Alison Roberto Gonçalves

THE ORTHOGRAPHIC SIGNATURE IN SECOND LANGUAGE SPEECH ACQUISITION AND PROCESSING

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Orientadora: Prof.ª Dr.ª Rosane Silveira

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Esta Tese foi julgada adequada para obtenção do Título de "Doutor em Estudos da Linguagem" e aprovada em sua forma final pelo Programa de Pós-graduação em Inglês.

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Quem vê daqui não vê o fim
Quem vê daqui não vê inteiro
Mas é capaz de ver de longe
Uma agulha no palheiro

Quem vê daqui não sente falta de visão
Não sente falta de vizinho
Quem vê daqui
Não tá sozinho
Nem cabe em si

[...]
Luz
Pra quê?
Pra reluzir
Pra quê?
Pra refletir
O quê?
Tudo que vi

Sol
Pra quê?
Para solar
Pra quê?
Pra colorir
O quê?
O que vivi

Som
Pra quê?
Para somar
Pra quê?
Pra ressoar
O quê?
O que senti
Som e sol tocando em nós

Dante Ozzetti & Luiz Tatit, *Visões*

ABSTRACT

Gonçalves, Alison Roberto. **The orthographic signature in second language speech acquisition and processing**, 2017. 156 p. Thesis (Doctorate in Language Studies). Graduate Program in English, Federal University of Santa Catarina, Florianópolis, 2017.

The present study investigated orthographic effects on phonological processing in an additional language. Evidence from recent research points to two different processes that result from the activation of the orthographic system over phonological processing. A research strand posits that orthography aids the establishment of phonological representations, acting as a source of metalinguistic knowledge, as a late literacy effect. In this vein, orthographic and phonological knowledge are jointly associated and interact unconditionally in linguistic processing. Disputably, another research strand adheres to the position that orthographic recruitment over phonological processing is a result of task requirements, which renders varying types of information that would be strategically employed just to perform the task at hand. Hence, orthography would act strategically to assist, for example, the categorization of sounds in early stages of acquisition of an additional language. This effect would also be conditioned to selective attention that is stimulus-driven. To investigate orthographic recruitment, bilingual speakers of Brazilian Portuguese and English underwent training to learn new lexical items that simulated opaque and transparent grapho-phonic English relations. This was a repeated-exposure training paradigm in which subjects were introduced to the lexicon phonological forms associated with their visual forms, and then to the phonological forms associated with their visual and orthographic forms. Subjects were tested with an Auditory Lexical Decision task to investigate orthographic recruitment in perception and with a Timed Picture Naming task to investigate orthographic recruitment in production. Results of the Auditory Lexical Decision task indicated that the orthographic effects acted strategically because they only affected latencies for the “no” answers, whose words were items presented only in the task, differently from the “yes” responses which were trained items. This result evidences that orthography aided lexical analysis for the categorization of these new items with which participants were not familiar. Results of the

Timed Picture Naming task showed that orthography influenced naming of the trained items, indicating that the process of converting a visual input into its phono-articulatory representations for production involves orthographic activation. This result was interpreted as a frequency effect of the grapho-phonic combination, which resulted in lack of skill to compute this operation in the sublexical route. In general lines, this piece of research claims that orthography can be accessed conjointly with phonology for lexical processing, but such an excitatory mechanism works strategically to assist lexical analysis of phonological categories for perception and lexical selection for production.

Key-words: Second Language Acquisition. Phonology. Psycholinguistics.

RESUMO

Gonçalves, Alison Roberto. **A assinatura ortográfica na aquisição e no processamento da fala em língua estrangeira**, 2017. 156 p. Tese (Doutorado em Estudos da Linguagem). Programa de Pós-Graduação em Inglês. Universidade Federal de Santa Catarina, 2017.

O presente estudo investigou os efeitos ortográficos no processamento fonológico em língua estrangeira. Evidências de pesquisas recentes apontam para dois processos diferentes que resultam da ativação do sistema ortográfico durante o processamento fonológico. A primeira linha de pesquisa dispõe que a ortografia auxilia no estabelecimento de representações fonológicas, atuando como uma fonte de conhecimento metalinguístico, como um efeito tardio da alfabetização. Neste sentido, o conhecimento ortográfico e o conhecimento fonológico estão fortemente associados e interagem incondicionalmente no processamento linguístico. A outra linha de pesquisa asserta que o recrutamento ortográfico durante o processamento fonológico é resultante do tipo de tarefa aplicada, dispondo de tipos diferentes de informação que são aplicados estrategicamente para executar a tarefa dada. Assim, a ortografia agiria estrategicamente para auxiliar, por exemplo, na categorização de sons em estágios iniciais da aquisição da língua adicional. Este efeito também seria dependente à atenção seletiva direcionada ao estímulo. Para investigar o recrutamento ortográfico, bilíngues falantes de português brasileiro e de inglês como língua adicional participaram de um treinamento para aprender novos itens lexicais que simulavam relações grafo-fono-fonológicas opacas e transparentes do inglês. O treinamento foi baseado em um paradigma de exposição repetida em que os sujeitos foram, consecutivamente, apresentados às formas fonológicas associadas às formas visuais das novas palavras e, em seguida, às formas fonológicas associadas às formas visual e ortográfica. Os sujeitos foram testados com uma tarefa de Decisão Lexical Auditiva para investigar o recrutamento ortográfico na percepção e com uma tarefa de Nomeação de Figuras Temporalizada para investigar o recrutamento ortográfico na produção. Resultados da tarefa de Decisão Lexical Auditiva indicam que os efeitos ortográficos agiram estrategicamente, pois atuaram somente sobre as latências das respostas negativas, cujas palavras eram itens apresentados somente na tarefa, diferentemente das respostas positivas que eram itens com os quais os participantes foram treinados. Esse resultado evidencia que a ortografia auxiliou na análise lexical para a categorização desses novos itens apresentados com os quais os participantes não tinham familiaridade. Já resultados da tarefa de Nomeação de Figuras Temporalizada demonstraram que a ortografia atuou sobre a nomeação dos itens lexicais com os quais os participantes foram treinados, indicando que o processo de conversão de um item visual à sua representação fono-articulatória para a produção envolve a ativação ortográfica. Esse resultado foi interpretado como um efeito de frequência da combinação grafo-fônica, que resultou em maior inabilidade para a computação dessa operação na rota sublexical do processamento linguístico. Em linhas gerais, a presente pesquisa demonstra que a ortografia pode ser acessada conjuntamente com a fonologia durante o processamento lexical, mas este mecanismo funciona estrategicamente para auxiliar na análise lexical de categorias fonológicas na percepção e na seleção lexical para a produção.

Palavras-chave: Aquisição da Língua Estrangeira. Fonologia. Psicolinguística.

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INTRODUCTION

1.1 CONTEXT OF INVESTIGATION

The present work offers a glance into the cognitive processing of bilinguals. The chief interest that motivated its inquiry relies on the mechanisms involved in the acquisition and processing of second language speech. Historically, investigations on language acquisition permeate the field of Psycholinguistics. The study of speech is at the core of the discipline, as almost all diaries written by pioneering investigators[1] reported the order of infant acquisition of speech sounds (Levelt, 2013). Notably, Psycholinguistics and experimentalism with speech consist of the budding of the youngest root of the discipline, language production and perception of normal adults, with early studies in perception and production dating back to the beginning of the 19th century, when acoustic and articulatory phonetics thrived (Levelt, 2013).

The constituent role of abstract representations as phonological categories in long-term memory was long ago called into question, as speech theorists demonstrated that auditory and visual information are integrated in speech perception (McGurk &MacDonald, 1976). Moreover, the role for abstract representations has more recently been combined with a role for "veridical representations of speech episodes or exemplars" (McQueen & Cutler, 2010, p. 490), in which both types of representations[2] are placed at the same level in a hybrid, rather than abstractionist, model (Ernerstus & Baayen, 2014).The co-existence of all these frameworks places speech perception theory in a stimulating state of transformation

Another relevant research field in the present academic enterprise has examined the long-lasting cognitive effects that literacy poses to language processing. The learning of orthographic skills deeply influences language and visual processing, as well as memory functions (Kolinsky, 2015), as attested by a handful of studies. These studies rendered literacy to affect basic perceptual processes, such as categorical perception and word recognition (Serniclaes, Ventura, Morais, & Kolinsky, 2005), and

[1] Refer to Chapter 4 in Levelt (2013) for a timeline.

[2] In this framework, both fine-grained acoustic-phonetic details and indexical details of speech and episodic contextual information are maintained (Pisoni &McLennan, 2015).

metalinguistic abilities, such as phonemic manipulation and detection (Gottardo, Pasquarella, Chen, & Ramirez, 2015; Scliar-Cabral, Morais, Nepomuceno, & Kolinsky 1997); whereas demonstrating that literacy also assists verbal working memory[3] (Pattamadilok Lafontaine, Morais, & Kolinsky, 2010; Reis & Castro-Caldas, 1997). Lexical representations are also affected when one undergoes literacy, for scholars have claimed that representations become co-structured between orthography and phonology (Veivo & Järvikivi, 2013), and may function as two faces of the same coin (Frost & Ziegler, 2007). Hence, the recognition of speech, a general processing capability (Kuhl, 2000; Werker & Gervain, 2013), is transformed with the achievement of literacy, when writing skills are acquired and lead to a profound cognitive change (Kolinsky, 2015; Morais & Kolinsky, 2005; Saletta, 2015; Tarone, Hansen, Bigelow, 2013). The research problem of this dissertation arises from this scenario.

A protracted debate has revolved around whether and, more specifically, how orthographic knowledge influences speech acquisition and processing. Some studies maintain that aural information automatically elicits orthographic information, such that one type of stimuli is processed by two different systems[4] working in tandem (Chéreau, Gaskell, & Dumay, 2007; Damian & Bowers, 2003; Frost & Ziegler, 2007; Perre & Ziegler, 2008; Ziegler & Ferrand, 1998; Ziegler, Ferrand & Montant, 2004). Other scholars oppositely adhere to the position that orthographic knowledge is evoked strategically due to task requirements, thus the degree of involvement of the orthographic system is flexible to task demands (Cutler & Davis, 2012; Cutler, Treiman, & van Ooijen; 2010; Taft, 2011; Yoncheva et al., 2013). In the case of a second language[5](L2), the extent to which such claims hold true are unclear, as well as the evidence available is still mitigated because studies have shed light on orthographic influence of various types. Advantageous effects were found for speech

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[3] The cognitive faculty responsible for the temporary maintenance and manipulation of verbal information (Acheson and MacDonald, 2009).

[4] I hereby adopt the definition of *systems* coined by Lewis and Phillips (2015), who claim that a system is “a collection of cognitive mechanisms with a distinct purpose, operating over representations of a distinct kind” (p. 28).

[5] I follow Pavlenko (2014) on the use of the term *second language* (L2) to refer to any language learned late in life, after the L1. As the bilinguals of the present study are late bilinguals, the use of the term *L2* to refer to English is consistent. Moreover, the term *additional language* is broadly applied to refer to any languages other than the L1, including the L2.

processing when orthography matched phonology straightforwardly (Erdener & Burnham, 2005; Escudero et al., 2014; Veivo & Järvikivi, 2013). Other scientific sources showed that orthography hindered subjects' performance when it presented incongruent graphophonic[6] matchings (Escudero et al., 2008; Escudero et al., 2014; Hayes-Harb et al., 2010), as well as no influence at all was observed by other scholars (Simon et al., 2010; Pytlyk, 2011).

As concerns the population hereby investigated, it is fitting to note that the term *bilingual* is employed to denote speakers who use two languages in their daily lives, either simultaneously or consecutively, regardless of proficiency level in the two (Pavlenko, 2006). Investigations on bilingualism in academia are "a natural consequence of globalization, transnational migration, and increased ethnolinguistic diversity in the Western world" (Pavlenko, 2014, p. 20). Bilingualism was consolidated as a field of research through the 1980s and 1990s, when foundational texts appeared and scholars started putting together international symposia (Pavlenko, 2014). Throughout the 2000s, a great bulk of research has overseen the impact that speaking two languages has on cognitive performance and the architecture of the brain (Bialystok & Craik, 2010; Dong & Li, 2015). In general lines, it is believed that speaking more than one language represents gains in conflict resolution and executive control, and a loss for lexical access with negative implications for verbal fluency and vocabulary size (Bialystok, 2009,). Another stimulating finding that revolves around bilingualism is that of cognitive reserve, a concept that explains the protective effects that being bilingual provides to sustain cognitive functioning in elderly bilinguals (Bialystok, Craik, & Freedman, 2007).

In general lines, this investigation takes on the interaction between an experience-dependent capability that results from learning, that is, acquiring the written representation for reading and writing, with an experience-expectant process that is embedded in our biology, speech processing (Werker & Gervain, 2013). Hence, this PhD dissertation explores in more depth the interaction between a process that is innate with a process that is resulting from human culture and impacts human cognition profoundly. Next, the research objectives of the present enterprise are depicted.

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[6] The term graphophonic matchings or graphophonic relations are used interchangeably to regard conversions from graphemes to phonic forms, the latter being either phonetic or phonological, in which such a distinction is unimportant.

1.2 OBJECTIVES

This work aims to promote an experimental and theoretical account of the influence of orthographic knowledge on speech acquisition and processing in the L2, and whether such effects reflect a strategic or a mandatory operation in speech processing. This becomes of special interest with the increasing number of bilinguals worldwide, who are in touch on a daily basis with two or more orthographic systems that might be of different depths, as is the case of the present investigation, in which the subjects come from an L1 of relatively transparent graphophonic relations (Brazilian Portuguese) to learn an opaque L2 (English). Such an idiosyncrasy assigns a still unknown signature to the mechanisms that underlie L2 speech.

1.3. THE STUDY

To observe whether orthography is recruited for speech perception and production in a second language and to observe whether such effects reflect a strategic or a mandatory operation, the present study employs an exposure-based training paradigm, which consists of study and verification blocks as fabricated exposure to an artificial lexicon that simulates English graphophonic relations. Research subjects initially learn the phonological forms of a new lexicon through associations composed by pictures and their auditory forms to subsequently be introduced to their orthographic information. This learning paradigm allows subjects to have relevant exposure to the trained lexicon in order to acquire stable representations of such items. The new lexicon contains single-syllable words that compose experimental and control items, which differ in the consistency of the spelling-to-sound association in nuclear position. To observe whether orthographic effects arise in perception and in production, subjects are lastly tested with an Auditory Lexical Decision task and a Timed Picture Naming task.

1.4 SIGNIFICANCE OF THE STUDY

The present work is nested in related research fields, namely, Psycholinguistics and Second Language Acquisition. With reference to what Leeser (2014) outlines, this study tackles two critical areas that psycholinguistic research appertains to: the role of native language in non-native processing, and how processing can provide insights into the nature of linguistic representation (p. 232).

Within the first matter, this research considers how the orthographic knowledge of the native language, characterized as a transparent orthography, influences the processing and learning of the phonology in the L2, an opaque language. This issue has not been explored protractedly and such phenomena (orthographic recruitment for speech processing) have been investigated separately, but should be looked at in tandem as reading and speaking share important mechanisms (Saletta, 2015). As concerns the second matter, this study sets out to understand more of how phonological and orthographic knowledge interact in tasks when speech is processed in the L2. By examining the conditions in which orthographic knowledge interacts with phonological knowledge and the effects of such interaction (facilitative or disruptive), new understandings on the processes involved in speech acquisition might be achieved, and potentially yield a more detailed analysis of the automaticity of orthographic knowledge and of processing principles that apply to spoken production (e.g., Damian & Bowers, 2009).

This study also brings implications for Second Language Acquisition (SLA). As VanPatten (2014) asserts, adult SLA is tightly linked to psycholinguistics and language processing. A more elaborate understanding of speech acquisition shall be achieved with this study, with special concern to their experience with written language. Moreover, some researchers have conceded that orthographic input should be treated as an empirical variable in the study of L2 phonological acquisition (Bassetti et al., 2015; Silveira, 2016), as various traits of learners' phonological development, as observed in perception and production, can be traced back to their L1 grapho-phonic matchings, thus causing orthographic input to "filter" aural input (Young-Scholten & Langer, 2015).

In this vein, research agendas have not dealt in satisfactory manner with orthographic recruitment as a process involved in spoken production and spoken word recognition. It is paramount that in the realm of cognition, a principled account of such related phenomena is offered, given its numerous implications to models of spoken and visual word recognition, and speech acquisition. Likewise, models of second language speech acquisition have not heretofore offered satisfactory accounts of the powerful influence the orthographic system exerts over the acquisition and processing of sounds. Such knowledge is of utmost importance for teachers and language practitioners, as they need to be equipped with strategies regarding when to assist learners with the written code through the course of phonological acquisition and when to teach graphophonic combinations. As Treiman and Keslller (2007) note, teachers cannot teach every orthographic pattern, but can provide the conditions under which such patterns are learned most effectively. An appraisal to this is still accountable in further research in Applied Linguistics.

This study also offers a perspective on the cognitive processing of language by bilinguals. Scholarly work is still unveiling idiosyncrasies of the processing hierarchy of such individuals, who carry multi-faceted linguistic repertoires to perform complex identities (Valdés, Poza, & Brooks, 2015), and still needs to provide an account on the way bilinguals handle two orthographic systems of differing depths and its implications to processes of perception and production.

1.5 ORGANIZATION OF THE STUDY

Chapter 2, entitled *Underpinnings of speech perception and processing,* discusses the primordial role of speech perception in the emergence of representations, as well as their importance to the constitution of the lexicon. Last, it addresses the development of higher-order lexical knowledge to process speech in relation to the subjects' proficiency level.

Chapter 3, *The visual nature of speech,* firstly characterizes orthography and its impact on cognitive systems when one becomes literate, while also offering an account of the studies published so far that dealt with orthographic influences on second language phonological processing tasks. This chapter also discusses the benefits of using an artificial lexicon in experimental research, while offering a brief account of analyzing speed in the field of Psycholinguistics. Finally, Chapter 3 presents the Research Question and Hypotheses that guide the present investigation.

Next, Chapter 4, *Method,* describes and explains in detail all factors that were considered for participant recruitment and for the creation of the stimuli utilized in the present study. All procedures and apparatus involved in data collection are also fully explained. Finally, the chapter presents all results gathered with the pilot of the study, pointing out the changes the study underwent.

Chapter 5, *Results and discussion*, draws on the main findings of the present study, while referring to the literature discussed in previous chapters.

Last, Chapter 6, which is entitled *Final remarks*, summarizes the main findings of the present research and presents the study limitations that warrant further inquiry.

CHAPTER 2 - UNDERPINNINGS OF SPEECH PERCEPTION AND PROCESSING

How linguistic knowledge is hosted in our cognition and the changes that linguistic representations undergo with the events of life gather much scientific interest. In infancy, sensitivities to the categorical regularities in the language input function as a trigger to form the primitive phonological representations. These representations are believed to be the key component that support word learning and word recognition for the phases that will come next in language development (Ainsworth, Welbourne & Hesketh, 2016; Werker & Gervain, 2013). With vocabulary growth, these representations are sharpened up (Werker & Curtin, 2005), and when literacy unfolds, phonological representations become co-structured with orthographic information (Veivo & Järvikivi, 2013).

The present chapter firstly discusses the underpinnings that endorse language acquisition and the importance of speech perception[7] in such enterprise. The nature of representations and how they emerge from ambient language is depicted, as well as the aforementioned developmental changes that these undergo with vocabulary growth and literacy. Further in the chapter, the relationship between speech perception and native and non-native language acquisition is addressed. Notwithstanding, language representation is discussed with special regard to the interaction of the phonological and orthographic representations for the L2 learner, followed by the notion of the lexicon. Finally, a brief discussion of the relation between proficiency and lexical knowledge closes the chapter.

2.1 THE EMERGENCE OF REPRESENTATIONS AND THE ACQUISITION OF LANGUAGE

Infants' keen sensitivity to phonetic contrasts has provided a potential account for speech perception to be placed at the forefront of language acquisition (Kuhl, 2000; Werker, 1995; Werker & Curtin, 2005; Werker & Gervain, 2013). Research has consistently revealed that, from an early age, infants show preference for speech sounds over similarly

[7] Speech perception is hereby conceived as "a succession of processes operating on the acoustic signal with varying levels of complexity" (p. 183-4) in which spectral (acoustic) contrast operates early, with trading relations and categorical perception operating later (Kluender & Kiefte, 2006).

complex nonspeech sounds (Vouloumanos & Werker, 2007), and are able to discriminate any phonetic contrasts extremely well (Maye, Werker, Gerken, 2002). However, by 10 to 12 months of age, they no longer maintain sensitivity to contrasts other than those in the native language, showing that these become language-specific with the establishment of native phonetic categories (Werker & Gervain, 2013).

Werker and Gervain (2013) argue that the perceptual and learning mechanisms responsible for acquiring input language over the first year of life are best described as experience-expectant[8] processes that are embedded in our biology and await minimal environment input. Hence, infants are able to parse ambient language and extract the statistical[9] distribution of phonemes and syllables that are available in the input, which is used to begin the establishment of relevant categories in their native language. This is possible due to a domain-general, preexisting discriminative auditory mechanism, which is operated on to facilitate learning of a domain-specific system (Maye et al., 2002). Such a domain-general processing mechanism has been named so for being observed in other non-human animals (Hauser, Newport, Aslin; 2001; Maye et al., 2002), a claim that was motivated by the discovery of categorical perception in other species during the 70s (Kuhl & Damasio, 2012).

Humans are therefore able to operate on universal learning mechanisms (Werker & Gervain, 2013, p. 909) that parse statistical information, such as the co-occurrence of phonemes and syllables, which will lead to the formation of phonetic categories in the infant lexicon. Such a mechanism draws only on meaningful statistical information and is refined as experience with language unveils with the acquisition of vocabulary (Werker & Curtin, 2005). In this enterprise, Kuhl (2000) advocates that what is innate about language is not a universal grammar and phonetics, but innate biases and learning strategies (*universal learning mechanisms*, as referred to in Werker & Gervain, 2013) that place constraints on perception – what makes language "innately discoverable" (p. 11856). Language therefore is posterior to birth and conceived as a

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[8] As opposed to experience-dependent, which characterizes capabilities that emerge only as a function of learning, e.g., reading and writing.

[9] Siegelman and Frost (2015) outline statistical learning in the following manner: "the ability to pick up regularities in the world is taken as a domain-general central mechanism by which cognitive systems discover the underlying structural properties" (p. 105).

form of cognition that "[…] evolved to match a set of general perceptual and learning abilities" (Kuhl et al., 2008, p. 982), a cognition that evolves in response to the influence of a genetic potential (Werker & Gervain, 2013).

In the conceptual framework put together by Werker and Curtin (2005), PRIMIR[10], phoneme-level representations are proposed to emerge gradually from the phoneme plane as statistical regularities that are extracted from word-level input. In concert with this, perceptual salience also exerts a role in guiding the extraction of relevant acoustic information from input. Initially, acoustic variability is used to discern phonetic organization (Maye et al., 2002), and as the phoneme plane emerges and experience with language is gained, infants are able to detect acoustic dimensions that are most informative (Werker & Gervain, 2013), which can contribute to the modifiability of phonetic categories (Werker & Curtin, 2005). Notwithstanding, Werker and Curtin (2005) also propose that indexical detail is encoded in the phoneme plane of a representation, which will include paralinguistic information, such as speaker identify, gender, affect, and emphasis, types of information that infants have been attested to discriminate.

As regards the primitive of the representation, PRIMIR never takes an explicit stance, for the authors state "it is designed to allow all forms of available information to be used" (Werker & Curtin, 2005, p. 222). However, as explored above, acoustic information is initially used as the main source for the perceptual parser infants are able to apply to ambient language when using their statistical learning mechanism. Yet, Werker and Curtin (2005) already acknowledge articulatory features and their contribution to the formation of phonetic categories as they co-occur and share gestural properties that can be integral to the formation of a category. More recent scientific evidence has supported the claim that audiovisual cues are used in early infancy (6 months) to aid auditory discrimination of speech categories, which demonstrates that the co-occurrence of acoustic categories and speech gestures augment early speech perception (Danielson *et al*., 2017).

It is during the second year of life, by 17 to 18 months of age, that the refinement of previous phonetic representations will occur, giving rise to the aforementioned phoneme plane, when native categories are

[10] Processing Rich Information from Multidimensional Interactive Representations.

stabilized into phonological representations that are used as part of the grammar of the native language to support word learning and word recognition. Relatedly, Werker and Gervain (2013) explain that

> […] by 17 to 18 months, language-specific phonetic sensitivities have become organized into more stable, "phonological" representations that have begun to act much like the phoneme categories adults use to guide word learning and word recognition. With such a stable representation, infants' attention is weighted toward the phonetic, allowing them to more easily summarize across irrelevant information such as gender and affect in the voice, and attend instead to the criteria phonemic difference (p. 91, 2013).

For this phase to be achieved, vocabulary expansion is a necessary mechanism of change. As the infant lexicon grows, more words with overlapping features are added, leading to the emersion of phonemes as stable categories. These categories, more firmly established and resistant to change, are treated as higher order regularities that gradually coalesce into a system of contrastive phonemes (Werker & Curtin, 2005, p. 217).

As concerns the development of representations in a nonnative language, two models will be now discussed, the L2LP[11] (van Leussen & Escudero, 2015), and the Native Language Magnet-extended (Kuhl et al., 2008). These models are highly compatible with PRIMIR, specially when elucidating the foundations of native and nonnative language learning. Such models are thus presented as an account for second language learning, and the existing idiosyncrasies among them are discussed in relation to PRIMIR.

The L2LP model proposes an analogous developmental path for categories in acquiring L2 speech, growing from an early acoustic to a stable phonological representation, whereas considering psycholinguistic constructs that buttress language acquisition, such as the importance of lexical categories for the acquisition of speech as a meaning-driven process. Figure 1 below portraits the architecture of the development of

[11] Second Language Linguistic Perception.

representations, which is made up of three representational levels and the existing relations among them.

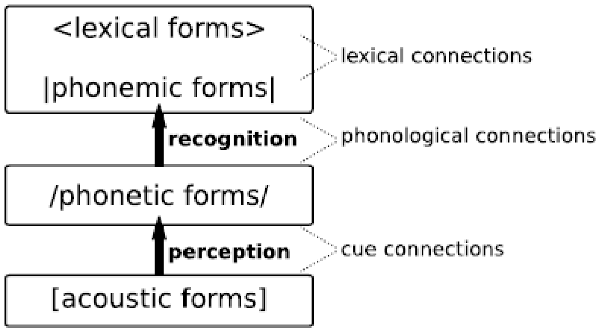

Figure 1. Types and levels of representations in the L2LP model.
Source: van Leussen and Escudero (2015)

Moreover, Werker and Curtin (2005) appreciably contrast their framework to other existing models of speech acquisition and processing, among which are two influential models that account for nonnative acquisition also, namely, Kuhl's Native Language Magnet model and Best's Perceptual Assimilation model[12].

Firstly, Werker and Curtin (2005) argue that Kuhl's and Best's models do not link speech perception to word learning, a relationship that is at the foundation for language development, whereas the L2LP does state that what drives language acquisition are meaning-based categories prevenient from lexical knowledge.van Leussen and Escudero (2015) claim that L2 learners have direct access to meaning conveyed by lexical categories and thus infer the phonological categories that are available within.

Werker and Curtin (2005) also claim that Kuhl's and Best's models do not account for the psychological processes that underlie children's evaluation of speech. However, more recent, revised versions[13] of these models do. In fact, in an extended version of their model, Kuhl and collaborators (2008) propose that statistical learning is the mechanism that prompts speech perception to trigger language acquisition during infancy,

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[12] I do not focus on Best's model for her research strand focuses on gestural phonology, which has different primitive units: the phonological gestures.

[13] Refer to Best and Tyler (2007) for a revised version of their model.

thus both theoretical stances (Werker & Curtin, 2005; Kuhl et al., 2008) hold now a quite similar approach to language acquisition.

In the same vein as Werker and Curtin (2005), Kuhl *et al*. (2008) use acoustic cues as the primitive source of information available for infants, which is another similarity shared by van Leussen and Escudero's model, the L2LP. The LP2LP states the result of L1 acquisition[14] would be the initial stage of L2 learning, and predict that "acoustical differences and similarities between the phonemes of languages will shape development" (van Leussen & Escudero, 2015, p. 02).

In the theoretical enterprise documented by Kuhl and collaborators, the authors explicate that historical models of speech perception were based on selection, which implied a process of maintenance or loss of phonetic categories. This ability would stem from an innate specification of phonetic units (an "internal grammar"), as infants would be equipped with phonetic feature detectors (Kuhl & Damasio, 2012). However, Kuhl et al. (2008) argue that such models could not explicate a range of phenomena related to speech perception, namely: a) facilitation patterns that were seen for native language contrasts among 6 and 12 months of age; b) the decline for non-native contrasts at the same point in time; c) the variability observed across phonetic contrasts; and d) the relationship between native and non-native speech perception

As experience with language perception involves the creation of mental mappings, neural structure becomes "committed" in some level, which brings implications for learning another language later in life. Neural commitment is a principle of relevance for understanding hurdles in learning a second language later in life. In the Native Language Magnet-extended, Kuhl et al. (2008) argue that the brain is committed with changes in neural tissue and circuitry as an effect of early coding of language, which will exert major influence in subsequent abilities to learn new phonetic scheme because these changes reflect the statistical and perceptual properties of the language(s) previously learned. As a result, attentional networks are biased in favor of a language.

Relatedly, another principle in this model is that the binding between perception and production occurs developmentally. The model posits that first, sensory learning occurs, that is, a map of phonetic representations

[14] "Learners will initially perceive L2 sounds in a manner resembling the production of these same sounds in their L1 environment" (van Leussen & Escudero, 2015, p. 02).

is created, which will then guide the development of motor patterns. The authors argue that "[…] the perceptual patterns stored in memory serve as guides for production, and this subsequently results in language-specific perception-production mapping" (Kuhl et al., 2008, p. 985). Other scholars have discussed that a distinction in perception will prompt learners to attempt a distinction in production, for perceived categories carve-up the acoustic-phonetic space map that defines the distribution of sounds that are used in production (Edwards, Beckman, & Munson, 2015; Rauber et al., 2005).

Another pertinent factor worth of appraisal in the present section is the inclusion of orthographic information in speech representations. Werker and Curtin (2005) interestingly suggest that their framework allows for expansion to an orthographic plane, although they do not develop on such an argument. Of relevance, Werker and Gervain (2013) note that literacy is another mechanism of change for representations, whereas van Leussen and Escudero (2015) do not mention orthography. In this vein, Veivo and Järvikivi's (2013) elucidation for orthographic and phonological information in word processing is worth consideration.

According to Veivo and Järvikivi (2013), there have been two main explanations to account for the activation of orthography during auditory processing. One is regarded as the on-line *co-activation account*, which posits that orthographic and phonological representations co-exist and are strongly linked at both pre-lexical and lexical levels. As representations are linked, they can be activated automatically. The other account is the *restructuration account*, which claims that there are no separate representations for each of the systems. Instead, phonological representations that are pre-existing fundamentally change when one learns to read an alphabetic script. Thus, these representations, in nature, are abstract and

> […] amalgamate both orthographic and phonological information. As a consequence, orthographic effects during spoken word processing are taken as arising within the phonological system and resulting from these abstract phonological representations influenced by orthography (Veivo & Järvikivi, 2013, p. 865).

However, Veivo and Järvikivi (2013) argue that a more plausible account is the *co-structuration account*, in which orthographic information contributes in parallel to the formation of lexical categories, along with phonological information. Therefore, the initial plane of representations would be phonetic in infancy, given the underlying psychological mechanism of statistical learning. With vocabulary growth, these representations are sharpened up into phonological representations, which are stable and encompass articulatory information as well. These representations then become co-structured with orthographic information because a functional link is established between orthographic and phonological representations with the attainment of literacy (Kolinsky, 2015).

Veivo and Järvikivi's (2013)claim can also be extended to the case of learning an L2. Their postulate allows one system to dominate over the other in specific cases, as with early learners in instructional settings, when orthography is believed to be more robust due to great amounts of written input, leading orthography to be regulatory over phonological encoding. Especially with an L2, the orthographic forms are learned either before or simultaneously to phonological forms, hence both of these systems are able to contribute to the formation of lexical entries, even if one is less autonomous than the other.

In the next section, the orthographic and phonological representations are discussed with an eye to the L2 learner and the constitution of the lexicon.

2.2 THE PHONOLOGICAL AND THE ORTHOGRAPHIC REPRESENTATION, AND THEIR INTERACTION IN THE LEXICON

The issue of lexical representations has heretofore become central to different disciplines. Cutler (2008) asserts that in recent years, traditionally separate domains of speech perception have begun to overlap: phoneticians have started to pay attention to word recognition and psycholinguistics have been more sensitive to the nature of speech. Processing of word forms by literate individuals involves prelexically-based representations of both phonological and orthographic systems (Cutler, 2008). In this section, phonological representations are firstly addressed, followed by the representation of orthographic knowledge, and finally the lexicon.

Bowers et al. (2016) argue that the existence of a common representation for somewhat acoustically-differing linguistic sounds exerts a role to the formation of the human lexicon:

> The lexicon is much more regular – and perhaps easier to learn – if lexical representations are formulated in terms of phonemes rather than context-specific or position-specific phones. This may also explain why we employ a common written letter ‘t’ for the spelling of *top* and *cat* rather than one letter for [t^h] and another for [t]” (Bowers et al., 2016, p. 72).

Two claims can be drawn from their position. It is not arbitrary that human cognition represents categories for when there is variation, in this case, phonetic variation. The second is that it is because of the categories we form that we are able to hold a lexicon. In the same vein, Kluender and Kiefte (2006) submit that phonemes provide efficient descriptors of lexical space, as emerging dimensions of the developing lexicon in which spectral (acoustic) contrast operates early, and categorical perception operating later (Kluender & Kiefte, 2006).

Relatedly, categorization of sounds occurs due to a mechanism known as categorical perception (CP). CP is explained as the phenomenon in which “we […] perceive our world in terms of the categories that we have formed. Our perceptions are warped such that differences between objects that belong in different categories are accentuated, and differences between objects that fall into the same category are deemphasized (Goldstone & Hendrickson, 2009, p. 65). To illustrate this, Goldstone and Hendrickson (2009) allegorically mention the rainbow. Even though it presents itself with a full range of visible wavelengths of light, we tend to see it as distinct colors, such as blue, violet, red etc.

Therefore, the sensitivity of our innate auditory processing mechanism in tandem with the psychological mechanism of statistical learning calibrate our perceptual skills with alignment to the representations of speech. Goldstone and Hendrickson (2009)also argue that categories are not simply based on the output of the perceptual systems. On the contrary, our perceptual system grows accustomed to the efficiency of these linguistic categories in the ambient language. The phenomenon of Categorical Perception thus demonstrates an adjustment of perception to enable the necessary categorizations.

When it comes to the representation of orthographic knowledge, Katz and Frost (2001) allege that

> the process of forming an orthographic representation is not completely based on perceiving, coding, and storing visual orthographic information alone. The claim is that the internal orthographic representation is not formed simply as a passive reflection of the visuo-spatial characteristics of the print but, rather, the reader's knowledge of the relations between orthography and phonology shapes the internal representation (Katz & Frost, 2001, p. 299).

Hence, it is noteworthy to say that orthographic forms will hold greater influence in the shaping of phonological forms when: 1) subjects become literate and therefore hold knowledge of graphophonic relations; 2) orthography is a robust stimulus in input available in instructional settings, with learners having their attention constantly driven to it, as is the case of acquiring an L2 (Veivo & Järvikivi, 2013; Yoncheva et al., 2013).

In this vein, Cutler (2015) argues that phonological representations in the lexicon are not compiled only from experience with speech perception. These representations are also distinguished by nonspeech, metalinguistic information such as visual-articulatory information (Bertelson, Vroomen, & de Gelder, 2003). The author has argued that "L2 learners exploit every type of help they can get with the language-learning task, and one result is that they set up phonological representations in the lexicon that include information that they have not extracted from the input" (Cutler, 2008, p. 1607).

Another source of metalinguistic information is the recruitment of orthography to aid the construction of separate entries in the lexicon. Cutler (2015) posits that auditory perception of spoken items is not the only source for the storage of lexical distinctions, as some contrasts that are indistinguishable in perception can be recognized with the assistance of orthographic information, prompting learners to attempt a distinction in production. Relatedly, Saletta et al. (2015) attested for Cutler's claim when submitting that orthography induces the process of lexicalization of word forms because participants produced pseudowords more accurately after reading them, but not after just hearing them. This would show that new words would be integrated into the lexicon after subjects' repeated exposure to their written forms.

However, when lexical representations are implemented without their bondage to speech perception, the use of orthography can also represent a hindrance. Cutler (2015) discusses that "incorporating a distinction at the lexical level without being able to perceive it in the lexicon works substantially against the learner's interest, in that it increases competition" (p. 120). For instance, when presented with novel auditory information that has not been previously mapped onto orthographic forms, the word <deaf> can compete with the prefix def- and with daff-, giving rise in activation to a number of words that begin with such structures.

In general lines, orthographic effects can both benefit and hinder the formation of the lexicon. In perception, if distinctions are implemented in the lexicon solely based on orthographic information without a functional link to perception, this might hinder processing by increasing competition in processes of word recognition. However, orthography may also be advantageous for it compels the learner to attempt a developmental distinction in production that later may also aid the perception of that specific distinction. In the next section, the notion of the lexicon is presented.

2.3 THE LEXICON

When discussing lexical processing, it is also relevant to make reference to the mental lexicon. Words in the lexicon are believed to be represented by a network of three different levels: a word-form level that includes a word phonology and morphology; a lemma level that contains the syntactic constrains of the representation; and, a conceptual level that contains conceptual features expressed in nodes (Levelt, Roelofs, & Meyer, 1999). In the model put forward by Levelt et al. (1999), related conceptual nodes[15] are connected to one another, but each conceptual node is connected to one lemma only. Lemmas are not interconnected. A lemma will pass activation on to phonological

[15] Different standpoints exist in psycholinguistic literature regarding the existence of semantic information and conceptual knowledge as different entities in the lexicon. In general, the guiding question is whether concepts can exist independently of word knowledge. Refer to Dóczi and Kormos (2015) for a debate and a review of how models that deal with the lexicon have delineated this issue.

forms, which connect to all segments of the form and to morpho-phonological rhymes[16].

Lexical representations can also be accessed independently as, for instance, a semantic node can be activated without having a subsequent phonological node activated as well. The tip of the tongue effect is considered evidence for such a claim. When one experiences a tip of the tongue effect, the semantic node (meaning) is accessed, but there is delay for accessing the phonological form of the word. The opposite also serves as evidence. When one errs a word form, for instance, saying "single" instead of "signal", this mis-selection occurs due to their similarity in sound, which causes activation to spread among competing nodes (Cutler, 2002). Errors can also occur on the base of affixes and inflections, which are represented as entries in the lexicon. In addition, it is relevant to note that slips of the tongue rarely occur on the base of syntactic relations, that is, getting the word place wrong in the sentence. As lemmas are not connected to each other, there is no competition among them. Thus, slips of the tongue almost always adhere to the 'syntactic category constraint', that is, nouns replace nouns, verbs replace verbs, and so on (Poulisse, 2000). According to Poulisse (2000), 97% of L2 lexical slips in her corpora accounted for such a constraint.

Hence, the mental lexicon encompasses hybrid, flexible units, i.e., both entire words, and discrete units, such as frequent constructions, and affixes and inflections. Cutler (2002) delineates the lexicon in the following manner:

> Entries in the mental lexicon may correspond to words such as *give* and so on, but they may also be other forms which speakers store as discrete units: fixed phrases such as *bon appetite*, manipulable idiomatic phrases such as *let the cat out of the bag*, productive derivational affixes such as *re-* or *un-* or *-ish*, inflections for pluralization, tense and so on, stems which occur in multiple words. That is, the forms in the mental lexicon are those which language users store as discrete entities, and they may or may not coincide with forms which are written as discrete words (Cutler, 2002, p. 858).

[16] Refer to Cutler (2002) for a fragment of a lexical network.

Next, as proficiency is of relevance in the present investigation for its influences on the way lexical knowledge is applied in word processing, the following section briefly discusses this factor.

2.4 THE PROFICIENCY OF THE LEARNER AND ITS IMPORTANCE TO LEXICAL KNOWLEDGE

Language processing appears to be highly influenced by the subject's proficiency. This factor is of particular importance for the present research for affecting how lexical knowledge is used in word processing (Samuel & Frost, 2015).Proficiency is put forward by Hulstijn (2015) as a term which "[…], like language cognition and language ability, refers to both knowledge of language and the ability to access, retrieve and use that knowledge in listening, speaking, reading or writing" (p. 21).

Veivo and Järvikivi (2013) posit that lower proficiency learners have stronger orthographic representations for the L2 words. This is likely to be due to over-reliance on orthographic forms that is reinforced by the robust exposure to print they experience in the early stages of L2 acquisition. This could also be extended to provide an understanding of L1 orthographic interference over L2 phonological processing. By processing L2 sounds with constant reference to orthographic information, these learners are not only likely to reinforce graphophonic relations prevenient from their L1, which will result in unstable L2 phoneme-to-grapheme bindings, but they also concede orthography as mandatorily recruited upon the phonological demands of the environment for being constantly referred to during the learning process. Thus, more interference from L1 orthography could be expected on the L2 phonology for less proficient learners.

Samuel and Frost (2015) provide a cogent understanding for what Veivo and Järvikivi (2013) point out. They explicate that lexical knowledge poses a downward influence on the ability to perform phonetic encoding, thus arguing for increased L2 proficiency to sustain fully functioning lexical representations that will support phonetic processing. Learners of increased L2 proficiency are believed to own a lexical "look-up" mechanism that is able to derive the correct pronunciation for a given item, without having to perform sub-lexical encoding, because such a mechanism gathers lexical knowledge of higher hierarchy, which is represented in greater-sized lexical units.

Thus, it can be argued that less proficient learners, for not being able to rely on higher-level support from lexical representations, might turn to orthography as a compensatory mechanism for assisting the processing of phonological forms, at least in initial stages of acquisition. On the other hand, more proficient learners are able to make use of fully functioning lexical knowledge of higher nature that supports their processing of word forms, therefore not presenting with any effects of orthographic recruitment.

2.5 SUMMARY OF THE CHAPTER

Overall, orthography is twofold in nature. It is a factor that requires abstraction in levels of human speech perception (Cutler, 2008). Research has failed to acknowledge that without abstraction, "communication would be a much slower and errorful affair" (Cutler, 2008, p. 1616). Not only abstract, orthography has also become empirical in the sense that it permeates the route of phonological development in a number of L1 and L2 learners. It can influence the L2 phonological acquisition due to considerable exposure to print and deficits in spoken input that learners are likely to undergo when learning in instructional settings. Orthography renders more competition in the processing of spoken forms when different phonetic categories are assimilated into one orthographic representation, thus resulting in delays in lexical access[17].

In this chapter, we observed that the issue of representations, which are abstract in nature, is object of joint attention by different disciplines. We also learned that representations emerge from acoustic variation encountered in ambient language that will be used for forming primitive phonetic representations, which later on, will stablish phonological categories during the second year of life, a process that is boosted by vocabulary learning. With literacy, it is thought that representations become co-structured with phonological and orthographic information that can both contribute in parallel to the formation of the lexicon. We also learned that percepts may not only be implemented from experience with speech perception, but also from metalinguistic sources, such as

[17] Lexical access is regarded here as "the retrieval of a lexical entry from the lexicon, containing stored information about a word's form and its meaning" (Field, 2004, p. 151).

orthography. To end, the importance of L2 proficiency for the interaction of phonological and orthographic information over word processing was presented.

Relevant studies that have been conducted on phonological processing that envisage cross-linguistic orthographic effects shall be reviewed in Chapter 3. It is apparent that most evidence has been gathered on perception, and less attention has been cast on production.

CHAPTER 3 - THE VISUAL NATURE OF SPEECH

A challenging undertaking psycholinguistic research has adopted is to find the signature that orthography assigns to phonology over the processing of speech. A surge of studies has demonstrated that with the attainment of literacy, aural speech is processed with reference to the written code. To put it bluntly, the incoming acoustic signal is also mapped into its corresponding orthographic codes, thus eliciting engagement from both phonological and orthographic systems. The retrieval of phonology in speech perception and production would thus result in the activation of visual forms, suggesting that speech is encapsulated with all linguistic subsystems in a unified manner. Even though the nature of speech is profoundly transformed after one's attainment of literacy, such an issue has been explored to a little extend in perception and production studies, as Rastle et al. (2011) deplore the fact that one's experience with orthography and its influence on spoken abilities has been overlooked, despite having major cross-linguistic influences on speech acquisition.

Empirically-based research has shown that learning hurdles arise from the fine-grained similarities and dissimilarities between different sound systems in contact that impinge on the perception of non-native sounds, leading to miscategorization and difficulties in production (Smiljanic, 2011). Notwithstanding, only recently psycholinguistics made a strong case for orthography to be modeled as part of the knowledge that underlies L2 speech processing (Escudero, 2011), but long ago as part of word recognition abilities (Frost, 1998; Kolinsky, Pattamadilok, & Morais, 2012).The underlying claim being that reading and speaking are connected by shared mechanisms of processing and learning (Saletta, 2015).

Besides, orthography plays a significant role in the constitution of phonological representations in the lexicon when subjects are schooled (Ventura et al., 2001), and inL2 instructional contexts when subjects are exposed to copious amounts of written input (Veivo & Järvikivi, 2013). Still, research has also revealed that new words are lexicalized, that is, they are integrated into the lexicon in functional manner, after exposure to their orthographic forms (Saletta, Goffman, & Brentari, 2015), attesting for the powerful influence of orthographic knowledge to the adult lexicon.

Indeed, orthographic influences in the L2have been observed to appear on speech production, as attested by a handful of studies(Erdener & Burnham, 2005; Han & Kim, 2017;Rastle, et al., 2011), and more evidently on speech perception (Cutler, 2015; Escudero et al., 2008; Escudero& Wanrooij, 2010). However, research has provided conflicting claims as to the influence exerted by orthography for positive, negative, mixed, and no influences at all have been observed. Positive effects tended to appear when the orthographic system tested had congruent graphophonic mappings (Erdener & Burnham, 2005; Escudero et al., 2014; Veivo &Järvikivi, 2013), thus presenting advantageous effects. Mixed effects were also encountered, as orthography acted as a redundant source that just reinforced an already available acoustic trait (Escudero, 2015). Yet, negative effects were attested for when orthography hindered subjects' performance due to incongruent mappings (Escudero et al., 2008; Escudero et al., 2014; Hayes-Harb et al., 2010). In addition, a few studies reported orthography as bearing no effects to perception or production (Simon et al., 2010; Pytlyk, 2011).

The reasoning behind the recruitment of orthography can be split into two positions, for which evidence is still mitigated. This system aids the establishment of phonological representations, thus acting as a metalinguistic knowledge source (Cutler, 2008; 2015; Escudero, 2015).When one becomes literate, both orthographic and phonological information are jointly associated and contribute to the constitution of lexical knowledge, "as two faces of the same coin" (Frost & Ziegler, 2007, p. 115). Thus, both orthography and phonology comprise lexical knowledge that is active and interact when linguistic units (phonemes, morphemes, words etc.) are recognized. Orthographic knowledge would also play a role in defining lexical space, as English words would be aligned in this space by their orthographic similarity, as evidenced by experiments with morphological priming[18] that is not semantically-dependent (ex., brother – broth) (Frost, 2009).

Other scholars disputably adhere to the position that the activation of orthography is a result of task requirements, which renders varying types of information that would be strategically employed just to perform the task at hand (Cutler et al., 2010; Taft, 2011), thus arguing against orthographic automaticity. For instance, orthography would aid the

[18] According to Trofimovich and McDonough (2011), "'priming' refers to the phenomenon in which prior exposure to specific language forms or meanings either facilitates or interferes with a speaker's subsequent language comprehension or production. Psycholinguists frequently use priming to examine how the input available to learners is related to their comprehension and production of the L2" (p.03).

recognition of phoneme exemplars for tokens that contrasted minimally in a timed incoming signal(Cutler & Davis, 2012), or assist the decoding of a degraded acoustic signal, for which the processing system becomes redundant and recruits orthographic information (Pattamadilok, Morais, Kolinsky, 2011). In this vein, orthographic engagement in spoken word recognition is conditioned to selective attention to phonology, when one's attention is driven to listening to stimuli for a certain immediate purpose (Yoncheva et al., 2013). In the case of an L2, learners employ orthographic knowledge to help categorize sounds in earlier stages of acquisition, which influences perceptual encoding of sounds and spoken words. This effect would be context-dependent, as learners have their attention explicitly directed to written and spoken forms particularly in instructed settings. Therefore, the same processing principle might apply to when these learners are compelled to learn new words in experimental conditions, as it will be discussed in Section 3.4.

Activation of orthography that is motivated by aural exposure to speech has arguably been supported by Perre and Ziegler (2008) under the neurolinguistic rubric. These authors provided what they consider to be "the strongest evidence available so far that orthographic information is computed on-line as we listen to spoken words" (p. 135). The experimenters developed a study based on event-related brain potentials (ERPs[19]) to observe on-line activation of orthography whereas stimuli containing spoken words were processed. Subjects who spoke French as their native language took an auditory lexical decision task in which they had to decide whether the stimulus presented was a word or not. The word set consisted of monosyllabic French words that were selected according to their sound-spelling consistency, containing both consistent and inconsistent items that presented either early (e.g., lymphe) or late (e.g., grippe) inconsistencies. The experiment revealed that words with early orthographic inconsistencies created a brain signal that peaked negatively at 320ms after stimulus-onset. Thus, the authors tentatively explain that the N320 is a component linked to sublexical activation of phonology to print, suggesting that this would confirm sublexical mapping between orthography and phonology, even when subjects encountered only with spoken words.

[19] Mannel and Friederici (2008) argue that "the ERP method features excellent temporal resolution, as it delivers information in millisecond accuracy about the time course of brain responses. In this way ERPs provide a mental chronometry, i.e., an exact temporal sequencing of information processing" (p. 32).

Thus, our general approach departs from a scenario in which: (a) research has overlooked the role of orthography in processing and learning of speech in an L2;(b) studies have not been able to determine the type of influence that orthography poses to speech processing and the conditions under which such influences arise; and (c) it is still controversial whether the retrieval of phonology results in the evocation of orthographic knowledge when no exposure to print takes place, or if orthography is just evoked upon specific task demands. This last argument has the potential to reveal important underlying mechanisms applied in speech perception and production. By the end of this review, the reader is expected to have a clear understanding of how orthography can affect the generation of phonology and under what circumstances such influences are more likely to occur.

3.1 THE NATURE OF ORTHOGRAPHY

Within this paradigm, a paramount issue revolves around the consistency of how a phoneme maps onto a grapheme. This is of relevance for languages of alphabetic (English, Portuguese) and consonantal (Hebrew, Arabic) scripts. Languages such as these are concerned with the phoneme as the representational unit (Cook & Bassetti, 2005). The orthography of these languages can be classified either as transparent, when connections are isomorphic, i.e., a graphemic node is connected to only one phonological node, or as opaque, when a graphemic node is connected to several phonological alternatives (Frost & Katz, 1989; Katz & Frost, 1992, 2001). Other terms have been employed in the literature, such as ‘deep’ and ‘shallow’, but here I have opted for ‘transparent’ and ‘opaque’ to guarantee consistency.

The orthographic system of English is thus characterized for reflecting the consistency of meaning-based morphological relations, rather than its phonology (Katz & Frost, 2001). Katz and Frost (2001) observe that “the pronunciation of a root morpheme or inflection often changes as a function of the syntactic or phonotactic context (p. 297)”, as can be seen in the examples of “h**ea**l” and “h**ea**lth”, or “magi**c**” and “magi**c**ian”. In a nutshell, derivations and inflections, addition of affixes and suffixes will normally result in pronunciation changes.

Additionaly, Cook and Bassetti (2005) have argued that English correspondence rules also depend on a certain knowledge of grammar, such as the distinction of content and function words (e.g., <th>[20] as /ð/ in function words as <this>, and as /θ/ in content words such as <thesis>), and the spelling <ed> that is used for the different spoken forms /Id/ 'started', /t/ 'liked', and /d/ 'stayed' for the past tense <ed> morpheme.

Frost (2012) asserts that English orthography is the most inconsistent writing system of the Indo-European linguistic family, mostly due to regularity and consistency, the two factors from which English degree of opacity stems.

When explaining regularity, Cortese and Simpson (2000) argue that

> a word is considered to be irregular if it violates grapheme-to-phoneme correspondence rules, which typically correspond to the most frequent pronunciations of graphemes. For example, the rule for *i* is /i/, because this is the dominant pronunciation for *i*. Thus, according to this definition of regularity, *pint* is irregular because the *i* rule is violated (Cortese & Simpson, 2000, p. 1269).

These authors also elucidate that consistency is a measure that encompasses the distribution of pronunciations associated with a particular word body. They explicate that words high on this measure have many more friends (items with the same body and a common pronunciation) than enemies (words that contain the same body but with a different pronunciation). They exemplify that "*storm* has *worm* as an enemy, but many more friends (*form,norm*, *dorm*, etc.). A word lower on this consistency dimension would be one with more enemies than friends, such as *pint*, which has the enemies *mint*, *hint*, *lint*, *tint*, and no friends" (Cortese & Simpson, 2000, p. 1269).

From a historical perspective, Frost (2012) argues that a lesson to be learned from English opacity is that writing systems evolve to provide readers with the meaning of the printed forms by denoting their morphological origin, rather than simplifying phonological decoding (p. 07). Interestingly, this would also reflect an optimization of information, given that the most semantic cues are provided by a script with relatively

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[20] Written forms will appear between angled brackets, whereas phonetic forms will appear between slashes. Phonetic font used in this dissertation: SILSophiaIPA.

impoverished phonological notations, using minimal orthographic symbols (Frost, 2012).

In the case of Brazilian Portuguese (BP), its orthographic system is relatively consistent, having predictable graphophonic mappings and stable contextual rules that establish grapheme–phoneme conversions (Defior, Martos, & Cary; 2002). As no writing system is entirely transparent or opaque (Cook & Bassetti, 2005), BP presents graphemes which are assigned different phonological alternatives as context-dependent cases, such as <s> as /s/ in ‘sapo’ (frog) and as /z/ in ‘casa’ (house).

Portuguese not only differs from English in orthographic depth, but also in syllabic complexity. This dimension can be drawn as a distinction between Romance languages(e.g. Italian, Spanish, Portuguese),which have a predominance of open CV syllables with few initial or final consonant clusters (*br-, pr-*, in BP), and Germanic languages(e.g. Danish, English, German), which have numerous closed CVC syllables and complex consonant clusters in both onset and coda position (*str*-, in English;*-mpfst*in German) (Seymour, Aro, Erskine; 2003).

In the next section, the influence of orthography on processing of speech is discussed, followed by the presentation of the Orthographic Depth Hypothesis and its tenets.

3.2 ORTHOGRAPHIC INFLUENCES AND A HYPOTHESIS

The issue of graphophonic relationships has long been looked at because the specificities of the orthographic systems will bear great impact on the acquisition of literacy and reading development (Seymour, Aro, Erskine; 2003; Schmalz et al., 2016), granted the impact onto the processing of auditory and visual word forms. Ziegler and Ferrand (1998) discovered that inconsistent rhymes (rhymes with multiple graphophonic mappings) produced slower responses in auditory word recognition, suggesting the existence of “a coupling between orthography and phonology that is functional in both visual and auditory word perception” (p. 686). Ziegler et al. (2004) not only attested for the same effect, but also discovered that it was more robust with inconsistent words that carried less frequent spellings, thus replicating their findings.

Research in reading has revealed that inconsistent graphophonic mappings can yield difficulties in reading acquisition, as phonological awareness, the best predictor of reading development in opaque languages

(Ziegler et al., 2010)[21], is highly influenced by such a trait. A large scope of research has submitted that skilled reading in alphabetic orthographies can be achieved through instructional methods that involve the teaching of graphophonic mappings (Ziegler & Goswami, 2006). To take a case in point, Scliar-Cabral (2015) advocated that such aphonic method, which apply graphophonic mappings as the underlying object to teach infants to read, has proved more fruitful in Brazilian Portuguese.

Moreover, Ziegler and Muneux (2007) unveiled that the orthographic effect in auditory lexical decision is highly related to experience with reading. Other studies have suggested that this relation might exist because graphophonic relations are reinforced through print experience (Hamada & Koda, 2008; Muljani, Koda, Moates, 1998; Katz & Frost, 2001). Dich (2011) argued that with the increase of print experience, the quality of orthographic representations changes as these become stronger, that is, the stronger the orthographic knowledge, the more it interferes with spoken language processing. To illustrate a case as such, Saletta (2015) argues that the Stroop Color and Word Test[22] evidences how unable the reader is to resolve conflicting responses because of failure in deactivating a word's orthographic form, as they persist in reading aloud the written code instead of naming the color in which the letter string is presented.

Ziegler, Perry, and Zorzi (2014) offer some insight on why experience with print is important for learning to read. They explain that with every successful decoding, connections between the letter string and whole word phonology are reinforced, thus becoming more automated, which results in the improvement of decoding mechanisms. Cross-linguistic studies have also claimed that acquired decoding skills,

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[21] Ziegler et al. (2010) discuss that children who have higher phonological awareness will have better levels of reading performance. This is especially true in languages with an opaque orthography, in which the process of mapping letters onto sounds is more difficult. This is explained by the fact that "one-to-one mapping between letters and sounds promotes access to phonemes, thus boosting basic phonological awareness skills and helping to trigger the development of phoneme-sized representations" (p. 556). In contrast, the authors claim that rapid automatized naming (RAN) is a better predictor of reading development in transparent languages.

[22] "This measure of cognitive control assesses the ease with which a person can maintain a goal in mind and suppress a habitual response in favor of a less familiar one (Strauss, Sherman, Spreen, 2006, p. 477).

specially grapho–phonic correspondences, transfer easily between the L1 and the L2 (Bialystok, Luk, & Kwan 2005; Koda, 1994).

To understand the impact that learning a graphophonic mapping mechanism has on cognitive processing, Reis and Castro-Caldas (1997) offer a detailed account in cogent arguments:

> Learning to match graphemes and phonemes is learning an operation in which units of auditory verbal information heard in temporal sequence are matched to units of visual verbal information, which is spatially arranged. This type of treatment of auditory verbal information modulates a strategy in which a visual-graphic meaning is given to units that are smaller than words, and thus independent of their semantic representation. […] If we, as normal adult readers, are asked to spell a word, we evoke a visual image of its written form. The awareness of phonology also allows us to play with written symbols (which can be transcoded to sounds) to form pseudo-plausible words, independently of semantics. Therefore, learning to read and write [an alphabetic script] introduces into the system qualitatively new strategies for dealing with oral language; that is, conscious phonological processing, visual formal lexical representation, and all the associations that these strategies allow (Reis &Castro-Caldas, 1997, 445).

A tenet in this avenue of inquiry is the Orthographic Depth Hypothesis (ODH). The ODH predicts that there are differences in processing between languages that are opaque and languages that are transparent (Frost, 1992, 1998), while addressing some of the main dimensions involved in the processing of visual words, such as the speed of assembling phonology, and the size of the representational orthographic units (Frost, 2005).

A perennial debate that permeates the ODH is whether phonology would be a mandatory cognitive component in word recognition, being generated pre or postlexically as a function of orthographic depth (Frost, 1998). According to this hypothesis, phonology would be assembled prelexically in transparent orthographies given that readers of such a script have consistent and complete connections between graphemes and phonological codes. Lexical access would therefore be posterior to phonological assembly. In this case, phonology would also contribute to the recognition of visual words (Morais & Kolinsky, 2015) because of its direct connections. On the other hand, phonology would be retrieved as an output that follows the activation of the visual lexicon in an opaque orthography. In this case, phonology would be addressed, that is, retrieved from the lexicon. Access to a certain item would be orthographically-based and shaped by lexical knowledge (ex.: body rhymes) that cannot be retrieved prelexically due to the impoverished phonological representations that are provided by an opaque script (Frost, 2005).

Frost (2005) claims that the weaker version of the ODH has gained more support. This version claims that lexical shaping is always necessary because orthography does not convey syllable stress, which is not always predictable. Therefore, pronouncing words will involve both prelexically assembled phonology and lexical knowledge, suggesting that information flows in interactive pathways. Frost and Ziegler (2007) argue for the existence of a bidirectional flow of activation that is able to feed-forward and feedback directions, thus being a critical feature that guarantees stable and fast learning.

In a recent review of behavioral and neurological evidence, Carreiras, Armstrong, Perea, and Frost (2014) argued that higher-order linguistic representations, such as phonology and semantics, exert a top-down influence on early orthographic processing in visual word recognition. This would enable "partially resolved phonological and lexical-semantic representations to feed back and provide constraints on other (lower) levels of representation […] such as orthography" (Carreiras et al., 2014, p. 02). Likewise, lexical knowledge is also believed to support phonetic processing in downward manner, attesting for higher-order influence on more basic perceptual and recognition processes (Samuel & Frost, 2015). According to Carreiras et al. (2014), the influence of higher-level lexical information on pre-lexical processing is evidenced by effects of lexical frequency.

As concerns the strong version of the ODH, which has been refuted in the field for allowing bottom-up shaping only, the hypothesis posits that in transparent orthographies "the phonological representation is derived exclusively through the translation of letters or letter clusters into phonological units" (Katz & Frost, 1992, p. 282), therefore not involving any kind of lexical information.

Another dimension that underlies the ODH is related to the size of the orthographic representational units, which would differ as a matter of orthographic depth. Ziegler et al. (2001) showed that cognates (ex., length - leicht; sand– Sand; some of them were homographs, some were not) were read differently in languages with different orthographic depths. German and Australian participants took part in a reading-aloud procedure from which response latencies were captured. The experimenters controlled for the length of the words (3 to 6 letters), orthographic rhyme (body-N) and lexicality (words X non-words). They found that effect of length was stronger in German than in English, which suggested a small-unit processing for speakers of a more transparent language. On the other hand, the body-N effect was only strong in English, attesting for large-unit processing for speakers of an opaque language. The authors posit that the coding schemes are flexible across languages, and that "orthography consistency appears to determine the very nature of the orthographic and phonological processes and not only the relative contribution of orthographic and phonological codes" (Ziegler et al., 2001, p. 383).

Grainger, et al. (2012) advocated more recently in their model of L1 reading that phonological recoding strategies based on fine-grained orthographic representations slowly decrease, shifting to a "more parallel mapping of letters onto higher level orthographic representation such as graphemes and affixes" (p. 03) that will give access to semantics faster. To investigate this, the authors examined whether 334 French children (attending grades 1 to 5) were more sensitive to classifying pseudo-homophones (e.g., brane) as real words, thus basing their responses on phonological representations activated sublexically through spelling to sound correspondences, or to transposed-letter pseudowords (e.g., talbe), thus basing their responses on orthographic representations activated via course-grained orthographic codes. They concluded that word reading by beginning readers is achieved via phonological recoding and, "as reading skills develop, this initial predominance of phonological recoding is gradually replaced by an increasing role for direct orthographic access" (p. 08). However, when encountering with a strong effect for word length, Grainger et al. (2012) concluded that phonological recoding continues to be used as a strategy to decode new words, conjointly influencing word recognition along with a more direct and more frequently accessed orthographic route. Overall, the study confirms the prediction that readers from an opaque language background (French) will decode words based on greater representational units.

As demonstrated above, phonological decoding is an important mechanism for learning to read. Ziegler, Perry, and Zorzi (2014) consider it a self-teaching device "because the explicit learning of a small set of spelling-sound correspondences allows the child to decode an increasingly large number of words, which bootstraps orthographic and phonological development" (p. 01). These authors take up a dual route perspective, according to which reading development will therefore occur through two main processes. A non-lexical process maps orthography to phonology in a two-layer associative network, which is responsible for learning linear relationships between graphemes and phonemes very quickly. Thus, in this route, orthographic information is first transformed into sublexical phonological units that will contact whole word phonology and, later on, the lexicon, in order to correctly arrive at the word's pronunciation. On the other hand, the lexical process connects orthography to phonology in a hard-wired interactive activation network, linking orthographic entries of words to their phonological counterparts. It is a more direct route in which sublexical orthographic information contacts whole-word orthographic representations, which will provide access to whole word phonology and semantics while bypassing the grapheme-phoneme rules (Grainger & Ziegler, 2011; Van Orden & Kloos, 2005; Ziegler et al., 2014). For being interactive and based on activation, this route also allows top-down influences from higher-order linguistic representations onto orthographic processing (Carreiras et al., 2014). The non-lexical pathway can read non-words because it can assemble phonology based on the linking between orthographic and phonological mappings. However, when spelling–sound relationships are either ambiguous or difficult to decode, it can produce incorrect phonology[23]. Oppositely, the lexical processes cannot read non-words as these do not have entries in the lexicon (Ziegler et al., 2014).

[23] Treiman and Kessler (2007) identify a few problems related to the dual-route perspective when dealing with the degree of predictability of some graphophonic combinations. To these authors, "the dual route downgrades patterns that are useful for relatively small subsets of words or that are less predictable" (p. 661), such as the translation of <oo> to /u/, when such a digraph can also correspond to /ʊ/ (e.g., book, cook), and <ea> to /ɛ/ and it can also be translated onto /i/ (e.g., bead, mead).

Schmalz et al. (2016) explain that words with irregular graph-phonic correspondences are likely to produce incorrect responses because of a conflict that takes place in the phonological buffer, when the output of the sublexical route is insufficient for arriving at the correct pronunciation of a given word and the lexical route is still an impoverished mechanism. Thus, such a conflict might seek resolution by postponing the initiation of the verbal response, until sufficient activation from the lexical route has accumulated to trump the incorrect phonetic activation from the sublexical route. On the other hand, when graphophonic correspondences are regular, or the reading skill of the learner is high given his increased overall proficiency, the pronunciation does not need to be delayed because of the efficiency of the lexical route that is able to trump the activation of the sublexical one, thus requiring stronger lexical involvement, based on greater representation units.

The overall purpose of the present study is to contribute to the understanding of the influence of orthographic knowledge on L2 phonological processing. Particularly, it seeks to attest for the plausibility of orthographic recruitment when subjects perform phonological processing with no exposure to print in a second language whose orthographic system transparency differs from that of their first language. The theoretical background reviewed above demonstrates that readers from more transparent orthographic backgrounds tend to decode visual words on the base of smaller, grain-sized representational units. Moreover, it has been argued that lexical knowledge will also influence the generation of phonology, a process of pre-lexical nature, due to unpredictable word stress and knowledge of the frequency of word forms (combinations of letter strings, and rhymes, for instance). Still, nor direct access from whole-word orthography to semantics in which phonological generation is postlexical, nor phonologically-mediated lexical access can claim “unequivocal empirical support” (p. 67), as research has provided evidence from homophone errors and priming studies for both stances (Van Orden & Kloos, 2005).

In this section, we learned how orthographic knowledge can actively interfere in phonological processing, as well as variations in the granularity component are observed according to orthographic consistency. It appears that phonology becomes a less autonomous system after one becomes literate, for being highly entrenched and even dependent onto orthographic relations because of a “functional link”

(Kolinsky, 2015). Moreover, orthography, a system that is functional in reading, also appears to be functional for speaking.

In the next section, the reader shall learn more about the abstract nature of the representation of orthography and how it should be treated as a variable in studies in L2 speech acquisition and processing.

3.3 CROSS-LINGUISTIC ORTHOGRAPHIC EFFECTS ON PHONOLOGICAL PROCESSING

The scope of research in this review sheds light on the signature of orthography on phonology in studies in which auditory processing is the underlying cognitive operation, observed via responses with speech perception or production, within a variety of experimental conditions, both on-line, as processing unfolds (e.g., auditory lexical decisions), and off-line, as the outcome of processing (e.g., word recall). I, therefore, have not selected studies that focused on measures of L2 phonological awareness, nor studies on production that showed orthographic influences by using reading as a means of data elicitation. I have also focused on studies with cross-linguistic influences, in which subjects were either bilinguals or considered learners of an additional language. I included two studies conducted with monolinguals given their relevance to the methodology of the current study (Rastle et al., 2011) and for using an artificial language that could resemble the learning of an additional language (Hayes-Harb et al., 2010) . Moreover, all studies were conducted with speakers of an alphabetic language background.

Erdener and Burnham (2005) tested for the influence of auditory-visual stimuli on speech production by examining the production of pseudowords in a transparent (Spanish) and in an opaque language (Irish) by Australian English and Turkish speakers. Native speakers of the tested languages recorded the stimuli and had their facial expressions video-recorded for the experiment. Participants were asked to repeat words as quickly as possible. They were tested within four conditions, including audio only, audio-visual (facial expressions), and audio plus orthography. In the conditions including orthography, they were also asked to write down the target item. The addition of visual information decreased the number of phoneme errors, irrespective of language background. However, this was only apparent in the absence of orthography. One of the reasons for such a finding is, as Erdener and Burnham (2005) claim, the fact that the gesture is redundant enough to facilitate speech production, as they consider auditory-visual speech perception an ecologically valid process. On the other hand, the symbolic representations that connect speech to orthography are powerful enough that they affect basic auditory processes.

Erdener and Burnham (2005) also found that Turkish participants made fewer errors when the orthographic information presented to them was transparent. Yet, when such information was opaque, they were outperformed by their Australian English counterparts. This was also corroborated by their findings with the writing task in which Turkish participants made fewer spelling errors for when they were presented with Spanish words than for when they were shown Irish words. This suggests that they tend to process this type of input on the basis of grapheme-to-phoneme conversions. In contrast, the Australian participants, speakers of English, performed better with the Irish words, as both of these languages share opaque orthographies. Overall, these results show that participants from a transparent language background are likely to be misled when the orthographic information displayed does not match phonology straightforwardly. The authors conclude by saying that "when the target language has an opaque orthography, it seems better not to provide the learners with orthographic input, at least in the initial stages of exposure […], and especially if they themselves have experience only with a transparent orthography" (p. 219-20).Overall, their results corroborate the underpinnings presented by the Orthographic Depth Hypothesis, when they confirm that speakers do not process different orthographies in the same fashion, specially when it comes do the granularity issue, which results in evident cross-linguistic influence.

Escudero, Hayes-Harb, and Mitterer (2008) investigated the effects that the phonemic mapping of /æ/ and /ɛ/ posed to the learning of auditorily confusable novel words (e.g., t**a**ndek, t**e**nzer). Fifty participants who spoke L1 Dutch were paid to participate. Their self-reported English comprehension was controlled for, thus indicating that they were considered to be highly proficient in English (*M:* 5.46, on a scale up to 7). Ten words were created for the experiment, 5 for each target phoneme. They all adhered to English phonotatics and each of them was paired with a control word that was identical to the target, except for the vowel in the first syllable, which was /u/ (e.g., tenzer – tunzer). According to the authors, this was done in order to make subjects pay attention to the stimuli and also to have balanced vowel contrasts that later on could be compared based on their level of difficulty - /ɛ/ and /u/ are relatively easy, and the target contrast, /æ/ and /ɛ/, is not only difficult given the acoustic characteristics of the phones, but also do not exist in Dutch, as /æ/ is not found among Dutch vowels. Two learning conditions were created: Auditory + Spelled forms and Auditory Forms only. Subjects would participate in 10 learning blocks in which they would be required to click on the object that they though represented the new word and then on a geometric form, thus they would learn to associate each word with a visual object. The words were embedded in a carrier sentence ("Click on the ____ and then on the triangle"). Feedback was promptly provided during learning sections. This learning phase lasted for 30 minutes approximately.

Next, participants were tested with an eye tracker[24].Their task was to identify the picture that represented the target word they had heard. Among the visual items displayed, the picture that represented the target's competitor was also included. Escudero et al. (2008) discovered that participants tented to improve block by block, and there was a significant effect of block number, showing that the order that the stimulus was presented made a difference for learning. Still, there was an assymetric pattern for the recognition of words that were learned through the presentation of both aural and orthographic inputs. Words containing /æ/ would trigger participants to look at words that contained both /æ/ and /ɛ/, whereas /ɛ/ would only trigger participants to look at words with /ɛ/. For the Auditory Only condition, participants would fixate equally on words containing /æ/ or /ɛ/. Therefore, the investigators concluded that lexical knowledge of spelled forms can trigger assymetric lexical activation, that is, a lexical contrast is established on the basis of metalinguistic knowledge, but participants were not able to successfully map this contrast to the phonetic forms in the time given. Even though each target phoneme investigated was consistently mapped onto a graphemic representation (/æ / - <a>, /ɛ/ - <e>), participants succeeded only in learning the new words in 30 minutes, but were not able to tell a distinction between the

[24] Tatler et al. (2014) indicate that eye tracking offers crucial insights to understand human behavior because "the locations selected for fixation provide us with insights into the changing moment-to-moment information requirements for the behaviours we engage in," and because "eye movements provide an ideal and powerful objective measure of ongoing cognitive processes and information requirements" (p. 03).

contrasts when it came to sublexical processing. This indicates that the participants might need more time than the amount provided in order to consolidate new lexical entries. Overall, Cutler's (2008, 2015) reasoning that orthography can hinder lexical access to some extent is corroborated by Escudero et al. (2008).

Escudero and Wanrooij (2010) investigated whether orthography influenced the perception of Dutch vowels (without lexical context) by Spanish learners of the language. Spanish is a transparent language, in which readers tend to visually decode new words by the conversion of letters onto phonemes on a one-by-one basis, whereas Dutch is an opaque language, in which the mental lexicon can also be accessed using the word's complete orthographic structure (Frost, 1992) for posterior lexical influence. Moreover, Spanish has five vowel monophthongs, while Dutch has 15 vowels, 9 monophthongs, and 3 to 6 diphthongs that are dialect-dependent. The authors predict that Spanish learners would treat Dutch as a transparent orthography, thus transferring the decoding skills employed in their L1. They would, therefore, link graphemes such as <ie> to the diphthong /je/ instead of the vowel /i/, for instance. All the 204 volunteers to the study were residents to Netherlands at the time of testing and had arrived in the country after the age of 15. Their general comprehension proficiency in Dutch was determined through a listening task in a standard language assessment. The stimuli used in the task consisted of 20 natural speech tokens for each of the vowels /ɑ/, /a/, /ʏ/, /y/, /ɪ/ and /i/, which were produced by male and female Northern Dutch speakers.

Participants took part in two tasks: Audio only, and Audio plus orthography. In the Audio task, listeners were required to decide whether the first sound was more similar to the second or more similar to the third. Escudero and Wanrooij (2010) explain that "the task was presented as a computer game in which the first sound was always produced by a cartoon of a teacher while the two response options, A and B, were produced by two different students. The listener's task was to click on the square above the student who had best imitated the teacher" (p. 351). Results yielded that learners tended to associate Dutch /ɪ/ to the front unrounded Spanish vowel that was represented by <i>, while Dutch /y/ was linked to rounded Spanish vowel represented by <u>, /ɪ – y/ being the auditorily less confused pair, whereas /a–ɑ/ had a significantly lower correct responses than the other contrasts. In the orthography condition, subjects were asked to choose from the orthographic representations of the 12 Dutch monophthong vowels (<aa>, <a>, <ie>,<i>, <uu> and <u>), visually presented on a computer screen. Contrarily, the /a–ɑ/ contrast was the easiest, as the doubling of the letters <aa> versus <a> led listeners to pay attention to the durational cue. Thus, the orthographic cues enhanced the temporal cues and helped learners identify this vowel. On the other hand, /y/ was the most difficult vowel for learners in this task, being identified as <u> instead of <uu>.

Overall, the study showed that the presence of orthographic information reversed findings between the two conditions, being of facilitative nature for some percepts and representing a hindrance for others. Such an orthographic influence appears to the phonetically sensitive to some cases that will favor the use of L1 knowledge (such as the orthographic doublings).

Han and Kim (2017) investigated the effect of orthography on the production of Korean allophones by Mandarin learners of the language. Sixty participants, who were paid to participate, were trained with 20 nonwords that contained /h/ in the syllabic onset of the second syllable where it can be produced similarly to [ÿ] (a voiced fricative), [w] (a labial-velar approximant), or deleted. Training consisted of sound-picture associations split into nine sessions in four days. In each session, each target word was heard 10 times in randomized order, eight of which were realized with a deleted /h/, and the other two being the variants [ÿ] and [w]. After the end of training, the orthographic representations of the nonwords were introduced in a single session in which participants would be exposed to the spellings along with the corresponding pictures. Participants were grouped into three different groups that were exposed to specific spellings. The 'ø-letter' group was exposed to the deletion case in which the spelling <ㅇ> corresponded to the null consonant; the 'h-letter' group were exposed to the spelling corresponding to the segment [ÿ], <ㅎ>, and the other group was the 'no-letter' group, which received auditory input only. Stimulus presentation in this session was not timed, thus participants could spend as much time as they needed looking at the spellings. Testing took place with a picture naming task and a spelling recall task in which participants were required to write the spelling of each nonword.

For the analyses, participants were group differently according to two proficiency levels (beginner and advanced), which was measured through their experience studying Korean (length of learning). Results from picture naming demonstrated that participants tended to produce tokens influenced by the spelling they had been exposed to. The deletion group produced the novel words with allophonic variation only 10% of times, regardless of proficiency level. On the other hand, in the ‘no-letter’ group, participants with lower proficiency produced the nonwords with allophones only 5% of times, whereas participants of higher proficiency were able to reproduce allophonic variation in their speech 19% of times. However, the group which received exposure to the symbols that represented the allophones produced the novel words with the greatest allophonic variation, 20% of time - 23.5% for the beginners and 22% for advanced learners. Therefore, the spellings reinforced the allophonic variation that was presented auditorily during the training phase, thus influencing such a group of participants to produce it more often. This also shows that orthography can reinforce recently acquired phonological representations, as in the case of the allophones in the present study.

Hayes-Harb, Nicol, and Barker (2010) investigated whether orthographic forms affected the learning of new words by native adult speakers of English. The study had three groups who were presented to the auditory forms of these new words followed by pictures that represented their invented meanings. One group was exposed to orthographic forms which were consistent to English, such as <kamad> for the aural form [kAm´d]; another group was exposed to inconsistent written forms, e.g., <kamand> for the aural form [kAm´d]. The third group was not presented with written forms. Participants were informed that they would learn words in a new language. Therefore, Hayes-Harb et al. (2010) suggested that the study, given the way it was designed, would render second-language generalizable results. Their inconsistent stimuli encompassed items that contained an extra letter, for instance, <lp> mapped onto /l/ and <nr> mapped onto /n/; and what the authors called “wrong letter” in which the graphophonic mappings were highly inconsistent, e.g., <z> mapped to /ʃ/ and <b> mapped to /v/. These participants were tested by an auditory word-picture matching test.

Hayes-Harb et al. (2010) found no significant interactions between group and consistent orthography, nor between group and extra-letter inconsistent orthography. The researchers argue that results in the extra-letter condition may be due to how familiar English speakers are with silent letters, which are quite common in their language (ex., know, sword, comb). However, such reasoning cannot be extended to explaining the significant results found between group and wrong-letter inconsistent word forms, given the relative lower accuracy by participants in this condition. The authors claim that it is unclear why such an effect arose in their study. An interesting fact is that participants had one hour to learn the new forms of the words (in fact, they were assessed shortly after the learning phase before moving on to the testing phase). The tentative explanation I offer is that the wrong-letter words were more difficult to be learned in such short amount of time, therefore participants might have been confused by the stimuli and tended to rely more on orthography as an aid to help memorize the target words. Previous evidence has shown that unconsolidated phonological representations are more strongly assisted by the recruitment of orthography to shape lexical entries (Kolinsky et al., 2012; Veivo & Jarkiviki, 2013). As these words were inconsistent, participants might have nothad enough experience with them to be able to build successful mappings in the timeframe offered. Overall, the authors concluded that orthography did not help the participants to learn the new words. In fact, it hindered their performance with inconsistent items, even though their L1 background consisted of a language with highly inconsistent graphophonic mappings. However, I consider such statement subject to bias given their study validity.

Mitsugi (2016) investigated orthographic activation through eye-movement data by speakers of English who were learners of L2 Japanese with different proficiency levels. Participants would hear a spoken word and would be required to click on printed word that matched the spoken input. The author focused on the recognition of hiragana, a script in which a letter is used for each symbol in the language, thus being considered syllabic. Their stimuli consisted of 12 quadruplets of words. Each quadruplet consisted of a target word (e.g., *sakana* "fish") and a competitor that shared one mora (e.g., *sakura* "cherry blossom"), plus two distractors that were phonologically and orthographically unrelated (e.g., *tsumori* "intent", *mukashi* "past"). The author claims that more proficient learners demonstrated increasingly more attention to the target word already in the first window of analysis (from 200ms after the onset of the target word to 400ms), which suggested that orthographic information is activated rapidly during spoken word recognition. However, the author recognizes the shortcoming of the study for the task required direct orthographic activation in order for participants to identify the target word. Thus, the task is limited in recognizing the trigger of orthographic information.

Simon, Chambless, and Alves (2010) trained American participants to learn the French vowels /u/ and /y/, which have been shown to be a difficult contrast for such participants, in two conditions: auditory information only and auditory information linked to spelling. Participants were not exposed to any other languages at the time of testing. They were trained with words that contained the target vowels, forming minimal triplets (e.g., dûge, douge, dige).Training consisted of displaying a picture along with its orthographic form on a computer screen, followed by its corresponding audio form, or just the picture and the corresponding audio form. Participants were tested on their ability to match the picture to its audio form. Moreover, a perception task (AXB) was designed to test for the ability of generalizing the novel stimuli. In trials with triplets, participants had to identify if the second word they heard was either the same as the first word or as the third word. No significant results were found for the word learning experiment, which presented a great deal of variation. As concerns the perception task, no significant results were found between groups and participants tended to perform very well. Simon et al. (2010) argued that the lack of significant results in their tasks was due to the great stimuli load in declarative memory: subjects had to learn the meaning of 36 new words and of 12 distractor words in a 25-minute training section.

Simon et al. (2010) revised the experiment, presenting participants with a longer training phase and fewer items to learn. They also hypothesized that the AE listeners did not have single-category assimilation for French /y/ and /u/ and that orthographic information would assist learning only in cases of single-category assimilation. The objective of this experiment was to identify to which native categories participants mapped the French vowels. The stimuli was presented over headphones while five words were displayed on the screen (peek, pick, booth, book and poke), containing the English vowels /i:/, /ɪ/, /u:/, /ʊ/, and /oʊ/. Participants had to choose the vowel that most resembled the vowel aurally presented. Much variation was found in the categories which participants assigned French /y/ tokens to, and no single-category assimilation was found for both of the target categories, /u/ and /y/, to English /u/ (e.g. booth). Interestingly, the authors discovered that the consonantal context helped participants to distinguish between French /u/and /y/, especially in a bilabial context. This might have been the reason why they did not have to recruit orthography to better learn the vowels of the task, as they already could distinguish between the two.

The next step taken by Simon et al. (2010) was to adapt the first two experiments, having only one native speaker of French record the stimuli and all the vowels inserted in a constant alveolar context, for these factors might have influenced the previous results. Again, in the word learning task, no differences were found between groups, who once more performed considerably well. As for the perception task, by keeping the coda consonant constant, /u/ and /y/ were categorized in similar ways to English /u:/, attesting for the presence of single-category assimilation. As for the effects of orthography, the authors surmise that these listeners may not rely on spelling to create distinct phonological categories as would speakers of a more transparent orthographic system. Finally, they suggest that further research should carry out experiments with speakers of a language with a consistent orthography that contain the target French phonemes investigated.

Pytlyk (2011) inquired whether Canadian participants who learned Mandarin via a familiar orthographic script (Pinyin, the Romanized transcription) differed from participants who learned it via a non-familiar script (Zhuyin, the syllabary system), in terms of perception of English-Mandarin consonant-pairs. Some of the targets tested, followed by their phonic mappings in English and Mandarin, respectively, are: <c>→ [s], [ts^{h}]; <z>→ [z], [ts]; <r>→ [ɹ], [z̯], <h>→ [h], [x]. The author's careful design work included a pre-test, an instruction phase that lasted 4.5 hours distributed over three meetings, and a posttest. While receiving training, participants were not allowed to write alphabetic symbols to help them remember any Mandarin sounds. The researcher created the stimuli by using CV syllables, in which the target consonant appeared in onset position, followed by an [a] vowel. The stimuli were inspected for contour naturalness. Native judges assessed the created syllables by orthographically transcribing them and indicating the tokens that best represented the target sounds, which were later on included in the stimuli triad sets. The perception test was an AXB discrimination task in which participants had to choose the odd item out.

Statistical analyses in Pytlyk's (2011) study revealed that there were no significant differences in the responses among the experimental groups (familiar orthography, unfamiliar orthography, and control group with no orthography). The scholar tentatively offers the explanation that this may reflect an inability to disassociate the L2 forms from the L1 orthography, given the constant reference to the latter in language classrooms. Thus, no interference in perception occurred given how constant those targets mapped among the L1 forms. Anecdotal evidence from the study also suggested that the participants found it difficult to disassociate themselves from thinking in terms of letters, which was "virtually impossible" (p. 552). Pytlyk (2011) also regards that cognitive load, which was not controlled for, might have been a contributing factor that should warrant further research. In addition, the researcher wisely acknowledges that the 4.5 hours of training received by the participants were not "able to 'out-influence' a lifetime of associations made in the L1 orthographic code" (p. 554), which, as previous research has attested for, is reinforced through print experience (Hamada & Koda, 2008; Muljani, Koda, Moates, 1998; Katz & Frost, 2001). Overall, her study showed how difficult it might be to set up an experimental condition that resembles a more ecological learning experiment.

Cutler and Davis (2012) tested for the influence of orthography in a phoneme-processing task for which orthography was not considered necessary, thus not allowing for any type of orthographic strategic deployment. The authors selected real words that had <c>, <s>, and <ss> consistent rhyme sets for [s] (e.g., voice, house, press etc.), and developed non-words that were analog to the real words (e.g., bloice, frouse, pless etc.). Participants were instructed to rate the final segment that varied on a continuum from [s] to [z], by using a 7-point scale. The study consisted of three groups: in Experiment 1, 46 native English speakers who rated [s] on words that had <s>, <ss>or <c>; in Experiment 2, 24 Dutch listeners who rated [s] in the same words from Experiment 1; In Experiment 3, 14 native English speakers who rated the non-words. As concerns the results in Experiment 1, participants assigned higher ratings for [s] and [S] tokens that were spelled with <s>, thus showing that orthography influenced their ability in phoneme detection. In fact, <c> maps less frequently onto [s] and much more frequently onto [k]. No orthographic effect for <s> or <c> was found for Experiment 2, but the non-native listeners assigned higher ratings for [z] tokens as good exemplars of [s], possibly due to influence of their native-language experience, as Dutch has no [s]-[z] contrast. No significant effects were found for Experiment 3. To this result, the authors attribute articulatory differences between words and non-words, as this can affect the lexical status of the item and, consequently, the goodness of the rating. As a final word, Cutler and Davis (2012) argue that orthography did not yield performance improvements. They also say that it is difficult to say why some sounds are interpreted as more or less canonical exemplars of [s].

Veivo and Järvikivi (2013) investigated orthographic influences in French spoken word recognition by Finnish learners. To observe whether the activation of the orthographic form facilitated in the processing of the phonological form, these authors used masked-cross modal priming in a lexical decision task. Experiment 1 presented real word repetitions of the target in both auditory and orthographic forms ([staʒ] <stage>) and nonword pseudohomophones that could be pronounced like the target words ([staʒ] <staje>). In experiment 2, Finnish-based primes preceded French auditory words with (1) orthographic overlap (Finish <huivi> "scarf", French <huile> "oil"), which were semantically unrelated and presented no phonological overlap; (2) Finnish pseudohomophones that could be pronounced like the target words (phonological overlap), e.g., <yil> ([yil]) to prime <huile> ([ɥil]). Both experiments also presented a third condition that used words with no semantic, phonological, or orthographic overlap with the target. Participants were instructed to decide as quick and accurate as possible if the spoken word was a French word or not.

Veivo and Järvikivi (2013) also factored in learners' L2 proficiency as an intervening variable to which the use of orthography in spoken word processing would be conditioned. Therefore, the 75 participants of the study were assessed by a standard French proficiency test. They were residing in France at the time of testing. On top of that, the experimenters had participants rate the target words on the basis of subjective familiarity. This was an offline measure by which they assigned a rating from a 5-point scale to each word (e.g., "I have never seen this word before") and provided a Finnish translation to it.

In experiment 1, the visual primes facilitated the processing of the auditory targets, thus showing that the participants were able to map the orthographic forms into phonological forms. Repetition also reduced the number of errors. Such condition appeared to be stronger than the pseudohomophone effect. Familiarity was a good predictor of latencies and error data, whereas high proficiency participants showed stronger effects for repetition. With this experiment, Veivo and Järvikivi (2013) were able to establish cross-modal influence from orthography to phonology. Experiment 2 showed a facilitative effect due to orthography, but this effect was proficiency-dependent. More proficient learners did not profit from the availability of orthography, as the facilitative effect on the latencies decreased for familiar words. As concerns the lower proficiency group, stronger facilitative effects were induced by activating the phonology via L1 grapheme-to-phoneme mappings. Overall, the authors were able to conclude that orthography offers sublexical facilitation for L2 processing when the lexical representations are not yet fully stable, confirming the suitability of the *co-structuration account* that allows for both orthographic and phonological influences in lexical representation (even if one of overrides the other) (Veivo & Järvikivi, 2013).

Considering the premise that orthography is activated during non-native speech perception, Escudero, Simon, and Mulak (2014) set out to investigate whether orthographic congruence would influence participants' accuracy on a word recognition task, whose words contained either perceptually easy or difficult minimal and non-minimal pairs[25]. Escudero et al. (2014) had 73 Spanish listeners learn novel Dutch words. Forty-three of these listeners had varying levels of Dutch proficiency and 30 were unfamiliar to Dutch. The words (ex., "paag", "pag", "pieg" etc) adhered to Dutch phonotatics and were recorded by a native speaker of Dutch for the stimuli. During training, participants were exposed to either one of two conditions in order to examine the effects of exposure to orthography. They were taught word-object associations through the visual presentation of a picture and its corresponding aural form, or its corresponding aural form along with its orthographic form. During testing phase, participants were required to identify the picture from a pair of images that corresponded to the spoken pseudoword heard.

The experimenters predicted that the effect of orthographic congruence would be stronger for listeners exposed to the orthographic representation of non-words, regardless of their proficiency level, because orthography is always activated during word learning and therefore it can inhibit the learning process. Moreover, the authors claimed that a higher proficiency may deactivate the L1 orthography, leading to a decrease between congruent and incongruent orthographic mappings of both languages involved in the task (Spanish and Dutch). The results demonstrated an absence of effects concerning the Word-learning condition, as participants who were exposed to auditory forms only or both auditory and orthographic forms performed similarly without significant

[25] Perceptually difficult pairs: /ɪ–i/, /ɪ–ʏ/, /ɪ–y/, /i–ʏ/, /i–y/, /ɑ–a/, /ʏ–y/; Perceptually easy pairs:/ɪ–ɑ/, /ɪ–a/, /i–ɑ/, /i–a/, /ɑ–ʏ/, /ɑ–y/, /a–ʏ/, /a–y/ (Escudero et al., 2014).

differences. The exposure to orthography during training was not entirely beneficial or hindering. There was a benefit for congruent word pairs, but participants performed worse on incongruent word pairs. Therefore, the authors concluded that the influence of orthography on speech processing relies greatly on the congruence of grapheme to phoneme conversions, rather than simply the addition of a visual referent. As regards participants' proficiency, Escudero et al. (2014) showed that Spanish listeners who were naïve to Dutch did better in identifying members of non-minimal pairs compared to minimal pairs and were more accurate at perceptually easy contrasts. Dutch learners, on the other hand, were more accurate at distinguishing perceptually difficult minimal pairs and more accurate with non-minimal pairs. Overall, this shows that perception tends to improve as proficiency increases.

Another study to look at the orthographic signature on L2 phonology was Escudero (2015), which examined whether orthography affected the learning of novel spoken words. The participants were the 73 Spanish speakers who were reported in Escudero et al. (2014), plus 78 Australians who had never been exposed to Dutch. The experiments were also the same applied by Escudero et al. (2014). Escudero (2015) reports that orthographic effects were found for only 2 of the 7 perceptually difficult minimal pairs, namely /ɪ–y/ and /ɪ–ʏ/, whereas no effects were found for nonminimal pairs, with a large perceptual difference, or for perceptually easy minimal pairs. The psycholinguist also claims that orthography acted as an extra cue, enhancing the two contrasts that could already be perceived with more ease. With perceptually easy contrasts, involving low and high or semi high vowels, Spanish listeners unexpectedly outperformed the Australian listeners. This result was surprising given the small vowel inventory of Spanish, which could influence these listeners to assimilate non-native categories more frequently. Contrasts should be, therefore, more perceptually salient for English speakers, who have a larger vowel inventory. In fact, for having more categories available, Escudero (2015) ventures that this may have cause more competition, leading the Australian participants to be unable to discriminate among categories and assimilate them. The better performance lent to the Spanish speakers might have to do with the fact that they were already learners of the language, thus being able to more accurately distinct different non-native categories from the categories from the

L1. Overall, Escudero (2015) claims that "orthography may sharpen performance on contrasts that have been auditorily mastered" (p. 19).

The great variability - regarding whether orthography is actively recruited during speech processing and the nature of its influence (hindering or facilitative) - captured by the studies reviewed above can also be attributed to influence of orthography as a strategic source of knowledge that is specific to the tasks employed in the experiment. A study that discusses specific employment of knowledge as a response to task demands was conducted by Cutler, Treiman, and van Ooijen (2010). They explored whether phoneme detection is influenced by how target phonemes are orthographically portrayed. Forty-eight native speakers of British English had to detect the target sounds /b, m, t, f, s, k/ in word-initial position in sequences of isolated English words (e.g., 'bandit', 'motive', 'turban' etc.). The phonemes /f, k, s/ were considered inconsistent targets, given that they had more than one graphemic representation (e.g., <ph> as in 'phantom', <k> as in 'knock', <c> as in 'celery'). The researchers controlled for word frequency and word length (two or three syllables). Participants were instructed to press the response key as quickly as possible for when the target sound had been detected.

The results revealed that the detection of phonemes allowing inconsistent spellings was no harder than detection of phonemes that were consistently spelled. Thus, this would reflect the strategic responding that subjects are able to perform according to task requirements, which is in part responsible for variability in the results. As real words were used in the stimuli, participants might have relied on lexical processing, that is, in a top-down manner, therefore not triggering smaller-size orthographic units to aid phoneme detection. Such a result also evidences that the recruiting of a system is adaptive to task demand, thus strategically motivated, and can cause "different weighting of the information arriving from the various sources" (Cutler et al., 2010, p. 315).

In general lines, the influence that orthography might pose to speech is still undetermined. Some studies set up experimental conditions for training in which learners are compelled to rely on orthography as a metalinguistic aid, causing a great deal of variation, which most of times ends up in a biased view of orthography as a hindrance (Escudero et al., 2008; Hayes-Harb et al., 2010), or a redundant factor (Escudero, 2015; Escudero & Wanrooij, 2010). On the contrary, other studies that made use of less effortful designs attested for the influence of the congruency of the

L1 orthography in relation to the L2 phonology, thus corroborating the Orthographic Depth Hypothesis (Erdener & Burnham, 2005; Escudero et al., 2014; Han & Kim, 2017; Simon et al., 2010). In Table 1, I mapped these studies according to whether they examined perception or production, the general abilities in which orthographic effects were expected to surface.

Table 1 - Studies and the type of orthographic influences on perception and production

Type of influence	*Perception*[*]	*Production*
Negative effects	Escudero et al., (2008) Hayes-Harb et al. (2010)	
Positive effects	Cutler and Davis (2012) Han & Kim (2017) Veivo and Järvikivi (2013)	
Mixed effects	Escudero & Wanrooij (2010) Escudero et al., (2014)	Erdener & Burnham (2005)
Redundant effects	Escudero (2015)	
Null effects	Simon et al (2010); Pytlyk (2011);	

[*] Includes word learning, phonetic discrimination, and auditory lexical decision.

Rastle, McCormick, Bayliss, and Davis (2011) have developed a study of great methodological control that draws on developments in the area of word learning and can greatly inform the method of the current study. These scholars trained participants on sets of associations between novel spoken forms and novel pictures in a series of study and verification blocks on the first day. In study blocks, participants were shown a picture of a novel object while listening to its spoken form, and had to repeat the spoken form after each trial. In verification blocks, participants had to choose which picture, from a set of two or three, was associated with a spoken name. They received feedback regarding the correct picture-word pairing right after each trial. Overall, they had 2 hours of training, and were exposed to each target form a total of 12 times. In order to participate on the second day, participants should reach 80% accuracy.

On the second day, participants were introduced to consistent and inconsistent orthographic forms (e.g., surp/shurp for /ʃɜp/; chont/kont for /kɑnt/). In study blocks, each spoken name and picture pairing was presented along with its spelling. Participants were asked to type the target word form after each presentation. In verification blocks, participants had to choose, from a set of two or three pictures, the one that was associated with a particular spelling. At the end of day 2, participants were given a surprise spelling test that assessed the learning of the written forms.

On day 3, participants were given five different speech-processing tasks. In the auditory lexical decision task, they had to decide whether the spoken stimuli presented over headphones was a word (including the recently learned forms) or non-word. In picture naming, participants were required to name the novel objects in the pictures learned as fast as possible. In shadowing, participants had to repeat the new words and unfamiliar non-words as rapidly as possible. In picture spelling, participants had to write the names of the novel objects in the pictures learned during training. In forced-choice spelling, participants were asked to decide as quickly as possible which of two spellings they had learned in orthographic training.

Rastle et al. (2011) report that, concerning speech perception, significant orthographic effects were found in auditory lexical decision (longer latencies for incongruent items), but not for shadowing. These scholars discuss that the relative time course of phonological activation, which has a head start over orthography in shadowing, can drive the process of speech production, not allowing for much opportunity for orthography to exert any feedback onto phonology. As concerns speech production, significant results were observed both on the second day, when orthographic forms were introduced, and on the third, when participants were assessed again, attesting for the permanent effect of orthography. Rastle et al. (2011) also assert that participants had indeed enough time and the appropriate conditions to learn the novel inconsistent sound-spelling mappings, as they firstly learned the phonological forms of the new words, and were assessed both on the day of training and on the day that followed training in a number of different tasks that underlined speech perception and production. Thus, it is likely that orthographic effects arose because orthographic representations are activated automatically during speech processing.

For employing an exposure-based training paradigm, which consists of study and verification blocks as fabricated exposure to the target items, such a learning paradigm seems to allow subjects to have a relevant amount of experience with the trained lexicon in order to trigger the brain to start extracting regularities from the stimuli that will later on aid lexical consolidation. McMurray and McVeigh (2014) posit that

> "it is not until the brain has experience of a significant number of visual patterns and sequences consistent in sound and spelling that it can begin to make sense of the common elements in the specific formula (pattern) that make up, for example, rhyme patterns and sequences in general" (McMurray & McVeigh, 2014, p. 6).

Relatedly, repeated exposure to a lexical item is believed to make it easier to acquire a distinction within the stimuli than basing exposure on purely acoustic cues, such as duration (Goudbeek, Cutler, & Smits; 2008). Exposure-based training has been found to boost learning of both simple and complex grammar (Antoniou, Ettlinger & Wong, 2016), and has proven advantageous for lexical processing and word production (Van Assche, Duyck, Gollan, 2016). Yet, models of reading development have postulated that exposure to word spellings and their pronunciations implicate in the parsing of graphemes and phonemes from the input, resulting in the acquisition of their correspondences without explicit instruction (Pritchard, Coltheart, Marinus, & Castles, 2016).

Nevertheless, requiring subjects to orally repeat the pseudowords aloud after listening to them will exert a role onto the consolidation of these new phonological representations (Ellis & Beaton, 1993). Baddeley (2001) claims that one composing subsystem to working memory is the phonological loop. In this subsystem, two processes influence directly on the acquisition of vocabulary: the phonological store and the articulatory rehearsal system. When phonological representations are stored temporarily, they can be reinforced through repetition (sub-vocal rehearsal) which will lead to better vocabulary retention and avoid decay. Moreover, this rehearsal provides articulatory information in addition to phonological information, which is also believed to be encoded onto a representation (Bertelson, Vroomen, & de Gelder, 2003; Werker & Curtin, 2005). Yet, the importance of articulatory rehearsal in form of aloud repetition resides on the fact that if semantic associations between native and nonnative new words lack, as in the case of the present research, any form of articulatory suppression may bring about the disruption of vocabulary learning (Baddeley, 2001). It is also relevant to note that repeating the word aloud is different from what Baddeley calls "sub-vocal rehearsal", as this does not really require actual verbalization. However, aloud repetition also triggers vocal rehearsal, thus adding articulatory information to the encoding of a new representation and ensures to the experimenter that the participant is actually paying attention to the stimulus presentation.

The use of feedback in verification blocks is also of cognitive importance for learning a new lexicon. When presented immediately after subjects' responses, feedback has proven successful in exposure-based learning paradigms for leading to improved speed of learning and overall performance, once it directs the subject's attention to critical stimulus features that need to be differentiated (Antoniou & Wong, 2016; Antoniou et al., 2016; Goudbeeck et al, 2008), thus assisting a process of implicit (statistical) learning with an explicit feature for cases that are more difficult for the trainee.

The method of the present study is a conceptual replication of previous studies which employed training with an artificial lexicon (Escudero, et al., 2014; Han & Kim, 2017; Tamminen, Davis, Rastle, 2015; Taylor, Davis, & Rastle, 2017; Rastle et al., 2011), but specially of Rastle *et al*. (2011), given that the design of the training tasksis replicated here. Henceforth, the next session provides an understanding of the perks on employing such an approach in language acquisition research.

3.4. THE USE OF AN ARTIFICIAL LEXICON

The use of an artificial language for testing linguistic knowledge and modeling language acquisition has become a benchmark in experimental research (Taylor, Davis, & Rastle, 2017). Such an approach provides rigorous control over participants' prior knowledge to what is being taught, enabling the experimenter to dispense of restricted word lists and the use of real words, which would implicate in uncontrolled variables that take on participants' prior knowledge (Taylor, Davis, & Rastle, 2017; Taylor, Plunkett, & Nation, 2010). As the present enterprise applies an artificial lexicon to test for the plausibility of orthographic recruitment in phonological processing, such an approach was deemed suitable, given that subjects would have no prior experience with the stimuli they would be exposed to while taking the experiments.

Importantly, this approach also grants precise control over the input statistics to which subjects are exposed (Taylor, Plunkett, & Nation, 2010). In this vein, input statistics such as the frequency with which each graphophonic combination appears in the stimuli, the number of times each word occurs, the phonotatics that compose each item, and the confounding variables that take part in the processing of these word forms (neighborhood sizes, for example) can be carefully accounted for in the preparation of the stimulus.

Furthermore, the use of an artificial lexicon may provide an environment for learning which resembles that of natural language development, for the sub-lexical regularities tested are to be extracted purely through exposure to whole-word pronunciations without "[...] explicit feedback, teaching instruction, or engaging the subjects in explicit problem solving based on instruction" (Petersson, Folia, & Hagoort, p. 84, 2012). Taylor et al. (2010) yet elucidate that the use of an artificial language will bring about more confidence on the results obtained for the great meticulousness employed with such an approach. Next, as the present dissertation employs response latencies as its analytical data, the notion of on-line processing is delineated.

3.5 ANALYZING SPEED

Contemporary research methods employ a myriad of elicitation procedures to gather insight on the processes employed during early stages of language processing. Think-aloud protocols, eye-tracking, and reaction time (RT) are some of the methods used to address an on-line perspective that looks at the input and intake stages of language exposure, while processing is still unfolding (Jiang, 2012; Leow, Grey, Marijuan, Moorman; 2014; Sanz & Grey, 2015). The on-line perspective is used in different tasks (e.g., self-paced reading) and different procedures (e.g., eye-tracking), but they all gather "responses that are observed in close temporal proximity to the mental processes under examination" (Jiang, 2012, p. 5). Sekerina, Fernandez, and Clahsen (2008) explain that on-line techniques are quite powerful "[…] because they provide the means to study in great detail very early phases of processing, and because they rely little on conscious attention to or metalinguistic awareness of linguistic stimuli" (p. viii).

Figure 2 below shows the steps involved in language processing and acquisition. On-line perspectives remarkably represent a shift in focus from the output (Set III), when an outcome that has been traditionally operationalized in terms of accuracy is generated (Sanz & Grey, 2015), to input processing (Sets I & II), when processes of attention, awareness and, most importantly, implicit learning are understood to occur.

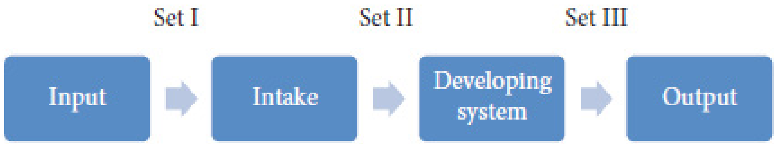

Figure 2. Input to output processes in language processing and acquisition
Source: Sanz and Grey (2015)

The use of RT has been extremely popular in cognitive psychology. Historically, Franciscus Donders was the trailblazer in studying "mental processing speed", as more than a century ago, in 1865, he pioneered with the research paradigm of reaction time measurement, still widely applied today in experimental studies (Levelt, 2013). Its popularity relies mainly on its adequacy for investigating different types of (low) information processing, memory, and implicit learning. Jiang (2012) submits that RT wide applicability is due to the vigorous variable control it provides when studying complex phenomena such as human language and behavior, so that a target variable under investigation can be isolated and linked to the observed RT data.

Notably, implicit learning is aligned with the processes that are employed in earlier stages of language learning, such as attention, noticing, and awareness (Leow, et al.; 2014), and therefore encompasses the processes under investigation in the present study. Previous research has demonstrated that adults develop sensitivity to the statistical regularities present in the input (Frost, Siegelman, Narkiss, & Afek; 2013; Siegelman & Frost, 2015; Van Assche et al., 2016). As exposure progresses, the tendency for latencies is to decrease, as evidence that learning is taking place. Therefore, RT data are extremely suitable for measuring epilinguistic knowledge, that is, unconscious phenomena which are not prone to recollection (Kivistö de Souza, 2015; Sekerina et al., 2008).

3.6 RESEARCH QUESTION AND HYPOTHESES

The present study is guided by the following research question and hypotheses:

> RQ1) *Does orthography influence phonological processing?*
>
> H1.1) If orthography is recruited during phonological processing, response latencies from the Auditory Lexical Decision task will be affected by the level of orthographic transparency of the pseudowords used.
> H1.2) If orthography is recruited during phonological processing, response latencies from the Timed Picture Naming task will be affected by the level of orthographic transparency of the pseudowords used.
> H1.3) If orthographic recruitment is mandatory for speech perception, orthographic effects are to continuously affect response latencies in Auditory Lexical Decision and in Timed Picture Naming.
> H1.4) If orthographic recruitment is strategic to perception or production, orthography will affect specific categories of pseudowords in speech perception.

As subjects are highly literate bilinguals, it is likely for them to recruit orthographic representations for performing lexical access. Research has argued for the co-structuration of lexical representations, in which both phonological and orthographic representations are activated altogether (Frost & Ziegler, 2007; Veivo &Järvikivi, 2013) and thus are not easily disassociated. In production, errors and delay in the initiation of the verbal response may occur in timed picture naming because of a conflict that takes place in the phonological buffer, when the output of the sublexical route is insufficient for arriving at the correct pronunciation of a given word, and the lexical route is still an impoverished mechanism that is not able to cascade higher-order lexical knowledge to help generate phonology. This conflict might seek resolution by postponing the initiation of the verbal response, until sufficient activation from the lexical route has accumulated to trump the incorrect phonetic activation from the sublexical route (Schmalz et al., 2016). In perception, the activation of orthographic codes might hinder the activation of the intended phonological codes of the percept, thus rendering delay in responses and errors in auditory lexical decision.

Moreover, research has also argued for the strategic nature of orthographic recruitment in phonological processing. According to this strand in literature, orthographic knowledge is evoked strategically due to task requirements in which the degree of involvement of the orthographic system is flexible to task demands (Cutler & Davis, 2012; Cutler, Treiman, & van Ooijen; 2010; Taft, 2011; Yoncheva et al., 2013).It is believed that in this case, the recruitment of orthographic information becomes strategic due to the availability of newly introduced graphophonic combinations, which are based on multiple conversion rules. Given the opacity of the stimuli, which contrasts to that of their L1, subjects may recruit orthographic codes as an aid to establish lexical representations of the new lexical items introduced in training until these representation become somewhat stable. As a result, more orthographic interference occurs because of a non-mandatory print-to-speech strategic processing mechanism in which orthography is rendered compensatory.

3.7 SUMMARY OF THE CHAPTER

In the present chapter, the role of orthography in phonological processing was observed, for which two positions are held: the on-line position holds that orthographic knowledge is strategically recruited for phonological processing as a compensatory mechanism to perform a given task. Thus, in the case of learning a second language, learners become strategic and recruit orthographic knowledge to help them recognize and establish lexical representations when phonological knowledge is still unstable. Contrary to this, the off-line position submits that orthography and phonology, as two faces of the same coin, comprise lexical knowledge that is active and interact in speech processing because literacy transforms phonological knowledge. Moreover, the involvement of visual representations in the processing of aural forms would argue for the encapsulation of sub-systems in language processing.

The Orthographic Depth Hypothesis, which establishes that there are differences in processing and representation of languages of differing orthographic depths, was discussed, followed by an overview of its strong version, which supports that lexical knowledge of higher nature exerts a downward influence on sublexical processing. Furthermore, the Chapter included a comprehensive review of studies that investigated orthographic effects over phonological processing in additional languages, whereas also dealing with two important constructs for the design of the current study, namely, the use of an artificial lexicon to test for orthographic influence and the caveats of analyzing response latencies. This account was, then, followed by the presentation of the research question and hypotheses that ground the current investigation.

In a nutshell, this piece of research seeks to attest for the plausibility of the argument that orthographic knowledge influences phonological processing, considering the different orthographic depths of the languages that the bilingual subjects speak. Researchers have generally adhered to two main positions. Orthography is believed to influence phonological acquisition and processing, considering that orthography and phonology are systems that interact, because both types of knowledge constitute lexical knowledge that is active and thus support processes of word recognition and production and, therefore, will remain active for perception and production. On the other hand, as a metalinguistic knowledge source, orthography may assist phonology when speech is being processed in initial stages of L2 acquisition, as learners categorize sounds in the L2 with reference to their written representation. Still, this last position would reflect strategically recruitment of orthography to perform certain tasks involving speech, for which the cognitive system is thought to become redundant. In the next chapter, all aspects involved in participant selection and recruitment, the creation of the auditory and visual stimuli, the preparation of the experiments, and the apparatus needed to data collection are presented in detail.

CHAPTER 4 - METHOD

The guiding objective of the present study[26] is to investigate whether phonological processing evokes orthographic knowledge, when no exposure to print takes place during testing, considering that the subjects' first language is a system that consists of a highly transparent script, whereas the L2 is a language of an opaque script. On condition that orthography is recruited for the processing of auditory stimuli, it is hypothesized that this system, along with phonology and semantics, are encapsulated subsystems that work in tandem to assist speech perception and production.

The present chapter firstly explains all the criteria involved in the creation of the stimuli, both auditory and visual. Next, it presents the study design and discusses the development of the experiments. This chapter also presents subjects' profiles and the factors considered for recruitment to, later on, present all the apparatus and the procedures involved in data collection. In the end, results from the pilot study are presented and discussed.

4.1 STIMULI: THE CRITERIA TO CREATE THE PSEUDOWORDS

This section explains in detail the factors that were taken into account for the creation of the words in this study, namely, the phonotatics, the target percepts and their spellings, and neighborhood density (phonological and orthographic). Each factor is detailed below.

4.1.1 Phonotactics and word length

Languages differ in both the number and the types of segments that can be grouped into syllables, and the types of segments that can occur in specific positions within the syllable. These sequencing restrictions are the phonotatics (Broselow & Kang, 2013). In the present study, all pseudowords created adhere to English phonotatics (Bauer, 2015) and have the same underlying syllabic structure, CVC.

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[26] The current project is certified in *Sistema nacional de informações sobre ética em pesquisa envolvendo seres humanos* (SISNEP) under the register 54197716.5.0000.0121. It was approved by UFSC Ethics Committee as attested by the register 1.518.285 issued on April 26th, 2016.

As no effects in naming latencies were found for mono and disyllabic words by Damien et al. (2010), the experimenter decided not to include word length as a factor to be tested. However, this factor is considered to be balanced in the stimuli, as words range from 3 to 5 letters in their written register, and all the targets have 3 phonemes.

Moreover, the metric of orthographic depth is manipulated at the nucleus of these pseudowords. This was done so because English vowels have many diphthongs at nucleus position, thus enabling such manipulations with different grapho-phonic combinations to guarantee orthographic transparency or opacity, and also to guarantee the study reliability regarding its main focus of analysis. The next section explains all criteria involving the choice for the target percepts and their written representations.

4.1.2 The target percepts and their spellings

To choose the percepts that integrate the nuclei of the target pseudowords, likely graphophonic mappings that each vowel may have in English were considered. Two percepts were chosen: /i/, a vowel that can be mapped onto <ee>, <ea>, <ei>, and <eo>; and /ʌ/, which can be mapped onto <u>, <ou>, and <oo>.

As the digraph <ee> is frequently associated with the tense high front vowel, it was considered a consistent pattern, therefore, a dominant spelling (Ziegler et al., 2004), which is used as a control. It has been attested that the doubling <ee> reinforces duration as an acoustic trait that aids the detection of this vowel in English words by learners of different backgrounds (Escudero, 2015; Rauber, 2006). Thus, this digraph would give learners an advantage. The phoneme /ʌ/ is tested as control when it is consistently mapped onto a single grapheme, <u>.

To observe how sensitive participants would be to the control spellings, two highly-proficient Brazilians, who were pursuing a PhD degree in English, were recruited. They were instructed to read an initial set of pseudowords aloud for recording as soon as the word appeared on the computer screen. The experiment was self-paced and they were in control of the button for slide change[27]. By doing an auditory inspection

[27] The testing took place in an acoustic booth. Participants were accommodated in front of a computer, which showed each target word in font 96, centered in the middle of the screen. They were instructed to read the words aloud as soon

of the recordings, the researcher was able to observe that the graphemes <ee> and <u>were regularly assigned the phonemes /i:/ and /ʌ/ almost always when they were read, which confirmed that the speakers process these two graphophonic biddings in a consistent manner.

To manipulate the consistency metric, the digraphs <ei> and <eo> for the percept /i:/ were selected as the experimental opaque mappings, as these are less frequently associated with the target percept (Ziegler et al., 2004). The digraph<ea> was excluded for being also very frequently mapped onto /i:/. As for /ʌ/, <ou> and <oo> were selected as the opaque experimental mappings. All of these four experimental digraphs can normally be mapped onto different vowels, which adds up to their degree of opacity in the experiment. As argued by Schmalz et al. (2016), multi-letter rules slow down sublexical processing because of a conflict between single-letter and grapheme pronunciations.

Care was also taken in vowel selection for the acoustic proximity of the two categories assigned to the pseudowords. Selecting two percepts that were positioned close in the vocalic space of these learners and could somehow resemble each other would certainly make the learning experiment more difficult and would likely hinder the acquisition of thepseudowords. Therefore, a high front vowel and a mid central vowel were selected. The level of difficulty that these vowels generally pose for Brazilian learners was also observed. Rauber (2006) claims that the high front vowel pair (/i-ɪ/) is the best distinguished in perception, and the second best in production. Thus, at least when tested without its orthographic information, the tense high front vowel is a percept that generally poses little difficulty to Brazilians who hold a certain level of proficiency in the language. As in the case of the mid central vowel, Baptista (2006) explains that this category was the one that was most difficult for Brazilian learners to acquire in a target-like fashion when learning English in a naturalistic environment.

All words are presented in a balanced lexical environment. Each percept is orthographically represented by three different combinations of graphemes. Each combination is used in three different words, adding up to a total of 18 target items. Other four items containing the vowel /ɥ/ in nuclear position are used as distractors. Thus, 22 items composes the

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as they appeared on the screen. They were also told that in case of misreading or self-corrections, the data would be discarded.

stimuli in the learning phase. All pseudowords that encompass the present study can be observed in Table 2 below.

Table 2 - Words that encompass the study stimuli

	Targets		
	/i:/	/ʌ/	Distractors
Control	geesh / keet / seeg	bup / nup/ sud	galm palb malp balsh
	deit / geib / meip	doup / soug / toud	
Experimental			
	geop / teog/ teob	dood/ pood / loob	

In order to guarantee that these were not actual English words, CLEARPOND[28] (Marian, Bartolotti, Chabal, & Shook, 2012) was used. CLEARPOND is a user-friendly, access-free database, available in five languages, that allows for the identification of densities for both real words and pseudowords. Therefore, all pseudowords had their "non-word" status confirmed by searches on this database.

After conducting the pilot study, two pseudowords were replaced. These items used the digraph <kn> at onset, hence standing out from the others for having a less frequent graphemic combination and for having two graphemes at onset position. They were adjusted so that they had single letters at the onset to make sure all pseudowords had the same metric.

[28] Cross-Linguistic Easy-Access Resource for Phonological and Orthographic Neighborhood Densities: http://clearpond.northwestern.edu/

4.1.3 Neighborhood density

Fernández and Cairns (2011) point out that an influential factor in the recognition of words is neighborhood density. Spoken words are believed to be recognized by processes that involve activation and competition among word form candidates or lexical neighbors of spoken words (Pisoni & McLennan, 2015, p. 241)

All words that are phonologically similar to a certain item integrate their phonological neighborhood. Words with larger cohorts take longer to retrieve or might be recognized with more delay, given that many competitors might be activated by their phonological similarity. According to Fernández and Cairns (2011), such a mechanism of retrieval is delayed as “more phonological information is required to specify uniquely a word from a dense neighborhood than from a sparse neighborhood” (p. 196). Related to this is the issue of homophony. Homophony is used to refer to words that have the same pronunciation, but differ in spelling and meaning. No pseudowords used in training are homophones to real words in order to avoid inadequate lexical selection and not to trigger direct lexical competition between two items that carry the same pronunciation.

Orthographic neighborhood is also controlled for. Any word integrates the orthographic neighborhood of a target word when it differs from it by a single letter, respecting length and letter position (van Heuven, Dijkstra, and Grainger, 1998). During word recognition, different words can be activated non-selectively across languages in the lexicon when they share orthographic similarities, but not necessarily the same phonological characteristics.

To identify phonological and orthographic neighbors, CLEARPOND was used. Measures of lexical frequency are also available in CLEARPOND, as provided by the Subtlex[29] databases.

For the present study, the procedure consisted of selecting the “EnglishPOND” option, followed by *Neighborhood size* and *Mean Neighborhood frequency* in the box “Features”. In “Neighbor type”, two searches were conducted: orthographic and phonological. The option *All neighbors* was ticked in “Neighbor frequency”. No cross-linguistic neighbors were searched for because Portuguese is not available in the database. The input for the orthographic search was the orthographic forms

[29] Available at http://crr.ugent.be/programs-data/subtitle-frequencies

of the words created with their exact spelling, whereas for phonological search the input was their phonological form in the SAMPA[30] phonetic alphabet. Table 3 displays neighborhood (*N*) sizes and frequencies[31]for orthographic and phonological word forms.

Table 3 - Orthographic and phonological neighborhoods measured by CLEARPOND

Nonword	Orthographic N-size	Orthographic N-frequency	Phonological N-size	Phonological N-frequency
Geesh	2	3,000	9	3,000
Keet	8	3,375	34	3,088
Seeg	7	2,857	17	3,000
Deit	5	3,600	26	3,000
Geib	1	4,000	4	3,000
Meip	1	1,980	20	3,000
Geop	1	3,000	15	3,000
Teog	0	0	11	3,000
Teob	0	0	11	3,000
Bup	16	2,938	21	3,048
Nup	9	0	13	3,000
Sud	17	3,176	32	3,125
doup	2	3,000	22	3,045
soug	8	3,375	25	3,120
toud	6	3,000	28	3,036
dood	10	2,889	32	3,045
pood	16	2,938	22	3,045
loob	7	2,857	20	3,050

Table 3 shows that neighborhood density of the pseudowords is relatively small, whereas their neighborhood frequency is rather small, if compared to the density of real words, such as *love* (orthography density: 18, frequency: 64.969;

[30] I used the phonetic alphabet made available by UCL as a reference: www.phon.ucl.ac.uk/home/sampa/

[31] This index refers to the frequencies of orthographically and phonologically similar words.

phonological density: 17, frequency: 758.228). This is considered beneficial for previous research has found inhibitory effects for pseudowords in high density neighborhoods (Balota et al., 2004; Luce & Pisoni, 1998). As the goal of the present study is not to test for effects of neighborhood density, Spearman correlations were run among orthographic and phonological neighborhoods and latencies from the Picture Identification Tasks from the piloting phase. As weak correlations (*rho*: < -,1;*p* =< .066)were found among all lexical measures and latencies, these pseudowords are believed not to trigger lexical competition.

It is relevant, though, to obtain a measure for graphophonic frequency, which is the frequency to which a grapheme maps onto a phoneme. Thus, the orthographic *N*-size of the graphemes used in the study was calculated by entering the digraphs and the grapheme that encompass nuclear position of the target words in CLEARPOND and asking for an index of their orthographic density from which the following was drawn:

Table 4 - Graphemic frequency for measuring graphophonic frequency

Phoneme	Spelling	*N* of orthographic neighbors	Frequency rating
i	<eo>	14	Infrequent
	<ei>	9	Infrequent
	<ee>	24	Frequent
ʌ	<ou>	9	Infrequent
	<oo>[32]	26	Infrequent
	<u>	56	Frequent

It should be noted that the dominant spellings that account for consistent orthographic patterns in the artificial lexicon, namely <ee> and <u>, were considered frequent graphophonic mappings for having

[32] This case was as exception. Given that the digraph <oo>, which had a higher N of orthographic neighbors, is usually mapped onto /ʊ/, but in the present study is mapped onto /ʌ/ instead, it was also considered an infrequent combination. The other spellings, <ee> and <u>, were considered frequent given their higher number of occurrences and the consistent graphophonic association to /i/ and /ʌ/, respectively.

a higher number of orthographic neighbors, as seen in Table 4 above. In contrast, all the other graphemes that consisted of opaque graphophonic mappings were considered to be infrequent spellings within this corpora for having a smaller number of orthographic neighbors.

4.1.4 Picture stimuli

In Psycholinguistics, it is tradition to use picture and word associations to investigate linguistic processes, such as the picture-word interference paradigm[33] that investigates semantic processing (Collina, Tabossi, & De Simone, 2013). Previous studies that grappled with orthographic effects have also successfully employed training paradigms in which subjects are compelled to associate pictures to pseudowords (Bartolotti & Marian, 2016; Escudero et al., 2014; Hayes-Harb et al., 2010; Rastle et al., 2011; Simon et al., 2010). Such a technique is advantageous for enabling testing without any sort of written exposure, thus providing an unbiased environment for observing the influence of orthography.

For the development of the visual stimuli that represent the pseudowords used in the experiments, initially three factors were taken into account. First, the drawings could not be so abstract in a way that remembering them would become too effortful. Second, the picture could not easily remind the learner of any other existing object, thus it should be something new. If any pictures directly resembled any existing object, it would prompt learners of a clue for that specific word. Last, pictures could not be colored, as colors may lead to better memory performance with certain items, specially due to the fact that certain color combinations can produce higher levels of contrast, which influences memory retention (Dzulkifli & Mustafar, 2013). Figure 3 below is an example of a picture developed for the present study.

[33] In this paradigm, participants are presented with pictures to name along with distractor words that could share or not a semantic relationship with them (Collina, Tabossi, & De Simone, 2013).

Figure 3. The visual representation of the word “seeg”.

However, after piloting the study, a new small pilot was conducted with the visual stimuli only. During the first data collection, through anecdotal evidence, participants reported that they were using imagery associations (mnemonics) in order to learn the pictures of the study more consistently. Therefore, a new small-scale pilot was conducted with nine participants, all of whom were older than 18-years-old and unfamiliar to the study, who were contacted by the experimenter and asked to evaluate 30 pictures that could be used in the experiments. These pictures were the same used in the first piloting along with new items designed in similar fashion.

The participants received through e-mail a PowerPoint file in which each slide contained a picture to be assessed based on the following guidelines. First, they needed to point out how many visual associations they could make to that picture. Next, based on the easiness of establishing such relations and on the number of associations made, they should evaluate how abstract they considered that image to be on Likert scale that ranged from one (little abstract) to five (very abstract). All pictures selected for the experiments then ranged below three (*M*: 2.24) according to participants’ intuitive evaluations. From the initial pool of images, six had to be replaced for reaching more than three according to the participants’ assessment.

The pictures were prepared by a graphic designer who volunteered to participate in the study, for which no monetary compensation was involved. Appendix D presents all words used in the stimuli and their visual representations.

4.1.5 Auditory stimuli

The auditory stimuli used in training and testing phases were recorded by a female native speaker of English who was invited to do the recordings, for which no compensation was involved. She was a 25-year-old from Herndon, Virginia (USA), who had been living in Brazil on a federal internship program.

The recording session took place in the acoustic booth at *Laboratório de Fonética Aplicada* (FONAPLI). All stimuli were digitally recorded by using OCENAUDIO[34] version 2.0.14, at a sampling frequency of 44100 Hz in mono channel, with 16 bits resolution. The microphone was a dynamic, unidirectional SHURE (modelSM48-LC). The computer used was an iMac 9.1.

The informant was instructed to read in natural speaking style. She was also explicitly instructed on how each set of words should be read in order to guarantee phonetic consistency in the recordings. Along with the words for reading aloud, the computer screen presented a note that informed real words to which the targets would be analogous, e.g., "geib" and "seeg" were analogous to "beat" and "beet". She was allowed to rehearse before reading.

To make sure phonetic consistency was guaranteed, each target word underwent an auditory and visual inspection on PRAAT. If the word was appropriately produced by the speaker, the stimulus was edited on the same software and each word was saved separately.

4.2 THE STUDY DESIGN

This study consists of two phases: a training and a testing phase. The training phase introduces participants to new spoken and written forms that encompass transparent and opaque graphophonic mappings, before the testing phase. The testing phase consists of two experiments, namely, auditory lexical decision, and timed picture naming. All phases are explained in more detail below.

[34] Ocenaudio.com.br

4.2.1 The training phase

In this phase, participants took part in study and verification blocks in which they were introduced to the study stimuli. Stimuli presentation was controlled with DMDX (Forster& Forster, 2003), version 5.1.3.6. (April 2016). Participants took the study and verification blocks in a quiet room, while sitting in front of a computer with a headset on.

The training session consisted of eight study and eight verification blocks. Each study block presented the stimuli three times, in three different sets. Among each set, participants were offered a short break. A verification block presented the stimuli twice, in two different sets, between which participants were offered a short break. The design of this scheme can be visualized in Table 5 below.

Table 5 - Study experimental design

Type of exposure	Design of treatment	
	Phase 01: Training	
Auditory only	Part 1: Study block 1	Verification block 1
	(three training sets)	(two testing sets)
	Part 2: Study block 2	Verification block 2
	(three training sets)	(two testing sets)
	Part 3: Study block 3	Verification block 3
	(three training sets)	(two testing sets)
	Part 4: Study block 4	Verification block 4
	(three training sets)	(two testing sets)

Auditory + orthographic	Part 5: Study block 5 (three training sets)	Verification block 5 (two testing sets)
	Part 6: Study block 6 (three training sets)	Verification block 6 (two testing sets)
	Part 7: Study block 7 (three training sets)	Verification block 7 (two testing sets)
	Part 8: Study block 8 (three training sets)	Verification block 8 (two testing sets)
	Phase 2: testing	
No input offered	Auditory Lexical Decision Task Timed Picture Naming Task	

In study blocks, participants were shown a picture of a novel object while listening to its spoken form over headphones. They needed to repeat the object's name after each trial. This was to guarantee articulatory encoding of the new lexical representations and to observe whether participants were paying attention to the stimuli presentation. In order to familiarize the participant with the procedure, three trials were provided as a familiarization block. The stimuli consisted of the 22 new words which werepresented twelve times each, adding up to a total of 264trials split into eight different study blocks during training.

A participant firstly took part in three training sets in one study block, with a total of 66 trials, which were then followed by a verification block with two testing sets. Each trial presentation in a study blocklasted2000ms to allow for object recognition and phonological encoding. This duration is comparable to previous research involving training on new lexical items (2000ms: Alves et al., 2010;Bartolotti & Marian, 2016; Escudero, 2015). The participants were explicitly instructed to repeat each spoken form while paying attention to the visual form that was presented simultaneously on the computer screen. No response was registered from study blocks.

After each study block, each subject took part on two testing sets in a verification block. Verification blocks consisted of a Picture Identification Task in which participants needed to choose, from two pictures displayed on the computer screen, the one that matched the stimuli heard. Feedback was given immediately for wrong responses with the message "*Wrong response! Try harder!*". Each trial was available for 5000ms before time out occurred in case the participant did not respond. In such a case, the message "No response" was displayed on the screen before the next trial came up. Four practice trials were provided to familiarize the participant with the experiment before the presentation of the verification block started. Each verification block in the Picture Identification Task contained 44 trials, divided into two testing sets.

Beginning with the fifth study block, participants were exposed to the lexicon written forms in conjunction with the spoken forms and the picture in study blocks. The procedure was very similar to the protocol followed with the first four study blocks. Each trial lasted 2200ms to allow for picture recognition, and orthographic and phonological encoding. These extra 200ms were allowed for orthographic input was presented, thus entailing in one extra process that was not present in the first four parts of training. After three study sets in a study block, participants were required to take the Picture Identification Tasks with two testing sets in a verification block in which they needed to select the target, from two pictures displayed on the screen, which matched the stimulus heard. Feedback was given immediately for wrong responses with the message "*Wrong response! Try harder!*". Each trial was available for 5000ms, before time out occurred in case the participant did not respond. In such a case, the message "No response" was displayed on the screen before the next trial came up.

Responses from the Picture Identification Tasks were used to observe how well participants performed in each stage of the training phase. Participants were informed of their progress as soon as they completed each Picture Identification Task and were explicitly told that they needed to reach ceiling effects in order to move to the testing phase.

4.2.2 The testing phase

Finally, participants were assessed by two experiments: Auditory Lexical Decision, and Timed Picture Naming. Information on these experiments is provided below.

4.2.2.1 Auditory lexical decision

Auditory lexical decision entails processes of lexical access or lexical search as well as the analysis of the speech signal (Goldinger, 1996). The execution of the task required participants to decide whether the stimulus was learned in training or not, by pressing "yes" or "no" corresponding buttons on the computer keyboard."Yes" responses should be given for the pseudowords that participants learned during training, whereas "no" words are items prepared just for this task. As participants are compelled to conduct lexical analysis of the items presented in the task, it is the aim of the study to observe whether orthography is recruited during this process to aid the spoken recognition of the item. Such a process can be evidenced by significantly different response times for "yes" pseudowords of differing orthographic depths, as well as accuracy of response. Response times for "no" responses will be looked at in comparison to the "yes" responses. Yet, it is expected that these will be slowed down given their degree of similarity to the "yes" pseudowords (Taft & Hambly, 1986).

Participants were instructed to answer as rapidly as possible and told that *words* refer to any word in English learned during training. For the "yes" answers, the 22 target words from the study were used. Other 20 words were initially created for the "no" answers. However, when piloting these words, the results of this task deemed inappropriate, as the words used for "no" were too easily distinguished from the trained lexicon. Taft (2011) argues that the earlier the deviation from a real word, the faster a pseudoword can be identified as not being an existing word. The same reasoning is extended to the deviation point from the trained and the "no" pseudowords from this task: as all the "no" pseudowords included percepts in nuclear position that were not present in the trained lexicon, no further activation from the sublexical route was necessary to disentangle ambiguities that might have been imposed in perception by the onset of the word, as the earlier subjects noticed the deviation, the less auditory analysis was necessary for them to conclude processing of the target item.

Therefore, the word-initial cohort theory (Marslen-Wilson & Zwitserlood, 1989), used for assessing spoken words, was revisited for the preparation of the "no" words in the present study. Marslen-Wilson and Zwitserlood, (1989) demonstrated that the decision space for the lexicality of words stands on their beginning. Their theory maintains that the speech input at the initial portion of a word maps onto all competing lexical items that phonologically share the same initial sequence. That is to say that words will compete for auditory recognition when they overlap in their initial structure. Hence, the new "no" pseudowords presented with a mismatch in relation to the "yes" pseudowords in either onset or coda positions. The same nucleus was kept for both "yes" and "no" pseudowords given that these were monosyllabic CVC words, and using a different nucleus for the "no" pseudowords would certainly make them stand out from the "yes" pseudowords. CLEARPOND was again used to check for their lexicality status.

For the "no" answers, the items displayed in Table 6 were used. In order to test for their validity, a list containing both unidentified "yes" and "no" items was given to a Psycholinguist experienced with lexicality judgements, who was asked to spot words that stood out from the list for presenting any outstanding syllabic patterns. After her examination, the items in Table 6 were selected.

Table 6 - Items used for eliciting "no" answers in the Auditory Lexical Decision task

Target percept	Words used for "no" answers
iː	/miːʃ; liːb; diːv; biːb; miːg; giːm; kiːv/
ʌ	/gʌʃ; lʌp; sʌv; tʌv; gʌd; kʌg; gʌg; mʌd; pʌv/

Each lexical item was presented twice in Auditory Lexical Decision task, which resulted in 76 trials. A trial consists of the presentation of a fixation point, followed by an aural stimulus. The fixation point lasts for 5000ms, which is then followed by the presentation of the aural stimulus.

The trial fades away as soon as the participant registers their response or is timed out 2000ms after the aural stimulus is presented. This time was deemed adequate as only 3,3% (*N*: 48; Total *N* of responses: 1,584) of responses for the "yes" words in this task were timed out during piloting. Moreover, the decision to present each item twice was to observe participant's reliability in executing the task, given the lexicality status of the items used, which might prone participants to err more. Hence, such a procedure was done principally to ensure the study's interval validity.

To familiarize the participant with the procedure, this experiment consisted of a practice block, with four trials, each with a word from the study. In sequence, there were two different blocks, with 38 trials each (22 "yes" items plus 16"no" items), presented in the automatic randomized order DMDX applies. After each block, the participant was given the choice to take a short break. All participants were required to use their dominant right hand for the "yes" responses.

4.2.2.2 Timed picture naming

In picture naming, participants are required to generate a matching spoken form to the picture presented on the computer screen. Any delay or wrong responses might be due to intervening factors that influenced the retrieval and encoding of that word form from long-term memory. Jiang (2012) states that picture naming involves three major cognitive processes, namely: object recognition, conceptual activation, and lexical access and production. The author also claims that this task has been used "to examine common and unique properties of lexical access in L2" (p. 148), as is the case of the present study. Accordingly, participants are instructed to name all 22 pictures seen in training as rapidly and as accurately as possible. Stimuli presentation and recording of voice responses is done with DMDX, which takes .rtf script file as input.

To familiarize the participant with the procedure, this experiment consists of a practice block, with six trials, each with a word from the study. In sequence, there are four different blocks, with 22 trials each, when the 22 words used in the study are presented in the automatic randomized order DMDX applies. After each block, the participant might choose to take a short break. A trial consists of a fixation point and a target picture. The fixation point lasts for 500ms, which is then followed by a target stimulus that stays on screen for 2500ms, when the time out occurs. Pictures are positioned to the center of the screen. The recording of voice responses is done by the headset the participant wears while taking the experiment. As Jiang (2012) advises, sensitivity of the voice key is adjusted to a medium level because normal vocalization can provide enough energy to trigger the voice key. If the sensitivity is too high, low-volume noise may stop the timer, causing RTs to be very short.

To analyze naming data, the oral responses were scored offline with CheckVocal (Protopapas, 2007). This is a software developed to help process the results of naming tasks from DMDX. It checks for accuracy (correct, wrong or no responses) and timing (to see if the voice key is properly triggered). The program takes three different files as input. The .azk file that DMDX generates with the RTs from a given participant, along with a previously prepared .txt file containing the answers in written form for each trial number. For instance, if the picture naming has four blocks with 22 trials each, the answer file needs to present 88 answers, each in a different line, properly numbered according to the trial to which it belongs. The last input file CheckVocal takes is the DMDX script that is written to run the naming experiment.

As shown in Figure 4, CheckVocal displays each naming waveform and spectrogram with the voice-key mark. On the top of the screen, it also shows the expected answer for any trial in written form. The experimenter needs to observe if the timing mark is properly placed on the onset of the voice response. If not, in case it has been mistriggered to a premature onset because of lip smacking, or late-triggered because of a low-volume oral response, the experimenter can click on the waveform to reset the voice-key trigger. The software also presents an option that automatically re-triggers the mark to a subsequent onset. Figure 4 displays the inspection of the word “seeg” on CheckVocal.

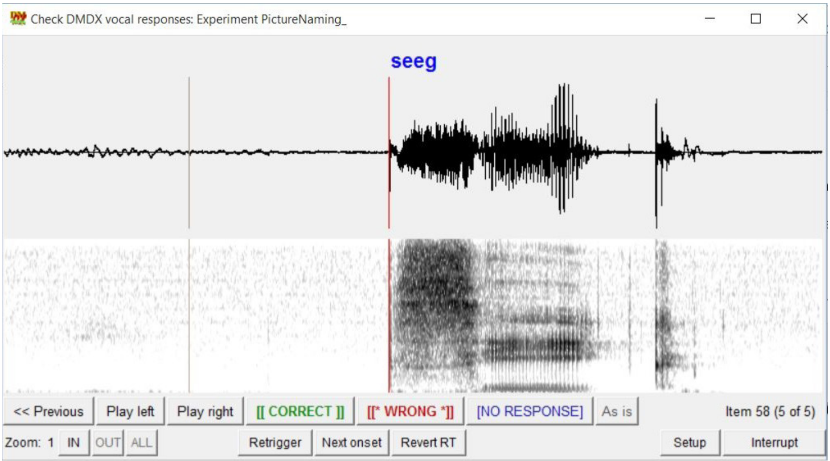

Figure 4. Inspection on CheckVocal.

After inspecting the placing of the timing mark, the experimenter needs to check for the accuracy of the participant's response. The software displays three buttons on the bottom of its screen, for "correct", "wrong" and "no response" options. When the response is wrong, a negative mark is assigned to that RT. When there is no response, that RT is automatically set to -2500ms in the data list answer-file it generates. In order to define for correctness of voice responses, all phonemes of a given word need to be correct in initial, medial, and final position. Slips of the tongue are to be considered as wrong responses. When this inspection is over, the output of CheckVocal is a data list .txt file that shows different rows with each trial number followed by its corrected RT.

4.3 INSTRUMENTS

Participants in this study were given a questionnaire whose main objective is to gather information about their knowledge of additional languages, and other variables that encompass a protocol of their experience learning English: amount of exposure to the language and age in which the subject started studying the language (see Appendix A). The questionnaire was given either at the beginning or at the end of the data collection, depending on participants' schedule.

Along with the questionnaire, participants received an Informed Consent Form that describes in detail all that is required for taking part in the study, as well as their rights to anonymity. This is in accordance with the University Ethics Committee guidelines for research with human beings (see Appendix B), specifically in accordance with Resolution CNS 466/12.

4.4 PARTICIPANTS

This study required the recruitment of older than 18 years-of-age participants, who have normal speech and hearing, and normal or corrected-to-normal vision. Knowledge of additional languages and left-handedness were controlled for during participant's recruitment. Participants' knowledge of additional languages is controlled for because the languages of multilinguals are activated and interact during language processing, thus linguistic representation and processing may be altered (Bialystok &Craik, 2010; de Groot, 2011). Moreover, handedness is also controlled for because of the experimental setup of the present study, which measures response times by using particular keys across a series of different tasks. If the dominant hand differs across participants, the setup should be reverse, and having to adjust scripts during data collection might add an unnecessary burden for the experimenter.

Moreover, proficiency was also initially considered in the present study. Participants were asked to self-report their proficiency level, given that proficiency greatly affects processing of lexical knowledge (Veivo &Järvikivi, 2013). When in doubt, the experimenter intuitively assessed participants' spoken production as they encountered on the first day of data collection. However, it is important to say that this procedure took place only twice.

4.4.1. The participants of the final data collection

Thirty-six participants took part of the study final data collection. They all volunteered and were mostly personally invited by the researcher during undergraduate classes of the *Letras* program at Universidade Federal de Santa Catarina. Some participants were also recruited through personal contacts of the researcher. In this phase, participation consisted of one data collection encounter which, consecutively, started with a training phase whose objective consisted of participants' learning the artificial lexicon, followed by a testing phase.

The participants were thirteen men and twenty-three women, whose ages varied from 18 to 47 (*M:* 26,1). The number of early and late learners was unbalanced, as 29 of them were late learners (*M* for learning age:13,3*)*. Only seven participants reported being early learners (*M:* 6,5). All of these participants had normal or corrected-to-normal vision, and were right-handed.

As concerns their biographic data, all participants were or had been students at the *Universidade Federal de Santa Catarina.* Twenty-seven participants were students in the English Program, either at the graduate or at the undergraduate level, at the time the data collection occurred. Other two participants had been students at the graduate or at the undergraduate level of the same program. Two other participants were enrolled at the Graduate Linguistics Program. Two participants were graduate students enrolled at the Biochemistry and at the International Relations Programs. The other three participants of this sample were undergraduate students at the Accounting, Engineering and Philosophy Programs. Therefore, this sample of subjects can be considered highly literate, as they were in touch with academic written texts on a daily basis.

As concerns their proficiency in English, at this stage of data collection, the experimenter considered mostly their experience with the language (any proficiency tests taken and amount of use). Again, this sample of participants were highly proficient (*N:* 33), with only three participants reporting that their proficiency level was about intermediate. With regard to their knowledge of other additional languages, eighteen participants reported having knowledge of additional languages other than English, out of which 14 knew one additional language other than English (French, 3; German, 1; Italian, 2;Japanese, 1; Spanish, 6; or Ukrainian, 1.) Other three participants reported having knowledge of a third language (French, German, Italian, or Spanish), and one participant reported having knowledge of three other additional languages (Japanese, Korean, and Spanish). Participants' proficiency level of these other languages were not tested. A detailed account of participants' profile is available in Appendix C.

4.5 PROCEDURES

Participants encountered individually with the experimenter. The data collection took place in a quiet room, with participants sitting in a comfortable chair. The headset volume was adjusted to a comfortable listening level. A Microsoft LifeChat headset was used for auditory presentation and the recording of oral responses, and an Avell notebook was used to administer all the experiments. Firstly, participants were given the Consent Form and took part in the first training session. Next, they moved onto the second training session. Finally, participants were tested with the Auditory Lexical Decision and Timed Picture Naming tasks, besides being given a questionnaire that gathered some information on how they learned English and other additional foreign languages. At the beginning of all encounters, it was emphasized that answers should be given as quickly and as accurately as possible for when they were tested. All participants received a certificate for participation, and a book or a chocolate bar as a gratification.

4.6 DATA ANALYSIS

In order to validate the repeated-exposure training paradigm, RT data from the 11 subjects who participated in the pilot were computed as the output of the Picture Identification Tasks took during training sessions. These tasks presented the same word twice, thus consisting of two RTs for each word in each verification block, which results in six continuous variables. On the second day of piloting, the procedure was the same, but orthographic forms were included in the training phase. Overall, in the first statistical models for analyzes encompassing the first two days, 12 continuous variables were included (six response latencies from each day).

As regards the Auditory Lexical Decision and Picture Naming tasks, each of them generated continuous variables (the response latencies), which were combined with orthographic consistency, as the nominal variable. The models included orthographic consistency, which consisted of the graphemes that mapped consistently onto a phoneme (/ʌ/ onto <u> as in “sud”) and to cases that were considered inconsistent (/ʌ/ onto <oo> and <ou> as in “loob” and “toud”). Thus, this variable contained two levels (consistent and inconsistent).

From the Picture Identification tasks, the data spreadsheets were inspected for any data cases with response latencies slower than 2000ms, which were considered outliers and therefore excluded[35]. From day one,

[35] Lachaud and Renaud (2011) explain that “if abnormal values are kept, classical methods of analysis might be influenced to such an extent that they will lead to incorrect inferences” (p. 391).

2.5% of data were excluded (36 data cases), whereas from day two, 0.8% of data were excluded (12 data cases). This is comparable to Damien and Bowers (2009), who considered outliers any latencies slower than 1500ms. 500ms more were allowed in the present study for participants were learning pseudowords in an additional language in laboratorial conditions. Wrong responses were also excluded. From day one, 101 latencies were deleted from the spreadsheet (14,5%), whereas from day two, only 41 (2,8%). Overall, from day one, 17% of data were lost; whilst from day two, 3,6% of data were lost. A blind cutoff filter[36]of two or three standard deviations on overall distribution for eliminating outliers was not applied at this stage of data analysis for the effect it might cause, resulting in non-negligible loss of information (Sanz & Grey, 2015).

In the case of the Auditory Lexical Decision task, spurious and wrong responses were excluded from the spreadsheet of the final data collection. For items that required a positive response, which consisted of the trained lexicon, 197 wrong answers were excluded out of 1584 total, thus 12% of data were lost. For the negative answers, 34% of data were eliminated (546 data points). From the Timed Picture Naming task, incorrect responses and data cases in which participants failed to name the object were also excluded from the spreadsheet. With this task, about 32% (as opposed to about 40% in the pilot) of data were lost out of a database of 3,168 responses (valid final *N:* 2141). In all analyses, missing values[37] were unchanged, and the data were analyzed with multi-level statistical models, which are better equipped to analyze missing values (Lachaud & Renaud, 2011).

4.7 THE PILOT RESULTS

Over the course of month, the present study was piloted. Differently from the final data collection, the training and the testing phases of the

[36] Lachaud and Renaud (2011) explain that "the standard filtering procedures used by psychologists consists in using all RTs and blindly eliminating values above and below the ±2 SD limits around the mean of the general distribution (grand mean). […] Furthermore, this type of filter can bias inferences, depending on the structure of the data, by not filtering all outliers in the distribution of a specific experimental condition, as well as by truncating the distribution of one or several condition(s)" (p. 391).

[37] Missing values are sometimes replaced with the item or subject mean, but this may artificially reduce the variability in the data set (Sanz & Grey, 2015).

pilot study took place in different days[38]. Initially, results from training are presented with the objective of validating such a procedure. Later, results for the Auditory Lexical Decision and the Timed Picture Naming tasks are presented.

4.7.1 The pilot participants

Eleven participants[39] took part of the pilot study. They all volunteered and were recruited mainly through personal contacts of the researcher, or were personally invited by the researcher during undergraduate classes of the *Letras* program at Universidade Federal de Santa Catarina. As previously explained, participation in the pilot study consisted of a 3-day data collection which, consecutively, started with a training phase that encompassed two encounters, followed by a testing phase of one encounter.

The participants were six men and five women, whose ages varied from 18 to 42 (*M:* 26,5). Considering the cutoff of nine years of age for early, and 10for late acquisition (Archila-Suerte, Zevin, & Hernandez 2015),six of them were early learners (>9, *M:* 8,2), whilst the other seven were late (<10, *M:* 14,4). All of these participants had normal or corrected-to-normal vision, and were right-handed. This sample of subjects was considered highly literate, given the fact that they were all undergraduate and graduate students, who were in touch with academic written texts on a daily basis.

As concerns their proficiency in English, at this stage of data collection, the experimenter considered mostly their experience with the language (any proficiency tests takenand amount of use). Five participants

[38] Initially, participants' amount and quality of sleep during days of training were controlled for in the piloting phase. Hence, participants took part in the training on the first two days of day collection to be tested with the Auditory Lexical Decision and with the Timed Picture Naming tasks on the third day of data collection. However, after the consideration of the examining committee, the investigation of such a variable was dropped, given that it required a different design for further testing (e.g., different sleep conditions). Thus, for the final data collection, both training and testing phases would take place over the same encounter.

[39] Initially, data were collected with 13 participants, but two of them were considered outliers for often appearing in Boxplots that are generated by SPSS for the inspection of outliers and were thus removed from the dataset.

had taken TOEFL-ITP[40] and obtained considerably high scores, ranging from 470 to 623 (*M:* 559) out of a maximum score of 677. Another participant reported having taken TOEIC and scoring 820 out of possible 990. Four of the other five participants were English majors and reported being able to communicate and understand English very well. The 11th participant reported having some speaking proficiency and a good level of reading skills, and reported having studied English constantly in the past years for she had been enrolled in English courses at UFSC. More importantly, eight participants of this sample either held or were pursuing a major degree in English, in which six out of the eight had had experience teaching English. From this picture, we can see that they shared a good background experience in learning English and werefrequently in touch with the language.

As concerns their knowledge of other additional languages, three participants reported having no knowledge of additional languages other than English. Other five participants reported having knowledge of a third language (French, German, or Spanish), and the remaining participants reported having knowledge of other two (Spanish, German), or three additional languages (French, Spanish, Italian, and Russian, Danish, Swedish). A detailed account of participants' profile is available in Appendix C.

4.7.2 The repeated-exposure paradigm for learning

Exposure-based training has been found beneficial for learning grammar and for lexical processing and word production (Antoniou, Ettlinger & Wong, 2016; Van Assche, Duyck, Gollan, 2016).Hence, it is paramount to observe whether this paradigm was deemed adequate for the acquisition of an artificial lexicon.

To validate such a procedure, data from verification blocks were gathered during the piloting sessions in order to observe whether participants' performance improved as they underwent treatment. Initially, we shall inspect Table 7 below, which compares the descriptive statistics for latencies on days one and two from the piloting phase.

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[40] Many university students and staff have taken this test because it is freely offered in some federal institutions as an initiative of the English Without Borders Program.

Table 7 - Descriptive statistics for response latencies in the Picture Identification tasks from days one and two

Variable	Mean	Min.	Max.	SD
RT 1 – Test 1 – Day 01	1087ms	635ms	1861ms	270ms
RT 1 – Test 1 – Day 02	849ms	585ms	1788ms	205ms
RT 2 – Test 1 – Day 01	1104ms	622ms	1948ms	294ms
RT 2 – Test 1 – Day 02	897ms	514ms	1761ms	206ms
RT 1 – Test 2 – Day 01	922ms	530ms	1838ms	258ms
RT 1 – Test 2 – Day 02	855ms	549ms	1689ms	202ms
RT 2 – Test 2 – Day 01	936ms	588ms	1787ms	222ms
RT 2 – Test 2 – Day 02	839ms	512ms	1275ms	160ms
RT 1 – Test 3 – Day 01	921ms	516ms	1910ms	243ms
RT 1 – Test 3 – Day 02	873ms	555ms	1724ms	206ms
RT 2 – Test 3 – Day 01	928ms	581ms	1557ms	201ms
RT 2 – Test 3 – Day 02	830ms	552ms	1582ms	163ms

A gradual decrease in latencies is observable from day one to day two, as well as a smaller range in variation according to the SD values from day two. Subjects' more consistent performance indicates that their lexical representations became somewhat stabilized, thus allowing them to perform lexical access more easily (i.e., faster responses) to identify each item auditorily presented in the Picture Identification task trials to match it with its corresponding picture. Faster processing times from day two also indicate that this trained lexicon might have been integrated to previous lexical networks, given that any conflicts in integrating new orthographic information to phonological representations to, then, map each sound sequence to its picture, would have slowed down their latencies on day two, which did not happen. Clearly, participants' profited from a repeated-exposure training paradigm, as the decreasing latencies provide evidence that training from day one already resulted in learning.

Next, to confirm whether the spotted differences in subjects' performance from days one and two were statistically significant, normality tests (Kolmogorov-Smirnov and Shapiro-Wilk) were run, which indicated that the RT variables were not normally distributed (*p*

< .000). Thus, a Friedman[41] test was run to observe whether there were statistically significant differences across the continuous variables. As the probability value came out significant (*p*.: .000), a series of Wilcoxon[42] signed rank tests was run to spot the differences among latencies from day one and day two. The Bonferroni correction[43] was applied, thus the probability value of .05 was divided by the number of variables tested, thus meaning that to achieve significance, the probability values would be equal or smaller than .008. Table 8 displays the results of the Wilcoxon tests.

Table 8 - Differences between response times across days one and two in the Picture Identification Task

	RT 1 – Test 1 – Days 01 and 02	RT 2 – Test 1 – Days 01 and 02	RT 1 – Test 2 – Days 01 and 02	RT 2 – Test 2 – Days 01 and 02	RT 1 – Test 3 – Days 01 and 02	RT 2 – Test 3 – Days 01 and 02
Z	-8,610	-7,441	-3,352	-6,763	-3,756	-6,992
p.	,000	,000	,001	,000	,000	,000

Overall, the significant statistical results demonstrated above provide strong evidence that the repeated-exposure training paradigm was beneficial for the establishment of new lexical categories by the subjects who took part in the study. Therefore, this paradigm was considered suitable for the present investigation and was replicated for the final data collection. The only alteration conducted regarded the different days of training, as explained previously. The definite design thus encompassed a training phase with two parts (no orthographic input along with the auditory form of the lexical items, followed by the inclusion of orthographic input)

[41] Friedman test is the non-parametric alternative for a repeated measure ANOVA, but it is used for testing just one independent variable (Larson-Hall, 2010).
[42] Wilcoxon Signed Rank is the non-parametric alternative to a paired-samples t-test for comparing two mean scores that come from the same subject group (Larson-Hall, 2010).
[43] Larson-Hall (2010) explains that it is an adjustment made to the probability value, whereby the p. value is divided by the number of variables. This results in a new *p*. value, and to be statistical a test must be equal or below this level.

in addition to a testing phase, all conducted in a sequence throughout one encounter. This indeed facilitated participants' recruitment, as during previous participation calls of the study, many subjects became reluctant given the need of being available for encounters on three days in a row.

4.7.3 Pilot results for speech perception and production

We now move forward to the analysis of orthographic effects on speech perception and production. On the last day of piloting, participants took part in two experiments, Auditory Lexical Decision and Timed Picture Naming. In the first experiment, subjects needed to decide as fast as possible if the word heard was learned during training. In the second, participants needed to name the picture displayed on the screen as rapidly as possible.

The Auditory Lexical Decision task failed to measure any orthographic effects on the perception of the trained words for all participants achieved a ceiling effect[44]. All of them achieved a performance of near-maximum or maximum scores, recording more than 95% of correct responses, and thus showing that the task was too easy for no processing effort was necessary to identify the "no" pseudowords (e.g., "dirm") from the trained pseudowords. Moreover, ceiling effects indicate bias for reducing the true range of participants' scores and underestimating participants' variability (Uttl, 2005). This is likely to have happened because the experimenter failed to measure the cutoff point from which the pseudowords used for the negative answers deviated from the ones previously used in training (the "yes" answers).

Taft (2011) argues that the earlier the deviation from a real word, the faster a pseudoword can be identified as not being an existing word. The same reasoning can be applied to the deviation point from the trained and the "no" pseudowords from this task. As all the "no" pseudowords included percepts in nuclear position that were not present in the trained

[44] Uttl (2005) explains that "[…] ceiling effects occur with tests that are relatively easy, when a substantial proportion of individuals obtain either maximum or near-maximum scores and cannot demonstrate the true extent of their abilities, resulting in score distributions that are compressed at the upper end of performance. Ceiling effects are undesirable: They limit the ability of tests to ferret out differences among higher-scoring individuals; they reduce the true range of scores; and they underestimate variability among individuals, thus biasing any derived scores whose computation uses the sample variability" (p. 460).

lexicon, no further activation from the sublexical route was necessary to disentangle ambiguities that might have been imposed in perception by the onset of the word, as the earlier subjects noticed the deviation, the less auditory analysis was necessary for them to conclude processing of the target item. Hence, the stimuli for the present task underwent adjustments, as discussed previously in section 4.2.2.1.

For the analysis of data from the Timed Picture Naming task, the statistical model included a continuous variable (response latencies), along with orthographic consistency, with two levels (consistent and inconsistent). The data spreadsheets were inspected for any data cases with negative and “no response” latencies (latencies that are automatically set to 2500ms by CheckVocal), which were excluded. A considerable amount of 39,5% of data were lost because of participants’ wrong and absent responses. Again, missing values were unchanged, and the data were analyzed with multi-level statistical models, which are better equipped to analyze missing values (Lachaud & Renaud, 2011).

To inspect any differences in performance according to control (consistent) or experimental (inconsistent) items in the orthographic condition, descriptive statistics were run. Table 9 demonstrates that items from the control condition were named faster than items from the experimental condition. Moreover, SD values did not vary as much in the control condition when compared to the experimental, attesting that subjects tended to be more consistent with control items.

Table 9 - Descriptive statistics for the pilot of the Timed Picture Naming task

Descriptive statistics	Consistent orthography	Inconsistent Orthography
Mean	969ms	1034ms
SD	280ms	307ms
Min.	478ms	551ms
Max.	1790ms	1732ms

Tests of normality indicated that response latencies did not achieve normal distribution across the two conditions (*p*.:.000). Thus, a Mann-Whitney U test, using orthographic consistency as the grouping variable, demonstrated that orthography influenced picture naming with this sample of subjects, as the probability value reached significance: *Z*: -2,406; *p:* .016.

In this case, it can be argued that the process of converting the visual input into its phono-articulatory representations for production, which is mediated by lexical selection, involves the activation of orthographic codes, thus eckoeing previous research (Erdener & Burnham, 2005). The present results, therefore, provide evidence to support the claim that orthographic effects arise in spoken production.

However, the results from the present task need to be taken with a grain of salt. Considering that data from only eleven subjects was gathered for this initial piloting of the study and almost 40% of data from this task was lost, the orthographic effects might have been blurred by the insufficient amount of data used in the statistical model.Hence, such results might have been subject to statistical bias.

Notwithstanding, the role of subjects' L2 proficiency level in orthographic recruitment was included in the scope of the pilot study. We had predicted that lesser interference from orthography would be attested with subjects of higher proficiency for these are able to rely on support from higher-order lexical knowledge of bigger-sized nature (rhymes, and knowledge of frequency), as opposed to a more influential role of orthography in orthographic recruitment performed by less proficient subjects, for they had not yet developed a fully functional lexical processing mechanism.

In the pilot, the experimenter assigned a binary level of proficiency to each subject taking into account, on a respective degree of importance, (i) their self-reported proficiency result, (ii) their self-reported experience with English, and (iii) their spoken production that was holistically evaluated as they encountered on the first day of data collection. This nominal variable contained two levels (high *N* = 6, and low *N* = 5). In the Timed Picture Naming task, subjects of high proficiency tended to perform a bit faster than low proficiency counterparts. However, both groups tended to perform in similar fashion as their SD means only differed by 12ms. Table 10 below shows the descriptive statistics for the Picture Naming task according to proficiency level.

Table 10 - Descriptive statistics for the pilot of the Timed Picture Naming task according to Proficiency level

Proficiency Level	Min.	Max.	Mean	SD
High	478	1790	988	299
Low	545	1706	1011	287

Nonetheless, a Wilcoxon Signed Rank U test, which detects whether differences between groups are caused by an effect of the grouping variable, did not indicate that subjects' performance differed significantly according to proficiency level: *Z*: -1,304; *p*.: .192. However, such results were subject to bias and needed to be interpreted with a grain of salt for participants' proficiency level had been subjectively measured by the experimenter, without the use of any assessment instrument. Also, the sample was small and perhaps had not provided sufficient data for this variable effect to appear, as a considerable amount of almost 40% of data were lost with this task due to absente and incorrect responses.

In general lines, the results of the pilot study showed that orthographic effects on Auditory Lexical Decision could not be explored, given the experiment's failure to measure the cutoff point between the "no" and "yes" pseudowords. Moreover, significant orthographic effects were found in speech production, indicating that the stage of lexical selection in speech production involves activation of orthography, or that any orthographic effects were blurred given the amount of data that was lost.

As concerns the study design, the pilot study deemed the repeated-exposure paradigm adequate for the present enterprise, as subjects were able to learn the intended lexical items in training. The artificial lexicon used in training was also adequate, once that the investigated process was able to appear in spoken production. Relatedly, the "no" pseudowords for the Auditory Lexical Decision task had to be prepared again, as they were too easily distinguished from the "yes" pseudowords.In addition, investigating sleep with a Likert scale was considered unsatisfactory for such a variable would require a different approach to be tested, thus it was excluded from the study scope. From the pilot study, we also noted the importance of limiting the data collection to a single session, as many participants were reluctant to make themselves available for different encounters on following days. Next, in Chapter 5, the final results of the present study are presented and discussed.

CHAPTER 5 - STUDY RESULTS AND DISCUSSION

In this Chapter, results of the present study are discussed in light of the literature abridged in Chapters 2 and 3. To do so, relevant results are presented and discussed with reference to the extent they corroborate each hypothesis. Detailed information about the statistical tests used can be found in the footnotes as indicated throughout the Chapter. This Chapter firstly presents the results gathered with the Auditory Lexical decision task, followed by the results obtained with the Timed Picture Naming task. In the end, the nature of orthographic effects, whether mandatory or strategic, is discussed considering the results obtained with the present study.

5.1 THE ISSUE OF ORTHOGRAPHIC RECRUITMENT IN PHONOLOGICAL PROCESSING

The present section discusses the results involving orthographic effects in the processing tasks that encompass the present work. Initially, this work seeks to attest for the plausibility of orthographic recruitment in phonological acquisition and processing, as observed via processes of perception and production.

To measure such effects, two tasks were developed, namely, Auditory Lexical Decision and Timed Picture Naming. In the first experiment, subjects needed to decide as fast as possible if the word heard was learned during training. In the second, participants needed to name the picture displayed on the screen as rapidly as possible. whereas for the final data collection, participants took these tasks last in the single encounter that took place. In both data collection phases, perception preceded production.

5.1.1 Orthographic effects in auditory lexical decision

After the piloting phase, the experiment went through adjustments (see section 4.2.2.1) and a new version of the task was designed and used to collect data, which yielded the descriptive statistics displayed in Table 11. Note that the results are displayed separately for consistent (e.g., “seeg”) and inconsistent items (e.g., “toud”) to observe whether participants’ performance differed according to orthographic depth.

Table 11 - Descriptive statistics for reaction times in Auditory lexical decision

		Consistent Items		
	M	*SD*	Min.	Max.
RT1	945ms	238ms	387ms	1956ms
RT2	930ms	218ms	522ms	1893ms
		Inconsistent Items		
	M	*SD*	Min.	Max.
RT1	941ms	252ms	502ms	1953ms
RT2	943ms	251ms	421ms	1990ms

It is relevant to posit that two reaction times were registered for each word in each level of orthographic transparency to test for participants' reliability when dealing with pseudowords in a lengthy testing session (the learning and the testing phase were both administered on the same encounter). Upon visual inspection, it can be observed that the means for both consistent and inconsistent items are similar. However, participants' responses varied more with inconsistent items, as the SD means were higher than with consistent items.

Overall, participants made correct judgments for the positive responses 88% of time, whereas for the "no" items, participants scored 66% of correct answers. Participants timed out on only 2% of trials.

When running descriptive statistics, normality tests (Kolmogorov-Smirnov and Shapiro-Wilk) indicated that the latencies for this task did not achieve normal distribution (*p:* .000). Therefore, a Wilcoxon Signed rank test was run to observe whether there were significant statistical differences between reaction times 01 and 02 for the items conceived as "yes" answers, which were the lexicon learned by the participants in the training sessions. Results indicated that there were no significant differences between participants' answers from the first to the second reaction time, indicating that they performed consistently across different testing times with the learned items in this task (*Z:* -,954; *p:* .340).

Next, to observe whether orthographic consistency affected subjects' performance with the "yes" items, a new variable was computed, which consisted of the mean value of the reaction times 01 and 02, as there was no significant difference across both these measures. Orthographic consistency was used as the grouping variable, and a Mann-Whitney U test demonstrated that orthography did not influence participants' performance with the items that were learned during training (*Z:* -,291; *p:* .771).Therefore, we entertain the hypothesis that orthography is simply not necessary for the lexical search conducted with familiar words. Any orthographic activation caused by these items had been bypassed so that lexical access was not conducted with reference to written codes for speech perception.

It is also relevant to address whether reactions times differed significantly between "yes" and "no" items. To do so, variables containing the mean reaction times for each orthographic level of transparency were used and their descriptive statistics are displayed in Table 12. A Wilcoxon Signed Rank U test unveiled that participants' latencies were statistically different across "yes" and "no" items (*Z:* -,868; *p:* .000). This confirms that participants' performance with the lexical items learned throughout the training sessions differed from the lexical items introduced only in the task to elicit "no" answers, which signals again for participants' consistent performance with the trained lexicon. Table 12 below demonstrates that participants' scored relatively higher latencies for "no" items in both levels of orthographic depth, showing that opaque items took longer to be recognized auditorily.

Table 12 - Descriptive statistics for "yes" and "no" items according to orthographic consistency

Consistent orthography				
	M	SD	Min.	Max.
Yes items	971ms	194ms	572ms	1543ms
No items	1059ms	169ms	324ms	1527ms

Inconsistent orthography				
	M	SD	Min.	Max.
Yes items	937ms	192ms	462ms	1596ms
No items	1017ms	207ms	615ms	1764ms

The next analysis revolved around whether orthographic consistency affected latencies for the "no" items with the Auditory Lexical Decision task. A Mann-Whitney U test, using orthographic consistency as the grouping variable, demonstrated that answers for the "no" items were affected by the level of the orthographic depth of those lexical items: *Z*: -3,026; *p:* .002. This result unveils two relevant caveats for orthographic recruitment when learning a new lexicon, which are considered below.

First, it shows that upon encountering auditorily with an unfamiliar item, participants recruited orthography, even though this was a task that consisted only of aural stimuli. Thus, orthography was active as one of the mechanisms that aid lexical analysis in a lexical decision task. This demonstrates that orthography can be necessary to auditory tasks, when subjects are compelled to conduct auditory analyses of new lexical items, which leads us to the hypothesis that linguistic systems can act in an encapsulated manner according to task demands. Previous research has posited that systems of representation (i.e., phonological, orthographic, etc.) can work in encapsulated manner to execute lexical access (Damien & Bowers, 2009). In this vein, the presence of orthographic effects can be interpreted as evidence for orthographic recruitment to be a strategic process(Cutler & Davis, 2012; Cutler, Treiman, & van Ooijen; 2010; Taft, 2011; Yoncheva et al., 2013) that renders a unique processing principle that is specific to initial stages of instructed language acquisition. As written input is referred to constantly in initial stages of instructed language acquisition, orthography develops onto a system that strategically supports other linguistic processes that involve lexical knowledge for diverse tasks.

Therefore, by contrasting the results for the trained ("yes") and untrained ("no") items, we can hypothesize that orthographic effects are prevalent in earlier stages of acquisition because orthography acts as an aid for the establishment of new lexical categories. The orthographic system might assist the mapping of the phonological input to their grapho-phonic correspondences, thus leading to the creation of a "visual" lexical representation, which studies have argued to be stronger in the adult lexicon

(Veivo & Järvikivi, 2013). As for the absence of such an effect for the trained words, we entertain that subjects had already formed lexical categories for them, at least in their working memory system, rendering orthography unnecessary for the lexical decision task in this category of items.

Hypothesis 1.1 that foresaw orthographic influences in speech perception is considered to be partially confirmed, as orthographic effects were found only for the untrained items ("no" answers) in the Auditory Lexical Decision task.

5.1.2 Orthographic effects in speech production

To conduct the data analysis for the Timed Picture Naming task, the statistical model included a continuous variable (response latencies), along with orthographic consistency, with two levels (consistent and inconsistent). The data spreadsheets were inspected for any data cases with negative and "no response" latencies (latencies that are automatically set to 2500ms by CheckVocal), which were excluded. Participants scored 68% of valid responses (*N:* 2141 data cases containing correct responses with no time out values). This number was slightly higher than the amount obtained with the pilot, in which 60% of responses were valid cases for analysis. Participants timed out on 13% of trials (4,29% with consistent items and 9,62% with inconsistent items).Again, missing values were unchanged, and the data were analyzed with multi-level statistical models, which are better equipped to analyze missing values (Lachaud & Renaud, 2011).

Overall, participants scored a mean time of 1085ms to produce oral responses, with latencies ranging from 464 to 2366ms in response time. The average SD reached 354ms. To inspect any differences in performance according to control (consistent) or experimental (inconsistent) items in the orthographic condition, descriptive statistics were run. Table 13demonstrates that items from the control condition, that is, transparent pseudowords, were named faster than items from the experimental condition (consistent: 1038ms; inconsistent: 1134ms), as seen in previous studies with naming (Cortese & Simpson, 2000). Moreover, SD values did not vary as much in the control condition when compared to the experimental condition, attesting that participants varied to a lesser extent when producing consistent words (consistent: 332ms; inconsistent: 370ms).

Table 13 - Descriptive statistics for the Timed Picture Naming task

Descriptive statistics	Consistent orthography	Inconsistent Orthography
Mean	1038ms	1134ms
SD	332ms	370ms
Min.	464ms	496ms
Max.	2289ms	2366ms

Tests of normality indicated that response latencies did not achieve normal distribution across the two conditions (*p*: .000). Thus, a Man-Whitney U test, which detects if there are significant differences between conditions, was run to observe whether orthographic consistency was affecting subjects' performance in naming the lexicon learned during training. The probability value achieved significance (*p:*.000; *Z:*-6,343), thus demonstrating that orthography influenced picture naming with this sample of subjects[45].

Therefore, it can be argued that the process of converting the visual input into its phono-articulatory representations for production, which is mediated by lexical selection, involves the activation of orthographic codes, corroborating the hypothesis that for second language learners, orthography acts as a compensatory mechanisms that assists lexical selection in speech production. By calling it a compensatory mechanism, I argue that it compensates for lack of skill in computing the grapho-phonic combinations used in the inconsistent lexicon for the present study. In this vein, it is important to note that these orthographic effects might be due to a frequency effect caused by the graphophonic combinations used in the stimuli. Once that a new graphophonic combination was encoded by the subject, the orthographic information of this combination would be recruited in tandem with the phonological information as a way of "assisting" lexical access for recently established lexical categories that might still be unstable.

This echoes previous research that claimed that inconsistent mappings would affect subjects' performance in phonological tasks (Escudero et al., 2008; Escudero et al., 2014; Hayes-Harb et al., 2010).

[45] In the pilot, which was conducted with a sample consisting of eleven subjects, the *p* value also achieved significance: *Z*: -2,402.; *p*: .016.

However, the reason for this effect might not rely on the inconsistency of the graphophonic combination, considering that this sample of subjects is highly literate, but on the infrequency of such combination. This could be regarded as an effect of lack of skill for computing such associations in the sublexical route. The degree of activation of orthography in this particular case is rendered higher because of the graphophonic frequency, thus motivating an orthographic effect.

In such enterprise, research has argued that idiosyncrasies between languages orthographic depths can highly impact auditory and visual processing (Frost, 1992, 1998, 2005; Ziegler & Ferrand, 1998; Ziegler et al., 2004; Ziegler & Muneux, 2007). Thus, given that Brazilian Portuguese is a relatively transparent language if compared to English opacity, graphophonic frequency, that is, the frequency to which a grapheme maps onto a phoneme, affected subjects' phonological processing given that the opaque mappings are based on multiple conversion rules to which they are not adapted.

In order to analyze the incorrect responses of this task, the number of incorrect oral responses was calculated according to word by using the function "crosstabs" on SPSS. By conducting a visual inspection, the words "geop", "doup" and "pood", all of which present with inconsistent orthography, accounted for the most number of incorrect responses, as can be seen in Table 14 below.

Table 14 - *Words along with number of errors and neighborhood sizes*

Nonword	***N* of errors in production**	**Orthographic *N*-size**	**Orthographic *N*-frequency**	**Phonological *N*-size**	**Phonological *N*-frequency**
geesh	28	2	3,000	9	3,000
keet	18	8	3,375	34	3,088
seeg	25	7	2,857	17	3,000
deit	49	5	3,600	26	3,000
geib	52	1	4,000	4	3,000
meip	36	1	1,980	20	3,000

geop	99	1	3,000	15	3,000
teog	72	0	0	11	3,000
teob	43	0	0	11	3,000
bup	48	16	2,938	21	3,048
nup	32	9	0	13	3,000
sud	38	17	3,176	32	3,125
doup	87	2	3,000	22	3,045
soug	36	8	3,375	25	3,120
toud	49	6	3,000	28	3,036
dood	55	10	2,889	32	3,045
pood	65	16	2,938	22	3,045
loob	33	7	2,857	20	3,050

To observe if neighborhood size, both orthographic and phonological, motivated any sort of lexical competition that could result in errors in word retrieval for spokenproduction, the number of incorrect responses of each word was correlated to all neighborhood measures as demonstrated in the Table above. Spearman correlations did not achieve significance for any of the correlated variables (orthographic size: *p:* .312, *rho:* -.253; orthographic frequency: *p*: .770, *rho*:.074; phonological size: *p*: .927, *rho*: -.023; phonological frequency: *p:* .618, *rho*: -.126). Next, in another attempt to observe which variable motivated the errors in production, the experimenter recoded the number of errors in production and the neighborhood sizes into a total, according to the type of digraph that the lexicon encompassed. It is fitting to remind the reader that each word of the lexicon presented with a digraph in its nucleus position that was manipulated according to the orthographic metric (consistent and inconsistent). The results of such scrutiny can be seen in Table 15 below.

Table 15 - Total number of errors and neighborhood sizes according to nucleus

Type of nucleus	Orthographic metric	Total *N* of errors in production	Total orthographic neighborhood size	Total phonological neighborhood size
<ee>	Consistent	71	17	60
<ei>	Inconsistent	137	7	50
<eo>	Inconsistent	214	1	37
<u>	Consistent	118	42	66
<ou>	Inconsistent	172	16	75
<oo>	Inconsistent	153	33	74

Spearman correlations were run again to observe whether the type of digraph in each word could be correlated to the neighborhood sizes and to the number of errors in the naming task. Such correlations did not achieve significance (orthographic neighborhood size: *p*: .208, *rho*: -.600; phonological neighborhood size: *p*: .967, *rho*: -.029). However, it can be interestingly noted that the graphophonic combination with the most number of errors in oral production is the one with the smallest orthographic neighborhood (<eo>, which accounts for 214 incorrect responses, and one orthographic neighbor). This shows that the lack of subjects' familiarity with this specific graphemic string resulted in errors in the conversion of such a combination to its phonological components preceding production, which can be interpreted as evidence to the fact that orthographic information actively influenced subjects' generation of spoken responses to this specific item and throughout the task, in general. This also demonstrates that the orthographic effect was resulting of lack of skill in the sublexical route to compute such visual information onto its aural components.

As concerns subjects' incorrect answers provided for the task, they consist of similar-sounding words or of items that shared orthographic components in the syllable with the target pseudowords.To take a case in point, "calm" is a frequent word that was provided in many answers instead of the target pseudoword "galm" for both items rhyme. Moreover, other frequent words that shared the same onset and coda with the target pseudowords of the study were also provided: "dude" and "dad" instead of the target "dood"; "nap" instead of "nup", "sad" for "sud", "gum" for "galm". Taken together, these results illustrate evidence for the fact that subjects were able to encode the orthographic form of these new lexical items presented over training. However, due to lack of vast experience with the trained items that resulted in unstable lexical categories, or perhaps interference in processing due to lexical competition among the trained items and such real words, research subjects ended up providing these frequent words as responses for they were more strongly activated for naming.

Overall, the results presented in this Chapter provide evidence for the claim that orthographic information can be accessed conjointly with phonological information in strategic manner, but such an excitatory mechanism will work strategically due to an effect of graphemic frequency. In this case, orthographic information bypasses phonological information in their level of activation, thus influencing lexical access. This presents serious implications for additional language acquisition and models of lexical access because of orthography, a source of information that would appear to be redundant in auditory tasks, is used strategically due to a frequency effect in recently learned graphophonic combinations.

Notwithstanding, an operation that is performed for reading is also present in phonological processing, suggesting that systems of representation (phonological, orthographic, and semantic) can work in encapsulated manner to execute lexical access, as previous research has argued for (Damien & Bowers, 2009), granted the nature of the tasks involved to measure such an operation and the input stimuli.

Last, Hypothesis 1.2 that predicted orthographic effects in spoken production was confirmed. Next, the nature of orthographic recruitment, whether mandatory or strategic, is discussed.

Hypotheses 3 and 4 wondered whether orthographic recruitment is mandatory or strategic in phonological processing. Such an inquiry derives from two existing theoretical strands in the literature. The offline position argues that orthography and phonology are jointly associated as a result of literacy and contribute to the constitution of lexical knowledge (Chéreau, Gaskell, & Dumay, 2007; Damien & Bowers, 2003; Frost & Ziegler, 2007; Perre & Ziegler, 2008; Ziegler & Ferrand, 1998; Ziegler, Ferrand & Montant, 2004). Thus, both orthography and phonology comprise lexical knowledge that is active and interact when linguistic units (phonemes, morphemes, words etc.) are to be recognized auditorily. On the other hand, on-line activation of orthography is a result of task requirements, which renders varying types of information that are strategically employed to perform the task at hand (Cutler & Davis, 2012; Cutler, Treiman, & van Ooijen; 2010; Taft, 2011; Yoncheva et al., 2013).

Our results provide evidence to the claim that orthographic information is jointly associated to phonological information in the lexicon of literate adults (Cutler, 2008; 2015; Frost & Ziegler, 2007; Veivo & Jarvikivi, 2013), as an orthographic effect was present for the untrained words in the Auditory Lexical Decision task, according to what is discussed in session 5.2.1. However, differently from what Hypothesis 1.3 predicted, these effects were not continuous according to subjects' responses, as they were restricted to the untrained words used for the "no" answers. Thus, it can be argued that when new lexical categories are presented, the recruitment of orthography is strategic in phonological tasks and used as a compensatory mechanism to aid lexical access for these new lexical categories. Hence, such results more strongly add up to the hypothesis that orthographic information can be retrieved strategically in auditory tasks, when no exposure to print is taking place.

As concerns spoken production, orthographic effects influenced subjects' responses, as shown in section 5.2.2. We argued that this effect appears as a response to lack of skill in the sublexical route to compute such infrequent graphophonic combinations. This shows that bilinguals recruit orthography to assist oral production in cases as such, when this system functions as a strategic mechanism that aids lexical encoding and, consequently, influences lexical access.

Moreover, our results also favor the argument Kuhl (2000) puts forward when the neuroscientist argues that humans carry innate learning strategies. Being able to strategically recruit a system that is non-mandatory to assist processing of newly presented auditory information is a reflection of how proficiently able bilinguals are to deal with linguistic stimuli to which they are not familiar. Considering all of the above, Hypothesis 1.3, which projected that orthographic recruitment would be strategic, was confirmed.

CHAPTER 6 - FINAL REMARKS

The objective of the present chapter is to summarize the results obtained with this study, while discussing the pedagogical and theoretical implications of these findings, the limitations of the study and suggestions that should warrant further research within this research agenda.

6.1 SUMMARY OF FINDINGS

The present study sought to attest for the plausibility of orthographic recruitment over L2 phonological processing with a sample of Brazilian Portuguese/English bilinguals. To do so, research subjects were trained with an artificial lexicon that simulated English graphophonic relationships to be tested with an Auditory Lexical Decision task and with a Timed Picture Naming Task.

The Auditory Lexical Decision task brought to light profoundly interesting findings. Orthographic consistency did not affect subjects' responses with the trained ("yes") items in the task, even though latencies were relatively higher with opaque items. However, orthography indeed influenced latencies registered for the untrained "no" items. We argued that upon encountering auditorily with unfamiliar items, subjects recruited orthography as a mechanism that aids lexical analysis in the lexical decision task. In this vein, orthographic recruitment was conceived as a strategic process that supports lexical decision in auditory tasks. This evidences a relevant caveat for second language acquisition: learners are compelled to recruit orthography in initial stages of acquisition, as this system strategically supports processes of lexical analysis, while also exerting influence onto the integration of new lexical entries in the adult lexicon (Saletta, Goffman, & Brentari, 2015). Anecdotal evidence shows that adult learners expect orthographic information to be presented along with phonological information in instructed settings, as many claim that they are able to understand what they hear once they have been presented with its written form.

The Timed Picture Naming task indicated that orthographic consistency also influenced subjects' latencies in naming the trained lexicon. We argued that lexical selection involved the activation of orthographic codes as if orthography were a compensatory mechanism to assist lexical selection in speech production, at least for recently learned words. In such enterprise, we pointed out that this orthographic effect might have been due to a frequency effect because of the infrequency of the graphophonic combinations used in the lexicon so that phonological and orthographic information would be recruited in tandem as a way of assisting lexical access for recently stablished lexical categories.

Last, we interpreted the results aforementioned as evidence for orthographic recruitment to be a strategic process in phonological tasks which can be used as a compensatory mechanism to aid lexical access for new lexical categories in the adult lexicon. Such an excitatory mechanism works strategically because of a frequency effect motivated by the graphophonic combination. Importantly, these results show that a source of information that would appear to be redundant in auditory tasks is actively playing a role in lexical processing, showing that linguistic systems can work in encapsulated manner to execute lexical access (Damien & Bowers, 2009).

6.2 STUDY LIMITATIONS AND SUGGESTIONS FOR FURTHER RESEARCH

In this section, factors that were not regarded in the present study, but still are relevant for further studies to look at the role of orthographic and phonological processing are outlined.

Initially, the present study considered L2 proficiency level as a factor to be considered in subjects' recruitment. However, for the final data collection, the investigation of L2 proficiency level did not advance. Taking into account the discreet and unreliable results obtained with the pilot, the difficulty of findings learners with lower levels of proficiency who were willing to participate in the study, and the fact that adding one more task or a proficiency exam to have proficiency measured would add a considerable amount of time to an already lengthy session[46], we decided to focus on what was more urgent at that time, which was recruiting participants who would be able to fully participate in the training with the artificial lexicon. The role of proficiency for a nuanced understanding of the processing of lexical knowledge is of utmost importance and it

[46] Subjects took about two hours to complete all the tasks in both the training and the testing sessions. Participants who opted for more breaks prolonged the data collection session to about two hours and twenty minutes.

warrants further research to unveil its influence on the processing of auditory forms, as encompassed in the present study.

Another factor which has not been included in the scope of the present investigation is working memory capacity. Such cognitive faculty has a powerful influence on language learning for it defines “how much information can be managed, processed and integrated effectively all at once” (Wen, Mota, & McNeill, 2015 p. xx). It is well known that individuals vary in their working memory span, which results in different learning outcomes.

When it comes to the stimuli used in this study, listener-adaptation effects were also not regarded. Studies have demonstrated that listeners may form lexical representations by encoding a speaker-specific phonetic index, which is integrated during lexical activation and selection processes (Trude & Brown-Schmidt, 2012). As the same female voice was used for the training stimuli and the Auditory Lexical Decision task, future research should remediate for that.

Another methodological issue in the present study is the absence of a control group. This study sample encompassed Brazilian Portuguese speakers who were learners of English. Therefore, the two languages in contact contrasted in their orthographic depth, the former as a transparent language, the latter as an opaque language. Yet, it would be necessary another group whose additional language were also a transparent language, such as Spanish. This way, we would more certainly know that orthographic effects arise from the idiosyncrasies of contrasting orthographic depths.

As concerns baseline data, the present study did not make use of a baseline for reaction speed data from the participants. Participants’ latencies should be registered with other pseudowords so that the variance encountered in RT data could be attributed only to an effect of the investigated independent variable, and any variance caused by individual differences could be ruled out.

Last, research still needs to unveil whether the paradigm investigated here reflects a strategic, problem-solving operation or if such a mechanism belongs to long-term knowledge and is invariable to language activation. A different study design could be able to track whether the recruitment of orthography is committed to learning conditions, or if it engages in everyday, more naturalistic tasks of language use, in which attention is not so stimulus-driven (such as listening to music, watching TV, etc).

6.3 PEDAGOGICAL IMPLICATIONS

The present work attested for the influence of orthographic codes on phonological processing in a second language, especially for adult learners, given the powerful influence of orthography on the integration of new vocabulary for the adult lexicon. An appraisal to such an account is still expected in Applied Linguistics, as teaching methods and procedures need to demonstrate when and how orthographic information can be presented conjointly with phonological information to foster speech acquisition in instructed settings. The idiosyncrasies of the orthographic systems of the languages in contact need to be considered, as well as the challenges learners are posed with certain phonological features of the target system.

Previous evidence suggests that orthographic codes might hinder (Escudero et al., 2008; Hayes-Harb et al., 2010), facilitate (Cutler & Davis, 2012; Han & Kim, 2017) or present mixed effects (Escudero & Wanrooij, 2010; Escudero et al., 2014) to the learning of phonological forms. The overall claim such studies put forward is that when the orthographic system is opaque, it will interfere with the learning of phonological forms. Instructors and language practitioners need to be able to assist students with such cases and observe what graphophonic combinations might help learners implement a lexical distinction that will trigger the acquisition of certain phonemes. Orthographically-induced lexical distinctions might, at first, aid with the perception of a certain phoneme to, later on, result in a distinction in production, as well.

Conclusively, the main purpose of the present research was to contribute to a more nuanced understanding of bilingual cognition, with an eye to second language speech acquisition and processing. By no means, we intended to exhaust the questions or paradigms that composed the present inquiry, but to confront them, and observe whether they are fitting to offer us some insight into the fascinating and complex nature of human cognition. In this vein, investigating speech gave us a window into human cognition for "speech is our sixth sense, the sense by which we can observe, and have access to the contents of, our mind" (Levelt, 2013, p. 107).

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APPENDIXES

APPENDIX A–*QUESTIONÁRIO*

Prezado (a) participante,
Este questionário visa somente obter informações que serão utilizadas para direcionar a análise de dados desta pesquisa. Sob *nenhuma* hipótese, sua identidade será revelada, como também não serão divulgadas quaisquer informações que possam identificá-lo. Solicito informar nome e e-mail somente para que, no caso de necessitar alguma informação adicional, eu possa entrar em contato posteriormente.

1. Nome: ____
___________________________.

2. Idade: _____. 3. Sexo: FEM / MASC 4. E-mail: ________________
______________________.

3. **Além de inglês**, você fala alguma outra língua estrangeira?
Sim ❑ Não ❑
a) Qual língua fala? __________________.
b) Qual é sua proficiência nessa língua?
Básico❑ Intermediário❑ Avançado❑
c) Você já fez algum teste de proficiência nessa língua? Se sim, por favor, reporte o resultado:
____
____

4) Por quanto tempo você estudou Inglês?

	1 ano	2 anos	3 anos	4 anos
Pré-escola	❑	❑	❑	❑
Ensino Fundamental	❑	❑	❑	❑
Ensino Médio	❑	❑	❑	❑
Escola Particular	❑	❑	❑	❑
Outro	❑	❑	❑	❑

Se estudou inglês por mais de 4 anos, indique o local e o número de anos em que estudou inglês: ____ __________________________________.

5) Quantos anos você tinha quando começou a estudar inglês com regularidade? ______.

6) Você já esteve em algum país onde utilizou inglês como o principal meio de comunicação? Se sim, por favor, informe onde, quando e por quanto tempo permaneceu lá.
____ ______________.

7) Caso queira compartilhar alguma outra informação, por favor, descreva abaixo. ____ ________________________.

APPENDIX B – *CONSENT FORM*

TERMO DE CONSENTIMENTO LIVRE E ESCLARECIDO

Prezada/o participante,

você está sendo **convidado** a participar de uma pesquisa sobre o aprendizado de palavras em língua estrangeira. Essa pesquisa visa contribuir com o nicho de pesquisa em Aquisição de Língua Estrangeira, principalmente no que tange às disciplinas de Fonologia Aplicada e Psicolinguística. Esse projeto, intitulado*O processamento de palavras por adultos aprendizes de inglês*, trata da pesquisa de doutorado do aluno Alison Roberto Gonçalves, que é orientado pela professora Dra. Rosane Silveira, junto ao Programa de Pós-Graduação em Inglês na Universidade Federal de Santa Catarina (UFSC).

Os pesquisadores responsáveis por essa pesquisa, citados nominalmente no parágrafo anterior, serão os únicos a ter acesso aos dados por você cedidos e tomarão todas as providências necessárias para manter o sigilo de sua identidade. Os resultados deste trabalho poderão ser apresentados em encontros ou revistas científicas e mostrarão apenas os resultados obtidos como um todo, sem revelar seu nome, instituição ou qualquer informação relacionada à sua privacidade.

A legislação brasileira não permite que você tenha qualquer compensação financeira pela sua participação em pesquisa. Você não terá nenhuma despesa advinda da sua participação na pesquisa. Se necessário, você será integralmente ressarcido em dinheiro pelas despesasde transporte ao ter que se dirigir à UFSC, onde ocorre a coleta de dados. Conforme o item IV.3 (h) da Resolução 466/2012, haverá garantia de ressarcimento dos gastos pelo pesquisador responsável, bem como indenização diante de eventuais danos oriundos da pesquisa.
Não há benefícios associados à sua participação. Dentre os riscos associados à sua participação, estão:

a. cansaço físico, constrangimento ou aborrecimento ao participar de diversas tarefas que exigem a sua atenção;

b. desconforto ou constrangimento ao reportar ao pesquisador informações gerais e impessoais sobre a qualidade de seu sono;

c. desconforto ou constrangimento durante a gravação de áudio;

d. risco de quebra de sigilo.

Ao aceitar participar dessa pesquisa, você participará de***três encontros***, em ***dias consecutivos***, com o pesquisador responsável, para desempenhar as tarefas abaixo descritas:

Dia 01: No primeiro dia,você reportará ao pesquisador um número aproximado de horas dormidas na noite anterior e, em seguida, indicará a qualidade de seu sono em uma escala. Após o preenchimento dessa escala, você aprenderá novas palavras em inglês a partir da associação de imagens às suas formas auditivas em uma sessão de treinamento. O treinamento consiste de: (i) cinco blocos de aprendizado, em que, após ver uma imagem e ouvir a palavra correspondente, você deve repeti-la em voz alta e, (ii) outros cinco blocos de testagem, em que você deve associar cada forma auditiva *à sua imagem. Você pode fazer* intervalos de até cinco minutos para descanso a cada dois blocos. É recomendável fazer no mínimo um intervalo para ir ao toalete, checar seu telefone etc. Ao final desse encontro, você fará um teste de associação de som e imagens, que será gravado em áudio para análise das respostas. Para finalizar, você responderá um questionário de uma página (sete perguntas concisas) sobre como aprendeu inglês. O tempo previsto para a duração de sua participação nesse primeiro dia pode variar de 50 a 60 minutos, dependendo do número de intervalos que você decidir fazer. O pesquisador pode pedir para que você coloque seu celular em modo silencioso para evitar quaisquer distrações durante a sua participação no treinamento.

Dia 02: No segundo dia, você reportará ao pesquisador um número aproximado de horas dormidas na noite anterior e, em seguida, indicará a qualidade de seu sono em uma escala. Em seguida, você fará o mesmo treinamento do dia interior, descrito acima. Novamente, você pode fazer intervalos de até cinco minutos entre cada um dos blocos. É recomendável fazer no mínimo um intervalo para ir ao toalete, checar seu telefone etc. Ao final desse encontro, você fará um teste de associação de som e imagens, que será gravado em áudio para análise das respostas. O tempo previsto para a duração de sua participação nesse segundo dia pode variar de 60 a 70 minutos, dependendo do número de intervalos que você decidir fazer. O pesquisador pode pedir para que você coloque seu celular em modo silencioso para evitar quaisquer distrações durante sua participação nos experimentos.

Dia 03: No terceiro dia, você novamente reportará ao pesquisador um número aproximado de horas dormidas na noite anterior e, em seguida, indicará a qualidade de seu sono em uma escala. Em seguida, você fará quatro experimentos: no primeiro, você deverá decidir se a palavra que você ouve é uma palavra real ou não; no segundo, você deverá nomear as imagens que vê na tela do computador; em seguida, você receberá um formulário com imagens e deverá escrever seus nomes ortograficamente. Para finalizar, você ouvirá dez sentenças em inglês e deverá colocar as palavras de cada uma na ordem correta. Novamente, você pode fazer intervalos de até cinco minutos entre cada um dos experimentos. O tempo previsto para a duração de sua participação nesse terceiro dia é de 50 a 60 minutos, dependendo do número de intervalos que você decidir fazer.
Durante os procedimentos de coleta de dados, você estará sempre acompanhado por um dos pesquisadores, que lhe prestará toda a assistência necessária ou acionará pessoal competente para isso. Caso tenha quaisquer dúvidas sobre os procedimentos ou sobre o projeto, você poderá entrar em contato com o pesquisador a qualquer momento pelo telefone ou o e-mail abaixo informados. Sinta-se absolutamente à vontade para deixar de participar da pesquisa a qualquer momento, inclusive durante os procedimentos da coleta de dados, sem ter que apresentar qualquer justificativa. Ao decidir deixar de participar da pesquisa você não terá qualquer prejuízo. Apenas informe o pesquisador, via e-mail ou telefone, para que ele exclua os dados e informaçõescedidos por você.

Duas vias deste documento estão sendo **rubricadas e assinadas** por você e pelo pesquisador responsável. Guarde cuidadosamente a sua via, pois é um documento que traz importantes informações de contato e garante os seus direitos como participante da pesquisa.

O pesquisador responsável, que também assina esse documento, compromete-se a conduzir a pesquisa de acordo com o que preconiza a Resolução 466/12 de 12/06/2012, que trata dos preceitos éticos e da proteção aos participantes da pesquisa.
Você poderá entrar em contato com os pesquisadores pelos seguintes telefones e e-mails:

Alison: **(48) 9683-8179 /alison.rg@hotmail.com**.
Rosane: **(48) 9615 – 9978 / rosanesilveira@hotmail.com**

Você também poderá entrar em contato com o Comitê de Ética em Pesquisa com Seres Humanos da UFSC pelo telefone **3721-6094**,ou pelo e-mail **cep.propesq@contato.ufsc.br** ou pessoalmente na rua **DesembargadorVitor Lima, número 222, sala 401 - Prédio Reitoria II**.

Eu, ____ (nome completo), RG ____________________, li este documento e obtive dos pesquisadores todas as informações que julguei necessárias para me sentir esclarecido e optar por livre e espontânea vontade participar da pesquisa.

Assinatura do participante: _____________________________________

Assinatura do pesquisador principal, Alison Roberto Gonçalves: _______________________________

Assinatura da pesquisadora responsável, Profa. Orientadora Rosane Silveira: _____________________

Florianópolis, _____ de ____________ de 201__.

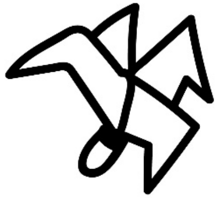
APPENDIX C – *PARTICIPANTS' INFO*

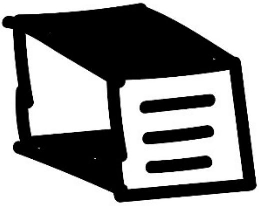
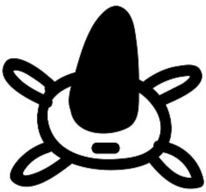
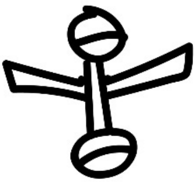
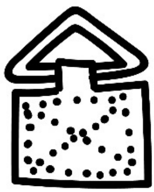
Pilot								
Code	Sex	Age	Occupation	English Proficiency measure		Proficiency rating	AoA	Other additional languages
1	M	29	PhD candidate in Engineering	567	TOEFL ITP	Low	17	French
2	M	19	English major	623	TOEFL ITP	High	7	German
3	F	25	English MA candidate	527	TOEFL ITP	High	9	French
4	F	33	PhD candidate in Linguistics	---		Low	12	French, Italian, Spanish
5	F	18	English major	---		Low	9	Danish, Russian, Swedish
6	F	42	PhD candidate in Biology	470	TOEFL ITP	Low	19	---
7	M	30	English MA candidate	---		High	12	Spanish
8	M	36	PhD candidate in English	820	TOEIC	High	12	Spanish
9	M	18	English major	---		High	8	---
10	M	24	English major	610	TOEFL ITP	High	8	Spanish, German
11	F	18	English major	---		Low	11	---

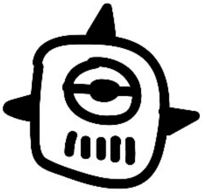
Final data collection								
Code	Sex	Age	Occupation	Proficiency	AoA	Other additional languages		
1	F	19	English major	H	6	French, Spanish		
2	F	20	Accounting major	I	5	Spanish		
3	F	21	English major	H	16			

4	F	18	English major	H	6			
5	M	26	English major	H	13	Italian		
6	M	18	English major	m	8			
7	M	32	MA candidate	I	10			
8	F	28	English major	H	22			
9	F	32	English major	I	13	Japanese, Korean, Spanish		
10	M	28	English major	H	18			
11	F	25	MA Candidate	I	10	French, Italian		
12	M	19	Engineering major	H	10	Italian		
13	M	19	English major	H	15			
14	M	24	English major	H	18	French		
15	F	46		H	18	Spanish		
16	F	20	English major	H	12	Spanish		
17	F	40	MA candidate	H	16	German, Spanish		
18	F	27	English major	H	15			
19	M	27	PhD candidate	H	8	French		
20	M	27	English major	H	18			
21	F	29	English in-structor	H	18			
22	M	22	MA candidate	H	11			
23	F	28	PhD candidate	H	14			
24	F	46	Japanese and Portuguese instructor	H	15	Japanese		
25	F	25	English major	H	16			
26	F	23	English major	H	5			
27	M	22	English major	H	17	Spanish		
28	F	29	MA candidate	H	15	German		
29	F	18	English major	H	11			
30	F	21	English major	H	16			
31	F	26	Philosophy major	H	13	Spanish		
32	M	30	PhD candidate	H	10	French		
33	F	20	English major	H	17			
34	F	19	English major	H	15			
35	F	47	PhD candidate	H	23	Ucranian		
36	M	20	English major	H	8	Spanish		

APPENDIX D – ***LEXICON USED IN THE STUDY***

 BALSH	 BUP
 DEIT	 DOOD
 DOUP	 GALM
 GEESH	 GEIB

 GEOP	 KEET
 LOOB	 MALP
 MEIP	 NUP
 PALB	 POOD

 SEEG	 SOUG
 SUD	 TEOB
 TEOG	 TOUD