Grapheme-to-Phoneme Mapping in L2 and L3: Lexical and Sublexical Processing in Reading Aloud

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Abstract

EMILY ALICIA ANDINO: Grapheme-to-Phoneme Mapping in L2 and L3: Lexical and Sublexical Processing in Reading Aloud
(Under the direction of Jennifer L. Smith)

In this study of non-native reading aloud, subjects with L1 English, L2 Spanish, and L3 Brazilian Portuguese were asked to read words that are spelled identically in their L2 and L3 but are pronounced differently. Each of these "homographic heterophones" was primed in either the L2 or the L3, and its subsequent pronunciation was assessed for context appropriateness. Participants were found to produce many more context-inappropriate pronunciations in L3 context than in L2 context, supporting the Foreign-Language Effect hypothesis (Meisel, 1983; Hammarberg, 2001); priming was not found to have a significant effect on pronunciation. The observation of mixed pronunciations, or single words produced partially with L2 and partially with L3 phonology, is incorporated into the development of a model of reading in non-native languages that allows for whole lexical representations to be broken into sublexical units when reading aloud, contrary to Coltheart (1993).

For my grandparents

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1 Introduction

While a large body of research is devoted to investigating second-language acquisition, there has been much less investigation surrounding the acquisition of subsequent languages. For instance, a Google Scholar search for "L2 acquisition" yields 28,500 results, but a search for "L3 acquisition" only yields 939 results. Although notable differences have been demonstrated between native and non-native language acquisition, the same brain areas have been shown to be activated during use of L2 and L3 (De Bot and Jaensch, 2015). Overlapping patterns of cortical activation demonstrate biological similarities in second- and third-language processing; however, the development of a cognitive model of L2 and L3 processing is still under discussion (Cenoz, 2001; Ecke, 2015; Kellerman & Smith, 1986; Marx & Mehlhorn, 2010; Tremblay, 2006). Building a model of L2 and L3 storage and interaction is an avenue to understanding the cognitive architecture of the mind; examining patterns of non-native language processing may also provide a critical point of comparison between non-native and native language acquisition, speaking to the greater debate in linguistics about what distinguishes native language learning from other kinds of learning.

The broadest question that will be examined in this thesis concerns the nature of non-native language storage. What degree of interaction is there between L2 and L3 in the mind of a non-native language learner? In which direction does phonological transfer flow between these languages? This general question will be investigated within the narrower context of reading aloud in L2 and L3. Interference effects, particularly priming, will be examined alongside order of non-native language acquisition and proficiency to determine which of these factors affects non-native speakers' ability to read aloud. These questions will be addressed using L2 Spanish and L3 Brazilian Portuguese as the foreign languages of study.

In the experiment conducted to test whether interference effects or proficiency-based transfer effects are dominant, participants with L2 Spanish and L3 Brazilian Portuguese were presented with *homographic heterophones* in the two languages to read aloud. Homographic heterophones, or words that are spelled the same but pronounced differently, were of interest because their identical orthographic forms in Spanish and Portuguese correspond to very different phonological forms. Each of these words was primed in either Spanish or Portuguese; afterward, each participant performed a self-paced reading task, in which each word appeared twice in Spanish sentences and twice in equivalent Portuguese sentences. The context-appropriateness of participant responses was measured to gauge the extent to which participants produced a Spanish pronunciation in a Portuguese sentence, and vice versa.

The results of this experiment showed an overwhelming tendency to produce L2 pronunciations in L3

context, regardless of the priming language. Participants with low proficiency in their L3 produced ninety-nine total context-inappropriate responses; of these, ninety-two were L2 pronunciations in L3 context. Even participants with high L3 proficiency produced more L2 pronunciations in L3 context than the other way around. These results strongly support the Foreign-Language Effect hypothesis, which predicts transfer from L2 to L3 in the early stages of L3 acquisition. Furthermore, the observation of the same pattern in high L3 proficiency speakers points to the importance of age of acquisition or length of exposure in directing language transfer. Every participant learned Spanish at a much earlier age than they learned Portuguese; they reported that they began learning Spanish at an average age of 12.6 years and began learning Portuguese at an average age of 21.8 years.

Of the context-inappropriate responses observed in this study, several constituted *mixed pronunciations*, or pronunciations of a single word that incorporated aspects of Spanish and Portuguese phonology. The occurrence of these mixed pronunciations holds important implications for revising a model of reading aloud for non-native languages: namely, a sublexical grapheme-to-phoneme mapping process must be incorporated into a lexical procedure of reading aloud in L2 and L3. These implications will be examined at length in the Discussion section below.

2 Theoretical Background

The general questions raised in the introduction will be discussed in further detail in this section. Non-native language storage will first be addressed, followed by a description of priming and competition effects. Theories of non-native language storage, namely, the Phonological Permeability Hypothesis and the Foreign-Language Effect, will be used to make predictions about participant behavior in the study at hand. Priming and competition effects will also be used to make predictions; however, these predictions will be different than those that follow from the Foreign-Language Effect and Phonological Permeability. The different predictions that follow from these theories will be discussed in depth in Section 3. Models of reading aloud will be discussed as well, though not relative to experimental predictions. Rather, the findings of this study indicate that current reading models must be revised; these findings and revisions will be discussed below in Sections 5.4 and 6.2, respectively. Finally, relevant aspects of Spanish and Brazilian Portuguese phonology will be discussed as they relate to the phonemes under investigation in this project.

2.1 Non-Native Language Storage

2.1.1 Transfer and Cross-Language Influence

The role that L2 knowledge plays in third language acquisition is related to the discussion of the relationship between L2 and the native language. Transfer from the L1 to the L2 is assumed to be a crucial part of acquiring a non-native language (Lado, 1957). Behaviorist scholars who viewed language learning as a subset of all learning proposed the general idea of transfer when learning a new skill (Postman, 1971). The transfer of language in particular is defined by Susan Gass (2013) as "the use of the first language (or other languages known) in a second-language context." Kellerman and Smith (1986) propose the more general term *cross-linguistic influence* to cover all processes by which the knowledge of one language affects the learning of another language. This influence across languages pertains not only to transfer from L1 to L2, but from L2 to L3.

The influence of L2 on L3 has been observed in a variety of aspects of L3 acquisition. For instance, Vildomec (1963) noted the transfer of articles, prepositions, and other function words from the L2, rather than the L1, to the L3. Selinker and Baumgartner-Cohen (1995) document French words placed within a German matrix grammar by a native English speaker. Exposure has been found to play a significant role in the extent to which known languages influence languages acquired later, with increased exposure to L2

resulting in more influence on L3 (Tremblay, 2006). For people immersed in their L1 environment, the L1 is the "strongest" language because its use is habitual due to high exposure. As Tremblay (2006) observes, however, increased exposure to L2 increases the habitual nature of L2 use, allowing for a greater degree of L2 influence on the L3.

Age of acquisition has also been found to affect degree of cross-linguistic influences, with older language learners found to be more susceptible to influence from previously learned languages (Cenoz, 2001). This finding is consistent with the *critical period hypothesis*, defined by Birdsong (1999: 1) as "a limited developmental period during which it is possible to acquire a language be it L1 or L2, to normal, native-like levels." Proponents of the critical period, therefore, believe that a foreign language cannot be acquired with a fully native-like result if the age of acquisition surpasses the critical period. Some scholars advocate a *sensitive period* rather than a critical period, which provides for a less sharp drop in ability to achieve native-like results in acquisition (Long, 1990).

Whether or not one is a proponent of the critical/sensitive period hypothesis, the theory that non-native language acquisition is mediated by language transfer and cross-linguistic influence is well-supported in the literature. That is to say, scholars of non-native language acquisition can agree that knowledge of previous languages influences the learning of a subsequent non-native language. The prevalence of transfer in non-native language learning, then, means that most people who have experience learning multiple languages can relate to the title of Selinker and Baumgartner-Cohen's 1995 work *"Damn it, why can't I keep these two languages apart?"*.

2.1.2 Possible Directions of Transfer

When considering the reality of transfer in non-native language acquisition, there are three logical possibilities of language storage in the mind. Either there is complete integration of L2 and L3, no interaction whatsoever, or a degree of interaction that falls somewhere in between the two extremes. The complete integration of the L2 and the L3 would suggest bidirectional transfer, from L2 to L3 and vice versa. If two non-native languages are stored as one combined "non-native" unit in the mind, we would expect to see the two phonologies of these languages influence each other. However, we would not expect the L2 phonology to interact with the L3 phonology in any way if there is no integration whatsoever of non-native languages in the mind. Therefore, this latter extreme leads us to predict no transfer in the case of completely separate storage.

While bidirectional transfer could result from an intermediate degree of interaction, the observation of unidirectional transfer would also be diagnostic of this mental organization. Neither the complete integration

of L2 and L3 nor the isolated storage of non-native languages would allow for the prediction of unidirectional transfer; the former predicts no discrimination in transfer between the two languages, and the latter predictions no transfer whatsoever. Therefore, an intermediate level of interaction between L2 and L3 would be the only scenario in which unidirectional transfer could be observed. In this case, *intermediate* refers to a level of non-native language storage that is somewhere between the two extremes of the spectrum: complete integration, and absolutely no integration.

In Sections 2.1.3 and 2.1.4 below, two theories of non-native language transfer will be discussed: the Phonological Permeability Hypothesis and the Foreign-Language Effect. While Phonological Permeability predicts L3 to L2 transfer for highly proficient L3 speakers, the Foreign-Language Effect predicts L2 to L3 transfer for L3 speakers with low proficiency. The predictions that each of these theories make are at odds with the predictions that follow from priming and competition effects in certain experimental conditions, as will be discussed below in Section 3.

2.1.3 Evidence for L3 to L2 Transfer: The Phonological Permeability Hypothesis

In a recent study on non-native phonologies, Cabrelli Amaro (2013) found evidence for regressive transfer from L3 to L2. In this study, speakers of English L1, Spanish L2, and Portuguese L3 displayed L2 phonological attrition effects when asked to perform production tasks in Spanish. Cabrelli Amaro proposes that L2 phonology is inherently less stable than L1 phonology; therefore, incorporating an additional non-native language causes L2 phonology to attrite. This *Phonological Permeability Hypothesis* thus predicts unidirectional phonological transfer, moving from L3 to L2. Because this prediction is consistent with real-world observations, Cabrelli Amaro's research supports a model of intermediate interaction between L2 and L3. The Phonological Permeability Hypothesis supports Cabrelli Amaro's experimental results, which show L2 attrition due to L3 learning. This observation of unidirectional transfer indicates that L2 and L3 cannot be stored entirely together, which would result in bidirectional transfer, or entirely separately, which would result in no transfer at all. Some degree of interaction in between is the reasonable explanation for L3 to L2 transfer.

2.1.4 Evidence for L2 to L3 Transfer: The Foreign-Language Effect

Several researchers of third language acquisition have described a *Foreign-Language Effect* (Bannert, 2005; Cenoz 2001; Fernandes-Boëchat & Seibenecher Brito 2008; Gut, 2010; Hammarberg, 2001; Hammarberg & Hammarberg 1993, 2005; Jessner, 2006; Llama, Cardoso, & Collins, 2010; Williams & Hammarberg, 1998; from Wrembel 2010). The Foreign-Language Effect refers to the use of L2 phonology in the production of the

third language. L2 transfer to L3 is prominent at the beginning of L3 acquisition but becomes less and less so as L3 proficiency increases (Wrembel, 2010). Therefore, the more proficient an L3 speaker is, the less likely they are to transfer use their L2 phonology when producing the L3. Although the Foreign-Language Effect predicts the opposing direction of transfer to the Phonological Permeability Hypothesis, these hypotheses are not necessarily at odds; the Foreign-Language Effect does not necessarily contradict the Phonological Permeability Hypothesis for proficient speakers.

2.2 Priming and Competition

The "interference effects" of priming and competition, which cause underlying lexical representations of words to compete with each other, may confound lexical access when a single grapheme maps onto two different phonological representations in L2 and L3. Priming and competition will be investigated here because these effects make different predictions about pronunciation than the Phonological Permeability Hypothesis and the Foreign-Language Effect. Interference due to priming and competition has been observed at the semantic and phonological levels, as evidenced by results of picture-naming and reading aloud tasks, respectively (Howard et al., 2006; Oppenheim et al., 2010; Mulatti et al., 2012). Mulatti et al. posit that these tasks, although different, share key similarities that allow for the comparison of their interference effects; namely, both tasks involve *priming*, *shared activation*, and *competition*. Furthermore, picture-naming and reading aloud are distinguished from recognition tasks because they require production, mandating an additional chain of cognitive processes that goes beyond what is necessary for lexical decision and similar recognition tasks.

Priming, as defined by Mulatti et al. (2012), refers to the process by which the activation of a unit X speeds subsequent access of X . This definition makes a distinction from other uses of the word *priming* in the literature of describing recognition tasks, which may use the term to describe the activation of several units. However, *priming* as it will be discussed here only mediates the subsequent access of a certain activated unit; for example, reading a word aloud primes the retrieval of that same word again, but not different words (Scarborough et al., 1977). The principle of *shared activation*, on the other hand, does refer to the activation of additional units that share qualities of the primed unit. For instance, the activation of the unit *sheep* will cause the shared activation of other units that fall into the set of barnyard animals: *pig*, *cow*, *horse*, etc. The concept of *competition* arises from this principle in that units that have undergone shared activation will compete with each other for selection. Thus, if a subject produces the unit *sheep* and is then prompted to produce the unit *pig*, these two units will compete with each other for selection under the principle of shared activation.

Like Howard et al. (2006) and Oppenheim et al. (2010), Mulatti et al. (2012) observed a cumulative interference effect when Italian speakers were asked to read phonologically similar lexemes aloud; that is to say, competition slowed response time as more orthographic neighbors were presented. These results led Mulatti et al. to propose a similarity-based interference effect claiming that competition inhibits production of units that share a similarity to a primed unit, be it phonological or semantic.

Effects of priming and competition are important because they influence lexical access, as well as the mapping of lexical representations onto phonological forms. Since experimental evidence indicates that L2 and L3 are stored with some level of integration, competition between lexical representations is a crucial component of developing a model of non-native reading aloud (see section 2.1 above for experimental evidence). If there is interaction between L2 and L3 lexical representations, competition will be a significant aspect of how graphemes map onto non-native phonemes when reading aloud in a non-native language.

2.3 Models of Reading

Phonology comprises only one piece of the puzzle in the investigation of reading aloud. While phonology underlies the pronunciation of written words, the mapping of graphemes to phonemes must also be examined. A *grapheme* as discussed here refers to an orthographic unit that maps onto a certain sound, or *phoneme* (Bisani and Ney, 2008). A grapheme is not necessarily the same as a letter of the alphabet; for instance, in English *th* contains two letters but would be considered a single grapheme because it stands for one sound: [θ]. The linking of an orthographic unit to an underlying sound unit is the process of *grapheme-to-phoneme mapping*.

Unlike the Foreign Language Effect, the Phonological Permeability Hypothesis, and the effects of priming and competition, models of reading will not be examined in order to make specific predictions about participant behavior in the study at hand. Models of reading aloud are discussed here because the findings in this study indicate that current models do not sufficiently represent reading aloud in L2 and L3. Current models of reading, proposed by Coltheart (1993) and Seidenberg & McClelland (1989), will be examined in this section. The findings that show a discrepancy with Coltheart's model will be discussed in Section 5.4, and my proposal for a revised model of reading aloud will be discussed in Section 6.2.

Coltheart's (1993) Dual-Route Cascaded (DRC) Model of reading aloud incorporates grapheme-to-phoneme mapping processes in one of the titular "dual routes." Under the DRC model, grapheme-to-phoneme mapping rules are used to read aloud words that do not have entries in the lexicon. For this reason, the route that relies on grapheme-to-phoneme mapping rules is referred to as the *nonlexical procedure*; it can be seen on the right-hand side of Figure 1.

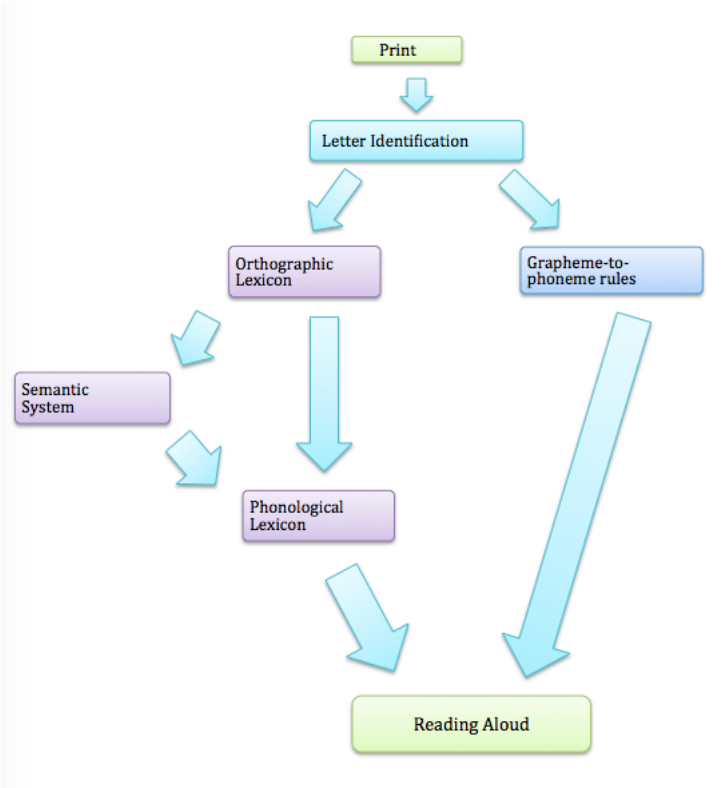

Figure 1: Dual-Route Cascaded Model of Reading Aloud

On the left-hand side of Figure 1 is the *lexical procedure* of reading aloud, used for processing words that have lexical representations. Coltheart divides the lexicon into three components: orthographic, semantic, and phonological. A representation in the orthographic lexicon is accessed upon the identification of a word; this representation contains information about what the word looks like in print. Following access of a word's orthographic representation, there are two possible routes. The corresponding semantic representation of that word may be accessed, which then prompts the access of the word's phonological form. However, the semantic system may be bypassed, causing the orthographic lexical representation to prompt the access of the phonological form directly. These two possible routes within the lexical procedure are demonstrated in Figure 1. This design which allows for orthographic representations to map onto phonological representations, without the access of semantic representations, explains the common phenomenon by which we can read aloud at great length without registering the meaning of what was just read.

The incorporation of a specialized lexical procedure in Coltheart's DRC model necessitates that the lexical entries accessed by this procedure are already learned. By its very definition, the lexical procedure operates by accessing complete representations that are stored in the orthographic, semantic, and phonological lexicons. These lexical entries are not broken down into smaller units during any step of the lexical procedure; they are processed in their entirety. A wordform that does not correspond to any lexical representation may be

broken into smaller units and then processed by grapheme-to-phoneme mapping rules via the nonlexical procedure.

Coltheart argues that this aspect of the DRC model is what distinguishes it as an accurate representation of adult reading (2006). He emphasizes the importance of *visual word recognition* in reading, claiming that "When we open a novel... we encounter many highly familiar words... which we recognize immediately and effortlessly" (p. 6). This claim, which only pertains to skilled (i.e., adult) readers, is centered on the concept that written words are recognized and processed as whole units. There is a competing reading model, however, that does not represent processing that way: Seidenberg and McClelland's (1989) connectionist model.

Seidenberg and McClelland's model does not distinguish between lexical and nonlexical processing. Rather, their model consists of three modules—orthographic, phonological, and semantic—which are linked by stochastically weighted connections. In other words, the connection between a grapheme and a phoneme becomes stronger as it is encountered more frequently. For instance, the connection between the grapheme *m* and the phoneme [m] will be very strong in English, due to the frequent mapping of that orthographic unit onto that phonological unit. The connection between the grapheme *a* and the phoneme [ej] is more tentative, however, since the English letter *a* can map onto various phonemes; consider the English words *sn<u>a</u>p*, *b<u>a</u>rge*, *c<u>a</u>ke*, and *photogr<u>a</u>phy*, in which the grapheme *a* maps onto [æ], [ɑ], [ej], and [ə], respectively. Thus, the system represented by Seidenberg and McClelland's connectionist model would, upon encountering a word like *father*, check the strength of the connections between the grapheme *a* and the possible phonemes that it can map onto, then choosing the phoneme with the heaviest connection weight. This process of using connection strength to determine which phoneme is accessed reflects the *learning* aspect of Seidenberg and McClelland's model. As new information about grapheme-to-phoneme mapping flows in, it is incorporated into the weighting of connection strengths by learning algorithms.

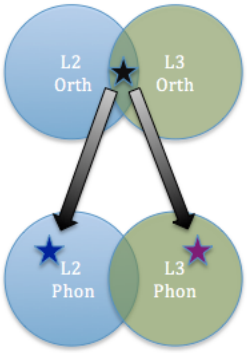

Figure 2: The DRC model revised for reading aloud in L2 and L3

This *learning* component of Seidenberg and McClelland's model makes it an attractive choice when considering reading aloud in non-native languages. What is foreign language acquisition if not a learning process? However, the lexical procedure in Coltheart's DRC model, which is designed around the local representation orthographic and phonological lexemes, provides for the visual word recognition that characterizes reading. In Section 6, a possible relationship between the connectionist and DRC models will be explored in more depth, as it relates to the observation of mixed pronunciations in this study.

In the meantime, the DRC model will be analyzed as the framework for non-native reading aloud. Figure 2 shows the orthographic and phonological lexicon components of Coltheart's DRC model reinterpreted for reading aloud in L2 and L3. This revised portion of the model demonstrates access of differing phonological forms in L2 and L3 that share a common orthographic representation. Such homographic heterophones are not unusual in languages that are closely related, both genetically and culturally. One common example from Spanish and Portuguese is the word *gente*, which means 'people' in both languages but is pronounced [xen̪te] in Spanish and [ʒẽⁿtʃi] in Brazilian Portuguese. Therefore, as demonstrated in Figure 2, one shared orthographic form may map onto two separate phonological forms, resulting in two routes between which the reader must choose. This model, as it stands, does not deviate from Coltheart's proposal in which lexical representations are accessed in their entirety. However, Section 6 will reexamine this assumption in light of experimental evidence from this study, which strongly indicates that orthographic lexical representations are broken into sublexical units, which are subsequently mapped onto sublexical components of phonological representations.

2.4 Spanish and Brazilian Portuguese Phonology

The theoretical questions of reading modeling, interference effects, and non-native language storage will be examined in this thesis through an investigation of grapheme-to-phoneme mapping in non-native speakers of Spanish and Brazilian Portuguese. In order to study grapheme-to-phoneme mapping in these languages, it is necessary to discuss these languages' phonologies and how phonemes are represented in each orthography. The orthographical units discussed in this section were found to be relevant for the purposes of this study because they are written the same in Spanish and Brazilian Portuguese but have different phonetic realizations.

Table 1 shows each grapheme sequence under investigation in this study. The appropriate pronunciation of these graphemes for each language was confirmed by cross-checking texts detailing Spanish and Brazilian Portuguese phonology (Schwegler et al., 2010 and Sá Pereira, 1948, respectively) with native-speaker pronunciations in both languages. These double grapheme units will henceforth be referred to as *bigrams*. The

orthographic units *t* and *d* correspond to dental stops in Spanish; however, the coronal stops [t] and [d] are alveolar in Brazilian Portuguese. Furthermore, in Brazilian Portuguese these stops are affricated before high front vowels. Therefore, the bigram *di* corresponds to the sound segments [dʒi]. The bigram *te* corresponds to the segments [tʃi] in unstressed syllables, following a more general phonological rule in the language that results in the raising of [e] to [i] in unstressed syllables. The phoneme [t] is not affricated before mid vowels; therefore, the bigram *te* is read as [te] in a stressed syllable.

Table 1: Target Bigrams and Pronunciations in Spanish and Brazilian Portuguese

	Spanish	**Portuguese**
unstressed *te*	[t̪e]	[tʃi]
ge	[xe]	[ʒe]
rrV	[rV]	[hV]
di	[d̪i]	[dʒi]
syllable-final *Vl*	[Vl]	[Vw]

The grapheme *rr* is pronounced very differently in Brazilian Portuguese and Spanish. Although this grapheme represents trilled [r] in Spanish, *rr* is pronounced as a glottal fricative [h] in most dialects of Brazilian Portuguese. In some regional dialects, most prominently the dialect of Rio de Janeiro, it is pronounced as a uvular trill [ʁ]. The single *r* grapheme is pronounced as a tap in both languages and is phonemically distinct from the sound represented by *rr*. It is important to note that the sound represented by this grapheme has several different dialectal variants in Brazilian Portuguese when it is syllable-final, including the glottal fricative [h] and even the retroflex [ɹ] in some areas of the state of São Paulo.

The consonant in the Spanish bigram *ge* has somewhat different pronunciations in varying regional dialects, generally corresponding to the velar fricative [x]. Certain dialects in the Americas pronounce this sound as the glottal fricative [h], and dialects in northern and central Spain pronounce it as the uvular fricative [χ]. However, the consonant in this bigram is pronounced as the alveopalatal fricative [ʒ] in Portuguese. As in Spanish orthography, the grapheme *g* is only pronounced as a fricative before front vowels; before back vowels, it is pronounced as the velar stop [g] in both languages. To represent the [g] sound before a front vowel, Spanish and Portuguese use the same orthographic convention: *gui* and *gue* are written for [gi] and [ge], respectively. For instance, the word *guerra*, which is under investigation in this study, is pronounced with an initial velar stop in both languages. Although the grapheme *j* will not be examined in this study, in both languages it represents the same phoneme as the consonant in the bigrams *ge* and *gi*.

The consonant in the *Vl* bigram corresponds to a Spanish alveolar [l]; the *l* grapheme corresponds to [l] regardless of its word position. Note that the *V* in this bigram, as well as in *rrV* represents any vowel. In Brazilian Portuguese, the bigram *Vl* is produced as [Vw] when the consonant is syllable-final. This aspect of Brazilian Portuguese phonology is particularly salient in the native pronunciation of the nation's own name:

[bɾɐziw]. In word-initial context, however, the grapheme *l* in Brazilian Portuguese is produced as an alveolar [l], as in the word *loja* [lozɐ] 'store.'

Despite the regional variation in the pronunciation of certain segments in Spanish and Brazilian Portuguese, the varying sounds in each dialect are similar enough to each other that it is appropriate to compare the pronunciation of the two languages at large. For instance, though the Spanish [x] may be produced as a [h] or a [χ], these sounds are very distinct from the Portuguese [ʒ], both in terms of production and acoustics. The same is true of the rhotic, whose dorsal variants in Brazilian Portuguese are very different from the trilled alveolar [r] found in Spanish.

3 Predictions and Hypotheses

In this section I will discuss general predictions about how non-native speakers will be expected to read words aloud as well as predictions specific to Spanish and Brazilian Portuguese. These predictions are relevant to the experiment described in Chapter 4, in which participants will be primed in one of their non-native languages by reading a short story in either their L2 or their L3. This priming task will be followed by a self-paced reading task that will have participants read aloud *homographic heterophones*, a term which refers to words that are spelled the same but have different pronunciations, in L2 and L3 contexts. General predictions about pronunciation of L2 and L3 caused by priming and language context will be outlined in sections 3.1 and 3.2 below. Section 3.4 will describe specific predictions for Spanish and Brazilian Portuguese, the two languages studied in the experiment.

3.1 Predictions based on Priming

The theoretical background outlined above provides a basis for making predictions regarding the interaction of L2 and L3 during the process of reading aloud. The Similarity-Based Interference effect posited by Mulatti et al. (2012) indicates that the ease of reading aloud L2 and L3 homographic heterophones would be inhibited by switching between L2 and L3 due to the principle of competition. If a word is encountered in the L2, its lexical representation has been primed to map onto the L2 phonological representation. The subsequent encountering of that same lexical representation in the L3 would inhibit the mapping of the lexical representation onto the L3 phonological form, due to the competition caused by the L2 phonological form's priming. This effect is not limited to priming in the L2, and we would expect to see comparable effects of competition if the word were encountered first in the L3.

Similarity-based interference effects (that is, priming and competition effects) on the grapheme-to-phoneme mapping processes used in reading aloud would ideally be quantified by measuring the reaction-time to reading aloud homographic heterophones. However, for the purposes of this project it was not feasible to measure reaction time, so the nature of decoding errors will be considered instead. For the purposes of this study, a *speech error* is considered a context-inappropriate pronunciation: that is, an L2 pronunciation in L3 context and vice versa. Other kinds of errors are not of interest for the experiment at hand. Table 2 shows pronunciation error predictions based on language priming as defined above in 3.

As seen in Table 2, priming a word in L2 is expected to increase the likelihood of L2 pronunciation, and L3 priming makes L3 pronunciation more likely. This prediction follows from the competition between

Table 2: Pronunciation Predictions based on Priming

	Reads in L2	**Reads in L3**
Primed in L2	L2 pronunciation	L2 pronunciation (error)
Primed in L3	L3 pronunciation (error)	L3 pronunciation

homographic heterophones that is initiated when one form is encountered (i.e., primed) before a subsequent form in the other language. Table 2 shows that priming in L2 opens the possibility for errors in L3 context and vice versa. The initial mapping of a lexical representation onto an L2 phonological form primes that same mapping for the next time the word is encountered, inhibiting the access of the L3 phonological form, and the other way around. Therefore, priming in one language increases the likelihood that a lexical representation will map onto that language's phonological form again. For this reason, we would predict errors for the language context that is not identical to the priming context.

3.2 Predictions based on Phonological Permeability and the Foreign-Language Effect

While the Phonological Permeability Hypothesis posits regressive transfer from L3 to L2, the Foreign-Language Effect proposes phonological transfer from L2 to L3; under the Foreign-Language Effect, L2 to L3 transfer is heavy in the early stages of L3 acquisition and lessens as proficiency improves. Table 3 incorporates both Phonological Permeability and the Foreign-Language Effect to make different predictions based on L3 proficiency. Under the Foreign-Language Effect, L2 pronunciations are predicted for L3 speakers with low proficiency; however, Phonological Permeability predicts that L3 pronunciations will be used in both L2 and L3 contexts.

Table 3: Pronunciation Predictions based on Proficiency

	Reads in L2	**Reads in L3**
Low L3 proficiency	L2 pronunciation	L2 pronunciation (error)
High L3 proficiency	L3 pronunciation (error)	L3 pronunciation

As shown in Table 3, errors are predicted in L3 context for low proficiency L3 speakers, while errors are predicted in L2 context for high proficiency L3 speakers. Low L3 proficiency will, according to the Foreign-Language Effect, result in L2 pronunciation in both non-native language contexts, constituting an inappropriate pronunciation in the L3 context. Phonological Permeability, on the other hand, posits regressive L3 transfer that causes the L2 to attrite, resulting in context-inappropriate pronunciations in L2 context.

3.3 Comparing Proficiency and Priming Predictions

Sections 3.1 and 3.2 above outline independent predictions based on interference effects, the Phonological Permeability Hypothesis, and the Foreign-Language Effect. This study, however, includes participants of various proficiencies in L2 and L3 who were randomly assigned a priming language. In this section, I will compare predictions for speakers with low and high L3 proficiency. Within these subsets of speakers, I will discuss what results would be expected if priming effects dominate proficiency effects, and vice versa.

Table 4 shows comparative predictions based on L3 proficiency and priming. Priming and proficiency based hypotheses make the same predictions for low L3 proficiency speakers who are primed in L2 as well as for high L3 proficiency speakers who are primed in L3. Priming predicts that low L3 proficiency speakers are more likely to use the L2 pronunciation when primed in the L2, whereas the Foreign Language Effect predicts that these speakers are likely to default to their L2 phonology, regardless of whether they read in their L2 or L3 following the prime. Although these hypotheses offer different explanations for speakers' behavior, their predictions align.

Similarly, priming and proficiency based hypotheses make the same predictions for high L3 proficiency speakers who are primed in L3. Priming predicts that these speakers will use their L3 pronunciation if primed in the L3; Phonological Permeability predicts that speakers with high L3 proficiency will use their L3 pronunciation as well, regardless of what language they are primed in. Therefore, both hypotheses offer identical predictions for how speakers will behave, making these conditions uninformative.

Table 4: Comparative Predictions for Priming and Proficiency

	L3 Proficiency	Low				High			
	Prime	L2		L3		L2		L3	
	Reads in...	L2	L3	L2	L3	L2	L3	L2	L3
Predicted Pronunciation	*Priming Dominant*	L2	L2	*L3*	*L3*	*L2*	*L2*	L3	L3
	Proficiency Dominant	L2	L2	*L2*	*L2*	*L3*	*L3*	L3	L3

The italicized cells in Table 4 highlight differences in priming and proficiency predictions: notably for low L3 proficiency speakers primed in L3 and for high L3 proficiency speakers primed in L2. Under the principles of priming and competition alone, language proficiency does not play a role in pronunciation predictions; therefore, participants who are primed in the L3 are expected to use L3 pronunciations, and participants who are primed in the L2 are expected to use L2 pronunciations. These predictions are spelled out in the *Priming Dominant* row of Table 4. Proficiency-based hypotheses, on the other hand, predict that low L3 proficiency speakers will default to their L2 phonology regardless of priming conditions due to the Foreign-Language Effect. High L3 proficiency speakers, however, are expected to undergo L2 attrition under the Phonological Permeability Hypothesis, resulting in the prediction that high L3 proficiency speakers will

produce L3 pronunciations, even when primed in the L2.

As illustrated in Table 4, priming and proficiency based hypotheses make different predictions for low L3 proficiency speakers primed in L3 and high L3 proficiency speakers primed in L2. Observing the actual pronunciations produced by these speakers under those conditions would therefore be informative as to which hypothesis is dominant: the interference effects arising from priming, or the Foreign-Language Effect and Phonological Permeability.

3.4 Language-Specific Predictions

The languages under investigation in this study are Spanish as L2 and Brazilian Portuguese as L3. Based on the effects of priming and competition, participants are expected to be more likely to produce a word with the same pronunciation appropriate to their priming language. That is, if they are primed in Spanish, they are expected to produce more Spanish pronunciations than Portuguese pronunciations during the study, and vice versa. In other words, participants who are primed in Spanish are likely to have a high error rate in Portuguese context and a low error rate in Spanish context, while the opposite pattern would be expected of participants who are primed in Portuguese.

The Foreign-Language Effect predicts that L2 Spanish speakers will transfer their Spanish phonology to their L3 of Brazilian Portuguese in the initial stages of language learning. As their proficiency improves, however, this language transfer will ebb. The Phonological Permeability Hypothesis indicates that highly proficient L3 Brazilian Portuguese speakers will experience the attrition of their L2 Spanish phonology. Participants with low Portuguese proficiency would therefore be expected to have a high error rate in Portuguese context, whereas participants with high Portuguese proficiency would be expected to have a high error rate in Spanish context.

4 Experiment

4.1 Participants

Participants are native English speakers with experience learning Spanish and Portuguese as non-native languages, Spanish being their L2 and Portuguese their L3. Participants were recruited from upper-level Portuguese language classes at UNC, specifically because most of the students enrolled in these courses have already learned Spanish.

Participants were surveyed about their general experience with Spanish and Portuguese. They were asked the age at which they began learning each language, whether they studied abroad (and if so, in what country and for how long), and which classes in each language they took at UNC. Furthermore, participants were asked to rate their proficiency in each language on a scale of 1 to 10, with 1 being "not at all" and 10 being "native-like." The full survey and all participant responses can be seen in Appendix C.

4.2 Design

Participants began by reading aloud a short story in either Spanish or Portuguese as a priming material. This story contained one instance of each *target word*, which will be discussed in detail in section 4.2.1. Following the priming task, participants performed a self-paced reading aloud task, in which target words were presented in the context Spanish and Portuguese sentences. Details of these tasks will be discussed below in section 4.2.2. Participant responses were analyzed for errors, or context-inappropriate pronunciations. Details of how responses were coded will be presented in section 4.3.

4.2.1 Target Words

The goal of the experiment was to elicit the pronunciation of target bigrams as they appear in target words. Target words were selected on the basis of having the same orthographic representation but different pronunciations in Spanish and Portuguese; that is, they are the *homographic heterophones* discussed above in Chapter 3. These words' differences in pronunciation are due to the presence of bigrams which have a different grapheme-to-phoneme mapping in Spanish and Portuguese. Table 5 shows the target words examined in the experiment, listed by bigram, as well as a key of their pronunciation in Spanish and Brazilian Portuguese. Bigrams in target words are underlined in Table 5.

Table 5: Target Words and Pronunciations

Bigram	Target Word	Spanish	Portuguese	Gloss
rrV	*a<u>rra</u>ncar*	[araŋkaɾ]	[ahãⁿkah]	'to uproot'
	ba<u>rri</u>ga	[bariɣa]	[bahigɐ]	'stomach'
	ce<u>rro</u>	[sero]	[sehʊ]	'hill'
	gue<u>rra</u>	[gera]	[gehɐ]	'gel'
	te<u>rre</u>moto	[t̪eremo̪to]	[tehimɔtʊ]	'earthquake'
te	*ar<u>te</u>*	[aɾt̪e]	[ahtʃi]	'art'
	benevolen<u>te</u>	[beneβolen̪t̪e]	[benevolẽⁿtʃi]	'benevolent'
	clien<u>te</u>	[kljen̪t̪e]	[kljẽⁿtʃi]	'client'
	gen<u>te</u>	[xen̪t̪e]	[ʒẽⁿtʃi]	'people'
ge	*<u>ge</u>l*	[xel]	[ʒew]	'gel'
	<u>ge</u>neral	[xeneɾal]	[ʒeneɾaw]	'(military) general'
	<u>ge</u>neroso	[xeneroso]	[ʒeneɾɔzʊ]	'generous'
	<u>ge</u>nte	[xen̪t̪e]	[ʒẽⁿtʃi]	'people'
	proteger	[pro̪t̪exeɾ]	[pɾoteʒeh]	'to protect'
di	*<u>di</u>rigir*	[d̪iɾixiɾ]	[dʒiɾiʒih]	'to manage'
	<u>di</u>stanciar	[d̪is̪t̪ansjaɾ]	[dʒistãⁿsjah]	'to distance'
	<u>di</u>vidir	[d̪iβiðiɾ]	[dʒividʒih]	'to divide'
	mun<u>di</u>al	[mun̪d̪jal]	[mũⁿdʒjaw]	'global'
Vl	*cart<u>el</u>*	[kaɾt̪el]	[kahtew]	'cartel'
	g<u>el</u>	[xel]	[ʒew]	'gel'
	gener<u>al</u>	[xeneral]	[ʒeneɾaw]	'(military) general'
	hot<u>el</u>	[o̪t̪el]	[otew]	'hotel'
	mundi<u>al</u>	[mun̪d̪jal]	[mũⁿdʒjaw]	'global'
	origin<u>al</u>	[oɾixinal]	[oɾiʒinaw]	'original'

As demonstrated in Table 5, these target words are orthographically identical in Spanish and Brazilian Portuguese; however, these written words correspond to very different pronunciations in the two languages. Note that the grapheme sequence *te* occurs in both stressed and unstressed syllables. In the words *gente* and *cliente*, this bigram is affricated in Brazilian Portuguese, but in the words *terremoto* and *proteger*, it is unaffricated. These instances in which *te* is unaffricated in Brazilian Portuguese were not considered instances of the target bigram in the data analysis.

4.2.2 Priming and Self-Paced Reading

The participants were divided into two groups: one primed in Spanish, the other in Portuguese. The first group was asked to read aloud a brief story written in Spanish while being recorded, and the second group was given the same story translated into Portuguese to read aloud. Both stories contained one instance of each target word. Because the bigrams under investigation are ubiquitous in the orthography of Spanish and Portuguese, their occurrence in other contexts within the stories was not controlled for, as doing so would have impeded the natural construction of sentences.

After reading aloud the priming materials, the participants were given a self-paced reading task. They

were told that they would be presented with sentences in both Spanish and Portuguese, one word at a time, and were instructed to read the sentences word by word, at their own pace. Participants were also asked not to backtrack or to correct themselves if they made a mistake, but rather to keep moving through the sentence.

Equivalent sentences in Spanish and Portuguese, each containing two target words, were presented in pseudo-random order on PowerPoint, one word at a time. For instance, the Spanish sentence *María cree que es muy* ***generosa*** *la* ***gente*** *de Colómbia*, containing the target words *gente* and *generoso*, would later be followed by the Portuguese sentence *Maria acha que a* ***gente*** *de Colômbia é muito* ***generosa***. Both sentences may be translated into English as *Mary thinks that the people of Colombia are very generous.* Note that *generoso* is inflected to agree with the feminine gender of *gente* in both languages. This morphological operation does not change the root of the target word nor does it affect the target bigram *ge*.

A random number generator was used to determine the order of sentences, and this order was further modified to prevent the occurrence of target words being presented consecutively in the same language context. Participants read through the sentences while their responses were recorded on Praat, version 5.3.83.

4.3 Data Coding

Participant recordings were text-gridded in Praat, and each target word was coded for context, trial, error, and priming language. *Context* referred to whether a target word occurred in a Portuguese or a Spanish sentence. Each target word was presented twice in Portuguese context and twice in Spanish context, for a total of four trials. A production was considered an *error* if it followed the grapheme-to-phoneme mapping rules of the opposite language context. For instance, the reading of the word *gente* as [ʒẽⁿtʃi] in Spanish context would be coded as an error for the *ge* bigram and for the *te* bigram. Other errors that did not correspond to the grapheme-to-phoneme mapping rules under investigation were not considered in the analysis.

Some participants produced pronunciations that did not conform perfectly to the phonological rules of the language in which they were reading. For instance, intervocalic voiced stops are realized as homorganic fricatives in Spanish, but some participants still produced these sounds are stops rather than continuants when reading aloud. This phonological rule would be expected to affect the pronunciation of the word-medial bigram *di* in *dividir*. Although the pronunciation [d̪iβid̪iɾ] is technically incorrect, it was still considered context-appropriate when produced in Spanish context, and therefore was not coded as an error. Only the production of the affricate [dʒ] for this bigram in Spanish context was coded as an error because this

pronunciation is appropriate in Brazilian Portuguese context.

Participants often corrected themselves upon encountering a target word, even though they were instructed not to do so. Common self-corrections involved producing the velar fricative [x] in the words *general* and *gel* in Portuguese context before correcting to the alveopalatal fricative [ʒ]. In this instance, the self-correction occurred before the entire word was uttered; however, other self-corrections were produced after the reading of the word in its entirety. Self-corrected erroneous responses were still counted as erroneous in the data coding. The fact that participants corrected themselves was considered a valuable qualitative observation, but instances of self-correction were not incorporated into the statistical analysis.

If a participant made errors producing every instance of a certain bigram within a certain context, the responses for that bigram in both contexts were omitted. The failure to produce any correct pronunciations of a bigram was seen as evidence that the phoneme or phonological rule represented by that bigram had not been acquired yet. Three participants produced the bigram *Vl* with a final [l] in both Spanish and Portuguese contexts, with no instances of the Brazilian Portuguese pronunciation of the final *l* as the glide [w]. Participant 8 produced every *rrV* bigram as a tap, in both Spanish and Portuguese contexts. Although this participant's survey indicates a high proficiency in Spanish, it is possible that they are unable to produce the trilled [r]; some L2 learners of Spanish fail to acquire the ability to "roll their r's." However, the initial segment in this bigram is pronounced as [h] in Brazilian Portuguese, a segment that is found in American English and should therefore be possible for an L2 learner of Portuguese to produce. Participant 8's failure to produce the [h] sound when encountering the *rrV* bigram indicates that they have not yet acquired this phoneme in Brazilian Portuguese, an assumption that would be consistent with the participant's self-described low proficiency in Portuguese. Participant 8's *rrV* responses were, therefore, omitted for both Spanish and Portuguese. A total of ninety-six responses was omitted, constituting 10.67% of the total 900 responses collected.

5 Results and Analysis

In this section I will discuss the results of the experiment outlined above and the statistical analysis of the data. I will also discuss qualitative observations about the data that were not incorporated into the statistical analysis.

5.1 Priming and Context Effects

Table 6 shows participants' error rates by priming language and sentence context. Priming language refers to the language in which the participant read the short story prior to the self-paced reading task. Context refers to the language in which a target word appeared during the self-paced reading task; each word appeared twice in Spanish context and twice in Portuguese context. The raw error counts provided in Table 6 show the number of context-inappropriate responses for each experimental condition out of the total responses for that condition.

The confidence intervals shown in Table 6 were determined by a logistic-regression analysis, which estimated each population mean (i.e., the error rate of each participant group) and its standard error in logits. For the 95% confidence level given, the standard error multiplied by 1.96 was subtracted from the estimated mean to yield the lower bound of the confidence interval and added to the estimated mean to yield the upper bound. Then, the mean as well as the upper and lower bound were transformed from logits to percentages.

Subjects, regardless of their priming language, had a much higher error rate for Portuguese contexts than for Spanish contexts, meaning that they were more likely to use an L2 pronunciation in an L3 sentence than vice versa. This result is inconsistent with the Phonological Permeability Hypothesis, which posits regressive transfer from L3 to L2; rather, the use of L2 pronunciations in reading the L3 follows the predictions of the Foreign-Language Effect. The error rates observed reflects the Foreign-Language Effect's prediction and aligns with the high L2, low L3 proficiency level reported by six out of the nine total participants.

Table 6: Error Rates by Context and Prime

Context	Prime	Error Rate	Raw Error Count	Confidence Interval
Portuguese	Portuguese	21.01%	50/238	11.70%–34.81%
	Spanish	34.34%	57/166	17.12%–56.97%
Spanish	Portuguese	1.26%	3/238	0.59%–2.67%
	Spanish	4.22%	7/166	1.38%–12.17%

The error rates calculated for each priming and context condition, as seen in Table 6, were analyzed by performing a two by two Wald's Chi-Square test with one degree of freedom, the results of which can be

seen in Table 7. For *Overall Context Effect*, the error rates within Spanish context were compared to those within Portuguese context for all priming conditions, with Portuguese context found to have a statistically significantly higher error rate than Spanish context. A significant context effect was also found within each priming condition. Table 7 shows that the p-values for each context effect—overall, for Portuguese primes, and for Spanish primes—are all less than 0.0001, and thus very highly statistically significant. In Table 7, marginal significance ($p<0.10$) is indicated by a period (.), significance ($p<0.05$) is indicated by an asterisk (*), high significance ($p<0.01$) is indicated by two asterisks (**), and very high significance ($p<0.001$) is indicated by three asterisks (***).

Priming effects, unlike context effects, were not found to be significant in either context condition or overall. That is to say, the difference in error rates between participants who were primed in Spanish and those who were primed in Portuguese was not statistically significant. *Overall Priming Effect* refers to the effect of priming on error rate across all context conditions. Table 7 shows that the overall effect of priming, as well as the effect of priming in each context, yielded high p-values. Although Table 6 shows an error rate for Spanish primes in Portuguese context (34.34%) that is numerically much bigger than that for Portuguese primes (21.01%), this difference is not significant according to the Chi-Square (see *Priming Effect (Portuguese Context)* in Table 7). The effect of priming within Spanish context was found to be only marginally significant.

Table 7: Chi-Square Results for Context and Priming Effects

	Chi Square	***p*-value**
Overall Context Effect	97.70	<.0001 ***
Context Effect (Primed Portuguese)	44.55	<.0001 ***
Context Effect (Primed Spanish)	58.94	<.0001 ***
Overall Priming Effect	2.65	0.1034
Priming Effect (Portuguese Context)	1.30	0.2539
Priming Effect (Spanish Context)	3.10	0.0785 .

5.2 Error Rates by Bigram

Error rates were calculated for each bigram and are summarized in Table 8. The raw error count shows the number of context-inappropriate productions of each bigram out of the total number of responses for that bigram. The confidence interval was determined by the same method used to calculate the confidence intervals in Table 6 with the same confidence level of 95%, as described in Section 5.1.

The percentages displayed in Table 8 represent a body of data that has been modified to remove unlearned segments. A segment was considered "unlearned" if a participant did not correctly produce it once within a language context. The bigram *Vl* was unlearned in Portuguese for three participants, and the bigram *rrV*

Table 8: Error Rates by Bigram

Bigram	**Error Rate**	**Raw Error Count**	**Confidence Interval**
Vl	6.25%	9/144	3.41%–11.19%
rrV	14.38%	23/160	5.99%–30.68%
te	5.56%	8/144	2.12%–13.80%
ge	10.00%	18/180	5.93%–16.39%
di	32.78%	59/180	23.28%–43.94%

was unlearned for one participant in both languages. To avoid skewing error rates by incorporating these unlearned segments, all responses for an unlearned bigram in both language contexts were omitted for these participants.

Table 8 shows that the bigrams *di* and *rrV* were most susceptible to error, with 14.38% and 32.78% error rates, respectively. Were the unlearned segments included, the rates for the bigrams *Vl* and *rrV* would be higher; however, with the adjustment, *Vl* only had a 6.25% error rate. The bigram *te* had the lowest error rate of all the bigrams examined, while an error rate of 10.00% for *ge* is the median of all the bigram error rates.

Table 9: Comparative Bigram Error Rates

	Chi-Square	p-value
Vl v. *rrV*	2.24	0.1341
Vl v. *te*	0.05	0.8246
Vl v. *ge*	1.19	0.2744
Vl v. *di*	44.35	<0.0001 ***
rrV v. *te*	16.86	<0.0001 ***
rrV v. *ge*	2.61	0.1059
rrV v. *di*	6.81	0.0091 **
te v. *ge*	3.49	0.0617 .
te v. *di*	24.54	<0.0001 ***
ge v. *di*	32.29	<0.0001 ***

Table 9 shows the results of Wald's Chi-Square analyses comparing the bigram error rates in Table 8 with each other. As in Table 7, each Chi-Square test was two by two, with one degree of freedom. An analysis of each pair of bigrams was chosen as the most informative statistical analysis of bigram error rates because it allows for the error rate of each bigram to be tested for significance relative to every other bigram under investigation. In Table 9, as in Table 7, marginal significance ($p<0.10$) is indicated by a period (.), significance ($p<0.05$) is indicated by an asterisk (*), high significance ($p<0.01$) is indicated by two asterisks (**), and very high significance ($p<0.001$) is indicated by three asterisks (***). As seen in Table 9, only the bigram *di* is statistically significantly different from every other bigram. The bigram *rrV*, however, had a significantly higher error rate than *te*, but not for any other bigram. The difference in error rates for no other combination of bigrams was found to be statistically significant, although *ge* was found to have a marginally

significantly higher error rate than *te*.

It is interesting to note that *di* had a significantly higher error rate than unstressed *te*. As discussed above in Section 2.4, these bigrams share phonological similarities within each language. In Spanish, the consonant graphemes *d* and *t* are both pronounced as the dental stops [d̪] and [t̪]; in Brazilian Portuguese, *di* and unstressed *te* are pronounced as [dʒi] and [tʃi] respectively, due to a phonological process by which coronal stops are affricated before high front vowels. Due to these phonological similarities, it would seem that *di* and *te* should not show such a discrepancy in error rates. However, *di* had the highest error rate of any bigram, and *te* had the lowest error rate. It is possible that the bigram's position within a word could affect error-rate. Every instance of unstressed *te* under investigation in this study was word-final: *ar<u>te</u>*, *benevolen<u>te</u>*, *clien<u>te</u>*, and *gen<u>te</u>*. The bigram *di*, on the other hand, did not appear in word-final position in this study: *<u>di</u>rigir*, *<u>di</u>stanciar*, *<u>di</u>vi<u>di</u>r*, and *mun<u>di</u>al*. The earlier position of *di* in these words, word-initial in many cases, could explain why this bigram was more prone to error than *te*. Reading a word aloud is a process that takes place in real time, potentially explaining why word-initial *di* is more error-prone than word-final *te*.

5.3 Effects of Proficiency

Due to the small number of eligible participants, it was not feasible to perform a statistical analysis of the effects of proficiency on pronunciation. However, almost all participants reported high proficiency in Spanish and a lower proficiency in Portuguese. The average proficiencies that participants reported were 7.5 for Spanish and 4.4 for Portuguese. Figure 3 shows how each participant rated their proficiency in Spanish and Portuguese on a scale of one to ten, with one being "not at all" and ten being "native-like." Proficiencies between one and five are considered low, and proficiencies between six and ten are considered high.

The majority of the participants reported a high proficiency in Spanish, with only one person rating their Spanish proficiency lower than seven. On the other hand, Portuguese proficiency was much lower overall with only one participant reporting higher proficiency in Portuguese than in Spanish. These data support a Foreign-Language Effect analysis; since the Foreign-Language Effect predicts that low proficiency in the L3 catalyzes transfer from the L2 to the L3, it is likely that the high error rates observed for L3 context may be attributable to the overall low L3 proficiency of the participants. In order to observe potential effects of Phonological Permeability, it would be necessary to find more participants who are highly proficient in Portuguese and less proficient in Spanish.

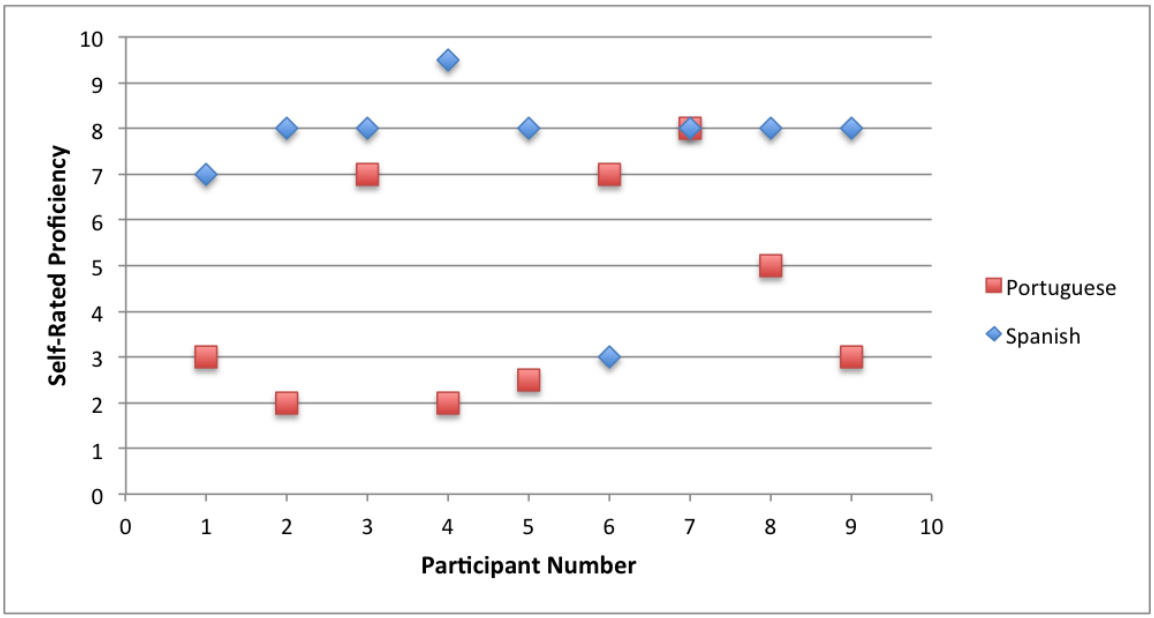

Figure 3: Self-Rated Proficiency of Participants

5.4 Mixed Pronunciations

Mixed pronunciations were an area of interest in analyzing productions of words with more than one target bigram: *gente* (*ge* and *te*) and *mundial* (*di* and *Vl*), for instance. The production of a target word was considered a mixed pronunciation if one bigram fell subject to error while the other did not. Table 10 shows double-bigram target words as well as examples of mixed pronunciations. Note that the intervocalic /d̪/ in *dividir* should be pronounced as a fricative in Spanish, due to a phonological rule by which intervocalic voiced stops become homorganic fricatives. However, mixed pronunciations that were produced in this study contained an intervocalic dental stop rather than a fricative, a pronunciation strategy that is not uncommon in L2 learners of Spanish. Therefore, pronunciations in Spanish context were coded as context-appropriate, and therefore not erroneous, if they contained intervocalic voiced stops.

Table 10: Mixed Pronunciations

Pronunciation	**Spanish**	**Portuguese**	**Mixed**
mundial	[mund̪jal]	[mũ^{n}dʒjaw]	[mund̪jaw] [mundʒjal]
gente	[xent̪e]	[ʒẽ^{n}tʃi]	[ʒent̪e] [xentʃe]
gel	[xel]	[ʒew]	[xew] [ʒel]
general	[xeneɾal]	[ʒeneɾaw]	[ʒeneɾal] [xeneɾaw]
dividir	[d̪iβiðiɾ]	[dʒividʒih]	[d̪ividʒiɾ] [dʒivid̪iɾ]

Of the total words produced by participants, 142 were susceptible to mixed pronunciations. This number represents the adjusted total of double-bigram items, modified to omit [l]-final words for subjects for whom the bigram *Vl* was unlearned in both languages, and thus removed from the data (see 4.3 above). Of these 142 double-bigram words, eighteen were produced with a mixed pronunciation, constituting 12.68%. The importance of mixed pronunciations will be discussed in further depth below in Chapter 6, as they pertain to the development of a model of reading aloud in non-native languages.

5.5 Error Rates by Proficiency

Table 11 shows the total number of errors and mixed pronunciations that participants made, dividing participants into three groups: low L3 and high L2 proficiency, high proficiency in L2 and L3, and low L2 and high L3 proficiency. Table 12 shows the error rates for each of these groups, or the information in Table 11 converted into percentages for easier comparison across the three groups.

Participants with low L3 proficiency and high L2 proficiency had high error rates in Portuguese context, as well as several mixed pronunciations. Participants who were highly proficient in both the L2 and the L3, on the other hand, had very low error rates overall, although they made more errors in Portuguese context. The participant who reported a high L3 proficiency and low L2 proficiency had a higher overall error rate than the participants with high proficiency in both L2 and L3, but the same rate of mixed pronunciations. The participant with high L3 and low L2 proficiency made more mistakes in Portuguese context than in Spanish context, which is inconsistent with the predictions made under the Phonological Permeability Hypothesis. According to Phonological Permeability, L2 attrition would be expected for someone with high proficiency in their L3. We would expect to see more errors in Spanish context than in Portuguese context for this participant; however, the opposite pattern was observed. This observation could be accounted for by the fact that this participant was primed in Spanish. Under the principles of priming and competition, we would expect priming in Spanish to inhibit the participant's ability to produce L3 pronunciations in L3 context, as was observed. However, the attribution of this participant's error patterns to priming is tentative; more subjects with high L3 and low L2 proficiency would have to participate in the experiment before any conclusions could be drawn.

Table 11: Total Errors by Proficiency

	Overall		**Spanish Context**		**Portuguese Context**		**Mixed Pronunciations**	
	Errors	*Total Responses*	*Errors*	*Total Responses*	*Errors*	*Total Responses*	*Errors*	*Total Responses*
Low L3, High L2	99	508	7	254	92	254	15	84
High L3, High L2	8	200	1	100	7	100	2	40
High L3, Low L2	9	100	1	50	8	50	1	20

Table 12: Error Rates by Proficiency

Error Rates	**Overall**	**Spanish**	**Portuguese**	**Mixed Pronunciations**
Low L3, High L2	19.49%	2.76%	36.22%	17.86%
High L3, High L2	4.00%	1.00%	7.00%	5.00%
High L3, Low L2	9.00%	2.00%	16.00%	5.00%

5.6 Qualitative Observations

Although participants were instructed not to correct any mispronunciations, they self-corrected often, frequently beginning to pronounce a word and then starting over with a more context-appropriate pronunciation. Several participants paused between sentences or even in the middle of a sentence to laugh or comment on the difficulty of the self-paced reading task. "Oh my goodness," one participant said during her recording, "I kept getting confused!"

Only the pronunciation of target bigrams was incorporated into the statistical analysis of this study; however, I observed a variety of quirky responses that are worth mentioning. The five bigrams under investigation in this study are not the only letter sequences in Spanish and Portuguese orthography that differ in pronunciation. Participants often produced mixed pronunciations of words that were not quantified as mixed pronunciations in this analysis. Grapheme sequences that map onto a velar fricative in Spanish and an alveopalatal fricative in Portuguese were particularly susceptible to context-dependent pronunciation errors. For instance, the *gi* sequence in *original* and *dirigir* was susceptible to mistakes, as was the target bigram *ge*.

One participant produced the mixed form [planexasemos] of the Portuguese *planejássemos*, pronouncing the *ja* bigram as it would be pronounced in Spanish. In Spanish, the consonant in *ja* maps onto the same velar fricative as the *g* in *ge* and *gi*. In Portuguese, however, the grapheme *j* maps onto the alveopalatal fricative [ʒ], as does the *g* in *ge* and *gi*. Therefore, the pronunciation of the Portuguese word *planejássemos* with a velar fricative indicates the access of Spanish phonology. To make matters more interesting, the word *planejássemos* is not a homographic heterophone—it does not exist in Spanish. Therefore, this participant incorporated Spanish grapheme-to-phoneme correspondences into the reading of a word that could not have a lexical representation in Spanish.

While reaction time was not quantified in this study, participants were often observed to pause for a notable amount of time before producing a target word. These long pauses were noticeable while participants were performing the self-paced reading task; however, they became even more apparent when viewed in Praat. Gaps of silence would precede words double-bigram words such as *gel* and *general*. In one instance, Participant 2 paused for 0.87 seconds before reading aloud *gente*.

It is possible that English cognate status added a layer of difficulty to the production of the target words under investigation in this study. Cognates, when encountered in a non-native language, are susceptible to L1 phonological interference (Jacobs, 2007). All participants had the same L1 of English in this study, in hopes that L1 interference effects would be uniform across the board. English cognates will be discussed further in Section 6.3.

6 Discussion

In this section I will discuss the implications of the experimental results as they concern language transfer and storage as well as the development of a model of reading aloud in non-native languages. Furthermore, I will discuss areas of future research.

6.1 Proficiency and Priming

Two theories of non-native language transfer have been examined here: the Foreign-Language Effect Hypothesis and the Phonological Permeability Hypothesis. The Foreign-Language Effect predicts transfer from L2 to L3 for L3 speakers with low proficiency; as L3 proficiency increases, this transfer decreases. Phonological Permeability, on the other hand, posits regressive transfer from L3 to L2, causing attrition of the L2 phonology. At face value, the Foreign-Language Effect and Phonological Permeability seem to be at odds with each other. The former predicts transfer from L2 to L3, and the latter posits transfer in the opposite direction. However, these two theories can be reconciled if proficiency is incorporated into the discussion.

For everyone who participated in this study, context was found to have a significant effect on the production of context-inappropriate responses, while priming was not found to be statistically significant. Participants were much more likely to produce a Spanish pronunciation in Portuguese context than the other way around, regardless of which language they were primed in. As seen above in Table 6, participants reading in Portuguese context had an error rate of 21.01% when primed in Portuguese context and of 34.34% when primed in Spanish. Compared to the error rates observed for participants reading in Spanish context—1.26% when primed in Portuguese and 4.22% when primed in Spanish—the Portuguese context error rates are overwhelmingly higher. Participants, therefore, had a strong tendency to use L2 pronunciations regardless of language context.

Due to varying comparative proficiency in L2 and L3, it was necessary to look at error rates for subsets of the overall participant pool. As seen above in Table 12, participants with low L3 proficiency and high L2 proficiency had the highest error rate of any participant group, with an overwhelming majority of their errors made in Portuguese context. Table 11 shows that of 99 total errors made by speakers with low L3 and high L2 proficiency, 92 were in Portuguese context, and only seven were in Spanish context. These results show that this subset of participants had a strong tendency to use L2 pronunciation in L3 context, in support of the L2 to L3 transfer proposed by the Foreign-Language Effect.

The participants with high proficiency in L3, however, did not behave as predicted under the Phonological Permeability Hypothesis. While the L2 phonological attrition predicted under this hypothesis invites the expectation that L3 pronunciations will be used in L2 context, the results show that participants with high L3 proficiency were still less prone to doing so than to using L2 pronunciations in L3 context. As shown in Table 11, speakers with high L3 proficiency made a total of seventeen errors (this total combines the responses of high L3 proficiency speakers with both low and high L2 proficiency). Of these seventeen errors, only two were made in Spanish context.

At face value, this result contradicts the Phonological Permeability Hypothesis, which predicts that more L3 pronunciations will be made in L2 context than vice versa. However, due to the small number of participants in this study, Phonological Permeability cannot be conclusively ruled out. Only three speakers out of the nine total participants reported high proficiency in L3. Furthermore, the one participant who had high L3 and low L2 proficiency was primed in Spanish; this speaker's high error rate in Portuguese context aligns with the priming-based prediction that a participant primed in L2 is likely to use L2 pronunciations regardless of context.

Although the speaker with high L3 and low L2 proficiency behaved in a way consistent with priming conditions, it cannot be concluded that priming dominates over proficiency for the same reason that Phonological Permeability cannot be conclusively negated: the sample size is too small. Priming was not found to have a statistically significant effect on the production of context-inappropriate pronunciations in this study; however, many more speakers with high L3 proficiency would have to be tested, under both priming conditions, before any statement can be confidently made about the dominance of proficiency effects over priming effects, or vice versa.

It is also important to note that in developing the Phonological Permeability Hypothesis, Cabrelli Amaro (2013) investigated different aspects of Spanish and Brazilian Portuguese phonology than I have looked at in this study. Namely, she looked at post-vocalic voiced stops, which are realized as continuants in Spanish but not in Portuguese, and word-final vowels, which are reduced in Portuguese but not in Spanish. Because these phonological phenomena were not investigated in this study, the results observed here do not directly contract Cabrelli Amaro's observation of L3 to L2 transfer in these specific areas of the phonology of Spanish and Brazilian Portuguese.

6.2 Modeling Reading Aloud in Non-Native Languages

Coltheart (1993) argues that the DRC Model of Reading Aloud is an accurate representation of the process by which an adult reads aloud in his or her native language The DRC model posits two different

procedures for reading aloud: the lexical procedure, which is used to read words that have an entry in the orthographic lexicon, and the non-lexical procedure, which is used to read words that do not correspond to a lexical entry. In the lexical procedure, a written word is matched with an entry in the orthographic lexicon, which is subsequently mapped onto a phonological form. Individual grapheme-to-phoneme mapping rules are, Coltheart claims, only accessed during the non-lexical procedure.

The evidence gathered in this study presents a problem for the DRC Model, as it stands for reading aloud in the L1. When participants were presented with sentences during the self-paced reading task, the language context in which they were reading was made clear before they arrived at the target word in each sentence. That is to say, early words in each sentence were clearly Spanish, such as the proper name *Juan*, or Portuguese, such as the name *João*. Therefore, the language context in which each target word was embedded was unambiguous. Were Coltheart's DRC Model an accurate representation of reading aloud in L2 and L3, we would not expect to see context-inappropriate pronunciations because context clues would provide for the access of the correct phonological lexicon after an orthographic form is mapped onto a unit in the orthographic lexicon. However, the observation of context-inappropiate speech errors demonstrates that the lexical procedure used in non-native reading aloud provides for the access of both the L2 and L3 phonological lexicons during the reading of a word in a single language context. Therefore, a revised DRC Model for non-native reading aloud must provide for the access of both phonological lexicons, even when reading in one language.

The observation of mixed pronunciations also provides evidence that two phonological representations are accessed during the reading aloud of a word in a single language. Of the double-bigram words examined, 12.68% were produced with a mixed pronunciation. This high rate of mixed pronunciations suggests that a lexical representation is not mapped onto an entire phonological representation of a lexeme as a single unit. In that case, a word like *gente* would either be pronounced [xen̪t̪e] or [ʒẽ^{n}tʃi], but never [xentʃi] or [ʒente]. Mixed pronunciations are evidence that units within a single lexical representation can map onto different phonological representations contained within the L2 and L3 phonological lexicons.

Figure 4 demonstrates this mapping of a single orthographic form onto L2 and L3 phonological units, using the word *gente* as an example. As demonstrated in this figure, the L2 and L3 orthographic lexicons can overlap when the L2 and L3 share an identical lexical representation. This system of lexical storage is posited for the homographic heterophones investigated in this study. Figure 4 shows units within this single lexical representation mapping onto units of the Spanish phonological representation, on the left, and of the Portuguese phonological representation, on the right. The result of this mapping would be the mixed pronunciation [xentʃi], which incorporates the first three segments in the Spanish phonological representation and the latter two segments in the Portuguese.

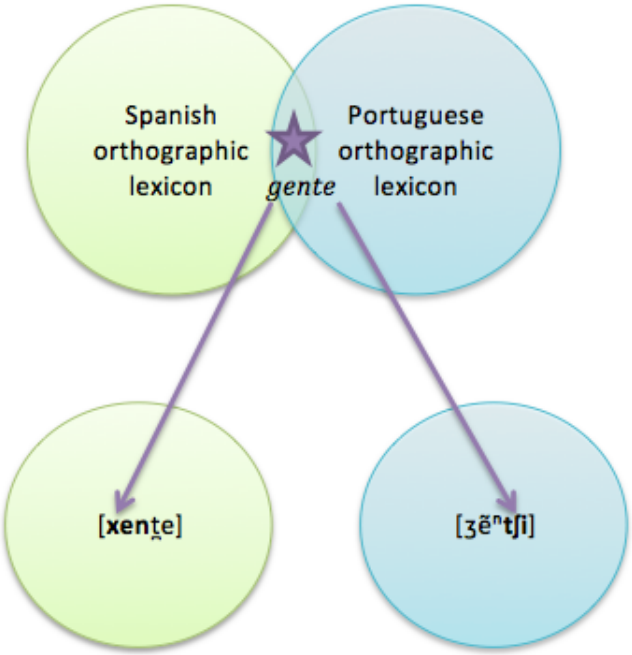

Figure 4: Mapping of *gente* onto distinct phonological forms in L2 and L3

A model of reading aloud in non-native languages must allow for two orthographic lexicons and two phonological lexicons. The patterns of transfer observed in this study indicate that these lexicons overlap, as shown in Figure 4. The process by which orthographic representations map onto phonological representations could change as proficiency improves. The two participants who reported high proficiency in both Spanish and Portuguese made very few mistakes overall, indicating that they were better able to map entire orthographic representations onto entire phonological representations than speakers with low L3 proficiency, who had higher error rates. Speakers with low Portuguese proficiency show evidence of mapping sublexical units onto pieces of different phonological representations in the form of mixed pronunciations, but highly proficient speakers display a pattern more similar to the lexical procedure within Coltheart's DRC Model, in which the entire lexical and phonological representations of words are accessed as complete units. This analysis is consistent with the error rates described above in Table 12, which shows high rates of mixed pronunciations for speakers with low L3 and high L2 proficiency and a much lower rate of mixed pronunciations for speakers with high proficiency in both languages.

The process of breaking apart an orthographic form into sublexical units, which are then mapped onto different units of varying phonological representations, resembles the non-lexical procedure in the Coltheart's DRC Model. The non-lexical procedure employs grapheme-to-phoneme mapping rules in the absence of lexical representations in the orthographic lexicon. If mixed pronunciations are interpreted as originating

in the accessing of grapheme-to-phoneme mapping rules, this interpretation would suggest that certain elements of the non-lexical procedure may be used even in the presence of a lexical representation. The accessing of grapheme-to-phoneme mapping rules to pronounce a written word that has a representation in the lexicon resembles Seidenberg and McClelland's (1989) connectionist model, in which orthographic units are connected to phonological units based on how frequently they are encountered.

The numerous productions of context-inappropriate speech errors observed in this study indicates that there are not separate procedures for reading aloud in L2 and L3. Therefore, I will work under the assumption that the procedures for reading aloud in non-native languages are contained within a single system. The strength of connections between graphemes and phonemes is, therefore, in flux when a speaker must switch between their non-native languages when reading aloud. A speaker who reads often in their L2 and less often in their L3 will strengthen the connections between orthographic units and L2 phonological forms, and vice versa.

Modifying exposure to either of the non-native languages can change the strength of the connections between graphemes and phonemes, strengthening or weakening these connections accordingly. This kind of connectionist model therefore provides for the incorporation of L2 and L3 grapheme-to-phoneme correspondences in the reading of one word within a single language. To return to the word gente, for instance, the strength of the connection between the bigram *ge* and the phonological representation [ʒe] could weaken, while the connection between the bigram *te* and the phonological represenation [tʃi] remains strong. The fluctuating strength of connections between sublexical orthographic units and phonological representations rather than complete lexical and phonological representations would account for mixed pronunciations.

Both models of reading discussed here, therefore, contain valuable aspects in the development of a model of non-native reading aloud. The lexical procedure of the DRC Model looks to be an accurate representation of reading for highly proficient speakers, whereas Seidenberg and McClelland's connectionist model reflects the numerous mixed pronunciations and context-inappropriate pronunciations produced by speakers with low L3 proficiency. This interpretation is consistent with the kinds of systems these two models are meant to represent. Coltheart's DRC Model represents a system that is already learned, making it an accurate model of reading for speakers who are highly proficient in both their L2 and their L3 and have sufficiently learned the correspondences between representations in the orthographic and phonological lexicons in each language.

Seidenberg and McClelland's connectionist model, on the other hand, is meant to represent a fluid system that continues to learn when presented with new information. This system, which changes the strength of connections between orthographic and phonological units, could be an accurate reflection of how an L3 speaker with low proficiency reads. Since Spanish contexts in the experiment had low error rates and

Portuguese contexts had very high error rates for low proficiency L3 speakers, it seems that these participants are still learning the connections between graphemes and phonemes in their L3, an aspect of their reading cognition that is in keeping with Seidenberg and McClelland's connectionist model.

6.3 Future Research

Although context was shown to be a significant variable in error rate, priming did not have an effect on the participants as they read aloud. It is likely that the one small story each participant was shown as a priming material was negligible in the greater scheme of their language use. Many of the participants who took part in this study were enrolled in Spanish and Portuguese classes or had lived in Hispanic or Lusophone countries (see Appendix C for details). It is not surprising that the long-term effect of months of classroom experience and/or living abroad would far outweigh the handful of paragraphs which were used for priming materials.

While differences in proficiency were not analyzed for statistical significance in this study, most of the participants reported higher levels of proficiency in Spanish than in Portuguese (see Appendix C for a full profile of all participants' proficiency). Furthermore, all of the participants had been studying Spanish for much longer than they had been studying Portuguese, which is to be expected within a demographic which could study Spanish through high school but did not have access to Portuguese classes until they came to university. This background information on the participants is a reasonable explanation for why target words in Portuguese context were much more susceptible to error than their Spanish counterparts; this view is consistent with the well-documented Foreign Language Effect. Although the small participant pool in this study did not allow for analysis of the effect of proficiency on error rate, this area of study would be promising for future research on grapheme-to-phoneme mapping. If more participants with high Portuguese proficiency were to be tested, it would be expected to find that they make a greater number of errors in Spanish context than in Portuguese context, a result that would be consistent with Phonological Permeability.

Future research would also ideally look at subjects who learned Portuguese as their L2 and Spanish as their L3. Unfortunately, no participants with this particular background could be identified to take part in this study; although Spanish and Portuguese are both major world languages, Spanish is much more prevalent in the United States in terms of availability of second language education. If speakers with high proficiency L2 Portuguese and lower proficiency L3 Spanish could be identified for a follow-up study, they would be expected to show the opposite pattern as the participants in this study; that is, they would be expected to use many more Portuguese pronunciations in Spanish context than vice versa.

English cognate status is another aspect of this study that may could have affected the results but was not

statistically analyzed. Of the twenty target words under investigation, twelve have cognate forms in English, the native language of every participant: *arte*, *benevolente*, *cliente*, *gel*, *general*, *generoso*, *proteger*, *distanciar*, *dividir*, *cartel*, *hotel*, and *original*. Cognates have been found to be susceptible to native language phonological interference when encountered in the L2 by a speaker who is not in an immersion environment (Jacobs, 2007). Despite the participants' enrollment in foreign language classes and their previous experiences abroad, they were all immersed in an English-speaking university environment at the time of this study. Therefore, the L1 forms of these cognates could have competed with the non-native forms when the participants were asked to read aloud, confounding non-native grapheme-to-phoneme mapping. In future research, reaction to English cognates in L2 and L3 could be compared to non-cognates in L2 and L3 to investigate the degree of L1 phonological interference in cognate production.

While cognate status could have influenced the nature of errors that participants made, the order of bigrams within multi-bigram words also could have affected the production of these target words. Table 10 above shows the double-bigram target words that were examined in this study: *mundial*, *gente*, *gel*, *general*, and *dividir*. Since reading aloud is an action that takes place in real time, it is possible that bigrams occurring earlier in these words were more susceptible to error than bigrams occurring later. Although such a hypothesis was not quantitatively tested in this study, qualitative observations showed that participants sometimes self-corrected in the midst of reading a word. If the self-correction was made after a word's initial bigram was produced with an error, the second bigram would be produced appropriately. The target bigrams under examination in this study were not balanced for position within a word; future research that does control for word position could shed light on the effect bigram position has on error rate.

Word frequency is another factor that could have affected participants' word productions in this study. A word such as *gente* 'people' would be used often in a classroom environment, for instance. However, a word like *gel* would be encountered much less frequently by an L2 learner of Spanish or Portuguese. It would be expected that less frequent words be more susceptible to error than words which L2 and L3 learners produce often.

The historic, orthographic, and genetic similarity of Spanish and Portuguese is both a help and a hindrance to students of the two languages. The transfer that takes place under the Foreign-Language Effect presents an initial advantage to L3 students, who may find that they can understand and read much of the L3 off the bat. However, as language study progresses, the impulse to use L2 pronunciations can be a difficult obstacle to overcome. The participants in this study often showed awareness at using context-inappropriate pronunciations; they demonstrated a great deal of frustration at failing to produce correct pronunciations and usually knew what context-appropriate production would be.

The Roman alphabet used in Spanish and Portuguese is one of the many writing systems employed

throughout the world. Future research on grapheme-to-phoneme mapping could take very different directions from the one explored in this thesis. Other languages share orthographic features but link them to very different underlying representations: Arabic and Farsi, for instance, or Chinese and Japanese kanji. If the Arabic script and logographic Chinese characters behave similarly to the Roman graphemes analyzed in this study, the L3 would be expected to undergo more L2 phonological interference than the other way around for L3 speakers with low proficiency. The study of non-Roman writing systems in future research would speak to the degree to which the orthographic medium influences grapheme-to-phoneme mapping, an area not investigated in this study.

APPENDIX A: PRIMING MATERIALS

This section contains the short stories that were used as priming materials in the experiment. The Spanish story was proofread for grammaticality by a native Spanish speaker of Honduran descent who resides in Miami. The Portuguese story was proofread for grammaticality by a senior lecturer of Portuguese at UNC. Target words are in bold. An English translation of the story is provided in 6.3.

A.1 SPANISH

El **General** Rodríguez llegó al **hotel** al amanecer. Había estado luchando una **guerra** contra el **cartel mundial** del comercio del **gel** de cabello. Compuesto de vainilla y cianuro, el producto olía a flores y hacía que el pelo de cada **cliente** brillaba. Sin embargo, a pesar de lograr un estilo **original** y bonito, morían las personas que lo usaban por el veneno en el cianuro.

Rodríguez era un hombre **benevolente** y por eso sufrió mucho por pensar en esto. Sufrió cuando pensó en cómo le dolia la **barriga** a cada víctima al exposición a las toxinas. Su carácter **generoso** hacía que quería **proteger** a la **gente** del peligro.

Rodríguez se hizo desviado de sus pensamientos en el destino de los humanos por el **arte** en el zaguán, que le causó una buena impresión. Los cuadros eran pintados en un estilo único. Mientras admiraba las pinturas, el piso empezó a temblar. Salió el botones gritando que fue un **terremoto**.

Rodríguez sabía que se debía **distanciar** de la construcción, pero no quería dejar los cuadros bellos. Comenzó a **arrancar** una pinturita de una iglesia en un **cerro**. Al separarla de la pared otra persona chocó con Rodríguez y la acción la causó a **dividir** en muchos pedacitos. Por eso Rodríguez llegó a una revelación profunda: como no pudo dirigir el destino de un cuadro, no pudo controlar el sino de las personas que murieron por el crimen.

A.2 PORTUGUESE

O **General** Rodrígues chegou ao **hotel** ao amanhecer. Tinha estado lutando uma **guerra** contra o **cartel mundial** do comércio do **gel** do cabelo. Composto de baunilha e cianeto, o produto cheirava a flores e fazia com que o cabelo de cada **cliente** brilhasse. Contudo, apesar de lograr um estilo **original** e bonito, sufriam as pessoas que o usavam pelo veneno no cianeto.

Rodrígues era um homem **benevolente** e por isso sofreu muito por pensar nisso. Sofreu quando pensou em como a **barriga** de cada vítima doia ao exposição às toxinas. O seu gênio **generoso** fazia com que quisesse **proteger** a **gente** do perigo.

Rodrígues se desviou dos seus pensamentos no destino dos humanos pela **arte** no saguão, que lhe impressionou. Os quadros eram pintados num estilo singular. Enquanto admirava as pinturas, o chão começou a tremer. O porteiro saiu gritando que foi um **terremoto**.

Rodrígues sabia que devia se **distanciar** da construção, mas não queria deixar os quadros belos. Começou a **arrancar** uma pinturinha duma igreja num **cerro**. Enquanto ele separava-a da parede, outra pessoa se bateu no Rodrígues e a acção fez **dividir** a pintura em muitos pedacinhos. Esta inversão levou Rodrígues a uma revelação profunda: como não pôde dirigir o destino dum quadro, não pôde controlar o destino das pessoas que sufriam pelo crime.

A.3 ENGLISH TRANSLATION

General Rodriguez arrived at the hotel at dawn. He had been fighting a war against the global hair gel cartel. Made of vanilla and cyanide, the product smelled like flowers and made each client's hair shine. However, although the gel created a beautiful and original style, the people who used it were killed by the poisonous cyanide.

Rodriguez was a benevolent man, so thinking of this caused him much pain. He suffered when he thought about how every victim's stomach would hurt from exposure to the poison. His generous character made him want to protect people from danger.

Rodriguez was distracted from his thoughts about the destiny of humankind by the art in the hotel lobby, which impressed him. The works of art were painted in a singular style. While he was admiring the paintings, the floor began to shake. The bellhop ran out screaming that it was an earthquake.

Rodriguez knew that he should get away from the building, but he did not want to leave the beautiful paintings. He started to detach a small painting of a church on a hill. Upon taking it off of the wall, another person bumped into him, causing it to break into tiny pieces. This turn of events brought Rodriguez to a profound revelation: just as he could not control the destiny of a painting, he was unable to control the fate of those who suffered from crime.

APPENDIX B: STIMULI

This section contains the stimuli sentences used for the self-paced reading task in the experiment. The Spanish sentences were proofread for grammaticality by a native Spanish speaker from Colombia. The Portuguese sentences were proofread for grammaticality by a senior lecturer of Portuguese at UNC. Target words are in bold. English translations are italicized underneath each sentence.

B.1 SPANISH SENTENCES

Juan era un **general** que luchó en la **guerra**.

John was a general who fought in the war.

Los soldados quieren que el **general** sea **benevolente**.

The soldiers want the general to be benevolent.

Me dolía la **barriga** después de almorzar en el **hotel**.

My stomach hurt after eating lunch at the hotel.

Tienen que **proteger** a los ciudadanos del **cartel** peligroso.

They must protect the citizens from the dangerous cartel.

Ese hombre puede **arrancar** el poder del **cartel**.

That man can uproot the cartel's power.

Ellos no deben **dirigir** la competencia **mundial**.

They should not be running the global competition.

Cuando comenzó la **guerra**, ninguna persona sospechó que se haría un conflicto **mundial**.

When the war started, nobody suspected that it would become a global conflict.

Buscan el **arte original** de un pintor famoso.

They are looking for a famous painter's original art.

No lo van a **dirigir** con la regulación **original**.

They will not run it with the original regulation.

Aunque planeábamos **dividir** la pizza, comí demasiado y quedé con **barriga** llena.

Even though we were planning to divide the pizza, I ate too much and wound up with a full belly.

No tienes que **arrancar** la hierba en el **cerro**.

You don't have to pull up the grass on the hill.

Vieron el **hotel** encima del **cerro**.

They saw the hotel on top of the hill.

Cuarenta días de preparación no los podían **proteger** del **terremoto**.

Forty days of preparation could not protect them from the earthquake.

Supo que el **terremoto** destruyó el **arte** en el museo.

He found out that the earthquake destroyed the art in the museum.

María cree que es muy **generosa** la **gente** de Colómbia.

Mary thinks that the people of Colombia are very generous.

Ella se irrit'o cuando vio la manera en que trataron a la **gente** que era **benevolente**.

She became angry when she saw the way they treated benevolent people.

La tiendita vendía **gel** al **cliente**.

The shop would sell gel to the client.

Eres muy **generoso** por **dividir** la torta en porciones tan grandes.

You are so generous for dividing the cake into such big pieces.

La madre de Pablo va a **distanciar** el **gel** del niño.

Paul's mother will distance the gel from the child.

Ellos se van a **distanciar** del **cliente**.

They are going to distance themselves from the client.

B.2 PORTUGUESE SENTENCES

João era um **general** que lutou na **guerra**.

John was a general who fought in the war.

Os soldados querem que o **general** seja **benevolente**.

The soldiers want the general to be benevolent.

Minha **barriga** doia depois de almoçar no **hotel**.

My stomach hurt after eating lunch at the hotel.

Precisam **proteger** os cidadãos do **cartel** perigoso.

They must protect the citizens from the dangerous cartel.

Esse homem pode **arrancar** o poder do **cartel**.

This man can uproot the cartel's power.

Eles não devem **dirigir** a competição **mundial**.

They should not be running the global competition.

Quando começou a **guerra**, nenhuma pessoa desconfiou que cresceria num conflito **mundial**.

When the war started, nobody suspected that it would grow into a global conflict.

Buscam a **arte original** dum pintor famoso.

They are looking for a famous painter's original art.

Eles não vão o **dirigir** com a regulação **original**.

They will not run it with the original regulation.

Ainda que planejássemos **dividir** a pizza, eu comi demais e me encontrei com **barriga** cheia.

Even though we were planning to divide the pizza, I ate too much and wound up with a full belly.

Não precisa **arrancar** o capim no **cerro**.

You don't have to pull up the grass on the hill.

Viram o **hotel** em cima do **cerro**.

They saw the hotel on top of the hill.

Quarenta dias de preparação não podiam os **proteger** do **terremoto**.

Forty days of preparation could not protect them from the earthquake.

Soube que o **terremoto** destruiu a **arte** no museo.

He found out that the earthquake destroyed the art in the museum.

Maria acha que a **gente** de Colômbia é muito **generosa**.

Mary thinks that the people of Colombia are very generous.

Ela se zangou quando viu a maneira em que trataram a **gente** que era **benevolente**.

She became angry when she saw the way they treated benevolent people.

A lojinha vendia **gel** ao **cliente**.

The shop would sell gel to the client.

Você é tão **generoso** por **dividir** o bolo em porções tão grandes.

You are so generous for dividing the cake into such big pieces.

A mãe de Paulo vai **distanciar** o **gel** da criança.

Paul's mother will distance the gel from the child.

Eles vão se **distanciar** do **cliente**.

They are going to distance themselves from the client.

APPENDIX C: PARTICIPANT SURVEY

The participant survey can be found in 6.3. Answers to the survey are included in 6.3.

C.1 SURVEY

What is your current age?

At what age did you start learning Spanish?

How would you describe the regional dialect of Spanish that you speak?

At what age did you start learning Portuguese?

How would you describe the regional dialect of Portuguese that you speak?

What Spanish classes have you taken at UNC?

What Portuguese classes have you taken at UNC?

Approximately how many hours a week do you speak Spanish?

Approximately how many hours a week do you speak Portuguese?

Have you ever studied abroad? If so, where, when, and for how long?

How would you rate your proficiency in Spanish on a scale of 1 to 10, 1 being "not at all" and 10 being "native-like"?

How would you rate your proficiency in Portuguese on a scale of 1 to 10, 1 being "not at all" and 10 being "native-like"?

C.2 SURVEY RESPONSES

Table 13 shows participants' responses to the survey questions about their Spanish abilities. The information includes the age at which each participant began learning Spanish (AoA), their regional dialect, any Spanish classes they have taken at UNC, the hours a week they spend speaking Spanish, when and in which Spanish-speaking countries they have lived abroad, and their self-rated proficiency.

Table 14 shows participants' responses to the survey questions regarding their experiences learning Portuguese. This table includes the same information as Table 13, as detailed in the paragraph above.

Table 13: Participant Responses to Survey Questions Regarding L2 Spanish Learning

Participant	**Current Age**	**AoA**	**Dialect**	**Classes Taken at UNC**	**Hours a Week**	**Studied Abroad**	**Proficiency**
1	19	12	"a bit of everything"	"255, 260, 376, 377, 677"	15	N/A	7
2	21	11	"Castellano"	"203, 204A, 329 (Spanish for the professions minor)"	0	"Sevilla, Spain; 5 months"	8
3	22	10	"North American"	"203, 204, 260, 376, 377"	"Music: 10+ hours; speaking 1-2 hours"	"Quito, Ecuador; summer"	8
4	32	14	"Guatemalan"	N/A	"Primary language at home is Spanish (husband is Guatemalan). Many conference calls/meetings in Spanish for work every week."	"Querétaro, Mexico; fall semester 2002 and Guatemala; 4.5 years"	9-10
5	26	14	"Neutral: lived in 3 Spanish speaking countries so learned neutrality"	N/A	4	"Chile, 6 months; Spain, 9 months; Guatemala, 27 months"	8
6	21	10	"Mexican/Latin American"	"310"	0	N/A	3
7	21	16	"neutral, dropped s's occasionally"	"Spanish 260H"	3-4	N/A	8
8	27	12	"Mix: I have spent extended time in Argentina, Ecuador, and Spain"	"Undergrad Spanish major, current PhD student in Spanish"	20	"Buenos Aires, 5 months, 2009; Ecuador, 2 months, 2010; Spain, 9 months, 2011-2012. Several brief trips to Nicaragua and Ecuador"	8
9	20	14	"South American"	"203, 204, 255, 260, 300, 350, 376, 377"	1	N/A	8

Table 14: Participant Responses to Survey Questions Regarding L3 Portuguese Learning

Participant	**Current Age**	**AoA**	**Dialect**	**Classes Taken at UNC**	**Hours a Week**	**Studied Abroad**	**Proficiency**
1	19	18	"probably closest to São Paulo"	"401, 402"	3	N/A	3
2	21	20	"Brazilian"	"101, 102, 203"	.5	N/A	2
3	22	20	"Brazilian"	"401, 402"	"Music: 10+ hours; speaking: 1-2 hours"	"Rio: summer"	7
4	32	30	"Brazilian"	"401, 402, 323, 502"	3-4	N/A	2
5	26	26	"Brazilian"	"401, 504"	1	N/A	2-3
6	21	18	"Southern Brazilian"	"101, 102, 203, 310, classes abroad"	0-1.5	"Brazil: 6 months"	7
7	21	18	"Brazilian: Carioca dialect"	"310, 323, 398, 395, 388, 504 (second major)"	5-6	"Rio: 2+ months, summer of 2013"	8
8	27	26	"Brazilian"	"402, 310, 504"	5	N/A	5
9	20	20	"Brazilian"	"401, 402"	.5	N/A	3

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