / average L2er similar to the 'ideal native speaker' phenomenon of language acquisition debates. It means that depicting the nature of such a complicated construct by controlling many of the variables is an oversimplified method that presumably jeopardizes the external validity of the results. In other words, reaching robust results by removing potential factors intervening in the reading process from the analyses is apparently a handicap to put forward pervasive arguments, hence a generalizability problem. It is expected that targeting specific groups and testing specific factors should accordingly have limited implications. Moreover, the way variables are controlled is a matter of choice; that is, when choosing a considerable number of representative participants / items for all prospective variables, it is natural to choose one constant group for all experiments but this cannot rule out the confounding effect of the aforesaid factor. This study served as an example for this argument; it seemingly controlled the frequency effect; however, choosing high-frequency items constantly for all conditions uncovered unpredicted results about the decomposition of the types of morphologically complex words compared to the previous literature.

Considering the immense space of probabilities due to the possible factors interacting to yield various outcomes, the goal of even a large-scale research should be to incorporate the results with what was done before rather than coming up with a brand-new full-fledged model in this area of investigation. Therefore, 'in pursuit of the black swan', this thesis was able to indicate several updates in the endeavors to account for the recognition of complex words by L2 users. As mentioned above, the findings about the effect of frequency and proficiency signaled the limits and conditions of native-like morpho-orthographic segmentation in L2. This is challenging for the descriptive and explanatory adequacy of the arguments (such as the Shallow Structure Hypothesis) drawing a firm distinction between the mental processing of grammatical forms in L1 and L2 because it undermined the fundamental difference hypotheses by aligning L2 performance with the L1 pattern. However, it also diverged from the assertions unconditionally adapting the Continuity Hypothesis to L2 due to the fact that the inferences made out of the experiments were limited to high frequency items and a comparatively outstanding level of proficiency ranging from upper intermediate to advanced. Hence, it can be argued that the results of this thesis contributed to description of a more precise portrayal of L2 morphological processing.

Another implication of this thesis addresses to the reconsideration of the unquestioned assumptions about the relationship between the extent of frequency and morphological decomposition in L2. The debates distinguishing between L1 and L2 acquisition generally emphasize the initial and final states, length and quality of the input, availability of the learning mechanisms. It is generally taken for granted that the way L1 users treat frequency does not differ from L2ers' reaction, so if a word is too frequent to process in L1 the same result is expected in the L2 contexts as well. This prediction is problematic because it sets criterion for the threshold of decomposability according to how often certain words are used or perceived in language environments of natives. It is argued that this fallacy of equating L1 and L2 in the recognition of frequent forms accounts for the unexpected findings in the conditions of morphological relatedness, hence, the morpho-orthographic segmentation. For this reason, the rationale that acknowledges the individuality of L2 in the analyses and evaluations should embrace the extent frequency modulates the mental processing of lexical items.

As regards the development of L2ers towards a native-like morphological processing pattern, the thesis pointed out that prioritizing grammatical information during the recognition of lexical items increases hand in hand with the improvement in proficiency. Other types of individual differences tested in the experiments, namely spelling accuracy and vocabulary size, are considered to be among the sub-components of overall proficiency, so it is unlikely to induce that such a parallel increase in proficiency and the magnitude of priming gives a hint of a mutual interaction between these constructs. However, it displays an advancement in L2 as a must for the desired linguistic behaviors. In particular, revealing positive correlation between the morphological decomposition and proficiency – unlike orthographic or semantic knowledge- in L2 implicitly proposed an L2 learning model that considers the effect of the synchronous acquisition and use of grammatical information.

The main claim of the section searching for the neural correlates of how L2ers read complex words is that each type of priming produced in the behavioral experiments echoes in the brain regions in a suggestive way. That is, form-focused morphemes lead to the involvement of different locations in the brain than the meaning-induced constituents. It exhibits the brain-based evidence for the long-standing arguments about the unique functions of the morphemes, which stresses that derived forms carry the meaning and prompt different locations in the brain (mostly left-angular parts) than the inflected forms that execute grammatical operations in the left frontal area of the brain. Therefore, assumptions and predictions regarding the reflections of brain regions in L2 need to be adapted on the basis of the types of morphemes. The same applies to the irregular forms which were found to activate two different locations most probably in line with the sequential operations at two levels of lexical processing.

5.4. Limitations and Suggestions for Further Research

L2 morphological processing is a considerably complicated field of study with quite a few factors mostly intervening in an uncontrolled way. In view of the handicaps of controlling variables as previously stated in this chapter, it would be seen an unrealistic goal to describe this phenomenon in every aspect by means of a single study. Accordingly, further studies are expected to dwell on the following issues:

- New experiments should test the priming effect of as many types of morphemes

as possible within the same study because it is sometimes misleading to reach a generalization out of various investigations that focus on one or a couple of these elements.

- Follow-up studies with larger scales should be conducted that take potential factors of morphological processing such as proficiency and frequency as continuous variables rather than categorical.
- Comparative studies are needed to provide precise information about the link between the level of frequency and decomposability of complex words in L1 and L2 at different levels of proficiency. Possible differences in such studies should be taken as the baseline of the further investigations into the L1 & L2 visual word recognition.
- Since the task has a profound effect on the results, further fMRI studies adopting the masked-priming lexical decision task are essential for the examination of the generalizability of the conclusions drawn from this thesis.
- More studies that directly look into the correlations between the behavioral and neural findings are needed for the precise identification of the brain locations involved in the recognition of complex words.

- The possible effect of testing conditions on morphological processing deserves additional inquiries that delve into other types of neural and behavioral test environments such as PET, MEG and eye-tracking.

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APPENDICES

APPENDIX A. EXPERIMENTAL STIMULI

APPENDIX A.1. DERIVATIONAL ITEMS

Prime Conditions		
Identical	**Related**	**Unrelated**
herb	herbal	king
music	musical	debt
coast	coastal	entry
norm	normal	year
form	formal	army
logic	logical	cake
digit	digital	steak
critic	critical	banana
person	personal	snake
origin	original	camera
nation	national	purple
region	regional	hungry
topic	topical	bread
magic	magical	abrupt
verb	verbal	poor
lyric	lyrical	tiny
post	postal	male
ethic	ethical	green
orbit	orbital	glad
act	actual	raw
fact	factual	idle
sex	sexual	wood
text	textual	warm
season	seasonal	honest

APPENDIX A. 2. REGULARLY INFLECTED ITEMS

Prime Conditions		
Identical	**Related**	**Unrelated**
pass	passed	silly
move	moved	tart
look	looked	oven
ask	asked	dry
want	wanted	ice
need	needed	flat
develop	developed	horrible
change	changed	silent
watch	watched	minor
seem	seemed	bird
happen	happened	church
help	helped	mode
play	played	rich
follow	followed	oxygen
offer	offered	rainy
die	died	hat
live	lived	poem
kill	killed	fork
reach	reached	jolly
raise	raised	brown
return	returned	sticky
decide	decided	guitar
agree	agreed	input
cover	covered	scary

APPENDIX A.3. IRREGULARLY INFLECTED ITEMS

Prime Conditions		
Identical	**Related**	**Unrelated**
beat	beaten	shoe
bite	bitten	acid
break	broken	flower
bring	brought	theory
buy	bought	wet
catch	caught	media
choose	chosen	frank
drive	driven	absent
fall	fallen	chief
fight	fought	juicy
forget	forgotten	rebel
forgive	forgiven	shallow
freeze	frozen	member
hide	hidden	unit
ride	ridden	tool
shrink	shrunk	cousin
speak	spoken	olive
teach	taught	pizza
think	thought	sugar
throw	thrown	spicy
understand	understood	parachute
write	written	sweet
fly	flown	sour
sleep	slept	misty

APPENDIX A. 4. OPAQUE ITEMS

Prime Conditions		
Identical	**Related**	**Unrelated**
corn	corner	recipe
broth	brother	deposit
sum	summer	permit
sir	siren	proof
sweat	sweater	harvest
show	shower	motion
leg	legion	unique
port	portion	studio
ration	rational	shoulder
iron	irony	alarm
arch	archer	series
brand	brandy	collar
count	country	register
disc	discern	category
invent	inventory	practice
treat	treaty	strike
miss	mission	budget
wit	witness	context
organ	organize	village
court	courteous	president
infant	infantry	address
splint	splinter	author
adult	adultery	sentence
lot	lottery	benefit

APPENDIX A. 5. ORTHOGRAPHIC ITEMS

Prime Conditions		
Identical	**Related**	**Unrelated**
less	leave	hint
pain	paint	urgent
shake	shock	husband
string	strong	chance
tooth	truth	lemon
click	clock	magazine
shoot	sheet	coffee
ant	antique	library
harm	harmony	bridge
gram	grammar	festival
nap	napkin	grocery
nick	nickel	surgery
pump	pumpkin	target
extra	extract	knife
bad	badge	truck
will	wild	secret
wall	wallet	divine
disco	discover	terrific
stub	stubborn	mineral
eleven	elevator	chocolate
wind	window	regret
spin	spinach	decade
pill	pillow	random
parent	parenthesis	adequate

APPENDIX A. 6. SEMANTIC ITEMS

Prime Conditions		
Identical	**Related**	**Unrelated**
photo	picture	journey
purpose	intent	distance
class	lesson	muscle
total	complete	fragile
fate	destiny	rumour
feature	attribute	bucket
satan	devil	hole
fool	idiot	melon
film	movie	plane
prize	reward	cheese
grab	seize	feel
cite	quote	drink
rush	hurry	make
battle	conflict	peasant
noon	midday	garlic
law	rule	bicycle
awful	terrible	decisive
ruin	destroy	observe
dull	tiresome	ceaseless
contrast	difference	treasure
costly	expensive	skepticism
stance	attitude	property
nominee	candidate	territory
weather	forecast	sandwich

APPENDIX A. 7. FILLERS

Prime (Real Word)	Target (Real Word)		Prime (Nonce Word)	Target (Real Word)
aboard	POLICE		seint	WOMAN
average	DISTRICT		moove	CHILD
awake	TRICK		boothe	THROUGH
brief	MOUSE		spruise	BETWEEN
black	ESSAY		stieve	MIGHTY
sparse	ASPECT		sprerse	COMPANY
taboo	EXPERT		glant	STORE
mellow	TUNNEL		gwirk	POWER
juvenile	CONTRACT		streef	INFORM
robust	KITCHEN		theeve	REASON
opposite	PLATFORM		phorth	SUPPLY
regular	DISEASE		twought	EXCHANGE
fresh	HOST		pleighth	CORPORATE
vulgar	BISHOP		criece	SHADOW
violet	TODAY		shraw	BOTTLE
quick	TOWEL		swourth	ENGINEER
harsh	RICE		throophy	PROSECUTE
private	HORROR		flaque	SCREAM
accept	FINISH		screem	LOCK
afford	STOP		phaught	SYMPTOM
borrow	EDUCATE		feighth	RARELY
bounce	MEASURE		slarve	JACKET
continue	FRIGHTEN		pralse	SPOON
explode	COME		blaive	STOMACH
influence	EXAMINE		yourn	SHELL
improve	STRIVE		reigln	BARRIER
murder	OVERSEE		greace	BOTTOM
go	KNIT		phake	STUPID
bear	SOW		chuice	SOLAR
begin	SWEEP		phraise	LIKELY
give	START		swich	FAST
feed	EARN		stoan	TRIBE
forbid	ENCOURAGE		yeuth	HUMOR
foresee	DWELL		phool	CABIN
slay	GET		flourse	SCRIPT
sling	THRUST		wheigh	SALMON

Prime (Real Word)	**Target (Nonce Word)**		**Prime (Real Word)**	**Target (Nonce Word)**
always	HOUNSE		place	PHRUP
during	PHOUD		system	TREBE
without	GLISED		program	TARB
small	SWOUSED		number	CROLT
hold	CUX		before	FLANE
point	HURST		mother	PLAIL
large	SKWEEN		story	BOATHE
next	SHRAWND		book	SKOURGE
night	TICED		word	STROUTE
business	SPOOLD		though	JORGUE
public	SWUFFED		head	THRAIL
around	WOUST		little	KNANGE
create	NOURCED		after	CLEETH
allow	STRISTE		issue	KNATCH
level	SWAUND		house	SCRURN
health	SCICKED		since	GLOACH
within	KNIFT		long	SMOW
sense	GNINS		provide	GNITH
probably	PRANZE		service	SPINK
expect	VOFT		father	THREUM
send	SPRUIS		city	THEAN
market	STIRST		almost	PHOWN
college	GHOOS		include	THREUM
death	ERSTE		later	SCAUCE
cut	DROARD		community	CRARGE
interest	TIRST		much	BREAP
should	SPENX		name	PHLAWSE
never	JOUNTS		five	SPOONCH
family	STRINGTH		once	BRINGE
while	ROP		least	SCRERF
group	GROURN		learn	DWAUL
talk	CLETT		real	SNAITCH
turn	SWAUGHT		team	WHAMP
where	PHLEAGUE		minute	STRERTH
problem	STILCH		best	KNORN
about	FUSK		several	PLAUSE

Prime (Real Word)	**Target (Nonce Word)**		**Prime (Real Word)**	**Target (Nonce Word)**
kid	CHUTCH		appear	LECK
body	JUSH		human	SUCE
nothing	HULE		wait	SNOWSE
ago	CRENCH		serve	FEANT
lead	WHORTH		build	SHENT
social	BLERGE		stay	TWOOR
whether	BRAUCE		someone	HULF
back	SLILGE		behind	SHRITH
together	CHOPE		remain	SPICHE
read	PHLEETH		effect	DWOURCE
door	SLAWSE		use	WRORGE
walk	LOUTH		suggest	WHOUCH
low	SHROIN		perhaps	JIEGE
win	DEG		sell	HEKE
research	WARR		linear	FLOOSH
girl	GWEEM		require	GWALPH
guy	SKEAL		along	PHILM
food	VORGUE		report	SHROOSH
moment	DWISH		effort	THWARF
himself	YINE		rate	SPREIGHTH
air	PRIRL		heart	THRES
please	GHIGHT		drug	GHIRQUE
force	CUZZ		leader	YIEK
enough	TUIN		light	SUILT
although	ZODD		voice	CLOAL
remember	SUSK		whole	WUFF
foot	MEDGE		finally	GLURVE
second	CLAUB		pull	YOUCH
boy	DREG		military	MARF
maybe	HUICHE		price	PLAIF
toward	SKOISE		according	DRALC
policy	SNENCH		decision	THOICE
everything	SCRARF		explain	VAUSE
love	CLILK		son	YARCE
process	SPLELVE		hope	PHAUTCH
consider	CLOOP		even	VIRGUE

Prime (Real Word)	**Target (Nonce Word)**		**Prime (Real Word)**	**Target (Nonce Word)**
carry	THOSS		past	GLIRT
town	SLAITH		focus	OWTH
road	PUPE		foreign	KOAF
thank	NAZZ		order	VAIF
receive	RIRTH		enter	BOUSE
value	SPAWP		than	WHIKE
tax	SPRINC		common	HINC
director	SWOZ		share	PSOMB
record	LERGE		race	THREACE
paper	ZATE		similar	PLETT
space	SMUMP		concern	PROAM
couple	JORT		response	PSYME
base	CRİV		animal	VAISE
table	STRUIB		except	RHORNE
produce	WHADD		answer	TUZZ
industry	DREAVE		hard	MOOL
recent	SHOWSE		resource	KIER
describe	CLUILE		degree	SHREBB
product	SMAUCHE		wonder	DRARM
doctor	TEEVE		attack	GROSH
patient	SNAUGE		herself	CHELCH
simply	WRAUK		general	PHRINT
third	BLUGE		standard	PSAUNCH
step	KULSE		message	TWIV
computer	NALF		outside	HORK
tree	GLALP		compare	SCUME
hair	PRED		discuss	WRUZZ
difficult	TRAN		event	FALVE
culture	CHAWP		song	KNATPE
billion	OUNGE		laugh	THOOB
period	SPLAFE		guess	OARSE
defense	GNERT		hang	PHLILGE
bank	CHISQUE		entire	CULE
west	CLOURSE		close	ILN
east	PSARCH		demand	ZISS
subject	THWEEK		religion	BECHE

APPENDIX B. LANGUAGE BACKGROUND QUESTIONNAIRE

Personal Information		
Last Name:	First Name:	Today's date:
Date of birth:	Female ( )	Male ( )
Department :	Email-address:	

What is your first language (mother tongue)?			
Language	From which age on?	For how long?	Context of acquisition (at home, at school, other) (please specify)
	0	(your age)	

Which language(s) have you learned?			
Language	From which age on?	For how long?	Context of acquisition (at home, at school, other) (please specify)
1.			
2.			
3.			
4.			

Current Language Use

In the first row please write the names of the languages you actually use in everyday life. Please indicate for each activity (speaking, listening) the average percentage you use for each of the languages with each communicative partner. **The amount should add up to 100% in each row.** Please write NA if a case does not apply to you.

EXAMPLE

How often do you use your languages in everyday situations?	Language 1 (Your native language) Turkish	Language 2 English	Language 3 French	Language 4 ………..	Language 5 …………..	**Sum**
Speaking	70	28	2			**= 100%**
Listening	85	15	NA			**= 100%**

TYPE YOUR ANSWERS IN THE TABLE BELOW

How often do you use your languages in everyday situations?	Language 1 (Your native language) …………..	Language 2 …………..	Language 3 …………..	Language 4 ………..	Language 5 …………..	**Sum**
Speaking						**= 100%**
Listening						**= 100%**
Writing						**= 100%**
Reading						**= 100%**
Overall						**= 100%**

Have you ever been abroad?	For how long?	At which age?	Why? (school, studies, vacation, etc.)
1.			
2.			
3.			
4.			

English Language Background

Please indicate your answers to the following questions:

1) How would you rate…	**poor**								**excellent**
… your *overall* proficiency in English?	1	2	3	4	5	6	7	8	9
… your *speaking* skills in English?	1	2	3	4	5	6	7	8	9
… your *listening comprehension* in English?	1	2	3	4	5	6	7	8	9
… your *writing* skills in English?	1	2	3	4	5	6	7	8	9
… your *reading* skills in English?	1	2	3	4	5	6	7	8	9
	extremely uncomfortable								**extremely comfortable**
2) How comfortable do you feel understanding and using English?	1	2	3	4	5	6	7	8	9
3) At which age did you first feel comfortable using the English language?									
4) How much did the following factors contribute to you learning English?	**minimal contribution**								**maximal contribution**
Classes and teachers…	1	2	3	4	5	6	7	8	9
Interacting with friends/relatives in English…	1	2	3	4	5	6	7	8	9
Interacting with family in English …	1	2	3	4	5	6	7	8	9

Watching TV in English …	1	2	3	4	5	6	7	8	9
Listening to radio/music in English …	1	2	3	4	5	6	7	8	9
Reading in English …	1	2	3	4	5	6	7	8	9
Self-instruction in English using videos, software etc…	1	2	3	4	5	6	7	8	9

General health condition				
Handedness?	Right ( )	Left ( )		
Eyesight?	Normal ( )	Near-sighted ( )	Far-sighted ( )	Other eye problems? Please specify.
	Corrected with?	Glasses ( )	Contact Lenses ( )	
Have you been diagnosed with any language related impairments (dyslexia, stuttering, etc.)	No ( )	Yes ( )	If yes, please specify	
Have you had any neurological problems? (seizures, stroke, epilepsy, etc.)	No ( )	Yes ( )	If yes, please specify	

APPENDIX C. FOLLOW-UP TASK

Write the past participle (V3) form of the bare verbs given below.

e.g. go…….. gone

be……..been

Beat ………………..

Bite ………………..

Break ………………..

Bring ……………….

Buy ………………

Catch ………………

Choose ……………….

Drive ………………

Fall ……………..

Fight ………………

Forget ……………..

Forgive ………………

Freeze ………………

Hide ……………….

Ride ……………….

Shrink ……………..

Speak ………………

Teach ……………..

Think ……………..

Throw ………………..

Understand ……………………

Write ………………………

Fly ……………………..

Sleep ………………………..

Pass ……………………

Move …………………….

Look …………………..

Ask …………………..

Want ……………………

Need ……………………

Develop …………………..

Change ………………….

Watch ………………….

Seem ………………….

Happen ……………………

Help …………………….

Play …………………..

Follow ………………..

Offer …………………

Die ………………….

Live ……………………

Kill ……………………

Reach ……………….

Raise …………………

Return …………………

Decide …………………

Agree ………………..

Cover …………………….

Please choose the best alternative that is closest in meaning to the words given below.

1.	**herb:**	a.) stone	b.) tree	c.) weed
2.	**music:**	a.) survey	b.) sound	c.) symphony
3.	**coast:**	a.) sail	b.) design	c.) seashore
4.	**norm:**	a.) standard	b.) medicine	c.) ordinary
5.	**form:**	a.) kind	b.) shape	c.) stretch
6.	**logic:**	a.) reasoning	b.) meaning	c.) currency
7.	**digit:**	a.) shares	b.) count	c.) number
8.	**critic:**	a.) policy	b.) review	c.) value
9.	**person:**	a.) body	b.) angle	c.) individual
10.	**origin:**	a.) root	b.) heel	c.) center
11.	**nation:**	a.) country	b.) people	c.) shelter
12.	**region:**	a.) area	b.) land	c.) spell
13.	**topic:**	a.) level	b.) idea	c.) subject
14.	**magic:**	a.) interest	b.) wizardry	c.) power
15.	**verb:**	a.) modal	b.) rotate	c.) word
16.	**lyric:**	a.) composition	b.) signal	c.) song
17.	**post:**	a.) business	b.) position	c.) denim
18.	**ethic:**	a.) moral	b.) duty	c.) grasp
19.	**orbit:**	a.) stain	b.) sphere	c.) circle
20.	**act:**	a.) twist	b.) perform	c.) produce
21.	**fact:**	a.) knowledge	b.) audience	c.) reality
22.	**sex:**	a.) gender	b.) operation	c.) couple
23.	**text:**	a.) word	b.) handbook	c.) wing
24.	**season:**	a.) period	b.) weather	c.) square

APPENDIX D. CLOZE TEST

CLOZE TEST

For each blank in the following passage, please circle one of three options given. Please choose the option appropriate for the context. Please choose one option only for each blank.

Joe came home from work on Friday. It was payday, but he wasn't [even | more | ever] excited about it. He knew that [then | when | while] he sat down and paid his [checks | bills | salary] and set aside money for groceries, [driving | pay | gas] for the car and a small [deposit | withdrawal | money] in his savings account, there wouldn't be [quite | not | too] much left over for a good [pleasure | leisure | life].

He thought about going out for [eat | dinner | eating] at his favorite restaurant, but he [just | only | very] wasn't in the mood. He wandered [around | at | in] his apartment and ate a sandwich. [In | For | After] a while, he couldn't stop himself [for | from | about] worrying about the money situation. Finally, [he | she | it] got into his car and started [drive | driven | driving].

He didn’t have a destination in [head | mind | fact], but he knew that he wanted [be | to be | being] far away from the city [which | there | where] he lived. He turned onto a quiet country [road | house | air]. The country sights made him feel [as good | better | best]. His mind wandered as he drove [past | in | to] small farms and he began to [try | think | imagine] living on his own piece of [house | land | farm] and becoming self-sufficient. It had always [being | been | be] a dream of his, but he [having | have | had] never done anything to make it [a | one | some] reality. Even as he was thinking, [their | his | her] logical side was scoffing at his [favorite | practical | impractical] imaginings. He debated the advantages and [cons | disadvantages | problems] of living in the country and [growing | breeding | building] his own food. He imagined his [farmhouse | truck | tractor] equipped with a solar energy panel [at | out | on] the roof to heat the house [in | for | over] winter and power a water heater. [She | He | They] envisioned fields of vegetables for canning [either | and | but] preserving to last through the winter. [Whether | Even | If] the crops had a good yield, [maybe | possible | may] he could sell the surplus and [store | save | buy] some farming equipment with the extra [economy | cost | money].

Suddenly, Joe stopped thinking and laughed [at | out | so] loud, “I’m really going to go [through | away | in] with this?

Adapted from American Kernel Lessons: Advanced Students’ Book. O’Neill, Cornelius and Washburn (1981).

APPENDIX E. VOCABULARY SIZE TEST

VOCABULAR SIZE TEST: VERSION A

1. <saw it>
a.) closed it tightly
b.) waited for it
c.) looked at it
d.) started it up

2. <time>
a.) money
b.) food
c.) hours
d.) friends

3. <period>
a.) question
b.) time
c.) thing to do
d.) book

4. <figure>
a.) answer
b.) place
c.) time
d.) number

5. <are poor>
a.) have no money
b.) feel happy
c.) are very interested
d.) do not like to work hard

6. <microphone>
a.) machine for making food hot
b.) machine that makes sounds louder
c.) machine that makes things look bigger
d.) small telephone that can be carried around

7. <nil>
a.) very bad
b.) nothing
c.) very good
d.) in the middle

8. <pub>
a.) place where people drink and talk
b.) place that looks after money
c.) large building with many shops
d.) building for swimming

9. <circle>
a.) rough picture
b.) space with nothing in it
c.) round shape
d.) large hole

10. <digs>
a.) solves problems with things
b.) creates a hole in the ground
c.) wants to sleep
d.) enters the water

11. <soldier>
a.) person in a business
b.) person who studies
c.) person who uses metal
d.) person in the army

12. <restored>
a.) said again
b.) given to a different person
c.) made like new again
d.) given a lower price

13. <a pro>
a.) someone who is employed to find out important secrets
b.) a stupid person
c.) someone who writes for a newspaper
d.) someone who is paid for playing sport

14. <compound>
a.) agreement
b.) thing made of two or more parts
c.) group of people forming a business
d.) guess based on past experience

15. <had a large deficit>
a.) spent a lot more money than it earned
b.) went down a lot in value
c.) had a plan for its spending that used a lot of money
d.) had a lot of money stored in the bank

16. <strap>
a.) promise
b.) top cover
c.) shallow dish for food
d.) strip of strong material

17. <wept>
a.) finished his course
b.) cried
c.) died
d.) worried

18. <haunted>
a.) full of decorations
b.) rented
c.) empty

d.) full of ghosts

19. <cube>
a.) sharp thing used for joining things
b.) solid square block
c.) tall cup with no saucer
d.) piece of stiff paper folded in half

20. <butler>
a.) man servant
b.) machine for cutting up trees
c.) private teacher
d.) cool dark room under the house

21. <nun>
a.) long thin creature that lives in the earth
b.) terrible accident
c.) woman following a strict religious life
d.) unexplained bright light in the sky

22. <olives>
a.) oily fruit
b.) scented flowers
c.) men's swimming clothes
d.) tools for digging

23. <shuddered>
a.) spoke with a low voice
b.) almost fell
c.) shook
d.) called out loudly

24. <threshold>
a.) flag
b.) point or line where something changes
c.) roof inside a building
d.) cost of borrowing money

25. <demography>
a.) the study of patterns of land use
b.) the study of the use of pictures to show facts about numbers
c.) the study of the movement of water
d.) the study of population

26. <malign>
a.) good
b.) evil
c.) very important
d.) secret

27. <strangled her>
a.) killed her by pressing her throat
b.) gave her all the things she wanted
c.) took her away by force
d.) admired her greatly

28. <dinosaurs>
a.) robbers who work at sea

b.) very small creatures with human form but with wings
c.) large creatures with wings that breathe fire
d.) animals that lived an extremely long time ago

29. <a jug>
a.) a container for pouring liquids
b.) an informal discussion
c.) a soft cap
d.) a weapon that blows up

30. <crabs>
a.) very thin small cakes
b.) tight, hard collars
c.) sea creatures that always walk to one side
d.) large black insects that sing at night

31. <quilt>
a.) statement about who should get their property when they die
b.) firm agreement
c.) thick warm cover for a bed
d.) feather pen

32. <tummy>
a.) fabric to cover the head
b.) stomach
c.) small soft animal
d.) finger used for gripping

33. <There was an eclipse>
a.) A strong wind blew all day
b.) I heard something hit the water
c.) A large number of people were killed
d.) The sun was hidden by the moon

34. <excreted>
a.) pushed or sent out
b.) made clear
c.) discovered by a science experiment
d.) put on a list of illegal things

35. <are ubiquitous>
a.) are difficult to get rid of
b.) have long, strong roots
c.) are found everywhere
d.) die away in the winter

36. <the marrow>
a.) symbol that brings good luck to a team
b.) soft center of a bone
c.) control for guiding a plane
d.) increase in salary

37. <cabaret>
a.) painting covering a whole wall
b.) song and dance performance
c.) small crawling creature
d.) person who is half fish, half woman

38. <in a cavalier manner>
a.) without care
b.) with good manners
c.) awkwardly
d.) as a brother would

39. <veered>
a.) moved shakily
b.) changed course
c.) made a very loud noise
d.) slid without the wheels turning

40. <yoghurt>
a.) dark grey mud found at the bottom of rivers
b.) unhealthy, open sore
c.) thick, soured milk, often with sugar and flavoring
d.) large purple fruit with soft flesh

41. <an octopus>
a.) a large bird that hunts at night
b.) a ship that can go under water
c.) a machine that flies by means of turning blades
d.) a sea creature with eight legs

42. <monologue>
a.) single piece of glass to hold over his eye to help him to see
b.) long turn at talking without being interrupted
c.) position with all the power
d.) picture made by joining letters together in interesting ways

43. <be candid>
a.) be careful
b.) show sympathy
c.) show fairness to both sides
d.) say what you really think

44. <nozzle>
a.) space that light passes through in a camera
b.) dry patch of skin
c.) pipe attachment that forces water
d.) sharp part of a fork

45. <a psychosis>
a.) an inability to move
b.) an oddly coloured patch of skin
c.) a body organ that processes sugar
d.) a mental illness

46. <ruck>
a.) region between the stomach and the top of the leg
b.) noisy street fight
c.) group of players gathered round the ball in some ball games
d.) race across a field of snow

47. <roubles>
a.) very valuable red stones
b.) distant members of his family
c.) Russian money

d.) moral or other difficulties in the mind

48. <canonical examples>
a.) examples which break the usual rules
b.) examples taken from a religious book
c.) regular and widely accepted examples
d.) examples discovered very recently

49. <puree>
a.) fruit or vegetables in liquid form
b.) dress worn by women in India
c.) skin of a fruit
d.) very thin material for evening dresses

50. <vial>
a.) device which stores electricity
b.) country residence
c.) dramatic scene
d.) small glass bottle

51. <a counterclaim>
a.) a demand response made by one side in a law case
b.) a request for a shop to take back things with faults
c.) an agreement between two companies to exchange work
d.) a decorative cover for a bed, which is always on top

52. <refectory>
a.) room for eating
b.) office where legal papers can be signed
c.) room for several people to sleep in
d.) room with glass walls for growing plants

53. <trill>
a.) repeated high musical sound
b.) type of stringed instrument
c.) way of throwing the ball
d.) dance step of turning round very fast on the toes

54. <talons>
a.) high points of mountains
b.) sharp hooks on the feet of a hunting bird
c.) heavy metal coats to protect against weapons
d.) people who make fools of themselves without realizing it

55. <plankton>
a.) poisonous plants that spread very quickly
b.) very small plants or animals found in water
c.) trees producing hard wood
d.) grey soil that often causes land to slip

56. <soliloquy>
a.) song for six people
b.) short clever saying with a deep meaning
c.) entertainment using lights and music
d.) speech in the theatre by a character who is alone

57. <puma>
a.) small house made of mud bricks

b.) tree from hot, dry countries
c.) large wild cat
d.) very strong wind that lifts anything in its path

58. <augured well>
a.) promised good things for the future
b.) agreed with what was expected
c.) had a color that looked good with something else
d.) rang with a clear, beautiful sound

59. <emir>
a.) bird with two long curved tail feathers
b.) woman who cares for other people's children in eastern countries
c.) Middle Eastern chief with power in his own land
d.) house made from blocks of ice

60. <is very didactic>
a.) tries hard to teach something
b.) is very difficult to believe
c.) deals with exciting actions
d.) is written with unclear meaning

61. <cranny>
a.) sale of unwanted objects
b.) narrow opening
c.) space for storing things under the roof of a house
d.) large wooden box

62. <lectern>
a.) desk made to hold a book at a good height for reading
b.) table or block used for church ceremonies
c.) place where you buy drinks
d.) very edge

63. <azalea>
a.) small tree with many flowers growing in groups
b.) light natural fabric
c.) long piece of material worn in India
d.) sea shell shaped like a fan

64. <a marsupial>
a.) an animal with hard feet
b.) a plant that takes several years to grow
c.) a plant with flowers that turn to face the sun
d.) an animal with a pocket for babies

65. <bawdy>
a.) unpredictable
b.) innocent
c.) rushed
d.) indecent

66. <crowbar>
a.) heavy iron pole with a curved end
b.) false name
c.) sharp tool for making holes in leather
d.) light metal walking stick

67. <spangled>
a.) torn into thin strips
b.) covered with small bright decorations
c.) made with lots of folds of fabric
d.) ruined by touching something very hot

68. <averred>
a.) refused to agree
b.) declared
c.) believed
d.) warned

69. <a retro look>
a.) a very fashionable look
b.) the look of a piece of modern art
c.) the look of something which has been used a lot before
d.) the look of something from an earlier time

70. <a rascal>
a.) an unbeliever
b.) a dedicated student
c.) a hard worker
d.) a bad girl

71. <tweezers>
a.) small pieces of metal for holding papers together
b.) small pieces of string for closing wounds
c.) a tool with two blades for picking up or holding small objects
d.) strong tool for cutting plants

72. <bidet>
a.) low basin for washing the body after using the toilet
b.) large fierce brown dog
c.) small private swimming pool
d.) man to help in the house

73. <sloop>
a.) warm hat
b.) light sailing boat
c.) left over food
d.) untidy work

74. <swinging fines>
a.) very large fines
b.) very small fines
c.) fines paid in small amounts at a time
d.) fines that vary depending on income

75. <cenotaph>
a.) large and important church
b.) public square in the center of a town
c.) memorial for people buried somewhere else
d.) underground train station

76. <denouement>
a.) ending of a story which solves the mystery
b.) amount of money paid for a piece of work
c.) small place to live which is part of a bigger building

d.) official report of the results of a political meeting

77. <bittern>
a.) large bottle for storing liquid
b.) small green grass snake
c.) false picture caused by hot air
d.) water bird with long legs and a very loud call

78. <reconnoiter>
a.) think again
b.) make an examination of a new place
c.) have a good time to mark a happy event
d.) complain formally

79. <magnanimity>
a.) very offensive and unfriendly manners
b.) courage in times of trouble
c.) generosity
d.) completely sincere words

80. <effete>
a.) weak and soft
b.) too fond of strong drink
c.) unable to leave his bed
d.) extremely easy to annoy

81. <rollicking>
a.) driving very fast
b.) staying away from school without being permitted to
c.) having fun in a noisy and spirited way
d.) sliding on snow using round boards

82. <gobbet>
a.) strip of torn material
b.) footprint
c.) piece of solid waste from the body
d.) lump of food returned from the stomach

83. <rigmarole>
a.) very fast and difficult dance for eight people
b.) funny character in the theatre
c.) form which must be completed each year for tax purposes
d.) long, pointless and complicated set of actions

84. <alimony>
a.) feelings of bitterness and annoyance, expressed sharply
b.) money for the care of children, paid regularly after a divorce
c.) giving praise for excellent ideas
d.) a metal which breaks easily and is bluish white

85. <rode roughshod>
a.) travelled without good preparation
b.) made lots of mistakes
c.) did not consider other people's feelings
d.) did not care about his own comfort

86. <copra>
a.) a highly poisonous substance used to kill unwanted plants

b.) the dried meat from a large nut used to make oil
c.) an illegal substance which makes people feel good for a short time
d.) strong rope used on sailing ships

87. <bier>
a.) folding garden chair
b.) grass next to a river
c.) place where boats can be tied up
d.) board on which a dead body is carried

88. <in a torpid state>
a.) undecided
b.) filled with very strong feelings
c.) confused and anxious
d.) slow and sleepy

89. <dachshund>
a.) warm fur hat
b.) thick floor rug with special patterns
c.) small dog with short legs and a long back
d.) old musical instrument with twelve strings

90. <cadenza>
a.) cake topped with cream and fruit
b.) large box hanging from a wire that carries people up a mountain
c.) slow formal dance from Italy
d.) passage in a piece of music that shows the player's great skill

91. <obtruded themselves>
a.) got themselves lost or forgotten
b.) did not agree with each other
c.) got mixed up with each other
d.) pushed themselves forward in the mind

92. <panzers>
a.) players in a marching band
b.) fighter planes
c.) large, slow windowless army cars
d.) policewomen

93. <a cyborg>
a.) an integrated human-machine system
b.) a musical instrument with forty strings
c.) a small, newly invented object
d.) a warm wind in winter

94. <a zygote>
a.) an early phase of sexual reproduction
b.) a lot of bother over nothing
c.) a small animal found in southern Africa
d.) a gun used to launch rockets

95. <sylvan>
a.) lost love
b.) wandering
c.) forest
d.) casual folk

96. <sagacious>
a.) instinctively clever
b.) ridiculous and wild
c.) about abusing people and being abused
d.) rebellious and dividing

97. <spatiotemporal>
a.) focused on small details
b.) annoying to people
c.) objectionably modern
d.) oriented to time and space

98. <play the casuist>
a.) focus only on self-pleasure
b.) act like a tough guy
c.) make judgments about my conduct of duty
d.) be stupid

99. <cyberpunk>
a.) medicine that does not use drugs
b.) one variety of science fiction
c.) the art and science of eating
d.) a society ruled by technical experts

100. <pussyfoot around>
a.) criticize unreasonably
b.) take care to avoid confrontation
c.) attack indirectly
d.) suddenly start

VOCABULARY SIZE TEST: VERSION B

1. <drives>
a.) swims
b.) learns
c.) throws balls
d.) uses a car

2. <jump>
a.) lie on top of the water
b.) get off the ground suddenly
c.) stop the car at the edge of the road
d.) move very fast

3. <your shoe>
a.) the person who looks after you
b.) the thing you keep your money in
c.) the thing you use for writing
d.) the thing you wear on your foot

4. <her standards>
a.) the bits at the back under her shoes
b.) the levels she reaches in everything
c.) the marks she gets in school

d.) the money she asks for

5. <basis>
a.) answer
b.) place to take a rest
c.) next step
d.) main part

6. <maintain it>
a.) keep it as it is
b.) make it larger
c.) get a better one than it
d.) get it

7. <stone>
a.) hard thing
b.) kind of chair
c.) soft thing on the floor
d.) part of a tree

8. <upset>
a.) tired
b.) famous
c.) rich
d.) unhappy

9. <drawer>
a.) sliding box
b.) place where cars are kept
c.) cupboard to keep things cold
d.) animal house

10. <joke>
a.) attempt at humor
b.) false statement
c.) way of speaking
d.) way of thinking

11. <paved>
a.) prevented from going through
b.) divided
c.) given gold edges
d.) covered with a hard surface

12. <roving>
a.) getting drunk
b.) traveling around
c.) making a musical sound through closed lips
d.) working hard

13. <lonesome>
a.) ungrateful
b.) very tired
c.) without company
d.) full of energy

14. <alleged it>
a.) claimed it without proof

b.) stole the ideas for it from someone else
c.) provided facts to prove it
d.) argued against the facts that supported it

15. <remedy>
a.) place to eat in public
b.) way to fix a problem
c.) way to prepare food
d.) rule about numbers

16. <dashed>
a.) moved quickly
b.) moved slowly
c.) fought
d.) looked quickly

17. <peel it>
a.) let it sit in water for a long time
b.) take the skin off it
c.) make it white
d.) cut it into thin pieces

18. <bacterium>
a.) small living thing causing disease
b.) plant with red or orange flowers
c.) animal that carries water in lumps on its back
d.) thing that has been stolen and sold to a shop

19. <thesis>
a.) talk given by a judge at the end of a trial
b.) first year of employment after becoming a teacher
c.) long written report of study carried out for a university degree
d.) extended course of hospital treatment

20. <authentic>
a.) real
b.) very noisy
c.) old
d.) like a desert

21. <a miniature>
a.) an instrument for looking at very small objects
b.) a very small thing of its kind
c.) a very small living creature
d.) a small line to join letters in handwriting

22. <fracture>
a.) break
b.) small piece
c.) short coat
d.) discount certificate

23. <has no patience>
a.) has no free time
b.) has no faith
c.) will not wait happily
d.) does not know what is fair

24. <scrubbing it>
a.) cutting shallow lines into it
b.) repairing it
c.) washing it energetically
d.) drawing simple pictures of it

25. <vocabulary>
a.) words
b.) skill
c.) money
d.) guns

26. <some accessories>
a.) papers giving us the right to enter a country
b.) official orders
c.) ideas to choose between
d.) extra pieces

27. <compost>
a.) strong support
b.) help to feel better
c.) hard stuff made of stones and sand stuck together
d.) plant material fertilizer

28. <the fens>
a.) a piece of low flat land partly covered by water
b.) a piece of high, hilly land with few trees
c.) a block of poor-quality houses in a city
d.) a time long ago

29. <puritan>
a.) person who likes attention
b.) person with strict morals
c.) person with a moving home
d.) person who keeps money and hates spending it

30. <in awe>
a.) with a worried expression
b.) with an interested expression
c.) with a sense of wonder
d.) with a feeling of respect

31. <bristles>
a.) questions
b.) short stiff hairs
c.) folding beds
d.) bottoms of the shoes

32. <erratic>
a.) without fault
b.) very bad
c.) very respectful
d.) unsteady

33. <was null>
a.) had good results
b.) did not help much
c.) had no effect

d.) lasted a long time

34. <perturbed>
a.) made to agree
b.) worried and puzzled
c.) corruptly sexual
d.) very wet

35. <peasantry>
a.) local people
b.) place of worship
c.) businessmen's club
d.) working class people

36. <palette>
a.) container for carrying fish
b.) wish to eat food
c.) young female companion
d.) artist's board for mixing paints

37. <devious>
a.) tricky and threatening
b.) well-developed
c.) not well thought out
d.) more expensive than necessary

38. <stealth>
a.) spending a large amount of money
b.) hurting someone so much that they agreed to their demands
c.) moving secretly with extreme care and quietness
d.) taking no notice of problems they met

39. <hallmark>
a.) stamp to show when it should be used by
b.) stamp to show the quality
c.) mark to show it is approved by the royal family
d.) mark or stain to prevent copying

40. <haze>
a.) small round window in a ship
b.) unclear air
c.) cover for a window made of strips of wood or plastic
d.) list of names

41. <gimmick>
a.) thing for standing on to work high above the ground
b.) small thing with pockets for holding money
c.) attention-getting action or image
d.) clever plan or trick

42. <yoga>
a.) handwork done by knotting thread
b.) a form of exercise for the body and mind
c.) a game where a cork stuck with feathers is hit between two players
d.) a type of dance from eastern countries

43. <sizzle>
a.) turn to stone

b.) release pressure and untwist
c.) make noise while being cooked
d.) force out liquid

44. <psychotherapy>
a.) the mutual operation of two things
b.) the ability to govern
c.) an unfriendly reaction
d.) treatment for a mental illness

45. <in its heyday>
a.) at its peak of success
b.) on top of the hill
c.) very wealthy
d.) admired very much

46. <his mystique>
a.) his healthy body
b.) the secret way he makes other people think he has special skill
c.) the woman he dated while he was married to someone else
d.) the hair on his top lip

47. <communique>
a.) critical report about an organization
b.) garden owned by many members of a community
c.) printed material used for advertising
d.) official announcement

48. <a thesaurus>
a.) a kind of dictionary
b.) a chemical compound
c.) a special way of speaking
d.) an injection just under the skin

49. <very dissonant>
a.) full of sounds that are not nice together
b.) full of signs of death
c.) full of unwanted stops and starts
d.) likely to get you into trouble

50. <a tracksuit>
a.) the upper part of a dress
b.) a set of clothing for running
c.) a knitted shirt with no buttons
d.) an angry expression

51. <spleen>
a.) knee bone
b.) organ found near the stomach
c.) pipe taking waste water from a house
d.) respect for himself

52. <caffeine>
a.) a substance that makes you sleepy
b.) strings from very tough leaves
c.) ideas that are not correct
d.) a substance that makes you excited

53. <impaled>
a.) charged with a serious offence
b.) put in prison
c.) stuck through with a sharp instrument
d.) involved in a dispute

54. <jovial>
a.) low on the social scale
b.) likely to criticize others
c.) full of fun
d.) friendly

55. <dingy>
a.) cold, damp
b.) poorly lit
c.) delightful
d.) hot, dry

56. <kindergarten>
a.) activity that allows you to forget your worries
b.) place of learning for children too young for school
c.) strong, deep bag carried on the back
d.) place where you may borrow books

57. <locusts>
a.) unpaid helpers
b.) people who do not eat meat
c.) creatures with wings
d.) brightly colored wild flowers

58. <lintel>
a.) beam across the top of a door or window
b.) small boat used for getting to land from a big boat
c.) beautiful tree with spreading branches and green fruit
d.) board which shows the scene in a theatre

59. <upbeat>
a.) upset
b.) good
c.) hurt
d.) confused

60. <his pallor>
a.) his unusually high temperature
b.) the faint color of his skin
c.) his lack of interest in anything
d.) his group of friends

61. <skylark>
a.) show with planes flying in patterns
b.) human-made object going round the earth
c.) person who does funny tricks
d.) small bird that flies high as it sings

62. <beagles>
a.) fast cars with roofs that fold down
b.) large guns that can shoot many people quickly
c.) small dogs with long ears
d.) houses built at holiday places

63. <atoll>
a.) low island with sea water in the middle
b.) art created by weaving pictures from fine string
c.) small crown with many valuable stones
d.) place where a river flows through a narrow spot with rocks

64. <hutch>
a.) thing with metal bars to keep dirt out of water pipes
b.) space in the back of a car used for bags etc
c.) round metal thing in the middle of a bicycle wheel
d.) cage for small animals like rabbits

65. <gauche>
a.) talkative
b.) flexible
c.) awkward
d.) determined

66. <the cordillera>
a.) a special law
b.) an armed ship
c.) a line of mountains
d.) the firstborn son of the king

67. <limpid>
a.) clear
b.) sad
c.) deep brown
d.) beautiful

68. <an aperitif>
a.) a long chair for lying on
b.) a private singing teacher
c.) a large hat with tall feathers
d.) a drink taken before a meal

69. <scrunched up>
a.) done with many mistakes
b.) crushed together
c.) cut into large, rough pieces
d.) thrown violently into the air

70. <instantiate that>
a.) make that happen quickly
b.) put that into the correct place
c.) give a real example of that
d.) explain that

71. <landfall>
a.) ceremony to bless the land for a church
b.) bike event on a mountain
c.) acceptance of foreign control after a war
d.) the seeing of land after a journey by sea or air

72. <headstrong child>
a.) very clever child
b.) child who has been given too many good things
c.) very fat child
d.) child that is determined to do what it wants

73. <supercilious>
a.) proud and not respectful
b.) extremely stupid
c.) able to think about only one thing
d.) over weight

74. <a torpor>
a.) a deep soft chair
b.) an inactive state
c.) a very unhappy state
d.) a bed cover filled with feathers

75. <coven>
a.) small singing group
b.) business that is owned by the workers
c.) secret society
d.) group of church women who follow a strict religious life

76. <sputnik>
a.) rare animal like a rabbit found in cold countries
b.) trap set by the police
c.) object that travels high in the sky round the earth
d.) secret organization with evil plans

77. <mozzarella>
a.) sweet sauce made from fruit
b.) cheap wine
c.) mild cheese
d.) substance that keeps insects away from you

78. <workaday clothes>
a.) plain and practical clothes
b.) clothes suitable for parties after work
c.) old and worn out clothes
d.) clothes that are thrown away after each working day

79. <lemur>
a.) priest from an eastern religion
b.) person with a very bad skin disease
c.) furry animal with a long tail
d.) purple fish from hot countries

80. <pantograph>
a.) instrument which plays music from a metal tube
b.) instrument which measures the amount of breath a person has
c.) framework of moving bars for copying plans
d.) pen with a metal point for writing on hard surfaces

81. <planetarium>
a.) place where planes are built
b.) place where a machine shows the way planets move
c.) course to teach people good planning skills
d.) place where fish are kept

82. <vitreous>
a.) very heavy
b.) easy to break
c.) full of small holes
d.) like glass

83. <cerise>
a.) a bright red color
b.) made of a thin, soft material
c.) a pale blue-green color
d.) made of expensive fabric with pretty patterns and small holes

84. <frankincense>
a.) sweet smelling white flowers
b.) soft cheese made in France
c.) food made from yellow colored rice and shellfish
d.) good smelling substance that comes out of trees

85. <feint>
a.) small cake with dried fruit
b.) thing with wheels for moving heavy objects
c.) pretend attack to trick the enemy
d.) serious mistake

86. <muff>
a.) tube of animal hair for keeping the hands warm
b.) cover for a teapot
c.) long rope of feathers to wear around the neck
d.) bed cover made from squares of material sewn together

87. <performed his ablutions>
a.) did his exercises to stay healthy
b.) played his very difficult piece of music
c.) did all his duties as a church minister
d.) washed himself to get ready

88. <exactitude>
a.) courage under pressure
b.) sense of fairness
c.) habit of making unreasonable demands
d.) ability to be very accurate

89. <speedometer>
a.) instrument that shows changes in the weather
b.) thing that measures how fast you go
c.) thing that keeps a room at an even temperature
d.) tube put into a person to let liquids in or out of their body

90. <serviette>
a.) girl who helps in the house
b.) piece of glass which makes things look bigger
c.) large flat plate
d.) piece of cloth or paper for wiping your mouth

91. <scrumptious>
a.) extremely funny
b.) very expensive
c.) delightful in taste
d.) very dirty and untidy

92. <poppadoms>
a.) thin, slightly hard pieces of fried bread
b.) small pieces of food, usually raw, eaten before a meal
c.) cloths for protecting clothes while eating
d.) small sweet baked cakes

93. <hydrofoils>
a.) crops produced from the sea
b.) devices that push boats clear of the water
c.) components of rocks
d.) amazing curls and twists

94. <bylaw>
a.) publisher's list of older books
b.) secondary law
c.) code made of lines, read by machines
d.) law that morally condemns people

95. <a nymphomaniac>
a.) a person expressing uncontrolled sexual desire
b.) an antisocial person
c.) an innocent rural person
d.) a person who repeats the same crime after punishment

96. <maladroit>
a.) feeling sick to his stomach
b.) physically awkward
c.) rather silly but likeable
d.) quickly angry and easily depressed

97. <taxon>
a.) tax category
b.) small and light container for fruit
c.) category of creature
d.) room for safely keeping valuables

98. <canoodling>
a.) spreading false and evil ideas about others
b.) looking for a free meal
c.) merging into the crowd
d.) stroking and kissing one another

99. <stupa>
a.) tall hairstyle
b.) woman with a bad sexual reputation
c.) temporary platform for a dead person’s body
d.) Asian religious memorial

100. < dramaturgical>
a.) theatrical
b.) glorious
c.) human-centering
d.) oily and unpleasant

APPENDIX F. SPELLING RECOGNITION TASK

PLEASE CIRCLE ALL ITEMS BELOW THAT YOU THINK ARE SPELT INCORRECTLY

attitude	critisism	benafit	refrences
misary	psycology	political	glamourous
reciept	available	addmission	tounge
appreciate	materilistic	independent	chronicle
seperate	senior	behaviour	atterney
sufficient	efficiency	implie	courtesy
mortgage	govenment	basicly	privalege
consequence	sieze	suspicious	prosedure
conveinient	insurance	imminant	guitar
elementary	sacrifice	commitment	decrepit
jeapordise	forfeit	fulfill	annihlate
distinguish	inquirey	sincirely	equivical
gaurantee	delecate	bachelor	annual
necesscarily	favourate	announcment	severe
occurence	insatiable	partitionining	asure
exhibition	warrent	interrogate	havoc
conscientious	parallel	interpretation	bureaucracy
importent	negotiate	proliferate	vigilent
missellaneous	curiculum	plagarism	acomplice
pollution	permanent	aplause	subpoena
accommodation	attentsion	rendezvous	subtlety
honerable	inhibition	classafied	assessor

APPENDIX G. CURRICULUM VITAE

PERSONAL INFORMATION

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Degree	Institution	Year of Graduation
MS	METU ELT	2012
BS	Başkent University FLE	2009
High School	Gaziçiftliği High School, Ankara	2005

SELECTED PUBLICATIONS

1. Jacob Gunnar,SAFAK Duygu Fatma,DEMIR ORHAN,KIRKICI BILAL (2018). Preserved morphological processing in heritage speakers: A masked priming study on Turkish. Second Language Research, Doi: 10.1177/0267658318764535

2. Lago Sol,GRACANIN YÜKSEK Martina,SAFAK Duygu Fatma,DEMIR ORHAN,KIRKICI BILAL,FELSER Claudia (2018). Straight from the horse's mouth: Agreement attraction effects with Turkish possessors. Linguistic Approaches to Bilingualism, Doi: http://doi.org/10.1075/lab.17019.lag

3. Gracanin Yüksek Martina,Lago Sol,Safak Duygu Fatma,DEMIR ORHAN,KIRKICI BILAL (2017). The Interaction of Contextual and Syntactic Information in the Processing of Turkish Anaphors. Journal of Psycholinguistic Research, Doi: 10.1007/s10936-017-9502-2

APPENDIX H. APPROVAL OF METU HUMAN SUBJECTS ETHICS COMMITEE

UYGULAMALI ETİK ARAŞTIRMA MERKEZİ
APPLIED ETHICS RESEARCH CENTER

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21 TEMMUZ 2016

Sayı: 28620816 / 313

Konu: Değerlendirme Sonucu

Gönderilen: Doç.Dr. Bilal KIRKICI

Yabancı Diller Eğitim Bölümü

Gönderen: ODTÜ İnsan Araştırmaları Etik Kurulu (İAEK)

İlgi: İnsan Araştırmaları Etik Kurulu Başvurusu

Sayın Doç.Dr. Bilal KIRKICI,

Danışmanlığını yaptığınız doktora öğrencisi Orhan DEMİR'in "İkinci Dilde Biçimbilimsel İşlemlemenin Davranışsal ve Sinirbilimsel İncelenmesi" başlıklı araştırması İnsan Araştırmaları Etik Kurulu tarafından uygun görülerek gerekli onay **2016-EGT-119** protokol numarası ile **01.08.2016-31.08.2017** tarihleri arasında geçerli olmak üzere verilmiştir.

Bilgilerinize saygılarımızla sunarız.

Prof. Dr. Canan SÜMER

İnsan Araştırmaları Etik Kurulu Başkanı

Prof. Dr. Meliha ALTUNIŞIK
İAEK Üyesi

Prof. Dr. Ayhan SOL
İAEK Üyesi

Prof. Dr. Mehmet UTKU
İAEK Üyesi

Prof. Dr. Ayhan Gürbüz DEMİR
İAEK Üyesi

Yrd .Doç .Dr. Pınar KAYGAN
İAEK Üyesi

Yrd. Doç. Dr. Emre SELÇUK
İAEK Üyesi

ODTÜ 2015

BU BÖLÜM, İLGİLİ BÖLÜMLERİ TEMSİL EDEN İNSAN ARAŞTIRMALARI ETİK ALT KURULU TARAFINDAN DOLDURULACAKTIR.

Protokol No: 2016-EGT-119

İAEK DEĞERLENDİRME SONUCU

Sayın Hakem,

Aşağıda yer alan üç seçenekten birini işaretleyerek değerlendirmenizi tamamlayınız. Lütfen "<u>Revizyon Gereklidir</u>" ve "<u>Ret</u>" değerlendirmeleri için gerekli açıklamaları yapınız.

Değerlendirme Tarihi: 21.07.2016

Ad Soyad: Metin girmek için tıklayın

☑ **Herhangi bir değişikliğe gerek yoktur. Veri toplama/uygulama başlatılabilir.**

☐ **Revizyon gereklidir**

☐ Gönüllü Katılım Formu yoktur.

☐ Gönüllü Katılım Formu eksiktir.

Gerekçenizi ayrıntılı olarak açıklayınız: Metin girmek için tıklayın

☐ Katılım Sonrası Bilgilendirme Formu yoktur.

☐ Katılım Sonrası Bilgilendirme Formu eksiktir.

Gerekçenizi ayrıntılı olarak açıklayınız: Metin girmek için tıklayın

☐ Rahatsızlık kaynağı olabilecek sorular/maddeler ya da prosedürler içerilmektedir.

Gerekçenizi ayrıntılı olarak açıklayınız: Metin girmek için tıklayın

☐ Diğer.

Gerekçenizi ayrıntılı olarak açıklayınız: Metin girmek için tıklayın.

☐ **Ret**

Ret gerekçenizi ayrıntılı olarak açıklayınız: Metin girmek için tıklayın

APPENDIX I. TURKISH SUMMARY

Giriş

Anadil (D1) ve ikinci dilin (D2) gerçek zamanlı işlemlenmesinin betimlenmesi, genellikle D2 edinimi artalanında göz ardı edilen bir konu olmuştur. Fakat dil edinimi olgusunun derinlemesine irdelenmesi, dil kullanıcılarının dil üretimi ve algılanması süreçlerinde zihinsel kurallardan nasıl faydalandığını açıklamakla mümkün olabilir. Dolayısıyla, D2 edinimi araştırmacılarının temel görevlerinden biri, farklı aşamalarda dilsel eylemlerin gerçekleşme süreçlerini tespit etmek olmalıdır. Bundan dolayı, bu çalışmanın esas amacı, D2 işlemleme sürecinin temel özelliklerine biçimbilimsel işlemleme özelinde ışık tutmaya çalışmaktır.

Polatsek ve Treiman'ın (2015) belirttiği gibi, modern toplumlarda ortaya çıkan okuma ihtiyacı, anadil ve ikinci dilde okumanın öğrenilme süreçlerini araştıran çalışmaları da beraberinde getirmiştir. 20. yüzyılın başında Huey'in (1908, 1913) okumanın psikolojisi üzerine ortaya koyduğu yayınlarla, davranışsal yaklaşım veya bilişsel paradigmayı temel alan, okumanın doğası ve güçlüğüne odaklanan akademik çalışmalar hız kazanmıştır. "Bilişsel devrim", araştırmacılara okuma sürecine yönelik analitik bir tutum geliştirme imkânı tanımıştır. Böylelikle, dilin farklı alanları çeşitli perspektifler ortaya konarak incelenmiş, imla yeterliğinden okuduğunu yorumlamada söylemin etkisine kadar geniş bir alanda sayısı gittikçe artan bilimsel ürünler elde edilmiştir. Temelde sesbilim, biçimbilim ve sözdizimi odak noktasına almak suretiyle, ruhdilbilim dil kullanıcılarının yazılı materyalleri okuma sürecinde geçtiği aşamaları ve yararlandığı stratejileri gün ışığına çıkarma adına kayda değer bir ilerleme göstermiştir. Ses ve kelime gruplarının işlemlenme süreciyle ilgili çalışmaların yanında; biçimbilimsel işlemleme, dilin algılanması ve anlaşılmasıyla ilgili temel soruları yanıtlama potansiyeline paralel olarak birçok araştırmanın konusu olmuştur.

Zihinsel Sözlük

Dilsel algılama üzerine yapılan kuramsal tartışmalarda biçimbilimsel işlemlemeyi önemli kılan unsur, bu konu üzerine yapılan çalışmaların zihinsel sözlüğün özelliklerini tanımlama gücünün olmasıdır. Bir cümle okuduğumuzda, genellikle yaptığımız şey bireysel sözcüklerin anlamlarını bir araya getirerek sonuca varmaya çalışmaktan ibarettir. Bunu yapmak için de, sözcüklerin anlamlarını muhafaza eden ana kaynağa ulaşmamız gerekir. Sözcüklere ait bilgilerin kaynağı olan bu kuramsal olguya *zihinsel sözlük* denir. Bu zihinsel aygıtta her sözcükle ilgili girdilerin olduğu varsayılmaktadır. Örneğin, *see* sözcüğünü okuduğumuzda, bu sözcüğün telaffuzu, anlamlı birimleri, yapısal özellikleri, cümle içindeki konumu, anlamı ve edimbilimsel özellikleri hakkında bilgiye ulaşırız. İnsan belleğinin kısıtları dikkate alındığında, bu kadar çok bilginin muhafaza edilebilmesi izah gerektiren bir durum olarak görülmüştür. Bu konunun merkezinde de zihinsel sözcüğün organizasyonu yer almıştır.

Bir işlemcinin etkili çalışabilmesi için donanımında sadece en gerekli varlıkları tutmasını beklemek mantıklı bir önermedir. Dilbilgisi olgusunun da bu şekilde organize olduğu düşünülmektedir. Chomsky’nin (2005) tarif ettiği gibi, kusursuz tasarıma sahip bir sistem olan dilbilgisi, düşünce ve seslendirme sistemlerinin etkili çalışmasını gerektirmektedir. Bu da, anlambilimsel ve sesbilimsel unsurlardan faydalanmayı elzem kılmaktadır. Sistemin merkezindeyse dilin hesaplamalı öğesi olan biçim-sözdizim bulunmaktadır. Biçim-sözdizimsel mekanizmaların dili sözcük ve cümle düzeyinde organize etmesi için gerekli öğeleri elde ettiği yer ise zihinsel sözlüktür (Radford, 2009). Bu işlemin gerçek hayatta olduğu gibi hızlı ve otomatik gerçekleşmesi iyi örgütlenmiş bir sisteme, ideal seviyede çalışan mekanizmalara ve güçlü aygıtlara, dolayısıyla bu operasyonların kaynağı olan zihinsel sözlüğün yeterliğine bağlıdır.

Yukarıda anlatılan adımların hızının önemi düşünüldüğünde, zihinsel sözlüğün süratli bir şekilde ulaşılıp işlemlenecek sözcüklere ve sözcük girdilerine sahip olması beklenir. Buna göre, tek biçimbirimli, diğer bir ifadeyle, basit sözcüklerle ilgili bir sav ortaya koymak mümkündür; bu sözcükler bireysel olarak zihinsel sözcükte muhafaza edilmektedir. Alanyazın bu konuda ciddi bir tartışmanın olmadığını gösterse de, birden fazla biçimbirim içeren yani karmaşık sözcüklerin zihinsel sözlükte depolanması uzun süredir ciddi tartışmalara yol açmaktadır.

Frost ve Grainger'ın (2000) belirttiği gibi, biçimbilimsel faktörler zihinsel organizasyon modellerinde belirleyici unsur olarak görülür. Özellikle de, biçimbilimsel olarak karmaşık sözcüklerin depolanması sürecinde devreye girerler. Karmaşık sözcüklerin depolanması konusunda, birbirilerinden tamamen ayrışan iki temel görüş mevcuttur. Aşağıda temel çerçevesi sunulan biçimbilimsel işlemleme artalanı da genel olarak bu iki görüş çerçevesinde oluşmuş ve gelişmiştir.

Kuramsal Artalan

Psikoloji ve sinirbilim alanlarında artan bilgi ve kaydedilen ilerlemeler, geniş çerçeveli bir okuma modelinin geliştirilmesini gerekli kılmıştır. Böyle bir modelin davranışsal ve nörolojik açılardan bilgilendirici olması beklenir. Bilişsel açıdan bakıldığında, basılı metinlerin okunması esnasında görsel sistemlerle dil işleme mekanizmalarının eşgüdüm halinde hareket ettiği bilinmektedir. Kelimelerin algılanması sürecinde harf dizinlerini anlamlı kılmak adına zihnimizin çalışma prensiplerinin betimlenmesi, olası bir okuma modelinin açıklayıcı gücü için son derece önemlidir. Karmaşık ve basit sözcüklerin zihinde işlemlenme süreçlerini karşılaştırmalı olarak açıklayabilmek, hedeflenen okuma modelinin kayda değer unsurlarından biri olmaya adaydır.

Karmaşık sözcüklerin zihinde nasıl işlemlendiklerine dair 40 yılı aşkın bir süredir önemli tartışmalar yürütülmektedir. Bu sözcük türlerinin unsurlarına (biçimbirimlerine) ayrılarak işlemlendiğini öne süren modeller ve tıpkı basit sözcükler gibi bütün halinde algılandığını iddia eden teoriler alanyazında yer almaktadır. Bunların yanında, deneysel veriler ışığında her iki modelin de güçlü ve zayıf yanlarını ortaya koyan hibrit yaklaşımlar mevcuttur.

Biçimbilimsel olarak karmaşık sözcüklerin işlemlenmesini sağlayan mekanizmaları açığa çıkarmayı hedefleyen ilk hipotezlerin odak noktası, zihinsel depolama kısıtları olmuştur. Bu noktadan hareketle, bellekte nicelik olarak en az yüke mal olacak formüller sınanmıştır. Taft ve Forster'ın *Önek Çıkarma Modeli* (1975), sonraları biçimbilimsel işlemlemede tam ayrıştırma yaklaşımının öncüsü olarak görülmüştür. Bu yaklaşım, zihnin karmaşık sözcüklere basit sözcüklerden farklı yaklaştığını varsayar. Bu yaklaşımının savunucularına göre, dilimiz basit sözcüklerin dilsel özelliklerini muhafaza eden girdileri içermektedir. Bu tür sözcükler dil edinimi sürecinde ezbere alınırlar. Karmaşık sözcüklerse, dilbilgisi kuralları ve anlamsal çağrışımların yardımıyla bahsi geçen girdilere erişilerek işlemlenirler. Sözcükler, algılandıkları anda biçimbilimsel ayrıştırma yöntemiyle unsurlarına ayrılırlar. Bu şekilde, her bir sözcük için ayrı bir girdinin bellekte tutulmasına gerek kalmaz. Örneğin, *see, sees* ve *seen* sözcüklerinin algılanması ve anlaşılması için bellekte tek bir girdi yeterlidir. *Sees* sözcüğü biçimbirimlerine ayrıldığı için (*see* + -*s*) *see* sözcüğüne ait girdiye erişmek işlemlenmeyi mümkün hale getirir. Dil edinim sürecinin erken aşamalarında edinilen dilbilgisi kuralları modelin öğrenilen kısmını oluştururken sözcüksel girdiler ezberlenen kısmını içermektedir.

Temelde Taft ve Forster'ın (1975) savıyla aynı doğrultuda hareket eden, diğer bir ifadeyle, karmaşık sözcüklerin biçimbilimsel analizini veya *soldan sağa biçimbirim temelli tarama mekanizması*nın varlığını savunan birçok yaklaşım tartışmaya açılmıştır. Kural temelli modellerden ayrışan yaklaşımlar ise, ikili mekanizmaları (Caramazza, Laudana ve Romani, 1988), bilinirliklerine göre basit ve karmaşık sözcükler arasındaki rekabeti (Schreuder & Baayen, 1995), biçimbilimsel temsillerin sözcük-altı veya sözcük-üstü seviyelerde varlığını (Giraudo &Grainger, 2000) ya da biçim-anlam bağlantılarında biçimbilimsel ilişkilerin etkisini (Plaut & Gonnerman, 2000) alternatif olarak önermişlerdir.

Kuralların uygulanması yerine her bir kelimenin doğrudan ve bütün halinde erişilebilir olmasını dil işlemleme mekanizmasının daha etkili çalışmasıyla ilişkilendiren yaklaşımı benimseyen Butterworth (1983), biçimbilimsel ilişkilerden ziyade her bir sözcük için bir girdinin mevcut olduğunu iddia etmiştir. Butterworth'ün Tam Kaydetme Hipotezi, sözcük işlemlemede dilbilgisel kuralları göz ardı eden bağlantıcı yaklaşımlar için öncü niteliğindedir. Rumelhart'ın (1977) sözcüksel işlemlemede çoklu mekanizmaları değerlendirdiği çalışmasından hareketle sözcükler arasında bağlam ve imla temelli çağrışımlar gibi kolaylaştırıcı etkenleri ortaya koyan hipotezler vasıtasıyla kural temelli argümanlar sorgulanmaya başlanmıştır. Kural temelli argümanlara nazaran bağlantıcı yaklaşımlarda, çağrışımsal bellekte yer alan tek bir çağrışım mekanizmasının dilin üretimi ve algılanması için sesbilimsel ve anlamsal temsiller arasında bağ kurmasının yeterli olduğu öne sürülür.

Bağlantıcı modellerin zihinsel sözlük ve dilbilgisini birbirinden ayırması beklenmez çünkü bu modellere göre çağrışımcı bellekte depolanan ilişkilendirmelerden dilin edinimi ve kullanımı süreçlerinde yararlanılır. Bu ilişkiler; bağlamsal kolaylaştırma (McClelland & Rumelhart, 1981; Rumelhart & McCllelland, 1982), imla benzerlikleri veya sıklık etkisi olabilir. Bu açılardan sözcükler arasında kurulan güçlü bağlar istatistiki önem arz etmekte ve dilbilgisi kurallarının ediniminden ziyade istatistiki öğrenmeyi kolaylaştırmaktadır. Dolayısıyla, bu modellerde biçim-sözdizimsel analizlerin etkisi gözlemlenmemekle birlikte kelimelerin ayrıştırılarak incelenmesi de savunulamaz. Örneğin, bu modeller *see, sees* ve *seen* sözcükleri için üç ayrı girdinin mevcut olduğunu öngörmektedir. *Sees* kelimesini kullanmak veya algılamak durumunda kaldığımızda ilgili girdiye doğrudan ve süratle erişiriz. Bu kelimenin zihinde tanımlanmasının algısal süreçleri, diğer sözcüklerle sesbilimsel ilişkilerini, kullanım sıklığını, kullanıldığı bağlamları vd. kapsarken *see* ve *seen* gibi sözcüklerle dilbilimsel ilişkileri yok sayılmaktadır. Bu anlamda, bahsi geçen sözcüklerle *sees* arasındaki ilişki, sesbilimsel benzerlik nedeniyle seed sözcüğü ile kurulan ilişkiden farksızdır.

Dilin sonsuz ifade gücünü kurallar veya bağlantıları temel alarak açıklamaya çalışan iki paradigmanın da yetersizliğine işaret eden Pinker (1991, 1998), birbirinden farklı bilişsel mekanizmaların süreçte devreye girdiğini iddia etmiştir. Bu mekanizmalar, çağrışımcı bellek ve sembollerle ifade edilen kurallardır. Sözcükler ve Kurallar Teorisi veya İkili Mekanizma Modeli olarak adlandırılan bu yaklaşım, düzenli ve düzensiz çekimlenen sözcüklerin işlemlenmesini temel alarak bu tür sözcüklerde görülen farklı davranışsal durumları, bağlantıların ve kuralların tek başına yetersiz oluşuyla açıklamıştır. Pinker'a göre, basit, cins ve kuralsız kelimelerin depolandığı bir zihinsel sözlüğün yanında sözcüklerin kendine has oluşumlarını sağlayan dilbilgisel kuralları barındıran ayrı bir sistem de mevcuttur ve bu sistem sembolik hesaplamaların yapıldığı ruhbilimsel bir mekanizmanın parçasıdır.

Yukarıda örneklendirildiği gibi, Taft ve Forster'ın kural temelli modeli *see, sees* ve *seen* sözcükleri için tek bir girdinin olduğunu iddia etmektedir. Diğer taraftan, bağlantıcı modeller bu kelimelerin her biri için ayrı girdilerin zihinsel sözlükte var olduğunu savunurlar. Pinker ve modelinin savunucuları ise (örn: Pinker & Prince, 1991; Pinker & Ullman, 2002), *sees* sözcüğü için kuralların *seen* sözcüğü için de çağrışımcı hafızada depolanmış bir girdinin devreye girdiğini varsaymaktadır. Yani, bu modelde *sees* ve *seen* sözcüklerinin işlemlenmesi farklı mekanizmalar vasıtasıyla gerçekleşir. Hesaplamalı mekanizmalar *see* fiili ve düzenli çekimlenen *–s* eki arasında dilbilgisel bağ kurarlar. *Seen* sözcüğü ise unsurlarına (*see* ve *-en*) ayrıştırılmaz ve bütün olarak erişilip algılanır.

Pinker'ın hayli tartışma yaratan Sözcükler ve Kurallar Teorisi (1998), birçok açıdan sınanmış ve eleştirilmiş; bunun sonucunda da alternatif modeller önerilmiştir. İkili mekanizma modeline kategorik olarak karşı olmasa da, Alegre ve Gordon (1999) sözcüklerin çağrışımcı hafızada depolanma kriterini tartışmaya açmış ve sözcüklerin unsurlarına ayrıştırılmaması için bazı şartların sağlanması gerektiğini öne sürmüştür. Bu araştırmacılara göre, bir sözcük yeteri kadar sıklıkla kullanılıyorsa ayrıştırılması imkansız hale gelir. Her ne kadar yeterli sıklıktan kastedilen net bir şekilde ortaya konamayıp yanlışlanabilirlik şartı karşılanamamış olsa da, Pinker ve Ullman (2002) düzenli ve düzensiz yapıların işlemlenmesinde sıklık etkisinin gücünü kabul etmişlerdir.

Pinker'ın kuramına yönelik başka bir itiraz, İngilizcede düzensiz geçmiş zaman eklerinin ayrıştırılabilirliği üzerine yapılan bir çalışmadan gelmiştir. Çocuk dilbilgisinde hesaplamalı mekanizmaların etkinliğini araştıran Yang (2000), Pinker'ın temel hatasının bahsi geçen eklerin kendine haslığını göz ardı ederek aşırı bir genelleme yapmakta yattığını iddia etmiştir. Geliştirdiği Sözcükler ve Rekabet Modeli'nde, geçmiş zamana işaret eden düzensiz fiillerin öğrenilmesinin ilgili türle çağrışım olasılığının ve *–ed* kuralına karşın bu türün kendine has kuralının uygulanma olasılığına bağlı olduğunu, bu yüzden de bütün düzensiz yapıların hafızada kalıp olarak bir bütün şeklinde depolandığı fikrinin geçersiz olduğunu ifade etmiştir. Alegre ve Gordon (1999) gibi, Yang da yegâne faktör olmasa da sıklık etkisine özel bir vurgu yapmıştır. Bunun dışında, Crepaldi vd., (2010) gibi bazı deneysel çalışmalar D1 konuşucularında düzensiz yapılar (örn: *seen*) ve bunların kökleri (örn: *see*) arasındaki ilişkinin işlemleme sürecinde kolaylaştırıcı bir etki yarattığını belirtmiştir. Aynı etki düzenli çekimlenen fiiller (örn: *watched*) ve kökleri (örn: *watch*) arasında da gözlemlenmiştir. Bundan hareketle, Pinker'ın düzensiz eklerin kendine has özelliklerine dönük ortaya attığı modelin farklı şartlarda ve yöntemlerle sınanması gerektiği vurgulanmıştır.

Karmaşık sözcüklerle karşılaşıldığında bu sözcüklerin devamında maruz kalınan köklerinin algılanmasını kolaylaştırdığına dair deneysel bulgular vardır. Örneğin, *sees* sözcüğünden sonra *see* ile karşılaşıldığında, ilgisiz bir sözcükten sonra *see* sözcüğünün görülmesiyle karşılaştırıldığında tespit edilen okuma hızından daha süratli bir algılama süresi gözlemlenmiştir. Hazırlama olarak adlandırılan bu olgunun bu iki sözcük arasındaki biçimbilimsel ilişkiden kaynaklandığı varsayılabilir. Bu görüşe göre, *sees* sözcüğünü see ve *–s* olarak analiz etmek için biçimbilimsel kuralları uygularız, aynı sözcükle (*see*) ikinci kez karşılaşmak da kökü tekrar etkinleştirdiği için işlemlemenin hızlı olmasına yol açar. Diğer bir görüş, sözcüklerin ortak harf sayısına paralel olarak zihinsel sözlükte aynı bölgede depolandığı, böylelikle de biçimsel benzerlikten kaynaklı karmaşık sözcüklerin köklerinin işlemlenmesi üzerinde kolaylaştırıcı bir etkiye sahip olduğudur. Yüzeysel biçimin yazılı dilin işlemleme sürecindeki etkisi (McClung vd., 2012 syf. 173), D1'de dilsel işlemleme sürecinde (örn: Sibley vd., 2008), ikinci dilde dilbilgisel işlemlemede (örn: Heyer & Clahsen, 2015) ve farklı dillerde D1 ve D2 olarak dilsel işlemleme durumlarında önemli bir faktör olarak görülmüş ve deneysel yöntemlerle test edilmiştir.

Alanyazında altı çizilen diğer bir nokta da, sözcükler arası anlamsal ilişkilerin okuma sürecindeki rolüdür. Harflerin benzerliği gibi, *sees* ve *see* arasında anlamsal olarak da çok yakın bir ilişki vardır. Bazı araştırmacılar, bu sözcüklere art arda maruz kalındığında ortaya çıkan kolaylaştırıcı etkinin bu anlamsal yakınlıktan kaynaklandığı fikrini ortaya atmıştır. İmgeleştirilebilirlik (Paivio, 1971), anlamsal ortak özellik sayısı (Pexman, 2012), sözcükler arası çağrışımlar (Balota vd., 2004) ve sözcüksel anlam belirsizlikleri (Beretta, Fiorentino ve Poeppel, 2005) anlam temelli kolaylaştırma etkisini savunan önde gelen savlardır. D1'in yanında D2'de oluşan kolaylaştırma etkisinin de sözcüksel-anlamsal ipuçları vasıtasıyla gerçekleştiğini iddia eden çalışmalar da ortaya konmuştur (örn: Clahsen & Felser, 2006).

İmla, anlam ve biçimbilimsel faktörlerin okuma sürecinin son aşamasında devreye girdiği konusunda herhangi bir soru işareti olmasa da (Marslen-Wilson vd., 1994; Diependeale vd., 2011), okuma sürecinde bu etkenlerin ne derece müdahil olduğu tartışmalıdır. Rastle ve arkadaşları (2000, 2004, 2008), biçim-ardından-anlam savıyla, karmaşık sözcüklerin işlemlenmesinin erken aşamasında biçimbilimsel faktörlerin yegâne sorumlu olduğunu iddia etmiştir. Diğer bir ifadeyle, harflerin benzerliğinin veya anlamsal yakınlığın okuma sürecinde ancak nihai aşamada devreye girdiğini ortaya koymuşlardır. Bu araştırmacılara göre, örneğin *sees* sözcüğüne 50 milisaniye gibi çok kısa bir süre maruz kalındığında sözcük insan zihninde kökü ve ekine *see* ve *–s* şeklinde ayrıştırılır, akabinde görülen *see* sözcüğünün daha hızlı algılanması da aynı köke ikinci defa maruz kalınmasındandır. Biçimbilimsel ilişkiye sahip olmayan *seed* veya *look* gibi sözcükler bu kadar kısa sürede see kelimesinin algılanmasında benzer bir kolaylaştırıcı etki yaratmazlar. Karşıt görüşte olanlar ise, biçimbilimsel ilişkinin özünde olan anlamsal yakınlık azaldığında kolaylaştırıcı etkinin de azaldığını belirtmiştir (Diependeale vd., 2005). Örneğin, *farmer* sözcüğünden sonra doğrudan kökü olan *farm* kelimesi okunduğunda ortaya çıkan kolaylaştırıcı etki, *corner* sözcüğünden sonra görülen ve anlamsal bir ilişkiden ziyade sadece biçimbilimsel alaka içeren *corn* sözcüğünün işlemlenmesinde görülmemiştir.

Görsel sözcüklerin tanınmasında etkili olduğu düşünülen diğer bir faktör de bireysel farklılıklardır. Etkili okumanın; her bir sözcüğün imla, sesbilimsel, anlambilimsel ve sözdizimsel özelliklerinin zihinde yüksek nitelikte temsiline bağlı olduğunu iddia eden Perfetti ve Hart'ın (2002) Sözcüksel Nitelik Hipotezi'nden hareketle araştırmacılar, görsel sözcüklerin algılanma sürecinde bireysel farklılıkların etkisini araştıran çalışmalar gerçekleştirmiştir. Andrews ve arkadaşları (2010, 2012), Perfetti'nin sözcüksel uzman ve nitelikli okuyucu terimlerini tartışmaya açmışlar ve biçimbilimsel işlemlemede bireysel faktörlerin ne denli etkili olduğunu tespit etmeye çalışan seri deneyler ortaya koymuşlardır. Andrews, nitelikli okurların sözcüksel temsilin alt alanlarındaki yetkinliklerine göre değişkenlik gösterdiğini, böylelikle de ilerleme durumlarına göre imlada yetkinlik veya sözcük dağarcığında genişlik elde edebildiğini savunmuştur. Andrews ve Lo (2013) tarafından gerçekleştirilen bir deney, okumanın ilk aşamalarında biçim veya anlamın sadece bazı okuyucular için devreye girdiğini göstermiştir. Üst düzey imla yetkinliğine sahip okuyucuların biçimsel yani harf benzerliklerine dayalı bir işlemleme düzenine uyduğunu, sözcük dağarcığı daha geniş olan grubun ise sözcükler arasındaki anlamsal ilişkiyi okumanın erken aşamalarında bile oldukça fazla dikkate aldığını vurgulamıştır. Çok fazla değişkenlik göstermediği varsayılan D1 konuşucularını hedef kitle olarak alıp deneye tabi tutsalar da bu bakış açısı dil kullanıcıları arasındaki olası farklılıklara verdiği önemden dolayı oldukça tartışma yaratmıştır. Fakat bu alanda halihazırda çalışma sayısının yetersiz oluşu güçlü ve kapsayıcı tespit ve betimlemelerin oluşumu için ciddi bir handikaptır.

İkinci Dilde Biçimbilimsel İşlemleme

D2 konuşucularının dil edinim ve kullanımlarının D1 konuşucularıyla ne ölçüde benzeştiği ikinci dil kuramlarının en temel sorusudur. Önde gelen yaklaşımlar, ikinci dilde faydalanılan kural ve stratejilerin anadil kullanımıyla aynı olup olmadığı ve eğer birtakım sapmalar mevcutsa dilsel olmayan bilgilerin nasıl kullanıldığı konularında ayrışırlar. Devamlılık Kuramı (Pinker, 1990; Crain, 1991)ve temel farklar hipotezleri (örn: Schachter, 1989)bu tartışmalarda başı çekse de özel olarak ikinci dilde biçimbilimsel işlemlemeye temas eden bir model geliştirilmemiştir, fakat bazı hipotezler sınanmak üzere ortaya konmuştur.

D1 ve D2'de biçimbilimsel işlemlemenin aynı zihinsel temsiller ve mekanizmaların kullanımı sonucu gerçekleştiği görüşücü bazı araştırmacılarca benimsenmiştir. D1 ve D2'de koşulsuz devamlılığı peşinen reddetseler de bu araştırmacılara göre karmaşık sözcüklerin tanınması sürecinde gözlemlenen benzer davranışlar anadile benzer D2 edincinin sonucudur. İkinci dilde biçimbilimsel işlemlemeye dair önemli bir yaklaşım, kelime tanımlamada dilbilgisel kuralların çevrim içi entegrasyonunun D2'de yeterlik seviyesine bağlı olduğudur. Bazı çalışmalar, ileri düzey yeterliğe sahip D2 konuşucularında (örn: Feldman vd., 2009; Feldman vd., 2010; Diependaele vd., 2011) veya bazı koşullar altında (örn: opak biçimlerde ve anlamsal geçirgen sözcüklerde) tepki süresi ve doğruluk oranlarının anadil performanslarına çok yakın olduğunu gözlemlemiştir. Bu çalışmalar, biçimbilimsel bilginin D1 ve D2'de etkin biçimde kullanıldığını ortaya koysa da biçimbilimsel işlemlemede süreklilik kuramını destekleyecek kadar güçlü bulgular sunmaktan uzaktır.

Kritik Dönem Hipotezi (Lenneberg, 1967), ikinci dilde dilbilgisel işlemlemenin eksikliklerini izah etmeye çalışan önemli bir yaklaşımdır. McDonald (2006), D2'de görülen yetersizliği D1 etkisine, işlemleme hızına ve hesaplama yeterliğine bağlamış; bunların da kritik dönemden sonra görülen dil edinimi yaşıyla bağlantılı olduğunu iddia etmiştir. Yaşı temel alan diğer bir argüman da ikinci dil edinimine nörobiyolojik bakış açısıyla yaklaşan Ullman'ın Bildirimsel-Yöntemsel

Modeli'dir (2001). Bu kuramın temel iddiası, kuralların örtük olarak bulunduğu yöntemsel hafızanın ve zihinsel temsillerin açık olarak bulunduğu bildirimsel hafızanın işlevselleşmesinde genlerin önemli bir role sahip olduğudur. Bu kurama göre, bildirimsel hafızada depolanan bilgiye hem D1 hem de D2'de erişilmesi oldukça hızlıyken aynı şey yaşa bağlı olgunlaşmanın yarattığı kısıtlamalardan dolayı yöntemsel hafıza için geçerli değildir. Bildirimsel hafızaya nazaran, yöntemsel hafızada tutulan bilgiye işlevsel bir şekilde erişilmesi ve kullanılması ancak erken çocuklukta görülebilir. Dolayısıyla, Ullman'ın (2015) özetlediği gibi, D2 öğrenimi hayatın ilerleyen aşamalarında başladığı takdirde yöntemsel hafızanın işlevselliği azalır ve bildirimsel hafızaya olan bağımlılık artar. Hipokampüs ve mediolateral lob yapılarında mevcut olan bildirimsel hafızanın, frontal kortekste etkinleşen yöntemsel hafızanın yerini almasının mümkün olmaması, örtük olarak edinilen yapılara erişimin ve bu yapıların kullanımının D2'de yetersizliğinin temel sebebi olarak görülür. Bu kuramsal yaklaşıma karşı olan Clahsen ve Felser (2006), ikinci dilde dilbilgisel işlemlemenin en tartışılan konularından biri olan Sığ Yapı Hipotezi'ni geliştirmiştir. Kritik Dönem Hipotezi ve Bildirimsel-Yöntemsel Model'in temel özelliklerini barındıran bu sav, Ullman'ın kurallar ve temsillere dair toptancı yaklaşımı yerine bağlam temelinde dilbilgisel olmayan bilginin çevrim içi kullanımı üzerine yoğunlaşmıştır. Clahsen ve Felser, D2 konuşucularının sözcüksel-anlamsal bilgilerden istifade edebildiği durumlarda anadile benzer performanslar ortaya koyduklarını, aksi halde niteliksel olarak benzer dilsel davranışları görmenin olası olmadığını iddia etmiştir. Örnek olarak, Kırkıcı ve Clahsen (2013) D2 konuşucularının yapım ve çekim eklerine yönelik farklı dilsel davranışlar gösterdiklerini görmüşler ve Feldman vd.'den (2010) farklı olarak, anlam temelli yapım eklerinin yapı temelli çekim eklerine nazaran bahsi geçen sözcüksel-anlamsal bilgilerden faydalanılmasını mümkün kılmasından dolayı bu farkın doğduğunu savunmuşlardır. Clahsen ve Felser (2018), bu temel farkın D1 etkisinden veya yeterlik seviyesinden değil, geç D2 ediniminin dilbilgisel işlemlemeyi işlevsizleştirmesinden kaynaklandığını öne sürmüştür.

İkinci dil ediniminde bireysel farklılıklar, uzun süredir ilgi çeken bir konudur ve bu alanda yapılan çalışma sayısı hayli fazladır. Araştırmalar, çoğunlukla kişisel (örn: inançlar, motivasyon, tavır) ve bilişsel (örn: öğrenme tarzları, üstbilişsel stratejiler, zeka) noktalara odaklanmıştır. Fakat incelemeler genellikle D2 sürecinin çıktılarının irdelenmesinden ibaret kalmıştır. Bilindiği kadarıyla, ikinci dilde biçimbilimsel işlemleme süreciyle alakalı yapılan çalışmalar, dil edinimine başlama yaşı ve dilsel yeterliğin etkisinden öteye geçememiştir.

İkinci dilde biçimbilimsel işlemlemenin nörolojik görüntülemesi incelendiğinde, görsel sözcük tanımlamasının tam olarak betimlenebilmesi için davranışsal ve sinirbilimsel kanıtların önemi açıkça görülmektedir. Zaman temelli sonuçlar, sürece etki eden olası faktörleri devre dışı bırakmakta yetersiz kaldığından ilk aşamalarda gerçekleştirilen olaya ilişkin beyin potansiyelleri (ERP) metodunu kullanan deneyler eleştiriye maruz kalmıştır. Dolayısıyla, beyin görüntüleme çalışmaları ilgili araştırma alanının açıklayıcı gücü olan bir model geliştirebilmesi için elzem görülmüştür. Son yıllarda, bu alanda birkaç çalışma gerçekleştirilmiştir (Lehtonen vd., 2009; Pliatsikas vd., 2014a, 2014b; De Grauwe vd., 2014) fakat nihai bir sonuca varmak için niceliksel olarak yetersiz oldukları açıktır.

Çalışmanın Kapsamı ve Önemi

D2 konuşucularının karmaşık sözcükleri işlemlemesinin erken safhasını ve bu süreçte devreye giren faktörleri ortaya koymak bu tezin nihai amacıdır. Yukarıda belirtildiği üzere karmaşık sözcüklerle karşılaşıldığında bireylerin ne tür dilsel davranışlar gösterdiklerine dair birçok model tartışılsa da, ikinci dilde biçimbilimsel işlemleme süreciyle ilgili herhangi bir fikir birliği oluşmamıştır. Biçim-ardından-anlam yaklaşımı anadilde işlemleme için kabul gören ve her geçen yıl güçlenen bir model olarak görülmektedir, fakat D2 için yapılan çalışmalar çelişkili sonuçlar ortaya koymakta ve alternatif yaklaşımlara ihtiyaç gitgide artmaktadır.

Öncelikle, bu araştırma alanında yapılan çalışmaların bir veya iki biçimbirim türünü ele alıp (örn: yapım ek – çekim eki veya düzenli – düzensiz ekler) bir genellemeye varmaya çalıştığını vurgulamak gerekir. Bunun dışında, farklı biçimbirimleri inceleyen çalışmalarda farklı zaman kısıtlarının kullanıldığı da görülmektedir. Ayrıca, test koşullarının farklı olmasının da yapılacak kapsayıcı değerlendirmeler için handikap olduğu düşünülmektedir (örn: Marelli vd., 2013; Marslen-Wilson vd., 1994). Aynı şartlar altında davranışsal ve nörolojik deneylerin gerçekleştirilmesinin ikinci dilde biçimbilimsel işlemlemenin daha isabetli bir betimlemesi için şarttır. Tüm bu koşullar dikkate alındığında, bu tezde tasarlanan deneyler, görsel sözcük tanımanın erken aşamalarında üç temel biçimbirimini incelemiştir; yapım ekleri, düzenli çekim ekleri ve düzensiz çekim ekleri. Tüm katılımcılar aynı şartlar altında bu öğelere maruz kalmışlardır. Karmaşık sözcükler –*al* yapım ekini, *-ed* çekim ekini ve düzensiz geçmiş zaman ekini içermiştir.

Zaman temelli davranışsal verinin elde edildiği ilk deneyde kullanılan öğeler, ikinci dilde biçimbilimsel işlemlemeye sinirbilimsel yönden yaklaşan ikinci deney olan fonksiyonel manyetik rezistans görüntüleme (fMRI) çalışmasında da aynı koşullar altında kullanılmıştır. Bu şekilde, karmaşık sözcüklerin algılanmasının hem zamansal hem de uzamsal olarak ortaya konması hedeflenmiş ve beklenmeyen faktörleri devreye girmesi mümkün mertebe önlenmiştir.

Bu tez, aynı zamanda ikinci dilde erken biçimbilimsel işlemlemede bireysel farklılıkların etkisini irdelemeyi de amaçlamıştır. D2'nin D1'e göre çok farklı değişkenleri barındırdığı bilinmektedir. Buna göre, dilsel yeterliğin yanında, sürece dahil olduğu düşünülen diğer olası etkenler de değerlendirilmelidir. Bu sebepten, anadil çalışmalarında da önem verilen sözcük bilgisi derinliği ve imla yeterliği, karmaşık sözcüklerin algılanmasında birer bağımsız değişken olarak bu tez kapsamında incelemeye tabi tutulmuştur.

Araştırma Soruları

Yukarıda vurgulanan araştırma boşluklarının göz önüne tutulmasıyla oluşturulan bu tezin araştırma soruları aşağıda sunulmuştur.

1. D2 konuşucuları biçimbilimsel olarak karmaşık sözcükleri, tanımlamanın erken aşamalarında unsurlarına ayrıştırır mı? İşlemleme modelleri biçimbirim türüne göre değişkenlik gösterir mi?
2. D2 konuşucularının erken biçimbilimsel işlemleme modelleri ile eş zamanlı hemodinamik beyin tepki modelleri arasında korelasyon mevcut mudur?
3. Bireysel farklılıklar D2 konuşucularının erken biçimbilimsel işlemleme modellerini ne ölçüde etkilemektedir?
4. Test koşullarının D2 konuşucularının erken biçimbilimsel işlemleme sürecinde ne derece etkisi vardır?

Bu sorulara yanıt vermek amacıyla ilk yapılması gereken, en isabetli sonuçların elde edilebileceği uygun metodun belirlenmesi olmuştur. Bir sonraki kısım, *maskelenmiş hazırlama* olarak adlandırılan ve bu araştırma sürecinde faydalanılan yöntemi açıklamaktadır.

Yöntem: Görsel Maskelenmiş Hazırlama

D2 konuşucularının karmaşık sözcükleri nasıl ayrıştırdığını sınamak ancak dolaylı yöntemlerle gerçekleştirilebilir. Hedef sözcükten önce gelen ilgili ve ilgisiz sözcüklerin kolaylaştırıcı etkisi anlamına gelen hazırlama, *see* sözcüğünden önce *sees* gibi çeşitli yönlerden ilgili bir sözcüğün, *corn* gibi tamamen ilgilisiz bir sözcüğe nazaran algılanma sürecini hızlandıran bir etki gösterdiğini ortaya koyabilir. Bu etki; ortografik, biçimbilimsel ve/veya anlamsal bilginin çevrim içi kullanıldığını gösterebilir. Bu değişkenlerin kontrollü bir biçimde incelenmesi, temel araştırma sorularına uygun yanıtlar bulunmasını sağlayabilir. Hazırlama sözcüklerinin bilinçli algılanmasını ve olaysal belleğin sürece müdahil olmasını engellemek için hedef sözcüklerden önce gelen hazırlama sözcükleri 50 milisaniye gibi çok kısa bir süre ve hash (#) sembollerinden sonra gösterilmiştir. 500 milisaniye maruz kalınan hedef sözcüklerden sonra ise katılımcılara ilgili sözcüklerin İngilizcede var olup olmadığı sorulmuştur.

Bilgisayar başında gerçekleştirilen ve davranışsal verinin elde edildiği deneyde ve hem ek davranışsal sonuçların alındığı hem de fMRI kayıtlarının alındığı sinirbilimsel çalışmada aynı deneysel öğelerden yararlanılmıştır. Hazırlama sözcükleri altı türde belirlenmiştir: yapım ekli sözcükler (örn: textual – TEXT), düzenli çekim ekli sözcükler (örn: watched - WATCH), düzensiz çekim ekli sözcükler (örn: forgiven - FORGIVE), opak sözcükler (örn: mission - MISS), ortografik sözcükler (örn: badge - BAD) ve anlamsal olarak ilgili sözcükler (örn: rule - LAW). Her grupta 24 öğe vardır. Davranışsal deneyde 112, fMRI çalışmasında ise ilk çalışmanın alt grubu olan 45 kişi yer almıştır. Katılımcıların tamamı üniversite öğrencisidir ve İngilizceyi ikinci dil olarak öğrenmektedir; hiçbir katılımcı kendini ikidilli olarak tanımlamamıştır. Davranışsal deneyi takiben katılımcılara deneysel sözcükleri bilip bilmediklerini sınayan sormacalar verilmiş, akabinde de bireysel farklılıkları ortaya koymak adına genel yeterlik, kelime ve imla bilgilerini belirleyecek testleri tamamlamaları istenmiştir.

Genel Sonuçlar

İlk deneyden elde edilen verilerin analizi, D2'de anadile benzer bir biçimbilimsel işlemleme modeli ortaya koymuştur; biçimbilimsel olara karmaşık (gerçek veya opak) sözcükler unsurlarına ayrıştırılırken salt anlamsal veya ortografik bilginin hedef sözcüklerin algılanmasını kendi başına kolaylaştırıp hızlandırmada etkisiz kaldığı görülmüştür. Bu çalışmanın sonuçlarının alanyazına göre açık bir tutarsızlık içermesi, önceki çalışmalara nazaran bu tezde yüksek sıklığa sahip sözcüklerin kullanılması ve beklenenin aksine bu sözcüklerin bütüncül bir okuma eğilimi göstermemesiyle açıklanmıştır. Bunun dışında, anadilde biçimbilimsel işlemlemede etkin olduğu düşünülen faktörler arasında sadece dilsel yeterliğin biçimbilimsel olarak ilişkili hazırlama-hedef gruplarının çevrim içi tanınmasında anlamlı bir etki yarattığı ortaya çıkmıştır.

fMRI deneyi iki önemli bulguyu ortaya koymuştur. Birincisi, maskelenmiş hazırlama sözcük kararı görevinde elde edilen davranışsal sonuçların ilk çalışmada gözlemlenen modelle tam uyumlu olduğu saptanmıştır. Diğer taraftan, sinirbilimsel bulgular yapım ve çekim eklerinin D2'de farklı bölgeleri etkinleştirdiğini göstermiştir. Buna paralel olarak, elde edilen sonuçlar; kuramsal tartışmalarda öne sürülen biçimbilimsel farkların beynin işlemleme sürecine yansıdığına dair ipucu olarak görülmüştür. Ayrıca, anadilde biçimbilimsel işlemlemede etkin olduğu varsayılan sol alt frontal korteksin (LIFG) D2'de etkinliğinin dilbilgisel içeriğe sahip olduğu düşünülen yapılarla sınırlı olduğu, anlamsal yönü ağır basan yapım ekleri içeren sözcüklerin tanınmasında ise etkin konumda olmadığı saptanmıştır. İstatistiki olarak anlamlı değerlerle ortaya konamasa da, anlamsal olarak ilişkili sözcük gruplarının işlemlenmesinde yapım eklerindeki hazırlama etkisi sırasında görülen beyin aktivasyonuna benzer bir etkinliğin oluşması; benzer bir durumun da ortografik koşul ve düzenli çekim ekleri arasında görülmesi yukarıda bahsi geçen biçimbilimsel yapılara dönük farklılıklara dair kuramsal bakışa dolaylı da olsa kanıt niteliğinde değerlendirilmiştir. Bunların yanında, düzensiz çekim eklerinin yarattığı hazırlama etkisinin beyinde iki farklı bölgede ve diğer biçimbirimlerden farklı alanlarda karşılık bulması, Crepaldi vd.'nin (2010) bu tarz yapıların kendine has bir biçimde unsurlarına ayrıştırıldığı iddiasını desteklemiştir.

Genel Tartışma

Bu tezin sonuçları, mevcut biçimbilimsel işlemleme modellerinin temel prensiplerine uyumluluk göstermemektedir. Gerçekleştirilen deneyler, işlemleme sırasında faydalanılan bilgilerin (örn: biçimbilimsel, ortografik, anlamsal) eş zamanlı olarak kullanılmadığını gösterdiğinden sonuçlar bağlantıcı yaklaşımları desteklememiştir. Diğer bir ifadeyle, biçimbilimsel unsurlardan farklı olarak, ortografik veya anlamsal bilginin okumanın erken safhalarında etkin bir şekilde devreye girmeyişi biçimbilimsel işlemlemenin paralel bir süreç değil, seri bir bilgi kullanım şeklinde gerçekleştiğine dair davranışsal ve sinirbilimsel veriler elde edilmiştir. Bu sonuçlardan, tüm okuma sürecinde biçim ve anlamın etkili olup olmadığına dair bir sonuç çıkarmak mümkün olmasa da bu çalışma zaman temelli okumaya dair öne sürülen bağlantıcı modellerin gözden geçirilmesi ihtiyacını vurgulamıştır.

Sonuçlar, okuma esnasında farklı zamanlarda farklı bilgi türlerinin kullanıldığına dair ipuçları sunduğundan dolayı seri modellerin yerelci yaklaşımlarını desteklediği iddia edilebilir. Fakat D2'de görsel sözcük tanımlamaya dair yoğun bir şekilde tartışılan hipotezlerle karşılaştırıldığında, bu tezin bulgularının hazırlama etkisi hususunda farklı biçimbirim türlerinin benzer etkiler gösterdiğini ortaya koymasıyla daha önce yapılan davranışsal ve beyin temelli yerelci çalışmalardan da ayrıldığı açıktır. Öncelikle, sonuçlar Sözcükler ve Kurallar Kuramı'nı desteklememiştir çünkü düzenli ve düzensiz çekimlenen yapıların benzer dilsel davranışlara neden olduğu görülmüş ve düzensiz yapıların bütüncül biçimde depolandığı önerisi çürütülmüştür. Benzer şekilde, Sığ Yapı Hipotezi ile bu çalışmanın sonuçları tutarsızlık içindedir; bunun temel sebebi ise yapım ve çekim ekleri içeren hazırlama-hedef sözcük gruplarının benzer seviyede kolaylaştırıcı etki sergilemiş olmalarıdır.

Diğer bir önemli husus, dilsel işlemlemede dilbilgisel bilgiden faydalanma çerçevesinde ikinci dilde süreklilik modelini savunan çalışmalar incelendiğinde alanyazın ve bu çalışmanın sonuçları arasında açık bir çelişki görülmektedir. Önceki çalışmalardan farklı olarak; hesaplamalı okuma ve algılama sürecinde eklerin düzenli olup olmamasının herhangi bir etkisinin gözlenmemesi (bkz. Feldman vd., 2010) veya ortografik hazırlama etkisinin bulunmaması (bkz. Diependeale vd., 2011), D2'de anadile benzer bir işlemleme modelinin varlığını savunanlar için tahmin edilemeyen bulgulardır. Fakat gerçek zamanlı dil kullanımında anadile benzer karmaşık sözcük ayrıştırma modelinin dilsel yeterliğe bağlı olduğu konusunda bu tezin sonuçları ilgili alanyazınla örtüşmektedir.

Alanyazınla karşılaştırıldığında sonuçların önceki çalışmalardan farklı olması bir izaha ihtiyaç duyulduğunu göstermektedir. Bu derecede bir uyumsuzluk, sözcük sıklığı ve ayrıştırma temelinde bir D1-D2 farkını ortaya koymaktadır. Yapılan analizler, yüksek sıklığa sahip ortografik ve anlamsal olarak ilişkili sözcük gruplarında kolaylaştırıcı etki mevcut değilken benzer sıklıkta görülen ve biçimbilimsel olarak ilişkili hazırlama - hedef ikililerinde unsurlara ayrıştırmanın gözlemlendiğine işaret etmiştir. Anadil çalışmaları bu tarz bir avantajın D1 konuşucuları için geçerli olmadığını göstermektedir; dolayısıyla, ikinci dilde biçimbilimsel işlemlemenin belirleyici unsuru olarak öne çıkan sıklık etkisi, önceki çalışmalarla bu tezin sonuçları arasındaki uyumsuzluğun en makul açıklaması olarak değerlendirilmektedir. Buna ek olarak, bazı çalışmalarda da belirtildiği gibi, kelime bilgisi ve imla yetkinliğinden ziyade dilsel yeterlik olası değişkenler arasında diğer bir belirleyici unsur olarak öne çıkmaktadır.

Hazırlama paradigmasıyla hazırlanan fMRI çalışmalarının sayıca azlığı, yeni çalışmalara önceki çalışmaların eleştirilmesi veya yanlışlanması yerine D2 nörobiyoloji kuramının oluşturulma sürecine katkıda bulunma misyonunu yüklemektedir. Dolayısıyla, alanyazını dikkate alarak elde edilen sinirbilimsel sonuçları yorumlamak an itibariyle yanıltıcı ve aşırı genellemelere neden olabilir. D1 beyninde dilsel bilgilerin bulunduğunu dair genel bir kanının oluştuğu LIFG lokasyonu odak noktası olarak alındığında, bu tezin sonuçlarının bu eğilimi kısmen desteklediği söylenebilir. Tüm biçimbirim türleri hazırlama etkisine yol açsa da ilgili bölgenin anlamlı derecede etkinleşmesine sadece dilbilgisel bilgiyi taşıdığı varsayılan düzenli çekim eklerinin ayrıştırılmasında karşılaşılmıştır. Yapım eklerinin ve düzensiz çekim eklerinin yarattığı hazırlama etkisi ise daha farklı beyin bölgelerinin aktivasyonuyla karşılık bulmuştur. Bu fark, zaman temelli davranışsal bir değişiklik yaratmamış olmasına rağmen karmaşık sözcüklerin okunması sürecinde biçimbirimlerin özelliklerine göre belirginleşen hemodinamik reflekslerin varlığına işaret etmektedir. Diğer taraftan, sonuçlar Crepaldi vd.'nin (2010) düzensiz çekim eklerinin iki aşamalı ayrıştırıldığını iddia eden yaklaşımına sinirbilimsel temellendirme niteliğindedir çünkü LIFG'den hayli uzak iki ayrı lokasyonun düzensiz çekim eklerinin sebebiyet verdiği hazırlama etkisine paralel olarak etkinleştiği ortaya çıkmıştır. Sonuçlar, düzensiz eklerin düzenli eklerden farklı bir işlemleme modeline sahip olduğunu önermektedir, fakat bu ekleri içeren sözcüklerin köklerinin çevrim içi algılandığı ve tanındığı göz önünde bulundurulduğunda bu farkın ilgili sözcüklerin basit sözcükler gibi bütüncül bir şekilde depolandığına dair kuramla örtüşmediğini de göstermiştir. Hazırlama etkisi yaratmayan ortografik ve anlamsal koşulları içeren MR verisinin derinlemesine irdelenmesiyle sonuçların geleneksek standartlarda istatistiksel olarak anlamlı bir değeri olmasa da önemli çıkarımlarda bulunulabileceği görülmüştür. Ortografik koşulun düzenli çekim ekleriyle benzer bölgelerde aktivasyon yaratması, biçimsel benzerliğe sahip sözcüklerin dilbilgisel bilgi içeren sözcüklerin tanınması sürecinde meydana gelen hemodinamik tepkiyle benzerlik gösterdiği şeklinde değerlendirilebilir. Benzer şekilde, anlamsal koşulun yapım eklerini içeren sözcük gruplarının yarattığına benzer sinirbilimsel bir aktivasyon modelini açığa çıkarması, yapım ekleri ve çekim eklerinin özellikleri ve işlevlerine dair kuramsal tartışmaları destekleyici sonuçlar olarak yorumlanabilir.

Çalışmanın Kısıtları ve Yeni Araştırma Önerileri

İkinci dilde biçimbilimsel işlemleme, birçok faktörün kontrol dışı bir biçimde devreye girebildiği oldukça karmaşık bir araştırma alanıdır. Daha önce bahsedildiği gibi, değişkenlerin kontrol altında tutulma güçlüğü dikkate alındığında tek bir çalışmayla konunun tüm yönlerini ele almanın gerçekçi bir hedef olmadığı barizdir. Dolayısıyla, aşağıda ifade edilen konularda yeni araştırmaların gerçekleştirilmesi, betimleyici ve açıklayıcı gücü yeterli bir D2 biçimbilimsel işlemleme modelinin oluşturulması için önerilmektedir.

- Bir veya birkaç olguya odaklanan tekil çalışmalardan sürecin tüm unsurlarına dair bir genelleme yapmak çoğunlukla yanıltıcı sonuçlara varmamıza yol açabilir; bundan dolayı aynı çalışma ve aynı koşullar altında mümkün olan en fazla biçimbirimde hazırlama etkisini inceleyen ilave araştırmalar gerçekleştirilmelidir.

- Dilsel yeterlik veya sözcük sıklığı gibi biçimbirimsel işlemlemenin muhtemel etkenlerini kategorikten ziyade sürekli bir değişken olarak analize dahil eden ve büyük ölçekli yeni takip çalışmaları yapılmalıdır.
- D1'de ve farklı dilsel yeterlik seviyelerine göre D2 bağlamında, sıklık oranı ve karmaşık sözcüklerinin unsurlarına ayrıştırılabilirliği arasındaki bağlantıya dair kesin bir neticeye ulaşabilmek için karşılaştırmalı çalışmalara ihtiyaç duyulmaktadır. Bu tür araştırmalarda çıkabilecek farklar, D1 ve D2 görsel sözcük tanımlama alanında gelecekte gerçekleştirilebilecek incelemeler için temel teşkil etmelidir.
- Deney esnasında verilen görevin sonuçlar üzerinde büyük bir etki yarattığı bilindiğinden, bu tezden çıkarılan sonuçların genellenebilirliğini sınayan ve maskelenmiş hazırlama paradigmasını kullanan sözcüksel karar görevinin tatbik edildiği ilave fMRI çalışmalarının yapılması oldukça önemlidir.
- Davranışsal ve sinirbilimsel bulgular arasındaki korelasyon derecesini belirlemeyi amaçlayan yeni araştırmalar, biçimbilimsel olarak karmaşık sözcüklerin çevrim içi tanınıp algılanmasında etkin durumda olan beyin bölgelerinin kesin bir biçimde tespit edilebilmesini sağlayacaktır.
- Test şartlarının biçimbilimsel işlemleme sürecindeki muhtemel etkisi; pozitron yayınlayıcı tomografi (PET), manyetoensefalografi (MEG) ve göz izleme gibi farklı deney ortamları sunan sinirbilimsel ve davranışsal çalışmaların artması gerektiğine işaret etmektedir.

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