

**Expanding the scope of orthographic effects:  
Evidence from phoneme counting in first, second, and unfamiliar languages**

by

Carolyn Pytlyk  
B.A., University of Saskatchewan, 1996  
M.A., University of Victoria, 2007

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Requirements of the Degree of  
  
DOCTOR OF PHILOSOPHY  
  
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University of Victoria

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## SUPERVISORY COMMITTEE

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### **Supervisory Committee**

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Dr Patrick Bolger (Department of Spanish and Portuguese, University of S. California)

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## ABSTRACT

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This research expands our understanding of the relationship between orthographic knowledge and phoneme perception by investigating how orthographic knowledge affects phoneme perception not only in the first language (L1) but also in the second language (L2), and an unfamiliar language (L0). Specifically, this research sought not only to confirm that L1 orthographic knowledge influences L1 phoneme perception, but also to determine if L1 orthographic knowledge influences L2 and L0 phoneme perception, particularly as it relates to native English speakers. Via a phoneme counting task, 52 participants were divided into two experimental groups—one with a Russian L0 and one with a Mandarin L0—and counted phonemes in words from their L1 (English) and L0. In addition, two subgroups of participants also counted phonemes in their L2 (either Russian or Mandarin). The stimuli for each language were organized along two parameters: 1) *match* (half with consistent letter-phoneme correspondences and half with inconsistent correspondences) and 2) *homophony* (half with cross-language homophonous counterparts and half without homophonous counterparts). The assumption

here was that accuracy and RT differences would indicate an effect of orthographic knowledge on phoneme perception.

Four-way repeated measures ANOVAs analysed the data along four independent factors: group, language, homophone, and match. Overall, the results support the hypotheses and indicate that L1 orthographic knowledge facilitates L1 and L0 phoneme perception when the words have consistent letter-phoneme correspondences but hinders L1 and L0 phoneme perception when the words have inconsistent correspondences. Similarly, the results indicate that L2 orthographic knowledge facilitates L2 phoneme perception with consistent words but hinders L2 phoneme perception with inconsistent words. On a more specific level, results indicate that not all letter-phoneme mismatches are equal in terms of their effect on phoneme perception, for example mismatches in which one letter represents two sounds (e.g., <x> = /ks/) influence perception more so than do mismatches in which one or more letters are silent (e.g. <sh> = /ʃ/).

Findings from this research support previous claims that orthographic and phonological information are co-activated in speech processing even in the absence of visual stimuli (e.g., Blau et al., 2008; Taft et al., 2008; Ziegler & Ferrand 1998), and that listeners are sensitive to orthographic information such that it may trigger unwanted interference when the orthographic and phonological systems provide conflicting information (e.g., Burnham, 2003; Treiman & Cassar, 1997). More importantly, findings show that orthographic effects are not limited to L1. First, phoneme perception in unfamiliar languages (L0) is also influenced by L1 orthography. Second, phoneme perception in L2 is influenced by L2 orthographic interference. In fact, L2 orthographic effects appear to override any potential L1 orthographic effects, suggesting orthographic

effects are language-specific. Finally, the preliminary findings on the different types of letter-phoneme mismatches show that future research must tease apart the behaviours of different kinds of letter-phoneme inconsistencies.

Based on the findings, this dissertation proposes the Bipartite Model of Orthographic Knowledge and Transfer. The model identifies two components within L1 orthographic knowledge: abstract and operational. The model predicts that abstract L1 orthographic knowledge (i.e., the general assumptions and principles about the function of orthography and its relationship to phonology) transfers into nonnative language processing regardless of whether the listeners/speakers are familiar with the nonnative language (e.g., Bassetti, 2006; Vokic, 2011). In contrast, the model predicts that operational knowledge (i.e., what letters map to what phonemes) transfers into the nonnative language processing in the absence of nonnative orthographic knowledge (i.e., the L0), but does not transfer in the presence of nonnative orthographic knowledge (i.e., the L2). Rather, L2-specific operational knowledge is created based partly on the transferred abstract knowledge.

The research here contributes to the body of literature in four ways. First, the current research supports previous findings and claims regarding orthographic knowledge and native language speech processing. Second, the L2 findings provide insight into the relatively sparse—but growing—understanding of the relationship between L1 and L2 orthography and nonnative speech perception. Third, this research offers a unified (albeit preliminary) account of orthographic knowledge and previous findings by way of the Bipartite Model of Orthographic Knowledge and Transfer.

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## **DEDICATION**

*For Mom, Dad, and Dragon*

## Chapter One

### INTRODUCTION

*“Writing changes the way we think about language and the way we use it.”  
(Coulmas, 2003, p. 17)*

#### *1.1 Background*

Research generally agrees that orthographic knowledge (especially alphabetic knowledge) plays a pivotal role in speech processing. In fact, so strong is the influence of alphabetic knowledge that Frith (1998) likens the possession of an alphabetic representation to a virus where the “virus infects all speech processing” and “language is never the same again” (p. 1011). Olson (1996) claims “people familiar with an alphabet come to *hear* [original emphasis] words as composed of the sounds represented by the letters of the alphabet” (p. 93). Research has demonstrated that alphabetic knowledge affects speech processing by influencing individuals’ abilities to 1) isolate phonemes, 2) perceive phonemes, and 3) separate phonemes and letters (see Appendix B for definitions of important terms.). First, research has demonstrated that learning to read creates a virtually unbreakable bond between letters and sounds such that individuals cannot completely separate sounds from letters (Treiman & Cassar, 1997) and cannot avoid thinking of sounds in terms of their orthographic representations (Burnham, 2003; Landerl, Frith, & Wimmer, 1996). Second, research has established that only individuals with alphabetic experience are able to breakdown words into their component sounds because alphabets “sensitise” individuals to the phonemic level (e.g., Bassetti, 2006; Carroll, 2004; Cheung & Chen, 2004; Cook & Bassetti, 2005; Derwing, 1992; Gombert,

1996; Read, Zhang, Nie, & Ding, 1986). For example, Read et al. (1986) discovered that only alphabetically literate individuals could successfully perform phoneme-monitoring tasks. Finally, more recent research has shown that when a mismatch occurs between the number of letters and the number of phonemes in a word, the orthographic representation overrides the phonological representation thereby causing individuals to misperceive sounds (Erdener & Burnham, 2005; Hallé, Chéreau, & Segui, 2000).

While an abundance of research exists regarding the effect of orthographic knowledge on first language (L1) speech processing, there is a surprising lack of research on how orthographic knowledge affects nonnative language speech processing. If the influence of an orthographic representation on a phonological system is as strong as the research suggests, it would have serious implications for how speakers perceive sounds not only in their L1, but also in their second language (L2) and in an unfamiliar language (L0). This research contributes to the sparse body of research on orthography's relationship to nonnative phoneme perception by shedding light on how much influence orthographic representation exerts on listeners' phoneme recognition and perception in an L2 and in an L0.

### ***1.2 The Current Study***

This study expands our understanding of orthographic effects by examining the relationship between orthographic knowledge and phonological knowledge via native English speakers' abilities to count phonemes in their L1, their L2, and an L0. This project revolves around two key concepts: 1) orthographic representation and 2) phonemic information. Orthographic representation refers to the visual representation of words, i.e., how words are written and the symbols used to represent words in written

language. Phonemic information refers to the auditory input of words, i.e., how words are pronounced and the sounds that make up words in spoken language.

This research seeks to discover whether orthographic representation influences how individuals perceive phonemes in words, specifically with respect to native speakers of Canadian English perceiving phonemes in a language unfamiliar to them—either Russian or Mandarin Chinese (the overall data). In addition, this research is also interested in determining how L1 and L2 orthographies interact (if at all) in influencing second language learners’ perception of L2 phonemes (the subgroup data). The general question is: in an auditory task, does the orthographic representation (i.e., alphabetic knowledge) override the phonological representation and determine the number of phonemes individuals “hear” in a word? That is, do literate native speakers of English rely on their knowledge of how words are spelt in order to count phonemes, and if so, how does this affect their perception of phonemes in other languages and the speed with which they identify those phonemes?

### *1.2.1 Research Questions*

To answer the general question raised above, a phoneme-awareness task—specifically a phoneme counting task where English speakers make decisions on how many phonemes are present in any given word—was employed to answer the following the four primary research questions outlined below.

1. ***Does L1 orthographic knowledge affect how native English speakers count phonemes in their first language (L1)?*** Specifically, do they count phonemes more accurately in words with consistent letter-to-phoneme correspondences (i.e., the numbers of letters and phonemes are the same)

than in words with inconsistent letter-phoneme correspondences (i.e., the numbers of letters and phonemes is not the same)? Also, are native English speakers faster at counting phonemes in consistent words than in inconsistent words? A supplementary question here is: are native English speakers more successful at counting phonemes in orthographically unfamiliar words with inconsistent letter-phoneme correspondences than in orthographically familiar words with inconsistent correspondences because they would not be affected by orthographic interference in the L0?

2. ***Does L1 orthographic knowledge affect how native English speakers count phonemes in an unfamiliar language (L0)?*** That is, when L0 words are homophonous with L1 words, does L1 orthographic knowledge affect participants' abilities to accurately perceive the phonemes in L0 words. Specifically, do native English speakers more accurately count phonemes in L0 words that are homophonous with the L1 words with consistent letter-phoneme correspondences than in L0 words that are homophonous with L1 words with inconsistent letter-phoneme correspondences?
3. The third primary research question is a two-part research question.
  - a. ***Does L2 orthographic knowledge affect how native English speakers count phonemes in their L2?*** That is, as predicted with the L1, do language learners count phonemes more accurately and faster in L2 words with consistent letter-to-phoneme correspondences (i.e., the numbers of letters and phonemes are the same) than in L2 words

with inconsistent letter-phoneme correspondences (i.e., the numbers of letters and phonemes is not the same)?

b. *If so, how does L2 orthographic knowledge interact with L1 orthographic knowledge?* That is, since “the nature of the L1 orthography influences the way L2 learners attend to the L2 orthographic units” (Wade-Woolley, 1999, p. 448), does L1 orthographic knowledge override L2 orthographic knowledge and affect phoneme perception in the L2?

4. *Does the strength of the orthographic effect vary depending on experience with the language?* Are listeners more likely to be negatively influenced by inconsistent letter-phoneme correspondences when they have more experience with the target language? In other words, is the difference between the matched and mismatched L1 words greater than the difference between the matched and mismatched L2 words, which in turn is greater than the difference between the matched and mismatched L0 words?

### *1.2.2 Research Hypotheses*

In answering the research questions, we can imagine two scenarios. If the orthographic representation does not intrude on the phonological representation, native English speakers should be able to transcend letter-phoneme associations. As a result, individuals should be able to ignore how the words are spelt and successfully count phonemes in their L1, their L2, and an L0. On the other hand, if, as the literature suggests, the orthographic representation does exert a strong influence on the phonological

representation and interferes with speech processing, then, native English speakers will have difficulty separating letter-phoneme associations. As a result, a mismatch between the number of letters and phonemes in a word will cause listeners to miscount the phonemes they hear. This, of course, is contingent on the individuals knowing how words are spelt. Thus, the orthographic representation will only interfere with individuals' performance in their L1 and L2 and with all cross-language (including the L0's) homophones (see §4.2 and Table 4.2 for a more detailed discussion of the experimental stimuli.).

In light of previous findings, namely that individuals cannot completely separate phonemes and letters (e.g., Burnham, 2003; Treiman & Cassar, 1997) and that the orthographic representation overrides auditory information (e.g., Erdener & Burnham, 2005; Hallé et al., 2000), the second scenario seems more plausible. Therefore, I hypothesise that native speakers of Canadian English will rely on their knowledge of how words are spelt to help them count phonemes. The numbered predictions below parallel the aforementioned research questions such that each research question has a corresponding research prediction. For the purposes of this research, **consistent words** refer to words where the number of letters equals the number of phonemes (e.g., *cat*, /kæt/, *hint* /hɪnt/, and *traps* /tɹæps/). In contrast, **inconsistent words** refer to words where the number of letters does not equal the number of phonemes (e.g., *house* /haws/, *peck* /pɛk/, and *tough* /tʌf/). In other words, consistent words have one-to-one letter-phoneme correspondences and inconsistent words have either one-to-many or many-to-one letter-phoneme correspondences.

1. Because L1 orthography *facilitates* L1 phoneme perception in consistent words but *hinders* in inconsistent words, native English speakers will count phonemes *more* accurately and faster in English words where a match between number of phonemes and the number of letters occurs (i.e., consistent letter-phoneme correspondences) than in English words where a mismatch between the number of phonemes and letter occurs (i.e., inconsistent correspondences).
2. L1 orthography *facilitates* L0 phoneme perception in consistent cross-language homophones because the associated L1 spellings help parse L0 phonemes, but L1 orthography does not affect perception in consistent nonhomophones because no spelling associations exist. In addition, L1 orthography *hinders* L0 phoneme perception in inconsistent cross-language homophones because the associated L1 spellings interfere with perception, but L1 orthography does not affect perception in inconsistent nonhomophones because, as with the consistent nonhomophones, no L1 spelling associations exist.
3. As with L1, L2 orthography *facilitates* L2 phoneme perception in consistent L2 nonhomophones but *hinders* in inconsistent L2 nonhomophones. In contrast, for the cross-language L2 homophones, which have associated L1 spellings, L1 orthographic knowledge *overrides* L2 orthographic knowledge and influences L2 phoneme perception such that L1 orthography *facilitates* L2 phoneme perception in L2 words with consistent L1 associations but *hinders* in L2 words with inconsistent L1 associations.

4. As native speakers, the listeners have many more years of experience with English than they do with their L2 and thus the L1 orthography is more entrenched and potentially exerts more influence on the L1 than the L2 orthography exerts on the L2. Therefore, the accuracy and response time differences between the consistent and inconsistent L1 words would be greater than the differences between the consistent and inconsistent L2 words, which in turn would be greater than the differences between the consistent and inconsistent L0 words (i.e., L1 differences >> L2 differences >> L0 differences).

In sum, with regards to the cross-language homophones, native speakers English should rely on their knowledge of how similar sounding L2 and L0 words are spelt in the L1 because of the ingrained L1 orthographic representations. Therefore, when the L1 associations have consistent correspondences, listeners should count phonemes more accurately and faster than when the L1 associations have inconsistent correspondences. With regards to the L1 and L2 nonhomophonous words, native English speakers should be more successful (i.e., higher accuracy and faster response times) with consistent words because orthographic knowledge helps in parsing phonemes than with inconsistent words because orthographic knowledge interferes with parsing phonemes. Finally, listeners should be as successful at counting phonemes in the L0 consistent nonhomophones as the inconsistent L0 nonhomophones because the listeners do not know the words' spellings and the words have no L1 associations.

To test the hypotheses, an experiment was conducted in which L1 English speakers counted phonemes in English, Russian, and Mandarin stimuli that were created and

organised according to two parameters: *homophony* and *match*. That is, each set of language stimuli had four types of words: 1) nonhomophonous words with consistent letter-phoneme correspondences (e.g., *big* /bɪg/, *ɔyu* /duf/, and *huā* /xwa/), 2) nonhomophonous words with inconsistent correspondences (e.g., *fish* /fɪʃ/, *юг* /juk/, and *yòng* /jɔŋ/), 3) cross-language homophonous words with consistent L1 associations (e.g., *brat* /bræt/ – *брат* /brat/ and *bow* /baw/ – *бào* /paw/), and 4) cross-language homophonous words with inconsistent L1 associations (e.g., *tree* /tri/ – *mpu* /tri/ and *rue* /ru/ – *рú* /zu/). The assumption here was that accuracy and speed differences between matched and mismatched words – as well as homophones and nonhomophones—would indicate an effect of orthographic knowledge on phoneme perception. Together, results from these stimuli allow us to determine that orthographic knowledge influences the perception of phonemes in our L1 and in other, less familiar languages.

### ***1.3 Dissertation outline***

This dissertation consists of seven chapters. Chapter One provides an introduction to the research project by outlining the research questions and hypotheses. Chapter Two discusses the relevant literature including theories of L1 influence on L2 learning, the current models of speech processing, phoneme awareness, and orthographic depth. Chapter Three discusses the orthographic representation of the Roman alphabet, the Cyrillic alphabet, and the Pinyin alphabet. This chapter also outlines the important language characteristics of English, Russian, and Mandarin Chinese with special attention to each language’s phoneme inventory, syllable structure, and orthographic system used to represent the phonemes in each language. Next, Chapter Four provides a comprehensive description of the methodology employed in the research project.

Chapter Five presents the results and analyses of the data. Chapter Six provides an in-depth discussion of the results by returning to the research questions and hypotheses, discussing the major findings in terms of the current literature, and proposing the Bipartite Model of Orthographic Knowledge and Transfer. Finally, Chapter Seven concludes this dissertation by summarizing the main findings, outlining the limitations of the project, highlighting the research contributions, and suggesting future research endeavours.

## Chapter Two

### BACKGROUND RESEARCH

***“Language and writing are two distinct systems of signs;  
the second exists for the sole purpose of representing the first.”  
(Saussure as cited in Aronoff, 1992)***

This chapter highlights the relevant background research regarding second language speech perception and orthographic influence on first language (L1), second language (L2), and unfamiliar language (L0) phoneme perception. To determine whether learners’ L1 alphabetic knowledge influences L2 and L0 sound perception, we must first understand L1 transfer and the current theories of speech processing in second language acquisition (§2.1). We must also understand how alphabetic knowledge promotes phoneme awareness and influences word and sound recognition as well as how orthographic depth influences and shapes speech processing (§2.2).

#### ***2.1 Second Language Acquisition***

Since this study investigates the relationship between orthographic representation and L2 speech processing, a section on L2 learning is important. This section includes two subsections. The first subsection (§2.1.1) discusses L1 influence (i.e., language transfer) on second language acquisition (SLA), and the second subsection (§2.1.2) discusses the theory that L2 learners/users perceive their L2 through the filter of their L1 and outlines the three current models of speech processing, namely the *Native Language Magnet* (NLM), the *Perceptual Assimilation Model* (PAM), and the *Speech Learning Model* (SLM).

### 2.1.1 Early models: First language transfer

In an attempt to explain the effect of the L1 on an L2, Lado (1957) proposed one of the first and most influential theories in second language acquisition (SLA), the Contrastive Analysis Hypothesis (CAH). In this model, CAH claimed that interference from the learner's L1 was the major barrier to the acquisition of an L2. Specifically, CAH claimed that learning (or the lack thereof) was contingent on the notion of transfer, which Archibald (1998) defines as “the process whereby a feature or rule from a learner's first language is carried over to the IL [interlanguage] grammar” (p. 3)<sup>1</sup>. In SLA, L1 transfer can be either positive or negative. Positive transfer occurs when an L1 feature is carried over into the interlanguage and *facilitates* learning and/or performance in the L2 while negative transfer occurs when an L1 feature is carried over into the interlanguage but *hinders* learning and/or performance in the L2. According to CAH, negative transfer from the L1 into the interlanguage grammar can explain ALL errors in the L2. Thus by systematically comparing the differences between the L2 and the L1, CAH proposed that researchers could predict where the learners would have difficulty and where they would not (Major, 2001): acquiring similar<sup>2</sup> L1 and L2 elements would be easy (positive transfer), and acquiring different elements would be difficult (negative transfer).

While the promise of predicting all errors was certainly appealing, in the years following its proposal, CAH encountered two major criticisms. First, contrary to its

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<sup>1</sup> The interlanguage, or IL, is the language system that an L2 learner uses. This is a system that is neither the L1 nor the L2 – it is a system that is somewhere between the two other systems. According to Major (2002), the IL is formed by three factors: 1) the L1, 2) the L2, and 3) universal principles.

<sup>2</sup> While researchers often use the terms *similar* and *dissimilar* to characterise the degree of difference between L1 and L2 elements, they have yet to satisfactorily operationalize their definitions. That is, researchers currently do not have any clear parameters for what constitutes a similar element and what constitutes a dissimilar element. Thus, the question still remains: at what point do elements become dissimilar from each other?

claim, CAH failed to predict all the errors that were made by language learners (what future SLA theorists would call “developmental” errors), and it predicted some errors that did not occur. Second, CAH also failed to account for why learners with different L1s substitute different L1 elements for the same L2 element (Brown, 2000; Major, 2001). Research has shown that learners with different L1s substitute different L1 phonemes for the same L2 phoneme even though the L1s may have the same substitute options. For example, CAH could not account for why Japanese English-as-a-second-language (ESL) learners substitute /s/ for /θ/ and Russian ESL learners substitute /t/ for the same fricative when both Japanese and Russian have /s/ and /t/ (Hancin-Bhatt, 1994).

In light of serious criticisms against traditional CAH, Oller and Ziahosseiny (1970) proposed a *moderate version* of CAH in an attempt to remedy its shortcomings. This moderate version considered degrees of similarity between L1 and L2 elements. In fact, Oller and Ziahosseiny were the first to suggest that similar L1 and L2 elements would cause more difficulty than dissimilar L1 and L2 elements. In their study of English spelling errors, they discovered that those learners whose native language used a different orthography from the Roman alphabet made fewer mistakes than those whose native language used the Roman alphabet. Based on their results, they claimed that learning similar “sounds, sequences and meanings” would cause more difficulty for language learners than dissimilar ones because “whenever patterns are minimally distinct in form in one or more systems, confusion may result” (p. 186). Since Oller and Ziahosseiny’s work, subsequent researchers have come to agree that more dissimilar L2 elements are easier than the similar ones. Why would dissimilar elements be easier than similar ones, and why would transfer hinder rather than facilitate L2 learning? Because dissimilar

elements have no corresponding structure in the L1, they are less likely to be influenced by negative transfer and are therefore more likely to be learnt (Major; 2001; Wode, 1983). Moreover, Major (2001) points out that the differences between similar L1 and L2 elements are not perceptually salient enough to allow learners to perceive the minute differences between the two languages. In other words, the greater the difference between structures (i.e., the more dissimilar they are), the more easily the learner should be able to perceive the difference and learn it.

### *2.1.2 Current models: The L1 filter*

Since the 1970s, considerable research in SLA has investigated Oller and Ziahosseiny's (1970) claim that similar elements are more difficult to acquire than dissimilar ones. By far, the most research has focused on the area of L2 phonology and attempted to characterize the relationship and interaction between the L1 phonological system and the target L2 phonology. SLA researchers agree that "L2 sounds are mapped on to L1 sounds" (Brown, 2000, p. 8), and recent perceptual models (e.g., Best, 1995, 2001; Flege, 1987, 1995; Kuhl, 1993, 2000) suggest that native sound experience gives learners an "organizing perceptual framework" with which to discriminate and classify nonnative phonemes (Best, 2001, p. 776). In other words, L2 learners perceive L2 language elements (not just phonology but also prosody, syllable structure, and syntax as well) through the filter of their L1, which, in turn, often leads to interference (i.e., negative transfer) from the L1.

Kuhl's (1993, 2000) *Native Language Magnet* (NLM) is one model that attempts to account for L2 speech perception. NLM accounts for the perception of individual phonemes and claims that both innate factors and linguistic experience influence speech

perception. This model accounts for 1) how native language categories are created and 2) how L2 phonemes interact with L1 phonemes. According to NLM, a “general auditory processing mechanism” allows infants to use the acoustic features of the sounds and group those sounds into gross universal categories. However, NLM also claims linguistic experience defines speech perception such that as infants gain experience and input from their native language (L1), they reconfigure the gross category boundaries and create language-specific mental maps of speech sounds. These language-specific maps then “warp” the phonetic space and “produc[e] a complex network, or filter, through which language is perceived” (Kuhl, 2000, p. 11854). Moreover, the reconfiguration process of phonetic boundaries establishes language specific prototypes, which act like “perceptual magnets” that distort the phonetic space, reducing the perceptual distance between the prototype and a given stimulus (Kuhl, 1993). These perceptual magnets attract nearby sounds to make them more similar to the category prototype. Thus, foreign sounds are more difficult to discriminate when they closely resemble native magnets because magnets distort the space surrounding them. Also by attracting L2 sounds, those L2 sounds that are closer to the L1 magnets are more likely to be assimilated to and indistinguishable from the L1 prototypes.

While Kuhl’s (1993, 2000) NLM considers perception of individual phonemes, Best’s (1995, 2001) *Perceptual Assimilation Model* (PAM) is a model that aims to account for the role that the L1 plays in the perception of nonnative contrasts. Like NLM, PAM holds that learners are heavily influenced by their knowledge of their established native phoneme categories. Because of this influence, PAM predicts that learners should assimilate nonnative sounds to native phonemes “whenever possible based on detection

of commonalities in the articulators, constriction locations and/or constriction degrees used” (Best, 2001). In this model, learners categorise nonnative sounds in one of three ways: as either (1) part of a native category, (2) as an uncategorizable speech sound, or (3) an unassimilatable non-speech sound. According to PAM, learners should more accurately distinguish an L2 phoneme contrast if the two contrasting phonemes are assimilated to two separate L1 phoneme categories rather than to one L1 phoneme category.

Like PAM, a third speech perception model, Flege’s (1987, 1995) *Speech Learning Model* (SLM), assumes that phonemes similar to L1 phonemes are more difficult for learners because of learners’ tendencies to equate similar nonnative phonemes with already existing native ones. SLM distinguishes two kinds of phonemes: *new* and *similar*. **New** phonemes (i.e., dissimilar phonemes) are phonemes that have no counterpart in the L1, while **similar** phonemes are phonemes with an L1 counterpart, though they differ from it systematically. SLM maintains that the greater the difference between an L2 phoneme and the closest L1 phoneme, the easier it is for the learner to discern the phonetic differences and produce as well as perceive the L2 phoneme (Flege, 1995). The differences between similar phonemes and their L1 counterparts are relatively subtle, and therefore, relatively difficult to discern. SLM attributes this difficulty to “equivalence classification,” such that a “single phonetic category will be used to process perceptually linked L1 and L2 sounds” (Flege, 1995, p. 239) and thus will hinder learners’ abilities to create new phonetic categories for similar sounds.

Just as the learners tend to view the L2 through the L1 at the segmental level, they also view the L2 through the L1 at the prosodic level. For example, research on

Mandarin learners of English and English learners of Mandarin found that both groups of learners failed to produce the appropriate prosodic characteristics of interrogatives in their L2 (Pytlyk, 2008; Visceglia & Fodor, 2006). Visceglia and Fodor (2006) discovered that native Mandarin speakers tended to compress pitch excursions in English declaratives and interrogatives to the final syllable rather than from the pitch accent to the boundary. In contrast, native English speakers tend to use a final rise on the final syllable in Mandarin *ma* particle questions, as they would in uttering an English question (Pytlyk, 2008; Visceglia & Fodor, 2006).

In sum, what the models have in common is that they capture the fact that L1 acts as a filter for L2 speech perception such that learners' L1 phonological system profoundly (and irrevocably) influences L2 speech perception. The NLM, PAM, and SLM establish that the L1 is a filter through which an L2 or L0 is perceived. More specifically, these models agree that the L1 system constrains L2 learners' abilities to perceive and produce L2 structures. In other words, L2 learners/users perceive L2 elements (such as phonemes and prosody) in relation to existing L1 elements. Therefore, given that elements constrain perception of nonnative phonemes, the current research investigates whether L1 orthographic knowledge is among the L1 elements that affect nonnative speech processing. The driving question here is: considering the inseparable connection between phonology and orthography (See §2.2 below.), is L1 orthographic knowledge another filter through which learners perceive nonnative speech?

## ***2.2 Alphabetic Knowledge***

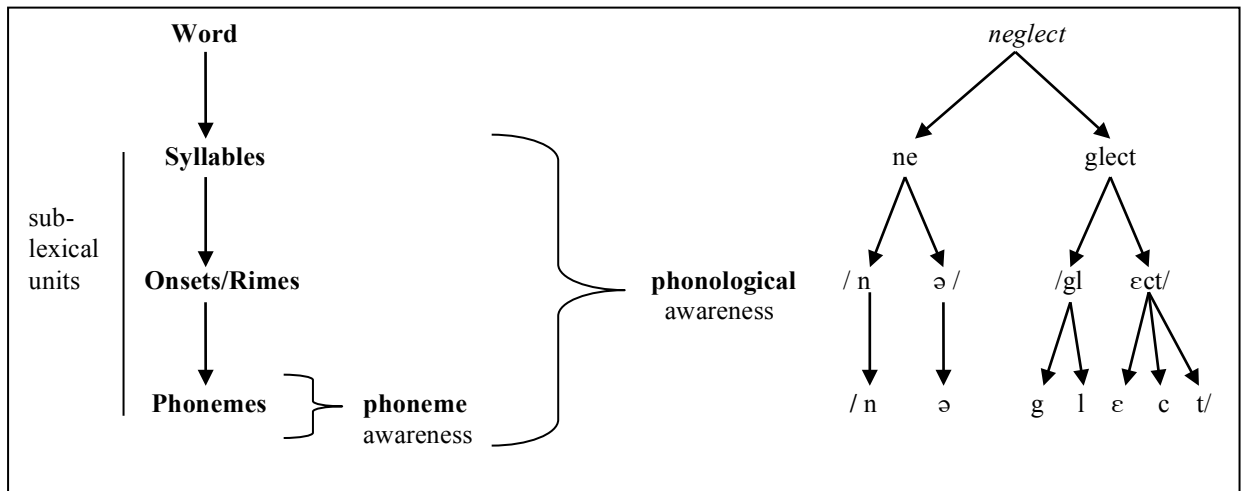
This section highlights the research that demonstrates that alphabetic knowledge **i)** creates phoneme awareness (§2.2.1), **ii)** affects sound and word recognition and is co-

activated with phonological representation (§2.2.2), **iii**) makes separating letter-phoneme associations extremely difficult (§2.2.3), and **iv**) overrides phonetic information and suggests sounds (§2.2.4). This section also highlights the research surrounding orthographic depth and its effect on alphabetic knowledge (§2.2.5).

### *2.2.1 Acquisition and development of phoneme awareness*

As this research is primarily concerned with phoneme awareness, we must first differentiate *phoneme* awareness from *phonological* awareness. In short, phonological awareness encompasses phoneme awareness. Cheung (1999) defines phonological awareness as “an individual’s ability to analyse spoken language into smaller component sound units and to manipulate them mentally” (p. 2). These smaller component sound units (i.e., sublexical units) can be either: 1) syllables, 2) onsets and rimes, or 3) phonemes (Bruck, Treiman, & Caravolas, 1995; Treiman & Zukowski, 1991). For example, people demonstrate phonological awareness (but not phoneme awareness) in a task where they can successfully identify and rearrange syllables (e.g., *cil-pen* from *pen-cil*). Similarly, people demonstrate phonological awareness (but not phoneme awareness) in a task where they can successfully identify and blend the onset of one syllable with the rime of another syllable (e.g., *map* from *mob* and *sap*). Finally, people demonstrate phoneme awareness (and thus phonological awareness) in a task where they can successfully identify and delete phonemes (e.g., *rack* from *track*). (See Table 2.1 below for a list of phoneme awareness assessment tasks.)

Figure 2.1 below visually represents the three aspects of phonological awareness and illustrates those levels with the word *neglect* as an example.



**Figure 2.1** Illustration of the levels of phonological awareness

In her analysis of phonemic awareness tasks, Yopp (1988) concludes that “phonemic awareness can be defined as the ability to manipulate individual sounds in the speech stream, or, more simply, as control over phonemic units of speech” (p. 173). In short, while *phonological* awareness refers to the ability to manipulate any sublexical unit, (i.e., syllables, onsets and rimes, or phonemes), *phoneme* awareness strictly refers to the ability to manipulate phonemes and as such phoneme awareness is the third level of phonological awareness. Table 2.1 below lists and describes the various tasks employed by researchers to determine phoneme awareness.

<b>Tasks</b>	<b>Description</b>	<b>Previous Studies</b>
<b>phoneme counting</b>	<ul style="list-style-type: none"> <li>- count (or tap) the number of phonemes in a given syllable or word</li> <li>- e.g., the word <i>tough</i> contains 3 phonemes /t/, /ʌ/, and /f/</li> </ul>	Arnqvist, 1992; Bassetti, 2006; Cheung, 1999; Cossu et al., 1988; Derwing, 1992; Ehri & Wilce, 1980; Gombert, 1996; Landerl et al., 1996; Lehtonen & Treiman, 2007; Liberman et al., 1974; Mann, 1986; Perin, 1983; Pytlyk, to appear; Spencer & Hanley, 2003; Treiman & Cassar, 1997; Yopp, 1988
<b>phoneme deletion</b>	<ul style="list-style-type: none"> <li>- isolate the target phoneme, delete it from the given syllable/word and then say the syllable/word that is left once the target phoneme has been removed</li> <li>- e.g., deleting the initial consonant from the word <i>flag</i> to create <i>lag</i>.</li> </ul>	Ben-Dror et al., 1995; Bertelson et al., 1989; Caravolas & Bruck, 1993; Carroll, 2004; Carroll et al., 2003; Castles et al., 2003; Cheung, 1999; Hu, 2008; Mann, 1986; Morais et al., 1979; Read et al., 1986; Saiegh-Haddad et al., 2010; Russak & Saiegh-Haddad, 2011; Tyler & Burnham, 2006; Wade-Woolley, 1999; Yopp, 1988
<b>phoneme segmentation</b>	<ul style="list-style-type: none"> <li>- identify the phonemes in a given word</li> <li>- e.g., the word <i>big</i> has the phonemes /b/, /ɪ/, and /g/</li> </ul>	Cossu et al., 1988; Russak & Saiegh-Haddad, 2011; Silva et al., 2010; Williams, 1980; Yopp, 1988
<b>phoneme isolation</b>	<ul style="list-style-type: none"> <li>- identify a specific phoneme in a give word</li> <li>- e.g., /k/ is the first phoneme in the word <i>cat</i></li> </ul>	Burnham, 2003; Caravolas & Bruck, 1993; Castles et al., 2009; Russak & Saiegh-Haddad, 2011; Saiegh-Haddad, 2007; Yopp, 1988
<b>phoneme reversal</b>	<ul style="list-style-type: none"> <li>- reverse two specific phonemes in a word</li> <li>- e.g., switch the first and last phonemes in the word <i>pit</i> to create <i>tip</i></li> </ul>	Alegria et al., 1982; Castles et al., 2003; Yopp, 1988
<b>phoneme blending</b>	<ul style="list-style-type: none"> <li>- combine given phonemes into a word</li> <li>- e.g., use the phonemes /g/, /e/, /s/, and /t/ to create the word <i>guest</i></li> </ul>	Cheung, 1999; Williams, 1980; Yopp, 1988
<b>word-to-word matching</b>	<ul style="list-style-type: none"> <li>- identify if the given words share the same phoneme</li> <li>- e.g., do <i>pen</i> and <i>hit</i> begin with the same phoneme?</li> </ul>	Cheung & Chen, 2004; Silva et al., 2010; Treiman & Zukowski, 1991; Yopp, 1988
<b>phoneme identity</b>	<ul style="list-style-type: none"> <li>- target phoneme illustrated in example word, then identify (from 2 words) which word starts (or ends) with the same phoneme as the target</li> <li>- e.g., <i>hop</i> and <i>hum</i> start with the same sound as <i>hit</i></li> </ul>	Bowey, 1994; Fletcher-Flinn et al., 2011; Wallach et al., 1977
<b>phoneme oddity</b>	<ul style="list-style-type: none"> <li>- identify the odd word out based on phoneme difference – either onset, medial, or final</li> <li>- e.g., <i>deck</i> is the odd word out of <i>fit</i>, <i>fan</i>, <i>deck</i></li> </ul>	Bowey, 1994; Hu, 2008
<b>phoneme monitoring</b>	<ul style="list-style-type: none"> <li>- push a button as soon as a the target phoneme is identified</li> <li>- e.g., push the “space bar” when you hear /p/</li> </ul>	Cutler et al., 2010; Dijkstra et al., 1995; Frauenfelder et al., 1995; Hallé et al., 2000; Morais et al., 1986
<b>invented spellings</b>	<ul style="list-style-type: none"> <li>- spell the words heard</li> <li>- e.g., <i>picture</i> is spelt &lt;piccher&gt;</li> </ul>	He & Wang, 2009; Morris, 1983; Silva et al., 2010

**Table 2.1** Phoneme awareness assessment tasks (adapted from Yopp (1988))

Not only is phoneme awareness the most fine-grained level of phonological awareness, but it is also much more difficult to acquire and develops much later than the other two levels of phonological awareness (Cossu, Shankweiler, Liberman, Tola, & Katz, 1988; Liberman, 1971; Liberman, Cooper, Shankweiler, & Studdert-Kennedy, 1967; Liberman, Shankweiler, Fischer, & Carter, 1974). According to Liberman and her colleagues, syllables are easier to perceive and manipulate than phonemes because syllables are temporally discrete units of sound; they have a peak of acoustic energy that provides a direct auditory cue for identification and explicit segmentation. In contrast, phonemes lack an independent existence; “the consonant segments of the phonemic message are typically folded, at the acoustic level, into the vowel, with the result that there is no acoustic criterion by which the phonemic segments are dependably marked” (Liberman et al., 1974, p. 204). In other words, because all phonemes are affected by co-articulation, individual phonemes often cannot be clearly delineated, and phoneme segmentation becomes much more difficult than syllable segmentation.

With respect to phonological awareness, writing systems dictate the sub-word language units literate speakers are aware of and thus can identify and manipulate (e.g., Bassetti, 2006; Cook & Bassetti, 2005; Derwing, 1992; Mann, 1986; Saiegh-Haddad, Kogan, & Walters, 2010). For example, syllabaries, like the Japanese *kana* and *hiragana*, make speakers aware of morae (Cook & Bassetti, 2005; Mann, 1986; Wade-Woolley, 1999), consonantal writing systems, like the Arabic and Hebrew systems, make speakers aware of consonant-vowel (CV) units (Cook & Bassetti, 2005; Saiegh-Haddad et al., 2010), and alphabets, like the Roman and Cyrillic systems, make English and Russian speakers aware of phonemes (e.g., Gombert, 1996; Goswami, 1999; Goswami & Bryant,

1990; Mann, 1986; Treiman & Cassar, 1997; Wade-Woolley, 1999). That is, different types of writing systems make different phonological units salient, and Derwing (1992) thus suggests:

the segment (or phoneme) may not be the natural, universal unit of speech segmentation, after all, and that the orthographic norms of a given speech community may play a larger role in fixing what the appropriate scope is for those discrete repeated units into which the semi-continuous, infinitely varying physical speech wave is actually broken down (p. 200).

Thus, while children/people acquire the first two aspects of phonological awareness (i.e., the ability to manipulate syllables and onsets/rimes) naturally without reading instruction, they can only acquire phoneme awareness (i.e., the ability to manipulate individual phonemes) with instruction in a written code—specifically an alphabetic code (Morais, 1991). In other words, alphabetic experience allows listeners to abstract the phonemes from the speech signal.

Indeed, a substantial body of research on children, dyslexics, illiterates, and nonalphabetic literates suggests that phoneme awareness is a product of alphabetic knowledge. In fact, the research indicates that alphabetic knowledge precedes phoneme awareness. That means, for individuals to perform successfully on phoneme awareness tasks (e.g., phoneme counting, phoneme deletion, blending, and so on), they must have experience with an alphabetic script. Chueng and Chen (2004) argue “phoneme awareness requires support from alphabetic reading [...] because the identity of the phoneme is made explicit only in alphabets” (p.3). Children learn how to isolate and/or segment phonemes via learning letters and their threshold for phoneme awareness is knowledge of a few letters and the phonemes those letters represent (Carroll, 2004). In

short, alphabetic knowledge allows listeners to parse words into their component phonemes because alphabets sensitise listeners to the phonemic level.

For children, the research suggests that whereas knowledge of syllables and onsets and rimes appears to develop spontaneously before children go to school, knowledge of phonemes appears to develop when children go to school and begin to learn to read in an alphabetic orthography (e.g., Cheung & Chen, 2004; Gombert, 1996; Goswami, 1999; Goswami & Bryant, 1990; Morais, Cary, Alegria, & Bertelson, 1979; Treiman & Cassar, 1997). According to Goswami (1999), phonological awareness develops in young children from the syllabic level via the onset/rime level (prior to learning to read) to the phonemic level (after learning to read). This sequence of development has been observed for child learners of alphabetic orthographies including English speaking children (Lieberman et al., 1974; Treiman & Zukowski, 1991), Italian children, (Cossu et al., 1988), German children (Wimmer, Landerl, & Schneider, 1994), Czech children (Caravolas & Bruck, 1993), Swedish children (Arnqvist, 1992), and Norwegian children (Høien, Lundberg, Stanovich, & Bjaalid, 1995). The research suggests that the development of phonological awareness—from awareness of syllables to awareness of onsets/rimes to awareness of phonemes—is similar for all children and independent of language background, provided that the language employs an alphabetic writing system.

Further support for the argument that alphabetic knowledge precedes phoneme awareness comes from research with non-literates (Bertelson, de Gelder, Tfouni, & Morais, 1989; Morais, Bertelson, Cary, & Alegria, 1986; Morais et al., 1979) and nonalphabetic literates (Cheung, 1999; Cheung & Chen, 2004; Read et al., 1986). For example, Morais et al. (1979) compared the segmentation skills of literate and non-

literate adults in Portugal to determine whether phoneme awareness can develop over time without literacy. Morais et al. discovered that only the literate adults could add and delete consonants at the beginning of non-words. In a follow up to Morais et al.'s study, Read et al. (1986) argued that a comparison of alphabetic literates and non-alphabetic literates would be a more direct test of whether phoneme awareness can develop over time without alphabetic literacy. In this study, Read et al. compared Chinese speakers who had learnt Pinyin—a romanized script used to teach Mandarin Chinese—in addition to Chinese characters (the alphabetic group) and Chinese speakers who had only learnt Chinese characters (the nonalphabetic group). They discovered that the alphabetic literates were significantly more successful at adding and deleting consonants than nonalphabetic literates, thereby concluding that differences in segmentation skills are a result of alphabetic literacy.

Finally, research in SLA also indicates that phoneme awareness is contingent on alphabetic experience. Alphabetic L1 orthographies facilitate L2 phoneme awareness such that L2 learners who have an alphabetic L1 orthography perform better on phoneme manipulation tasks than L2 learners who have a non-alphabetic L1 orthography. For example, via a phoneme deletion task, Ben-Dror, Frost, and Bentin (1995) discovered that the English speakers could accurately delete target phonemes in both English (L1) and Hebrew (L2) while the Hebrew speakers tended to delete initial CV segments rather than the single target phonemes in Hebrew (L1) and English (L2). Ben-Dror et al. suggest that since the orthographic units in English generally correspond to single phonemes, the L1 orthography enhances phoneme awareness. In contrast, they suggest that since the orthographic units in Hebrew (a consonantal system) generally correspond to CV

segments, the L1 orthography inhibits Hebrew speakers' abilities to accurately manipulate individual phonemes. Similarly, Wade-Woolley (1999) also argues that L1 orthographic experience is a contributing factor for performance in phoneme awareness tasks. In her study of Russian and Japanese ESL learners, Wade-Woolley (1999) discovered that Russian ESL learners performed significantly better in a phoneme deletion task than Japanese ESL learners. According to Wade-Woolley, the Russian learners' experience with an alphabetic orthography (i.e., Cyrillic) positively facilitated their ability to manipulate sublexical speech units (positive L1 transfer), while the Japanese learners' experience with a syllabic orthography (i.e., Kana) sensitised them to visual information but did not help them perform the phoneme deletion task (negative L1 transfer).

In sum, phoneme awareness is a type of phonological awareness that requires the ability to perceive and manipulate individual phonemes, and phoneme detection tasks, such as phoneme counting, phoneme deletion, and phoneme segmentation, measure listeners' degree of phoneme awareness. In the words of Castles, Holmes, Neath, and Kinoshita (2003) while

a certain level of phonological awareness is necessary for understanding the rudiments of the alphabetic principle, [...] as the learning of phoneme-grapheme correspondences progresses, this [alphabetic] knowledge in turn promotes the development and refinement of phonological awareness. (p. 447)

As we have seen from the above discussion, phoneme detection tasks in the research on children, illiterates, non-alphabetic literates, and L2 learners strongly suggest that phoneme awareness is contingent on learning to read an alphabetic orthography.

### 2.2.2 Word/phoneme recognition and automatic co-activation

Not only has research demonstrated that alphabetic knowledge creates phoneme awareness, but research has also demonstrated that alphabetic knowledge influences word pronunciation and recognition. For example, research into “consistency effects” has shown that word pronunciation and recognition is affected by knowledge of similarly spelt words. This means that spelling-to-sound or sound-to-spelling inconsistencies increase processing times and error rates (Glushko, 1979; Lacruz & Folk, 2004; Jared, McRae, & Seidenberg, 1990; Stone, Vanhoy, & Van Orden, 1997; Ziegler, Ferrand, & Montant, 2004).

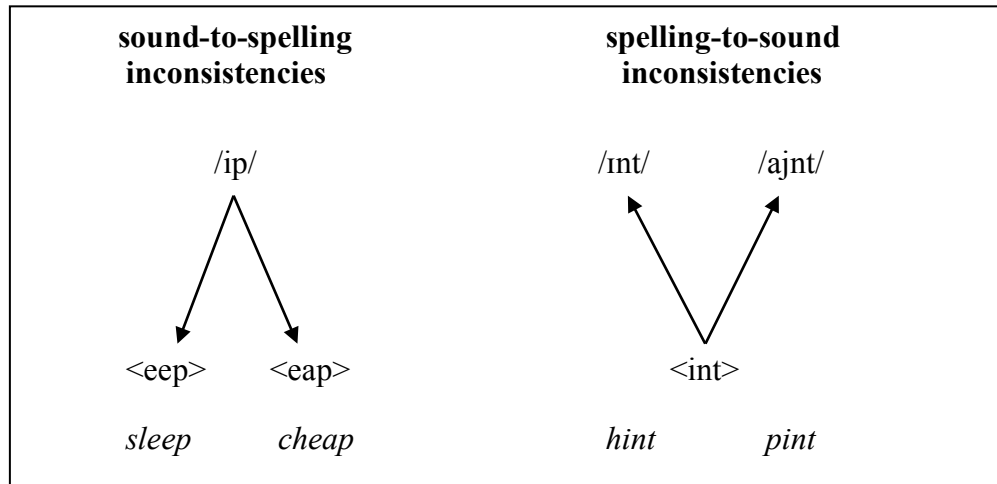
In his seminal work, Glushko (1979) was the first researcher to investigate consistency effects. He investigated three types of pseudowords, which were generated from real words (e.g., *hean* from *dean* and *heaf* from *deaf*). The first type were “regular consistent” words where the rimes do not have any alternate pronunciations. For example, the rime <eap> in a word like *heap* can only be pronounced in one way—/ip/<sup>3</sup>. The second and third types of words were “regular inconsistent” words where the rimes do have alternative pronunciations, and “exception” words where the rimes have irregular pronunciations, respectively. For example, words like *gave* are regular inconsistent words because their rimes have pronunciations that follow orthographic rules (/ejv/); however, these rimes also occur in exception words like *have*, which have irregular pronunciations that cannot be derived from any orthographic rule (/æv/). For both regular consistent and regular inconsistent words, the pronunciations are predictable based on general

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<sup>3</sup> With regards to notation, slant lines // refer to phonemic categories, square brackets [] refer to phonetic realisations, and angle brackets <> refer to graphemic representations. For example, in English, the phoneme /k/ can be realised as [k] or [k<sup>h</sup>] and spelt as <k>, <c>, <ck>, <ch> or even <q> as in the words *karma*, *tract*, *stack*, *anchor*, and *query*, respectively.

orthographic rules. Conversely, exception words have irregular pronunciations that must be memorized. The participants were asked to pronounce each target pseudoword, which was presented on a display screen. Glushko discovered that when participants pronounced regular inconsistent and exception words, they had higher error rates and longer response times. That is, exception pseudowords like *heaf* /hef/ had higher error rates and longer response times than regular pseudowords like *hean* /hin/ because according to Glushko, speakers' knowledge of words with similar spellings influences their pronunciation and recognition of target words.

Since Glushko (1979), a number of other researchers have examined consistency effects. These researchers have discovered that the effects of spelling consistency are contingent on other factors. First, low frequency words are more susceptible to consistency effects than high frequency words, which are rarely affected by consistency effects (Jared et al., 1990). Second, consistency effects influence words according to a "bi-directional flow of activation" such that both spelling-to-sound (ex. <int> to /ɪnt/ or /ajnt/ as in *hint* and *pint*, respectively) and sound-to-spelling inconsistencies (ex. /ɪp/ to <eep> or <eap> as in *sleep* and *cheap*, respectively) decrease accuracy and slow processing times (Stone et al., 1997). Figure 2.2 below illustrates this bi-directional flow of inconsistencies.



**Figure 2.2** Illustration of “bi-directional flow of activation” (based on Stone et al., 1997)

In short, both frequency and direction contribute to speech processing difficulties.

As with word recognition, research has also investigated consistency effects on “phoneme-related tasks”. In these studies, researchers have found evidence that phonemes that can be spelt in more than one way have higher processing costs than those that have only one possible spelling (e.g., Dijkstra, Roelofs, & Fieuids, 1995; Frauenfelder, Segui, & Dijkstra, 1990). Frauenfelder et al. (1990) conclude that the reason their French speakers took longer to detect /k/ than /p/ was because, while /p/ has only one possible spelling, /k/ has multiple spellings. In a similar study on /k/ detection, Dijkstra et al. (1995) found that Dutch speakers had more difficulty and took longer when detecting the phoneme /k/ in words where /k/ was spelt with its subdominant spelling <c>. Both consistency and letter-phoneme correspondence frequency appear to affect speech processing at the sub-word level by increasing difficulty and response latencies.

The research into consistency effects and co-activation of orthographic and phonological codes has led researchers to challenge the traditional assumption that speech processing is independent of orthographic representation such that speech

processing is primary and orthographic representation is secondary (Derwing, 1992; Ziegler & Ferrand, 1998). In fact, Landerl, Frith, and Wimmer (1996) claim that in adult literates, orthography and phonology are very closely connected—so closely connected that orthography “intrudes” on phoneme awareness and the two are automatically co-activated.

A growing body of research has demonstrated that orthographic representation is automatically activated during auditory processing tasks and affects spoken word recognition (e.g., Blau, van Atteveldt, Formisano, Goebel, & Blomert, 2008; Perre & Ziegler, 2008; Perreman, Dufour, & Burt, 2009; Taft, Castles, Davis, Lazendic, & Nguyen-Hoan, 2008; Ventura, Kolinsky, Pattamadilok, & Morais, 2008; Ventura, Morais, & Kolinsky, 2007; Ziegler & Ferrand, 1998; Ziegler et al., 2004; Ziegler, Muneaux, & Grainger, 2003). Specifically, research has demonstrated that even in the absence of visual information, orthographic knowledge influences the speech processing of alphabetic literate speakers. Ziegler and Ferrand (1998) asked French speakers to identify whether French words were real words or pseudowords in an auditory lexical decision task. They discovered that their French-speaking participants had higher error rates and longer response times when a phonological rime could be spelt in more than one way. For example, consistent French words like *stage* where the phonological rime can only be spelt as <age> as in *stage*, *rage*, *cage* were identified as real words more accurately and faster than inconsistent French words like *plomb* where the phonological rime can be spelt in different ways as in *nom*, *prompt*, *ton*, *tronc*, and *long*. Ziegler and Ferrand conclude that since orthographic consistency affects auditory processing,

phonological representation and orthographic representation are co-activated with the speech signal.

Additional evidence supporting the automatic activation of orthographic knowledge in speech processing comes from priming research studies. Chéreau, Gaskell, and Dumay (2007) examined the effect of orthographic overlap between a prime and the target in English real words and pseudowords. The primes and targets in this study had the same phonological rimes, but they differed in orthographic overlap. The orthographic overlap stimuli had primes and targets that spell their rimes in the same way (e.g., *winch-finch*). In contrast, the no orthographic overlap stimuli had primes and targets that spell their rimes in different ways (e.g., *lynch-finch*). Chéreau et al. also included a control condition where the prime and targets had unrelated rimes (e.g., *lump-finch*). They discovered a “substantial extra facilitation” for targets with primes containing orthographic overlap (e.g., *winch-finch*). That is, the primes with orthographic overlap helped the participants make significantly faster lexical decisions on real and pseudowords than did the primes without orthographic overlap and the unrelated primes. From their results in normal and speeded lexical decisions, Chéreau et al. conclude “spoken word recognition involves swift and automatic access to orthographic representations” (p. 347).

Similarly, Taft et al. (2008) used masked priming of pseudohomographs to confirm that orthographic representation is indeed automatically activated during auditory processing. In this study, the pseudohomographs were spoken nonword primes embedded in a stream of meaningless syllables that were presented before the targets. Taft and colleagues discovered pseudohomographs that could potentially be spelt in the same way

as their targets would facilitate lexical decisions on the targets (as measured in response times), whereas pseudohomographs that could not be spelt in the same way as their targets would not help with lexical decisions. For example, the pseudohomograph /dri:d/ would facilitate the lexical decision of /drɛd/ because /dri:d/ could logically be spelt as <dread>. In contrast, the pseudohomograph /fri:d/ would not facilitate the lexical decision of /frɛd/ because /fri:d/ could not possibly be spelt <shred>. These results, like Chéreau et al.'s (2007), confirm that the orthographic information associated with a speech utterance is automatically activated (Taft et al., 2008, p. 376).

The nature of the experimental tasks in the above studies has called into question the processing locus of orthographic information. The above studies have demonstrated orthographic information affects post-lexical and decisional language processing; however, other researchers have examined whether orthographic information also affects online pre-lexical language processing (Cutler, Treiman, & Van Ooijen, 1998, 2010; Perre & Ziegler, 2008). For example, using event-related brain potentials (ERP), Perre and Ziegler (2008) sought to “track the on-line time course of an orthographic effect on spoken word recognition” (p. 133) for native French speakers. Perre and Ziegler employed three types of stimuli: 1) consistent words, 2) early inconsistent words (inconsistency in the onset), and 3) late inconsistent words (inconsistency in the coda). Not only did they find ERP differences between consistent and inconsistent words, but they also found ERP differences that were “time-locked to the ‘arrival’ of the orthographic inconsistency” (p. 135). Specifically, the ERP differences occurred approximately 200ms after the onset of the inconsistency—around 320ms for the early inconsistent words and around 600ms for the late inconsistent words. From these results,

Perre and Ziegler claim that the “temporal synchronization” of ERP differences to the orthographic inconsistency provides strong evidence that orthographic information is activated during spoken word recognition and is processed on-line.

Researchers argue that co-activation of orthographic representations and phonological representations occur because orthographic knowledge permanently alters the way children and adults categorise and perceive spoken language (e.g., Burnham, 2003; Frith, 1998; Perre, Pattamadilok, Montant, & Ziegler, 2009; Ziegler et al., 2003). The effect of orthographic knowledge on spoken language is so strong that Frith (1998) likens the alphabetic code to a virus that “infects all speech processing” and concludes “language is never the same again” (p. 1011). Once children start to acquire an alphabet, the orthographic knowledge reorganises the L1 phonological system and the two systems become interdependent (Burnham, 2003). Similarly, Ziegler et al. (2003) argue that orthographic knowledge “provides an additional constraint in driving segmental restructuring” (p. 790). As a result of this restructuring, orthographic knowledge affects perception because this knowledge is automatically activated with print, which in turn provides information to the phonological system. Moreover, after restructuring, orthographic knowledge is so intimately linked to the phonological system that readers cannot avoid thinking about the letters even when specifically instructed not to do so (Landerl et al., 1996) and in the absence of visual stimulation (e.g., Ziegler & Ferrand, 1998; Ziegler et al., 2004; Ziegler et al., 2003). In short, by triggering phonological restructuring and reorganization, orthographic representation and the phonological system it has altered become irrevocably linked and are thus co-activated in spoken word recognition.

### 2.2.3 Letter-phoneme associations

Because alphabetic knowledge restructures the L1 phonological system, it also makes separating letter-phoneme associations almost impossible (e.g., Burnham, 2003; Treiman & Cassar, 1997). In fact, research suggests that both literate children and adults cannot completely ignore letter-phoneme associations and separate the phonemes from the letters used to represent them. For example, Treiman and Cassar (1997) found that listeners—both children and adults—are more likely to report a two-phoneme string (e.g., /ɑɪ/ and /ɛm/) as one phoneme when that string was also a letter name (e.g., <r> and <m>, respectively). Based on these results, Treiman and Cassar conclude that complete separation of letters and phonemes is impossible once individuals begin to learn to read.

The impossibility of separating letter-phoneme associations is further supported by other phoneme counting research. Generally speaking, research has demonstrated that, when asked to count phonemes in a phoneme counting task, listeners often count more phonemes in words with more letters and fewer phonemes in words with fewer letters (Bassetti, 2006; Ehri & Wilce, 1980; Perin, 1983; Spencer & Hanley, 2003). In a classic study, Ehri and Wilce (1980) discovered that when asked to count phonemes, fourth graders report more phonemes in words like *pitch* and *badge* than in words like *rich* and *page*. From these results, they conclude that orthography does affect how readers conceptualize the sound structure of words.

Similarly, in L2 research, Bassetti (2006) discovered that native English learners of Chinese (CFL) count one fewer vowel when the vowel is not represented in the Pinyin spelling. Specifically, in Mandarin words like *huí* /xweɨ/ (“return, go back”) and *xiū* /ɕjow/ (“to stop, to rest, to pause”), CFL learners count only three phonemes rather than

four because the triphthong is represented by only two letters (<ui> and <iu>). In contrast, in Mandarin words like *wéi* /wej/ (“do, act”) and *yǒu* /jow/ (“have”), CFL learners count three phonemes because each of those phonemes is represented by an individual letter. In a second experiment, Bassetti confirmed that CLF learners segment Mandarin vowels as they are spelt. Bassetti concludes that CFL learners interpret the L2 letters “as representing the same phonemes they represent in the L1” (p.110) and suggests that CFL learners are strongly influenced by L1 letter-phoneme conversion rules. These findings are particularly relevant here as the current research further investigates whether or not L1 orthographic knowledge determines how listeners perceive phonemes in two nonnative languages, Mandarin and Russian.

Evidence from other phoneme manipulation tasks also supports the virtual impossibility of separating letter-phoneme associations once those associations are cemented by learning letters. The research shows that listeners have more difficulty manipulating phonemes that are not present in a word’s orthographic representation. In an interesting study, Castles et al. (2003) discovered that their adult participants had lower accuracy rates and longer response times when deleting or reversing phonemes in “opaque” items (i.e., items without a straightforward correspondence between the target phoneme and the letter(s) representing it) than in “transparent” items (i.e., items with a direct one-to-one correspondence). For example, they found that their participants had extreme difficulty in deleting the phoneme /s/ in words like *fix* where the /s/ is not represented by the letter <s> but rather it is represented, along with /k/, by the single letter <x>. That the letter <x> makes isolating /k/ or /s/ difficult is not surprising considering that as children, in alphabetic orthographies like English at least, we are

taught that “one letter equals one sound.” Based on this alphabetic learning mantra, it is easy to see why children/listeners assume that <x>, like most of the other letters of the alphabet, also represents one phoneme, and as a result, they fail to perceive the two phonemes represented by this letter.

Although the aforementioned research suggests that letter-phoneme associations are extremely difficult to disregard once made, limited research has shown that in some cases, orthography can help L2 listeners distinguish between nonnative contrasts. For example, Escudero and Wanrooij (2010) found that different visual representations (i.e., <aa> and <a>, respectively) for the Dutch vowels /a/ and /ɑ/ aided native Spanish speakers in distinguishing between the two vowels. Specifically, Spanish-Dutch biliguals were significantly more accurate at distinguishing between Dutch /a/ and /ɑ/ (a contrast that does not exist in Spanish) in a forced choice orthographic task (where listeners heard a stimulus and identified which spelling option best matched the stimulus) than in a forced choice XAB auditory task (where from a series of three stimuli, listeners had to identify whether the first stimulus better matched the second or third stimulus). According to Escudero and Wanrooij, the representations of <aa> and <a> led the listeners to pay attention to the durational difference between /a/ and /ɑ/ which ultimately helped them distinguish between the two.

#### *2.2.4 Misperception of phonemes*

In addition to establishing that orthographic interference increases response latencies and error rates and fosters processing difficulties, research has also shown that orthographic spelling can “suggest” phonemes and override phonemic information. Hallé et al. (2000) demonstrated that native French speakers misperceived the phonemes they heard in

French words like *absurde* /apsyrd/ and reported hearing /b/ instead of the actual /p/ produced because the letter <b> in these types of words suggested the phoneme /b/. From their results, Hallé et al. conclude that orthographic representation affects the perception of phonemic representation. Specifically, when the phonetic and orthographic information do not match, the orthographic representation overrides the phonetic representation thus causing the listeners to misperceive the phoneme produced.

As with L1 orthography's effect on the perception of L1 phonemic representation, research has also shown that L1 orthography affects the perception of nonnative phonemes in SLA. In their research, Erdener and Burnham (2005) discovered orthography interferes with native Turkish speakers' production of Irish and Spanish nonnative phonemes. While the letter <j> exists in both the Turkish and Spanish alphabets, the letter represents the phoneme /z/ in Turkish and the phoneme /x/ in Spanish. In the experiment, when given only auditory information, the Turkish participants had 0% error rates for reproduction of the nonnative Spanish phonemes. However, when given both auditory and orthographic information, the Turkish participants' error rates increased to 46% (i.e., /x/ was pronounced as /z/). Erdener and Burnham conclude that these increased error rates result from the participants substituting the L1 phoneme /z/ associated with the letter <j> they saw, which, in turn, suggests that orthographic representation overrides the auditory information.

As with Bassetti's (2006) research, Erdener and Burnham's (2003) L2 research informs the present study by illustrating that listeners are affected by L1 orthographic knowledge. It demonstrates that listeners find it almost impossible to avoid L1 orthography when performing phoneme-related tasks in a nonnative language, which in

turn, affects how they perceive and thus produce nonnative speech sounds. In fact, according to Young-Scholten (1995), premature L2 orthographic exposure leads to increased L1 transfer such that when learners encounter L2 letters, they are compelled to search for phonological constituents that the L2 letters represent, and in the absence of established L2 phonology, these learners are only able access the L1 phonology.

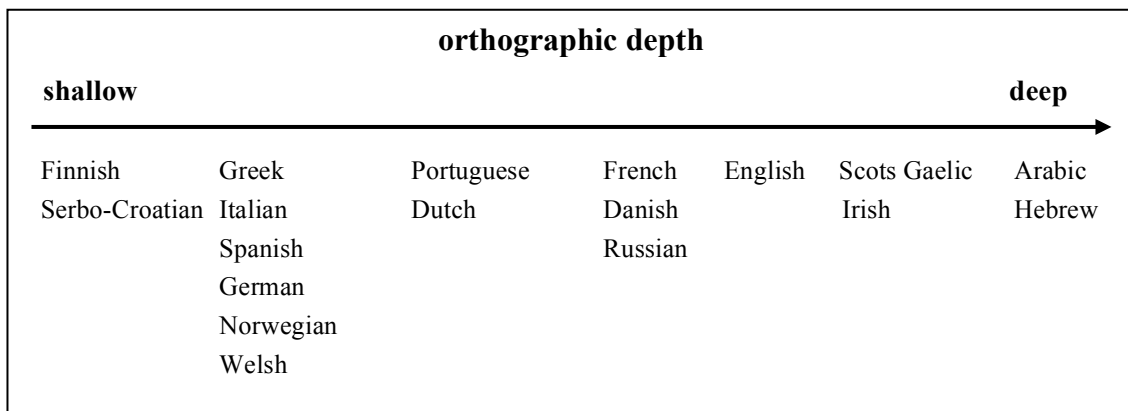
### *2.2.5 Orthographic depth*

When attempting to account for their results, Erdener and Burnham (2005) suggest that orthographic depth plays an important role in how orthographic representation influences speech processing. For alphabetic orthographies, orthographic depth refers to the consistency and predictability of letter-to-phoneme correspondences in a language (Ellis, Natwume, Stavropoulou, Hoxhallari, van Daal, Polyzoe, Tsipa, & Petalas, 2004; Frost & Katz, 1989; Katz & Frost, 1992; Liberman, Liberman, Mattingly, & Shankweiler, 1980). According to Liberman et al. (1980), orthographic depth depends on two variables: 1) the depth of the morphophonological representation (i.e., whether the system represents the language at the phonemic, syllabic, or morphemic level), and 2) the degree to which the orthography approximates the phonemic representation (i.e., the degree of letter regularity).

Essentially, the regularity and consistency of letter-phoneme correspondences determines the degree of orthographic transparency. **Transparent** (or shallow) orthographies have a high degree of regularity between the letters and phonemes such that one letter represents one phoneme. Spanish, German, Italian, Finnish, and Serbo-Croatian are languages with shallow orthographies. **Opaque** (or deep) orthographies, in contrast, have a high degree of irregularity in their letter-phoneme correspondences such

that letters often represent more than one phoneme (inconsistent *sound-to-spelling* correspondences) and phonemes often have more than one way of spelling them (inconsistent *spelling-to-sound* correspondences). English, Danish, Russian, French, and Scots Gaelic are examples of languages with a high degree of irregularity and inconsistency, and are thus categorised as deep orthographies, although some languages may be considered deeper than others. See Figure 2.3 below.

Because of the varying degrees of transparency, languages can be viewed along a continuum of orthographic depth (e.g., Danielsson, 2003; Ellis et al., 2004; Liberman et al., 1980; Seymour, Aro, & Erskine, 2003). Figure 2.3 visually illustrates this orthographic depth continuum.



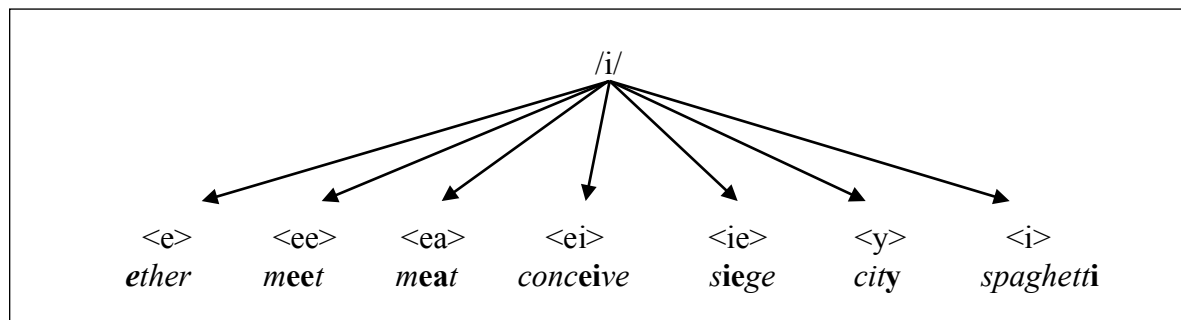
**Figure 2.3** Continuum of orthographic depth [based on Seymour et al.'s (2003) hypothetical classification of orthographic depth]<sup>4</sup>

This figure places languages along the continuum according to their varying degrees of transparency. Highly transparent languages, like Finnish and Serbo-Croatian, are at the

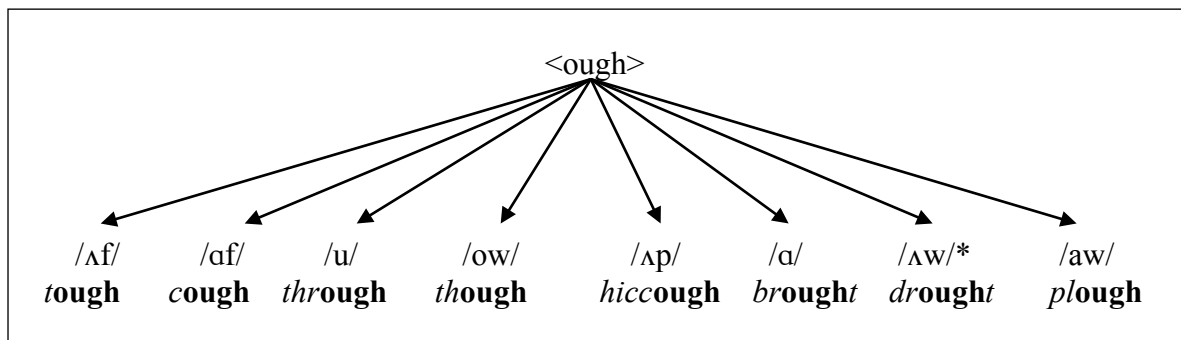
<sup>4</sup> This continuum only approximates the degree of orthographic depth for alphabetic languages. In a larger picture, the continuum could be extended to include much deeper orthographies such as logographies (e.g., the Chinese character system).

left edge of the continuum and the languages increase in depth as we move from left to right until we reach the deep orthographies like Arabic and Hebrew.

Notice that English exists at the deep end of the orthographic depth continuum due to its irregularity and the high degree of sound-to-spelling and spelling-to-sound inconsistencies. Figure 2.4 and Figure 2.5 below provide examples of these types of inconsistencies in English. Figure 2.4 shows that the phoneme /i/ can be spelt in at least seven different ways (i.e., sound-to-spelling inconsistency). Similarly, Figure 2.5 shows that the letter string <ough> can be pronounced in at least eight different ways (i.e., spelling-to-sound inconsistency).



**Figure 2.4** Example of inconsistent *sound-to-spelling* correspondences with the single phoneme /i/



\*This pronunciation is characteristic of Canadian English speakers – also known as *Canadian Raising*. Non-Canadian raisers pronounce the <ough> in *drought* as /ɑw/ like in *plough*.

**Figure 2.5** Example of inconsistent *spelling-to-sound* correspondences with the letter string <ough>

Research has shown that reading abilities are directly linked to whether the children learn to read in a transparent or deep orthography. The *Orthographic Depth Hypothesis* (ODH) (Katz & Frost, 1992) predicts that orthographic depth leads to processing differences in word recognition and lexical decisions. According to ODH, transparent orthographies support word recognition processes based on a language's phonology and deep orthographies support word recognition based on accessing lexical information through visual analysis of the orthographic structure (Danielsson, 2007; Ellis et al., 2004). ODH also predicts that learners of transparent orthographies should be able to read aloud and spell faster than those who learn a deep orthography. Research supports the ODH by demonstrating that shallow orthographies are easier for children to learn than deep orthographies (e.g., Goswami, Gombert, & De Barrera, 1999; Goswami, Porpodas, & Wheelwright, 1997; Seymour et al., 2003). For instance, Seymour et al. (2003) compared children's acquisition of foundation literacy in 14 European orthographies (including Scottish English) and found that the time needed to establish foundation literacy (i.e., decoding and word recognition skills) varied according to the depth of the orthography. In other words, children learning deep orthographies (Danish and English) exhibit a delayed acquisition of foundation literacy compared to children learning transparent orthographies. In fact, Seymour et al. (2003) estimate that after the first year of literacy learning, readers of English require an additional 2 ½ years, at minimum, of learning to gain mastery of word recognition—a mastery that most readers of transparent orthographies gain by the end of the first year of learning.

Research also supports the ODH by demonstrating that learners of shallow orthographies not only develop their reading and spelling skills more rapidly than

learners of deep orthographies (Ellis & Hooper, 2001; Juul & Sigurdsson, 2005; Landerl, 2000; Seymour et al., 2003; Spencer & Hanley, 2003, 2004; Wimmer & Hummer, 1990) but learners of transparent orthographies also develop their phonological awareness skills more rapidly than learners of deep orthographies (Cossu et al., 1988; Spencer & Hanley, 2003; Spencer & Hanley, 2004). Spencer and Hanley (2003, 2004) compared Welsh-speaking (a transparent orthography) children with English-speaking (a deep orthography) children in North Wales. They discovered the Welsh children outperformed their English children counterparts in both reading of words and nonwords and phoneme detection. Specifically, the Welsh children were much more likely to use letter-phoneme correspondences to read aloud words with which they were unfamiliar (i.e., the nonwords and English words). In addition, the Welsh children were significantly better than the English children at counting phonemes in both the Welsh and English words, and they performed equally as well counting phonemes in words that had the same number of letters and phonemes as counting phonemes in words that had more letters than phonemes. In contrast, the English children performed worse when the English words contained more letters than phonemes. From these results, Spencer and Hanley (2003) conclude “phonemic awareness test scores in an opaque orthography are much more strongly mediated by knowledge of the spellings of words than is the case with transparent orthographies” (p. 25). A follow up experiment also demonstrated that Welsh children maintain the performance advantage after the first year of reading instruction (i.e., one year later) for reading words and nonwords as well as for phoneme detection. In sum, Spencer and Hanley argue that the degree of orthographic transparency is a critical factor in reading and phoneme detection success.

In terms of the current research, we must consider orthographic depth since the depth of the English orthographic system may affect the degree of orthographic influence. L1 orthographic transfer is more likely to affect speakers of more transparent languages since there is a stronger correlation between letters and phonemes in transparent languages. In contrast, since deep orthographies have more inconsistencies between orthographic representations and phonetic information, speakers are less likely to rely on the inconsistent relationships between letters and phonemes. Therefore, if native English speakers do not rely on letters to aid them in counting phonemes, as predicted, then, a possible explanation is that deep orthographies do not foster strong bonds between letters and phonemes as transparent languages do.

### ***2.3 Summary and relevance to the current research***

As little research has investigated L1 orthographic influence on L2 speech perception (cf. Bassetti, 2006; Erdener & Burnham, 2005; Wade-Woolley, 1999), we must look to non-orthographic L1–L2 transfer effects (§2.1) and orthographic effects on L1 speech perception (§2.2) to provide us with clues for the current project. Research (outlined in §2.2) has shown that orthographic knowledge—specifically alphabetic knowledge—affects speech perception in six ways.

1. Alphabetic knowledge precedes phoneme awareness such that the ability to count phonemes is contingent on knowing an alphabet (e.g., Bertelson et al., 1989; Carroll, 2004; Morais et al., 1986; Morais et al., 1979; Read et al., 1986).

2. Orthographic knowledge influences response latencies and accuracy in spoken word and sound recognition (e.g., Glushko, 1979; Jared et al., 1990; Lacruz & Folk, 2004; Stone et al., 1997).
3. Even without visual stimuli, orthographic knowledge is automatically activated with speech processing (e.g., Burnham, 2003; Chéreau et al., 2007; Taft et al., 2008; Ziegler & Ferrand, 1998; Ziegler, et al., 2003).
4. Once children learn to read, the bonds between letters and phonemes are so strong that learners cannot ignore letters when thinking about phonemes (e.g., Bassetti, 2006; Castro-Caldas et al., 1998; Ehri & Wilce, 1980; Perin, 1983; Pytlyk, to appear; Treiman & Cassar, 1997).
5. Orthographic information overrides phonologic information and “suggests” phonemes (e.g., Erdener & Burnham, 2005; Hallé et al., 2000).
6. Orthographic consistency determines orthographic depth, which, in turn, affects phonological skills, word recognition, and lexical decisions (e.g., Cossu et al., 1988; Danielsson, 2007; Ellis et al., 2004; Katz & Frost, 1992).

What is not currently clear is how these ways might interact with each other and to what degree. If, as the above research (outlined in §2.1) suggests, an L2 is filtered through the lens of the L1 phonemes, phonology, syllable structure, and so on, then, we can reasonably hypothesise that an L2 (or an L0) will also be filtered through the lens of the L1 orthography. As mentioned above, little research has investigated the effect of orthography on nonnative speech perception; however, the pioneering works of Bassetti (2006), Erdener and Burnham (2005), and Wade-Woolley (1999) suggest that L1 orthographic knowledge does indeed affect how listeners perceive nonnative phonemes.

The current research builds on their research and contributes to the sparse body of literature surrounding the effect of orthography on nonnative language learning. By investigating native English speakers' abilities to perceive phonemes in their L1, their L2, and an L0, this research strives to determine whether L1 orthographic representation affects nonnative phoneme recognition.<sup>5</sup>

From the research outlined in this chapter, three key factors that shape L2 speech processing and learning are apparent. First, an L2 phonological system interacts with the L1 system whereby L2 phonemes are perceived and analysed with relation to the L1 phonological system. Second, the interaction between these two systems leads to transfer from the learners' L1 experiences such that negative transfer can interfere with L2 acquisition. Third, orthography and phonology are intimately connected. With these factors in mind, by analogy, we can first posit that, for English L1 listeners, English alphabetic knowledge should interfere with listeners' phoneme awareness in L0 cross-language homophones (i.e., words in an unfamiliar language that sound like English words such as *стул* /stul/ (*chair*) in Russian and *nǐ* /ni/ (*you*) in Mandarin). We can also posit that L1 and L2 orthographic systems may also interact with each other such that L1 orthography may interfere with learners' perceptions of L2 speech. By investigating English learners of Russian (which uses the Cyrillic alphabet) and Mandarin Chinese (which uses the Pinyin alphabet), the current research can determine whether L1 orthographic knowledge interferes with both L2 orthographic knowledge and with L2 and L0 speech processing.

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<sup>5</sup> Speech perception is distinct from phoneme recognition/awareness. Speech perception is a **subconscious** process that happens regardless of literacy while phoneme recognition is a **conscious** process that comes after the acquisition of alphabetic literacy (e.g., Burnham, 2003; Treiman & Cassar, 1997).

However, before we can investigate this important issue, we must first discuss and understand the orthographic systems used by English, Russian, and Mandarin Chinese. Therefore, the next chapter discusses writing systems in general, the phoneme inventories and syllable structures of English, Russian, and Mandarin, and the orthographic systems used to represent these phoneme inventories.

## Chapter Three

### ORTHOGRAPHIC REPRESENTATION

***“Writing can never be considered an exact counterpart of the spoken language. Such an ideal state of point-by-point equivalence in which one speech unit is expressed by one sign, and one sign expresses only one speech unit, has never been attained in writing.”  
(Gelb, 1963, p. 15)***

As the focus of this dissertation revolves around how orthographic representation affects the perception of phonemes in English, Russian, and Mandarin Chinese, we must discuss how each of these languages is represented alphabetically. The first section (§3.1) discusses writing systems in general including the 1) creation of writing, 2) types of writing systems, and 3) Roman, Cyrillic, and Pinyin alphabets. The second section (§3.2) presents the phoneme inventories, syllable structures, and orthographic systems of English, Russian, and Mandarin. Next, the third section (§3.3) compares the letter-phoneme correspondences of the three target languages. The fourth section (§3.4) discusses the impetus behind the current project, and finally, the fifth section (§3.5) outlines the four major predictions surrounding the research.

#### ***3.1 Writing Systems***

What is writing and what is its relationship to language? Writing *represents* language; it is *not* language itself. Coulmas (1999), in *The Blackwell Encyclopedia of Writing Systems*, defines a writing system as:

a set of visible or tactile signs used to represent units of language in a systematic way, with the purpose of recording messages which can be retrieved by everyone who knows the language in question and the rules by virtue of which its units are encoded in the writing system (p. 560).

Simply put, writing systems are (in general) visual means of expressing and recording specific linguistic forms (Read, 1983). Writing is an important form of communication that allows speakers “to record and convey information and stories beyond the immediate moment” and “to communicate at a distance, either at a distant place or at a distant time” (Rogers, 2005, p. 1). Writing systems are systematic in two ways. First, they have systematic relationships to language, and second, they have systematic internal structures (Rogers, 2005).

### *3.1.1 Important definitions*

Table 3.1 provides all the important terms and definitions used in this dissertation regarding writing systems and orthography (See also Appendix B for a glossary of all relevant linguistic terms.).

<b>Term</b>	<b>Definition</b>	<b>Example(s)</b>
<b>Abecedary</b>	An abecedary is an inventory of letters (in order) for an alphabet (Rogers, 2005).	
<b>Allograph</b>	Allographs are the non-contrastive variants of a grapheme (Rogers, 2005).	<G> and <g> are allographs of <g>.
<b>Alphabet</b>	An alphabet is “a writing system characterized by a systematic mapping relation between its signs (graphemes) and the minimal units of speech (phonemes)” (Coulmas, 1999, p. 9).	Roman, Cyrillic, Greek, Hebrew, Arabic...
<b>Grapheme</b>	A grapheme is a “contrastive unit in a writing system, parallel to phoneme or morpheme” (Rogers, 2005, p. 10). Graphemes can be represented by letters, characters, numerals, and/or other symbols.	The grapheme <z> contrasts with other graphemes like <p t h>.
<b>Homograph</b>	Homographs are words where the “phonemic distinctions are neutralized graphemically” (Rogers, 2005, p. 16). Homographs are words that are spelt the same but pronounced differently.	Present tense <i>read</i> /i:ɪd/ and past tense <i>read</i> /ɪɛd/
<b>Homophone</b>	Homophones are words where the “graphemic distinctions are neutralized phonemically” (Rogers, 2005, p. 16). That is, homophones are words that are spelt differently but pronounced the same way.	In English, <i>one</i> and <i>won</i> are pronounced the same /wʌn/ but spelt differently.
<b>Letter</b>	A letter is a shape that is “recognized as [an instance] of abstract graphic concepts which represent the basic units of an alphabetic writing system” (Coulmas, 1999, p. 291).	
<b>Logography</b>	A logography is a writing system where words or morphemes are the units of representation such that a written symbol can represent a word or morpheme (Coulmas, 1999; Cheung & Chen, 2004; DeFrancis, 1990).	Chinese characters Japanese Kanji
<b>Opaque orthography</b>	Opaque (or deep) orthographies have a high degree of irregular letter-to-phoneme correspondences. Some letters can have more than one phoneme attached to them, and some phonemes can have more than one graphemic representation.	English, Irish, French, Scots Gaelic, Hebrew, ...
<b>Orthographic depth</b>	Orthographic depth refers to the regularity of grapheme-to-phoneme correspondences (Frost & Katz, 1989; Katz & Frost, 1992)- see Opaque orthography and Transparent orthography, also defined in this table.	Shallow (or transparent) Deep (or opaque)
<b>Orthography</b>	Orthography refers to the “set of rules for using a script in a particular language” (Cook & Bassetti, 2005, p.3).	Canadian English orthography, Finnish orthography, ...
<b>Script</b>	A script is “the graphic form of the units of a writing system” (Coulmas, 2003, p. 35).	
<b>Syllabary</b>	A syllabary is a writing system where the syllable is the unit of representation such that graphemes represent syllables or moræ (Coulmas, 1999; Chueng & Chen, 2004; Rogers, 2005).	Taiwanese <i>Zhùyīn zìmǔ</i> Japanese <i>Kana</i> Cherokee
<b>Transparent orthography</b>	Transparent (or shallow) orthographies have regular one-to-one grapheme-to-phoneme correspondences. That means, graphemes have only one phoneme, and phonemes have only one representation.	Spanish, Italian, Serbo-Croatian, Finnish, ...
<b>Writing</b>	Writing is defined as “the use of graphic marks to represent specific linguistic utterance” where these marks “mak[e] an utterance visible” (Rogers, 2005, p. 2)	
<b>Writing system</b>	A writing system uses visual or tactile symbols to represent language. It has a systematic relationship to language and a systematic internal structure and organization (Coulmas, 1999; Rogers, 2005).	

**Table 3.1** Definitions of important terms regarding writing and orthography

An important note here is that, in this research, the terms *letter* and *grapheme* are NOT synonymous, although they have been used somewhat interchangeably in the literature. On the surface, they may appear interchangeable as both letters and graphemes are described as written symbols/characters that represent speech sounds. Here we must make an important distinction between the two. A letter is defined as a shape/symbol that is “recognized as [an instance] of abstract graphic concepts which represent the basic units of an alphabetic writing system” (Coulmas, 1999, p. 291), and a grapheme is defined as “a contrastive unit in a writing system” (Rogers, 2005, p. 10). While a single letter often does represent a single phoneme, which makes it a grapheme, there are certain instances where *more* than one letter is used to represent a single phoneme, which makes the combination of letters a grapheme. Consider the letters <s> and <h> in the English words *mishap* and *reshape*. In *mishap*, the letter <s> represents the phoneme /s/, and the letter <h> represents the sound /h/; in this case, each letter is an independent grapheme. Conversely, in *reshape*, both the letters <s> and <h> are used to represent the single phoneme /ʃ/, thus creating the grapheme (or digraph) <sh>. In this research, the assumption is that one grapheme equals one phoneme, and that inconsistency most often arises when a single grapheme (e.g., <sh>) representing a single phoneme (e.g., /ʃ/) contains more than one letter (e.g., <s> and <h>), or sometimes when a single letter or grapheme (e.g., <x>) represents more than one phoneme (e.g., /k/ and /s/). Therefore, letter-phoneme (in)consistency in this research refers to the relationship between the number of letters and the number of phonemes in a word. Specifically, **consistent** letter-phoneme correspondence refers to a match between the number of letters and the number

of phonemes in a word, and *inconsistent* letter-phoneme correspondence refers to a mismatch between the number of letters and the number of phonemes in a word.

### 3.1.2 Creation of writing systems

A writing system can be created in one of three ways (Coulmas, 2003; Rogers, 2005). First, a writing system may be created “from scratch”, i.e., with no prior model of writing. The creation of a completely new and original system is extremely rare. However, this phenomenon has happened at least three times (Daniels, 1996). The earliest known system is Sumerian Cuneiform, which was created by the Sumerians about 5500 years ago in Mesopotamia. Then, approximately 2000 years later the Chinese invented writing in Asia. Finally, in Mesoamerica 2000 years ago, the Mayans also invented writing. These three independently created systems are the three known instances of new original writing systems. Some scholars also claim that Egyptian Hieroglyphics was an original creation; however, there is debate about whether the hieroglyphics developed independently or by “stimulus diffusion” (see below) (Rogers, 2005).

Second, a writing system may be a new script but not a new idea. This type of creation is called *stimulus diffusion*. Unlike with new original creations, with stimulus diffusion, the idea of writing is not new. That is, the creators are aware of the concept of writing and create a new writing system based on the general idea of writing. This type of system is also rather rare. Some examples of languages whose writing systems were created in this way are Cree and Cherokee (Rogers, 2005).

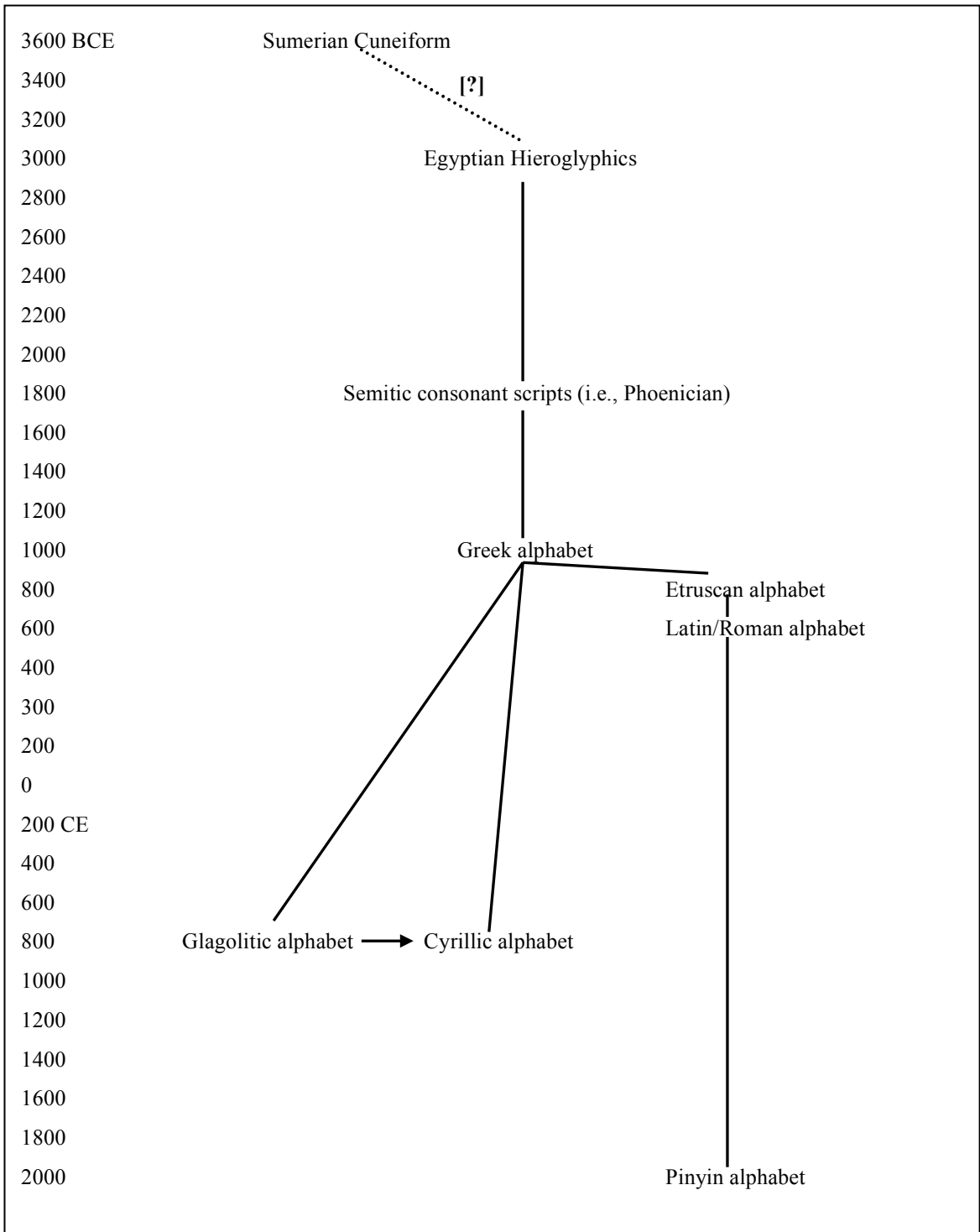
Third, a writing system may be created by borrowing the system from another culture and applying it to a new language. This type of creation is extremely common.

Indeed, most writing systems have resulted from the spread of other systems and the majority of all systems can be traced back to one of the three original creations (Coulmas, 2003). Not surprisingly, the two major sources behind the spread of writing are religion and commerce (Daniels, 1996). For example, the Roman alphabet was the writing system of the Roman Empire and Holy See, and the Roman alphabet “has been adopted to write so many languages as a direct result of the christianization of Europe” (Coulmas, 2003, p. 201). According to Rogers (2005), almost all of the world’s writing systems are descendants of either the Chinese or Semitic writing system.

Interestingly, what Coulmas (2003) calls the “chain of borrowing” is reflected in the rather static order of the letters. Coulmas declares that:

the great continuity of the alphabetic tradition is attested by a feature often disregarded as trivial, the order of the letters. Actually, it is a most remarkable fact that the letters of the Semitic alphabet have been handed down to us through roughly 140 generations in the form of the same canonical list, give or take a few additions and omissions along the way. (p. 207)

Figure 3.1 below traces the chain of borrowings that led to the Roman, Cyrillic, and Pinyin alphabets. See §3.1.4 for a more detailed discussion of the development and history of the Roman, Cyrillic, and Pinyin alphabets.



**Note:** BCE = Before the Common Era and CE = Common Era

**Figure 3.1** “Chain of borrowing” leading to the Roman, Cyrillic, and Pinyin alphabets (Cook, 2004; Coulmas, 2003; Gelb, 1963; Rogers, 2005)

As illustrated in Figure 3.1, the “alphabetic tradition” began with the Egyptian hieroglyphics, which influenced the Semitic consonant scripts<sup>6</sup>. Although these two scripts are not considered alphabetic, they created the foundation for the development of an alphabetic script. Circa the tenth century BCE, the Greeks adapted the Semitic script into the first phonetic system of writing (i.e., the first true alphabet) that represented not only consonantal but also vocalic segments (Cook, 2004; Coulmas, 1999; Gelb, 1963; Harris, 1986). Based on their need to represent vowels, the Greeks adapted the Phoenician consonantal signs that were not needed for Greek phonology, and used them to represent the necessary vowel sounds (Bloomfield, 1933; Daniels, 1996; Henderson, 1982; Rogers, 2005; Swiggers, 1996). That the Greek alphabet is derived from the Phoenician alphabet is evident in the shapes, ordering, and names of the letters (Swiggers, 1996; Threatte, 1996). Since the Greek adaption of the Phoenician alphabet, “nothing new has happened in the inner structural development of writing” (Gelb, 1963, p. 184). However, many cultures have borrowed the Greek alphabet. In fact, the letters of the Greek alphabet form the basis of all the alphabets that developed in the West (Swiggers, 1996). Most notably, the Etruscans in Italy borrowed the Greek alphabet for their Etruscan alphabet, which, in turn, the Romans borrowed for their Roman (i.e., Latin) alphabet. This is the alphabet now used by the majority of Indo-European languages and many indigenous languages around the world. The Chinese government based its “romanization” of Chinese—the Pinyin alphabet—on the Roman alphabet. The

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<sup>6</sup> The broken line in Figure 3.1 between the Sumerian Cuneiform and the Egyptian Hieroglyphics represents a possible borrowing of symbols from the Sumerians (Fischer (1977) and Schekel (1984) as cited in Daniels, 1996). However, evidence that the Egyptians did borrow from the Sumerians is still scant and there is much debate surrounding this theory.

Greek missionary Saint Cyril also borrowed the Greek alphabet for the Glagolitic and Cyrillic alphabets.

### 3.1.3 Types of writing systems

As mentioned above, writing systems are systems for graphically representing language utterances. The written symbols either have a relationship with the spoken sounds or a relationship with the meaning (Cook, 2004). For example, in English, the symbols (letters) <c>, <a>, and <t> are related to the sounds (phonemes) /k/, /æ/, and /t/ in the word *cat*. However, English also has some symbols that represent meanings rather than phonemes. For example, we recognise the symbols <\$>, <%>, <&>, and <7> as meaning *dollar*, *percent*, *and*, and *seven* (respectively) without any indication of each word's pronunciation. Languages show a "preference for a particular way of writing rather than to an absolute distinction" (Cook, 2004, p. 5); most writing systems use a mix of systems, and represent language in more than one way (Cook, 2004; Read, 1983). In other words, while no languages rely on writing systems that are strictly based on grapheme-phoneme relationships or grapheme-morpheme relationships, some languages like Chinese and Japanese (Kanji) use predominantly morpheme-based writing systems, and other languages like English, Tamil, Russian, and Cherokee use predominantly sound-based writing systems. The following subsections discuss morpheme-based (§3.1.3.1) and sound-based (§3.1.3.2) writing systems.

#### 3.1.3.1 Morpheme-based writing systems

Morpheme-based writing systems (also called *logographies*) employ written graphemes to represent morpheme. That is, the graphemes are linked to the morphemes rather than

pronunciation of words. The graphemes in morpheme-based writing systems such as Chinese characters, Sumerian cuneiform, and Egyptian hieroglyphics developed from drawings of natural objects (Coulmas, 2003; Gelb, 1963). All of these logographic systems appear to have developed independently from each other (Henderson, 1982). Because of the relationship between graphemes and morphemes, morpheme-based writing systems must have a separate grapheme for each morpheme. Consequently, these systems have an extremely large number of graphemes. For instance, typical Chinese dictionaries have up to 40,000 characters. However, functionally literate Chinese speakers know between 2000–3000 characters (Coulmas, 2003; Smith as cited in Read, 1983), educated Chinese speakers know approximately 5000 characters (Cook, 2004), and knowing between 4000–7000 characters is sufficient to read a newspaper (Wang, 1973).

The advantage of a morpheme-based writing system like the Chinese system is that although China has many regional dialects that are not mutually intelligible, the writing system transcends this barrier to communication. All literate Chinese, regardless of dialect, can read Chinese characters; while each character may be pronounced differently in each dialect, the meaning is the same across dialects. That is, although speakers of different dialects may not be able to communicate verbally, over 500 million Chinese can communicate visually via the writing system (Wang, 1973).

### **3.1.3.2 Sound-based writing systems**

In contrast to morpheme-based writing systems, sound-based writing systems employ graphemes to represent sound units. The advantage to such a system is that unlike morpheme-based systems, which require many thousands of graphemes, sound-based

systems require a small number of graphemes, roughly corresponding to the number of sound units in the language. For example, the Roman alphabet has 26 graphemes; the Japanese Kana has 49 graphemes (Coulmas, 1999), and Arabic consonantal alphabet has 28 consonant graphemes (Cook, 2004). While all sound-based systems link graphemes and sound units, the type of sound unit linked to the written graphemes varies among languages. Specifically, three types of sound units are represented by written graphemes in sound-based writing systems: 1) syllables, 2) consonants only, and 3) all phonemes – both consonants and vowels (Cook, 2004).

Syllable-based writing systems (also called *syllabaries*) represent speech “by means of graphemes each of which has a syllable as its value” (Coulmas, 1999, p. 483). Usually, the grapheme represents a syllable that is comprised of a consonant and vowel (Cook, 2004). This type of system works best with languages that have a limited numbers of syllables (i.e., simple CV syllables). For example, with limited number of consonants and vowels, in addition to its simple syllable structure (Japanese syllables are primarily of the shape (C)V, with an extremely limited set of allowable coda consonants.), Japanese has only about 75 possible syllables that need representation (Read. 1983). Some languages that use syllabaries are Japanese Katakana and Hiragana, Tamil (Indian), Cherokee (Iroquois language), and Cree (Algonquian language).

Consonant-based writing systems also use graphemes to represent sound units, but instead of representing syllables, consonant-based writing systems – as the name suggests – use graphemes to represent consonants. This type of system “operate[s] on the level of segments but do[es] not indicate vowels” (Coulmas, 1999, p. 91). Because only consonants are represented in the writing system, consonant-based systems require the

distribution of vowels within the language to be predictable; these usually indicate grammatical or derivational changes (Cook, 2004; Coulmas, 1999). Semitic languages like Arabic and Hebrew are examples of languages with consonant-based alphabetic systems.

Like consonant-based writing systems, phoneme-based writing systems (called *alphabets*) also represent phonemes. However, the alphabetic graphemes represent both the consonants and vowels of a given language. Coulmas (1999) defines alphabets as being “characterized by a systematic mapping relation between its signs (graphemes) and the minimal units of speech (phonemes)” (p. 9). Among all types of writing systems, alphabets are the most common writing system in use; they are used by approximately 49% of the world’s population (Cook, 2004; Rogers, 2005). Perhaps, the most familiar alphabets in use today are the Roman, Greek, and Cyrillic alphabets, but other modern alphabets include the Georgian, Armenian, Ethiopic, and Mongolian alphabets.

In theory, phoneme-based systems have a one-to-one relationship between single-letter graphemes and phonemes. In practice, however, a high degree of variation exists in the consistency of the letter-phoneme correspondences among languages such that no system has exact correspondences between the individual phonemes of the language and the individual letters used to represent those phonemes (Gelb, 1963). Some languages like Finnish, Serbo-Croatian, and Spanish have highly consistent writing systems (i.e., transparent orthographies) that rely heavily on the one-to-one letter-phoneme connection. Other languages like English and French have highly inconsistent writing systems (i.e., opaque orthographies) that contain a great deal of morphological information (Coulmas, 1999; Rogers, 2005). That is, in a deep orthography, some letter-phoneme inconsistency

arises because the system often spells different allomorphs the same way to preserve the meaning of the morpheme (e.g., *south-southern*, *child-children*) (Rogers, 2005). See §2.2.5 for a discussion of orthographic depth.

#### 3.1.4 *The Alphabets*

Since this dissertation investigates the influence of alphabetic knowledge on phoneme awareness for English speakers or English learners of Russian and English learners of Mandarin, we must understand the three alphabets around which this research revolves: the 1) *Roman*, 2) *Cyrillic*, and 3) *Pinyin* alphabets.

##### **3.1.4.1 The Roman Alphabet**

As mentioned above in subsection 3.1.2, in the seventh century BCE, the Roman alphabet borrowed the Etruscan alphabet, which had itself been borrowed from the Greek alphabet. In classical times, until the first century BCE, the Roman alphabet was comprised of twenty-one letters: <A, B, C, D, E, F, G, H, I, K, L, M, N, O, P, Q, R, S, T, V, and X>. At this time, the Romans used <I> to represent both /i/ and /j/, and they used <V> to represent the three phonemes /v/, /u/, and /w/. The Romans originally also discarded <Z> as they did not have a /z/ sound for it to represent (Rogers, 2005). In addition, while the Greeks used <C> to represent /g/, the Etruscans had no voiced consonants and used <C> to represent /k/ – along with <K> and <Q>. The Romans retained the Etruscan system of using <C K Q> for the phoneme /k/. Therefore, because Latin did have voiced consonants, the Romans needed a letter to represent /g/. They added a stroke to <C> to create <G> and placed this new letter as the seventh letter in their alphabet (Bonfante, 1996; Rogers, 2005).

Through the course of the Roman alphabet’s development, the Romans revised their alphabet by adding some new letters. For example, to accommodate the increase in Greek loan words into Latin, the Romans re-incorporated <Z>, but, instead of putting it back in its original position as the seventh letter of the alphabet (as with the Greek alphabet), the Romans placed <Z> at the end of their alphabet (Bonfante, 1996). Also, in mediæval times, four new letters <J, U, W, and Y> were developed. These letters were developed to differentiate /i/ from /j/ (previously both represented by <I>) and /v/, /u/, and /w/ from each other (previously all represented by <V>) (Cook, 2004; Rogers, 2005). Today, the modern Roman alphabet has a total of twenty-six letters: five vowel letters and twenty-one consonant letters. Figure 3.2 below gives the complete abecedy of the modern Roman alphabet.

Aa	Bb	Cc	Dd	Ee	Ff	Gg	Hh	Ii	Jj	Kk
Ll	Mm	Nn	Oo	Pp	Qq	Rr	Ss	Tt	Uu	Vv
Ww	Xx	Yy	Zz							

**Figure 3.2** Abecedy of the modern Roman alphabet

While the Romans adapted the Etruscan alphabet and kept the letter order relatively intact, the Roman alphabet differed from the Etruscan alphabet in two significant ways. First, the Romans did not borrow the letter names; rather, they created new letters based on the sounds of the letters (Rogers, 2005). For these new names, each vowel sound was a letter name; and the sounds /e/ and /ɛ/ were added before and after consonants respectively to create consonant names; for example, the letters for Latin were pronounced as <B> /be/, <C> /se/, <F> /ɛf/, <L> /ɛl/. The letter name for <Z> came

from the Greek letter *zeta* and has since evolved in to the modern name *zed*.<sup>7</sup> Second, unlike the Etruscan alphabet, which was written from right-to-left, the Roman alphabet is written from left-to-right. This reform effectively changed the orientation of the letters. That is, with the right-to-left Etruscan alphabet, letters faced to the left while with the left-to-right Roman alphabet, the letters face to the right (Rogers, 2005).

Other modifications have also occurred since the Roman alphabet was first created. Originally, the Roman alphabet consisted only of what we know today as capital letters. The lower case letters were developed by scribes to create a fast flowing writing style (Cook, 2004; Knight, 1996). In addition, traditionally Latin was written without spaces between words; however, in the eighth century CE, putting spaces between words became a common practice (Cook, 2004).

According to Rogers (2005), languages that use the Roman alphabet rarely create entirely new letters to add to the original 26 letters. Instead, languages use diacritics (e.g., French: <è é ê ç> and German: <ä ö ü>) and/or diagraphs (e.g., English: <sh th ch ng>) for sounds not represented by the standard 26 letters. The Roman alphabet has been used for the majority of the world's languages (Knight, 1996). Some examples of languages that write with the Roman alphabet are English, French, Spanish, German, Finnish, Italian, and Czech.

#### **3.1.4.2 The Cyrillic Alphabet**

Like the Etruscan alphabet, the Cyrillic alphabet was based on the Greek alphabet and also the Glagolitic alphabet – an alphabet used for approximately 100 years prior to the

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<sup>7</sup> In the United States, the pronunciation norm for <Z> is /zi/ as advocated by the nineteenth century American lexicographer Noah Webster who wanted to regularise this grapheme so that it rhymed with the other graphemes like /bi ci di and so on/ (Rogers, 2005).

Cyrillic alphabet to represent the Old Slavonic languages. At the request of the prince of Moravia, in 862 CE, the Byzantine Emperor sent the Greek missionaries Cyril and Methodius to convert the Slavs to Christianity. Since no one had previously attempted to write down any Slavic language, Cyril had to first create an alphabet that represented the Slavic sounds (i.e., Old Bulgarian, also called Old Church Slavonic) so that he could then translate the Bible for the Morovians (Dumbreck, 1964). While Cyril is commonly believed to be the creator of the Cyrillic alphabet (from whom the alphabet gets its name), scholars now believe that Cyril, in fact, created the older Glagolitic alphabet in the mid-ninth century CE. The Glagolitic alphabet – adapted from cursive Greek – was the first Slavic alphabet and was first used to translate the Bible into Old Bulgarian (Coulmus, 1999). According to Cubberley (1996), Cyril’s disciples in Bulgaria in the 890s felt the Glagolitic alphabet was not suitable for church books and created a new alphabet derived from the Glagolitic alphabet and the “more dignified” unial Greek. While the Glagolitic and Cyrillic alphabets existed concurrently for some time, by the twelfth century CE, the Cyrillic alphabet had replaced the Glagolitic—possibly because the Glagolitic letters were very similar to each other and were very difficult to read (Dumbreck, 1964).

As mentioned above, the Cyrillic alphabet was derived from the Greek and Glagolitic alphabets. Evidence of this comes from the old Cyrillic alphabet—i.e., the Cyrillic alphabet prior to Peter the Great’s and the 1918 reforms (discussed below)—containing three letters <и>, <і>, and <ѵ>, which all corresponded to the exact same vowel sound (/i/) in Russian and ninth century Greek. Also, since ninth century Greeks pronounced <β> as /v/, a new letter <Ѣ> was created in Cyrillic because Old Bulgarian

had both /v/ and /b/. Therefore, in the Cyrillic alphabet, <В> represents /v/ and <Ѣ> represents /b/ (Dumbreck, 1964).

In the eighteenth century, Peter the Great initiated a reform of the Cyrillic spelling system (Istrin, 1965). First, he simplified the characters, which since the alphabet's creation had become increasingly ornate. Second, he removed redundant letters. As mentioned above, the letters <и>, <і>, and <ѵ> all represented the same sound, /i/. Therefore, <і> and <ѵ> were removed, leaving <и> to represent /i/. Two other sounds in Russian also had multiple letters representing them. Specifically, <ѣ> and <е> both represented /je/, and <ѳ> and <ф> both represented /f/. In the Cyrillic alphabet reform, <ѣ> and <ѳ> were removed and only <е> and <ф> remain to represent /je/ and /f/, respectively. Finally, the spelling reform omitted <ѣ> (the 'hard sign') from the end of words since the absence of <ѣ> (the 'soft sign') at the end of a word indicates that a consonant is hard, i.e., non-palatalized (Dumbreck, 1964). However, because there was no mechanism to enforce Peter's reforms, it was not until the language reforms in 1918 that the redundant letters were removed entirely (Cubberley, 1996).

The modern Cyrillic Alphabet has a total of thirty-three letters. Of these 33 letters, 21 represent consonants, 10 represent vowels and 2 (<ѣ> and <ѣ>) do not have any phonemic value themselves and serve only to indicate that the preceding consonant is either hard (not palatalized) or soft (palatalised), respectively. Figure 3.3 provides the 33 upper and lower case letters in the Cyrillic alphabet.

The Cyrillic alphabet is used in the Eastern Orthodox Slavic areas such as Russia, Ukraine, Bulgaria, and Macedonia. In addition to these Slavic areas, many non-Slavic

languages in Eastern Europe and Asia are written in Cyrillic. For example, Kazakh, Uzbek, and Turkman are all written in Cyrillic.<sup>8</sup>

Аа	Бб	Вв	Гг	Дд	Ее	Ёё	Жж	Зз	Ии	Йй
Кк	Лл	Мм	Нн	Оо	Пп	Рр	Сс	Тт	Уу	Фф
Хх	Цц	Чч	Шш	Щщ	Ъ	Ыы	Ь	Ээ	Юю	Яя

**Figure 3.3** Abecedy of the Cyrillic Alphabet

### 3.1.4.3 The Pinyin Alphabet

Since the early seventeenth century CE, people have tried to “romanize” Chinese. In other words, people have sought to create an alphabetic system to represent Chinese. The first alphabetic system for Chinese was designed in 1605 by the Italian missionary Matteo Ricci. Since the mid-nineteenth century, “proponents of language reform believed that alphabetical writing was a key to the strength of a modern nation” (Duanmu, 2000, p. 6). As a result, between 1840 and 1930, reformers proposed over 30 different alphabetic systems.

After the Communist Revolution, the new government proposed the *Hanyu Pinyin* (“Chinese Spelling System”) as a standard writing system for Chinese (Coulmas, 1999). They believed that a romanized writing system would further the government’s goal of linguistic and ethnic assimilation where one standard language and one standard writing system would make the assimilation process smoother (Zhou, 2001). In 1958, Pinyin was adopted as the official spelling system by the Chinese government.

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<sup>8</sup> To my knowledge, there is no proven relationship between the number of phonemes in a language and the choice of alphabet employed to represent those phonemes.

The government originally intended for Pinyin to supplant the use of Chinese characters; however, the high level intellectual officials opposed the promotion of the Pinyin system, and Pinyin currently plays a secondary role (DeFrancis, 2006). Still, Pinyin has garnered widespread national and international popularity and acceptance, and it has been recognized as the standard form of romanization of Mandarin (Mair, 1996). For instance, Pinyin is the official transcription system in China. Chinese names have been standardized on the basis of the Pinyin orthography. The educational system requires the instruction of Pinyin to all children in grade one. Pinyin is used in dictionaries, library catalogues, and other reference materials; it is also used on street signs, building names, and product labels. Pinyin's proponents "have succeeded in consolidating Pinyin as THE [original emphasis] system of representing Chinese in an alphabetic script" (DeFrancis, 1990, p. 10) which makes Pinyin "the most important Chinese romanization system in modern usage" (Killingly, 1998, p. 5). Although not the only motivation for its creation, Pinyin makes the orthographic representation of Mandarin more similar to languages that also employ an alphabetic system of writing, such as English.

As for the system itself, Pinyin is a phonemic orthography (Coulmas, 1999) and the designers borrowed letters that had a basis in either western orthographies or linguistic notation to represent the individual Mandarin phonemes (DeFrancis, 1990). Abecedaries for this alphabet are usually organised according to the elements that form the syllable: the onsets and rimes (Coulmas, 1999). In Pinyin, these elements are called the initials and finals, and Mandarin syllables are created by combining one initial with one final (or sometimes two finals). For example, Pinyin combines the initial <ch> and the final

<ang> to form the Mandarin word *chāng* /tʂʰaŋ/ (“to sing”). Figure 3.4 below provides the initial and final letters associated with the Pinyin alphabet.

<i>Initials:</i>										
Bb	Pp	Mm	Ff	Dd	Tt	Nn	Ll	Gg	Kk	Hh
Jj	Qq	Xi	Zhzh	Chch	Shsh	Rr	Zz	Cc	Ss	Ww
Yy										
<i>Finals:</i>										
-a	-o	-i	-u	-ü	-r					
-ai	-ei	-ao	-ou	-an	-en	-ang	-eng	-ong	-ia	
-ie	-iao	-iu	-ian	-in	-iang	-ing	-iong	-ua	-uo	
-uai	-ui	-uan	-un	-ueng	-uang	-üe	-üan	-ün		

**Figure 3.4** Abecedary of the Pinyin alphabet

Unlike the Roman and Cyrillic alphabets, Pinyin is only used by one language, Mandarin.

### ***3.2 Language backgrounds***

In order to explore the relationships between letters and phonemes in English, Russian, and Mandarin, we need to not only understand the how the phonemes are represented in each language, but we must also familiarize ourselves with the phonemic inventories of each language.

#### ***3.2.1 English***

The following three subsections describe the North American English consonant and vowel inventories, English syllable structure, and the English orthographic system.

### 3.2.1.1 English phoneme inventory

North American English consists of 24 consonants, 10 simple vowels (monothongs), and 5 diphthongs (Boberg, 2004; Ladefoged, 1999).<sup>9</sup> As shown in Figure 3.5, English makes a phonemic distinction between voiced and voiceless stops, fricatives, and affricates (but not aspirated and unaspirated stops). English also has dental voiceless and voiced fricatives.

		LABIAL	DENTAL	ALVEOLAR	ALVEO-PALATAL	PALATAL	VELAR	GLOTTAL
STOPS	+asp	[p <sup>h</sup> ]		[t <sup>h</sup> ]			[k <sup>h</sup> ]	[ʔ]
	-v	p		t			k	
	+v	b		d			g	
AFFRICATES	+asp				tʃ			
	-v							
	+v				dʒ			
FRICATIVES	-v	f	θ	s	ʃ			h
	+v	v	ð	z	ʒ			
NASALS		m		n			ŋ	
LIQUIDS				l [ɫ]				
				ɹ				
GLIDES		w				j		

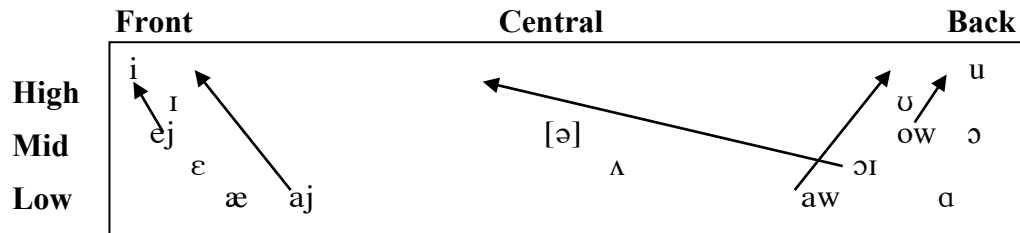
**Note:** The sounds in brackets [] are not considered to be phonemic.

**Figure 3.5** English Consonant Inventory (Boberg, 2004; Davenport & Hannahs, 2010; Ladefoged, 1999; Rogers, 2000)

In terms of vowels, North American English has 10 simple vowels (including schwa) and 5 diphthongs. Of the 10 simple vowels, 4 are front unrounded vowels (/i/, /ɪ/, /e/,

<sup>9</sup> The simplifying assumption here is that there are very few differences between the consonants in the general American and Canadian dialects of English (Rogers, 2000). The vowels do differ substantially across American and Canadian dialects, but since this research does not focus on vowel quality, the differences between the dialects are not addressed further.

and /æ/); 2 are central vowels (/ə/ and /ʌ/); 4 are back vowels (/ɑ/, /o/, /u/, and /ʊ/)<sup>10</sup>. In addition to these simple vowels, standard North American English has 5 diphthongs where the vowel starts as either a low or mid vowel and the glides rise to a high front or high back position (/aj/, /ej/, /aw/, /ow/, and /ɔj/) (Davenport & Hannahs, 2010; Ladefoged, 1999). The diphthongs in Figure 3.6 are represented at their starting point and the arrows indicate the direction and length of the off-glides. These diphthongs and simple vowels occur in syllables with primary stress. In unstressed syllables, vowels are most often reduced to either /ɪ/ or /ə/ and are usually very short (Rogers, 2000).



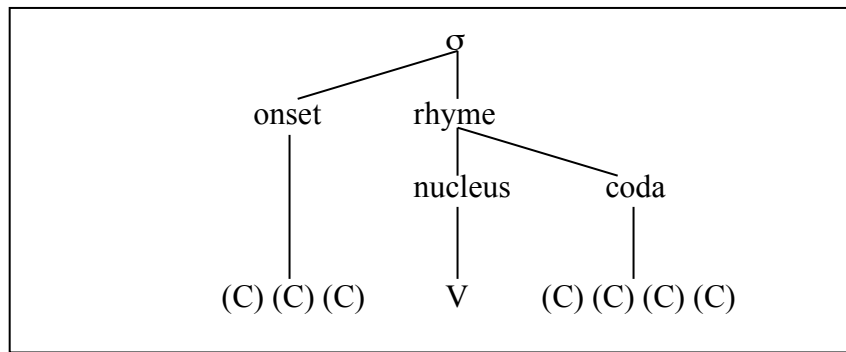
**Figure 3.6** English Vowel Inventory (Boberg, 2004; Davenport & Hannahs, 2010; Ladefoged, 1999; Rogers, 2000)

### 3.2.1.2 English syllable structure

English syllable structure is highly variable. That is, English allows many different types of syllables (Hammond, 1999; Rogers, 2000). (See Figure 3.7 below.). In short, English syllables are comprised of a nucleus (usually as single vowel) with optional onset and coda consonants. For example, English allows open syllables (i.e., syllables without codas in words such as *stew* /stu/), closed syllables (i.e., syllables with codas in words such as *an* /æn/ and *rip* /ɹɪp/). In addition, syllables can have up to three consonants in onset position (e.g., *sprint* /spɪnt/) and four in coda position (e.g., *worlds* /wɔ:ɹdʒs/). With

<sup>10</sup> An additional sound not included here is the rhoticised /ə/ as in *bird* /bɜ:d/ as I assume it to be /ə/ plus /ɹ/.

the exception of /ŋ/, all English consonants can appear in the onset position, and with the exception of /h/, all consonants can occur in the coda position (Rogers, 2000).<sup>11</sup> Figure 3.7 below visually illustrates English syllable structure.



**Figure 3.7** English syllable structure

### 3.2.1.3 English orthographic system

English orthography employs the Roman alphabet, where 21 consonant and 5 vowel letters represent over 40 phonemes (Ellis et al., 2004). The relationship between the letters and phonemes is very complex. Not only does English have sound-to-spelling inconsistencies, but also has spelling-to-sound inconsistencies. For example, the phoneme /i/ can be written as <e, ee, ea, ie, ei, y, and i> as in the words *ether*, *meet*, *meat*, *siege*, *conceive*, *city*, and *spaghetti*. Similarly, the letter sequence <ough> can be pronounced as /ʌf/, /ʌf/, /u/, and /ow/ as in the words *tough*, *cough*, *through*, and *though* (examples from Rogers, 2005, p. 5). See also Figure 2.2 and Figure 2.3.

In addition to its original 26 letters, English also uses digraphs to represent phonemes not accommodated by the single letter graphemes, namely the post-alveolar

<sup>11</sup> The parentheses indicate optional segments.

phonemes, the dental fricatives, and the velar nasal: <sh> represents /ʃ/; <j> and <dg> represent /dʒ/; <ch> represents /tʃ/; <th> represents /θ/ and /ð/, and <ng> represents /ŋ/.

According to Katz and Frost (1992),

English spelling represents a compromise between the attempt to maintain a consistent letter-phoneme relation and the attempt to represent morphological communality among words even at the cost of inconsistency in the letter-phoneme relation (p. 70).

Because of the complex relationship between graphemes and phonemes and the spelling-to-sound and sound-to-spelling inconsistencies, English orthography is classified as an opaque (or deep) orthography.

### 3.2.2 *Russian*

The following three subsections describe the Russian consonant and vowel inventories, Russian syllable structure, and the Russian orthographic system.

#### **3.2.2.1 Russian phoneme inventory**

The Russian sound inventory contains forty phonemes, which are presented below in Figure 3.8 and Figure 3.9. As illustrated in Figure 3.8, Russian consonants can be divided along two major distinctions: voiced/voiceless and hard (non-palatalized)/soft (palatalised) consonants (Press, 2000; Unbegaun, 1957; Wade, 2011). First, Russian has six pairs of voiceless/voiced obstruents (/p b/<sup>12</sup>, /f v/, /t d/, /s z/, /ʃ ʒ/, /k g/). Second, Russian also has consonants that are paired for palatalization. In fact, with the exception

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<sup>12</sup> Unlike English, Russian voiceless stops /p t k/ do not have allophonic aspirated variants (Unbegaun, 1957).

of six Russian consonants (/ʃ ʒ ts / only hard and /ʃʲ: tʃʲ j/ only soft), all the consonants have hard and soft alternations (Wade, 2011). For the palatal consonants, the middle of the tongue rises toward the hard palate. These soft and hard consonants in each palatalized pair (except for the velars) are considered to be separate phonemes since the palatal distinction between the two consonants can result in a meaning difference between two words (Kerek & Niemi, 2009; Unbegaun, 1957). For example, the word *мат*<sup>14</sup> /mat/ (with a non-palatalised <т>) means “checkmate” while *мать* /matʲ/ (with a palatalised <т>)<sup>15</sup> means “mother.” In addition to these two distinctions, Russian dental consonants (e.g., /т̪ ɖ/) are articulated further forward in the mouth than their English counterparts, which are alveolar (e.g., /t d/) and Russian voiceless obstruents are not articulated with aspiration as with English and Mandarin (Dumbreck, 1964).

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<sup>13</sup> While technically an alternation, /ʃ/ and /ʃʲ:/ differ in that only the shortened /ʃ/ is ever non-palatalised and only the lengthened /ʃʲ:/ is ever palatalized. In addition, each phoneme is represented by a different grapheme in the orthography. That is, /ʃ/ is represented by <ш>, and /ʃʲ:/ is represented by <шʲ>.

<sup>14</sup> In Russian, the cursive version of the grapheme <т> is written as <т̣>.

<sup>15</sup> The soft sign <ь> has no phonemic value itself but serves to indicate that the previous consonant is palatalised.

		LABIAL	DENTAL	ALVEOLAR	POST-ALVEOLAR	PALATAL	VELAR	GLOTTAL
STOPS	+asp							
	-v	p p <sup>j</sup>	t̪ t̪ <sup>j</sup>				k [k <sup>j</sup> ]	
	+v	b b <sup>j</sup>	d̪ d̪ <sup>j</sup>				g [g <sup>j</sup> ]	
AFFRICATES	+asp							
	-v			ts	tʃ <sup>j</sup>			
	+v							
FRICATIVES	-v	f f <sup>j</sup>	ʂ ʂ <sup>j</sup>		ʃ ʃ <sup>j</sup> :		x [x <sup>j</sup> ]	
	+v	v v <sup>j</sup>	ʐ ʐ <sup>j</sup>		ʒ		[ɣ]	
NASALS		m m <sup>j</sup>	n̪ n̪ <sup>j</sup>					
LIQUIDS			l̪ l̪ <sup>j</sup>					
TRILL				r r <sup>j</sup>				
GLIDES						j		

**Note:** The sounds in brackets [] are not considered to be phonemic.

**Figure 3.8** Russian Consonant Inventory (Kerek & Niemi, 2009; Robin et al., 2007; Press, 2000; Unbegaun, 1957; Wade, 2011)

In addition to the consonants, Russian has 6 vowel phonemes (Russian does not have any diphthongs (see the discussion below) or long versus short vowels.). Also, when the four vowels /i/, /e/, /a/, and /o/ are in unstressed syllables, they undergo different degrees of vowel reduction, depending on the position of the vowel compared to the stressed syllable (Dumbreck, 1964; Kerek & Niemi, 2009; Robin, Evans-Romaine, Shatalina, & Robin, 2007; Unbegaun, 1957). For example, the vowel /o/ is realised as /o/ in a stressed syllable, /a/ in the syllable before the stressed syllable, and /ə/<sup>16</sup> in a syllable more than one syllable before the stressed syllable and anywhere after the stressed syllable. The Russian word *голосá* (“voices”) is pronounced /gəlasa/. Unlike both English and Mandarin, Russian does not have diphthongs. In fact, Reformatzky (1996) points out that

<sup>16</sup> Schwa is not phonemic in Russian, and is, therefore, represented in square brackets in Table 3.9.

diphthongs are alien to the Russian language and when faced with borrowed words with diphthongs, Russian speakers either break them into two syllabic monothongs, creating an extra syllable, or turn the non-syllabic off-glide into a consonant, following licenced Russian phonotactics. For example, the German one-syllable *Faust* can become either the two-syllable *Файст* /fa.ust/ (a literary character) or the one-syllable combination with one vowel: *Фавст* /favst/ (proper name).<sup>17</sup> Also, like English, the glide /j/ in Russian is part of the consonantal inventory. Therefore, Russian words such as *май* /maj/ are considered CVC sequences—in contrast to the similar sounding English word *my* [maj], which is considered to be a CV sequence where the V sequence is a diphthong consisting of a V plus an offglide /j/ or /w/.

	Front	Central	Back
High	i	ɨ	u
Mid			o
Low	e	[ə]	
		a	

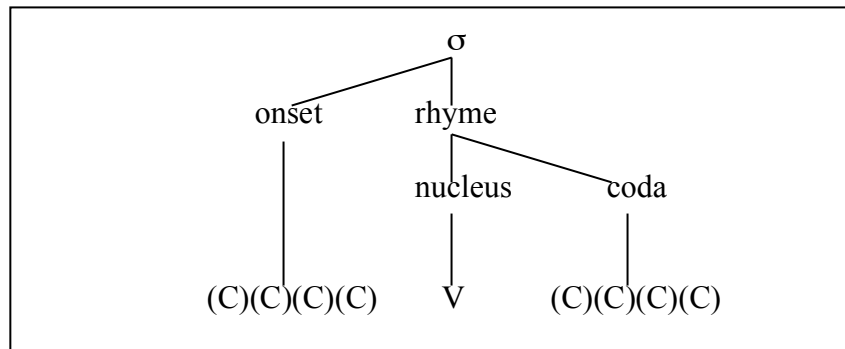
**Figure 3.9** Russian Vowel Inventory (Kerek & Niemi, 2009; Padgett & Tabain, 2005; Robin et al., 2007; Press, 2000; Unbegaun, 1957)

### 3.2.2.2 Russian syllable structure

Like English, Russian syllable structure is highly variable and allows many different types of syllables. Russian syllables are comprised of a nucleus (i.e., a single vowel) with optional onset and coda consonants (Kolnibalozky, 1938; Wade, 2011). Russian allows open syllables (e.g., *да* /da/ “yes” and *щю* /ʃʲ:i/ “cabbage soup”), closed syllables (e.g., *он* /on/ “he/it” and *лук* /luk/ “onion”). In addition, although the most common syllables in

<sup>17</sup> Thank you to Julia Rohtchina for helping translate Reformatsky (1996) into English.

Russian are consonant plus vowel syllables (Kolnibalozky, 1938), the language allows clusters of up to four consonants in both onset and coda position (e.g., *взгляд* /vzglʲat/ “look, glance” and *строительство* /straitʲilʲstʲf/ “of constructions”) (Kerek & Niemi, 2009). Figure 3.10 below visually illustrates Russian syllable structure.



**Figure 3.10** Russian syllable structure

### 3.2.2.3 Russian orthographic system

Russian uses the Cyrillic alphabet. According to Kerek and Niemi (2009), “the phoneme-grapheme correspondences are not always straightforward because many of the graphemes in the Russian alphabet are not bound to representing only one phoneme” (p. 6). Dumbreck (1964) attributes the irregularities and discrepancies between written and spoken Russian and the “illogicalities of orthography” (p. 5) to the fact that the Cyrillic alphabet was not devised for Russian; rather it was devised for Old Bulgarian. The 33 letters of the Cyrillic alphabet can be divided into three groups of letters: 1) letters that do not symbolize independent phonemes (<ѣ ѣ>), 2) letters that represent two phonemes (<е ё ю я>), and 3) letters that represent one phoneme (all others) (Grigorenko, 2006). Unlike the English and Mandarin Pinyin orthographies, the Russian orthography does not traditionally have any digraphs (although Russian does use digraphs for loan words such as *джаз* “jazz” /dʒac/). For example, both English and Pinyin represent the fricative /ʃ/

with the digraph <sh> (i.e., a grapheme consisting of two letters); Russian, in contrast, uses a single letter grapheme <ш> to represent the same phoneme.

While Russian letter correspondences contain four major irregularities, these irregularities are highly predictable. First, many phonemes share the same letter. That is, 14 of the consonant letters <б в д ж з л м н п р с т ф> represent two phonemes: the hard and soft phonemes. Palatalization (or lack thereof) is indicated by the following letter rather than as part of the letter itself. For example, <ф> can represent either /f/ or /fʲ/; the softness of the consonant is indicated by the letter following it, either a soft sign <ь> or a vowel letter (see below), and is entirely predictable. Second, while there are only 6 vowel phonemes, these phonemes are represented by 10 vowel letters <а э о ы у и > represent the simple vowel phonemes, and <я е ё ю> represent these vowels preceded by [j] in word-initial position or after a vowel. For example, the word *её* (“her”) is pronounced as /jɛjɔ/. When these 4 vowels follow a consonant, they indicate that the preceding consonant is soft (see above). Third, the soft sign <ь> does not represent a phoneme; rather it is used to indicate softness of a preceding consonant when the consonant is not followed by a vowel. For example, the <ь> indicates that the final consonant, /t/, in *брать* (“to take”) is palatalised (/bratʲ/) in contrast to the lack of <ь> in *брат* (“brother”) where the /t/ is non-palatalised (/brat/). Finally, the Russian orthographic system does not represent vowel reduction, and therefore, the vowel letters can represent different vowel sounds depending on where the stressed syllable is. (In second language teaching materials, stress is indicated by an accent over the vowel in the stressed syllable.) For example, in the word *окно́* (“window”), <о> is pronounced as /o/ in the second syllable (stressed) but as /a/ in the first syllable (unstressed). In addition, Russian has a number of

consonant clusters that have unpronounced consonants and consonants that are pronounced differently from what the letter suggests. Some of the common examples are listed in Table 3.2.

<b>Cluster</b>	<b>Pronunciation</b>	<b>Example</b>	<b>Translation</b>
<i>зdh</i>	<i>зн</i> /zn/	<i>праздник</i>	“holiday”
<i>рдц</i>	<i>рц</i> /rts/	<i>сердце</i>	“heart”
<i>лнц</i>	<i>нц</i> /nts/	<i>солнце</i>	“sun”
<i>стн</i>	<i>сн</i> /sn/	<i>лестница</i>	“stairs”
<i>вств</i>	<i>ств</i> /ctv/	<i>чувство</i>	“feelings”
<b>Combination</b>			
<i>его</i>	<i>ево</i> /jevo/	<i>его</i>	“his”
<i>что</i>	<i>што</i> /ʃto/	<i>что</i>	“what”
<i>сч / зч / жч</i>	<i>ц</i> /ʃ:/	<i>счастье</i>	“happiness”

**Table 3.2** Common Russian consonant clusters with unpronounced consonants (from Grigorenko, 2006)

In sum, while Russian orthography does not have straightforward one-to-one letter-phoneme associations, the irregularity is almost entirely predictable (except for stress). Therefore, in terms of orthographic depth, Russian is more transparent than English.

### 3.2.3 Mandarin

The following three subsections describe the Mandarin Chinese consonant and vowel inventories and the Mandarin orthographic system (Pinyin).

#### 3.2.3.1 Mandarin phoneme inventory

Standard Mainland Chinese Mandarin makes a phonemic distinction between aspirated and unaspirated stops and affricates and has only voiceless fricatives, except for the voiced alveo-palatal fricative /z/. Also, the Mandarin set of alveo-palatal sounds contains

all retroflex sounds. Mandarin also has a set of dental affricates. The sounds [tʃ<sup>h</sup>], [tʃ], and [ʃ] are considered to be allophones of the retroflex alveo-palatal consonants and only occur in limited environments, namely, before the high front vowels /i/ and /y/ (Lin, 2001). In addition to the twenty consonantal phonemes, Mandarin has six vowel phonemes: two high front vowels, one central low vowel, and three back vowels.<sup>18</sup> Figure 3.11 and Figure 3.12 below provide complete phoneme inventories for the Mandarin consonants and vowels, respectively. NOTE: Mandarin also employs tone phonemically, which increases the number of distinctions made on the vowels: while there are only 6 Mandarin tones, each one can take the 4 different tones, leading to 24 possible distinctions in the vowel system.

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<sup>18</sup> The non-high vowels /ɤ/ and /a/ each have allophonic variations. The vowel /ɤ/ has three variations: 1) [e] before the high-front-unrounded vowel [i], 2) [ɛ] after [i] or [ü] and before the syllable boundary, and [ə] before nasals. The vowel /a/ has two variations: 1) [ɛ] between the high front vowels [i] and [ü], before [n], and before [i] and 2) [ɑ] before [ŋ] (Lin, 2001).

		LABIAL	DENTAL	ALVEOLAR	ALVEO-PALATAL	PALATAL	VELAR	GLOTTAL
STOPS	+asp	p <sup>h</sup>		t <sup>h</sup>			k <sup>h</sup>	
	-v	p		t			k	
	+v							
AFFRICATES	+asp		ts <sup>h</sup>		tʃ <sup>h</sup>	[tʃ <sup>h</sup> ]		
	-v		ts		tʃ	[tʃ]		
	+v							
FRICATIVES	-v	f	ʃ		ʒ	[ç]	x	
	+v				ʒ			
NASALS		m		n			ŋ	
LIQUIDS				l				
				ɭ				
GLIDES		[w]				[j]		

**Note:** The sounds in brackets [] are not considered to be phonemic.

**Figure 3.11** Mandarin Consonant Inventory (Duanmu, 2000; Lin, 2001)

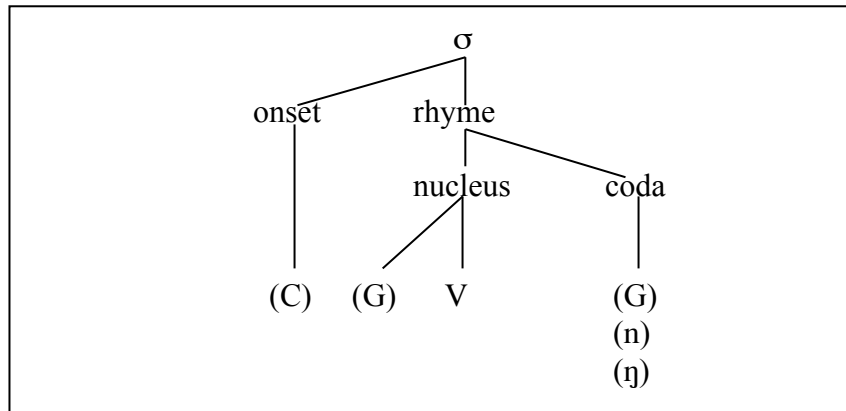
	Front	Central	Back
<b>High</b>	i y		u
<b>Mid</b>	[e] [ɛ]	[ə]	ɤ o
<b>Low</b>		a	[ɑ]

**Figure 3.12** Mandarin Vowel Inventory (Duanmu, 2000; Lin, 2001)

### 3.2.3.2 Mandarin syllable structure

Compared with English and Russian syllable structure, Mandarin syllable structure is much more restricted. In fact, there are only 405 possible syllable combinations (Lin, 2001). Specifically, Mandarin allows, at most, one consonant in onset position. This does not include glides. These can follow an onset consonant but are considered to be part of

the rhyme by native speakers (e.g., *guài* /kwaj/ “strange, odd”). Mandarin codas are even more restricted than the onsets. Codas may contain either a glide (e.g., *wèi* /wej/ “place, location”) or /n/ (e.g., *fàn* /fan/ “cooked rice”) or /ŋ/ (e.g., *míng* /miŋ/ “bright, brilliant”). Neither nasal /m/ nor obstruents are permitted in Mandarin codas. For clarity, Figure 3.13 below illustrates Mandarin syllable structure (Lin, 2001).



**Figure 3.13** Mandarin syllable structure

### 3.2.3.3 Mandarin orthographic system

As mentioned above, in addition to Chinese characters, Mainland Chinese Mandarin uses Pinyin. Compared with the English and Russian orthographic systems, Pinyin is a highly systematic and transparent alphabetic system (see Table 3.3 for a comparison of the systems). According to Coulmas (1999), Pinyin’s systematicity and transparency have allowed it to replace other romanization systems in China. While the Pinyin orthography is much more transparent than either the Russian or the English orthography, it is not without its letter-phoneme inconsistencies. Pinyin contains two major spelling irregularities. Although irregular, both are highly predictable. First, Pinyin has three digraphs that represent single phonemes; <sh>, <zh>, and <ng> represent /ʃ/, /ʒ/, and /ŋ/, respectively. Second, as well as diphthongs, Mandarin also has triphthongs (i.e., glide-

vowel-glide sequences), which are represented differently depending on whether or not they are preceded by a consonantal onset (Bassetti, 2006). Before the nucleus vowel, the glides /w/ and /j/ are represented orthographically as <w> and <y> when they do not follow a consonant onset. In contrast, they are represented as <u> and <i> when they do follow a consonant onset. In addition, when not preceded by a consonant onset, the main vowel in a triphthong is represented orthographically, but when preceded by a consonant, the main vowel is not represented orthographically. For example, compare the following Mandarin words *duì* /twej/ (“team/group”) and *wèi* /wej/ (“place/location”). In both words, the triphthong is /wej/. However, in *wèi*, the first glide is spelt as <w> because there is no preceding consonant, but in *duì*, the glide is spelt as <u> because it is preceded by the consonant /t/. Moreover, when not preceded by a consonant, each segment of the triphthong is represented orthographically: in *wèi*, /wej/=<wei>. However, when preceded by a consonant, only the glides and NOT the main vowel are represented orthographically: in *duì*, /wej/=<ui>.

### ***3.3 Letter-Phoneme correspondences in English, Russian, and Mandarin***

The following table compares the letter-phoneme correspondences in English, Russian, and Mandarin. This table shows that the English and Russian letters (with a few exceptions) represent more than one phoneme. As discussed in §3.2.2.2, although Russian orthography contains four irregularities, these irregularities are almost entirely predictable which makes Russian more transparent than English. The Mandarin Pinyin letters, in contrast, have more consistent one-to-one relationships between letters and phonemes.

English – Roman Alphabet		Russian – Cyrillic Alphabet		Mandarin – Pinyin Alphabet	
letter(s)	phoneme(s)	letter(s)	phoneme(s)	letter(s)	phoneme(s)
<b>Aa</b>	/æ/ /ej/ <sup>19</sup> /ə/	<b>Аа</b>	/a/ /ə/	<b>Bb</b>	/p/
<b>Bb</b>	/b/ /b <sup>h</sup> /	<b>Бб</b>	/b/ /b <sup>i</sup> /	<b>Pp</b>	/p <sup>h</sup> /
<b>Cc</b>	/k/ /k <sup>h</sup> / /s/	<b>Вв</b>	/v/ /v <sup>i</sup> /	<b>Mm</b>	/m/
<b>Dd</b>	/d/ /d <sup>h</sup> /	<b>Гг</b>	/g/ /g <sup>i</sup> /	<b>Ff</b>	/f/
<b>Ee</b>	/ε/ /i/ /ə/	<b>Дд</b>	/d̪/ /d̪ <sup>i</sup> /	<b>Dd</b>	/t/
<b>Ff</b>	/f/	<b>Ее</b>	/jε/ /i/	<b>Tt</b>	/t <sup>h</sup> /
<b>Gg</b>	/g/ /dʒ/	<b>Ёё</b>	/jɔ/	<b>Nn</b>	/n/
<b>Hh</b>	/h/	<b>Жж</b>	/ʒ/ /ʒ <sup>i</sup> /	<b>Ll</b>	/l/
<b>Ii</b>	/ɪ/ /aj/ /ə/	<b>Зз</b>	/z/ /z <sup>i</sup> /	<b>Gg</b>	/k/
<b>Jj</b>	/dʒ/	<b>Ии</b>	/i/	<b>Kk</b>	/k <sup>h</sup> /
<b>Kk</b>	/k/ /k <sup>h</sup> /	<b>Йй</b>	/j/	<b>Hh</b>	/x/
<b>Ll</b>	/l/ /ɫ/	<b>Кк</b>	/k/ /k <sup>i</sup> /	<b>Jj</b>	/tɕ/
<b>Mm</b>	/m/	<b>Лл</b>	/ɫ/ /l <sup>i</sup> /	<b>Qq</b>	/tɕ <sup>h</sup> /
<b>Nn</b>	/n/	<b>Мм</b>	/m/ /m <sup>i</sup> /	<b>Xx</b>	/ç/
<b>Oo</b>	/a/ /ɔ/ /ow/ /ə/	<b>Нн</b>	/n̪/ /n̪ <sup>i</sup> /	<b>Zz</b>	/ts/
<b>Pp</b>	/p/ /p <sup>h</sup> /	<b>Оо</b>	/o/ /a/ /ə/	<b>Cc</b>	/ts <sup>h</sup> /
<b>Qq</b>	/kw/	<b>Пп</b>	/p/ /p <sup>i</sup> /	<b>Ss</b>	/ʃ/
<b>Rr</b>	/ɹ/	<b>Рр</b>	/r/ /r <sup>i</sup> /	<b>Zhzh</b>	/tʂ/
<b>Ss</b>	/s/	<b>Сс</b>	/s̪/ /s̪ <sup>i</sup> /	<b>Chch</b>	/tʂ <sup>h</sup> /
<b>Tt</b>	/t/ /t <sup>h</sup> /	<b>Тт</b>	/t/ /t <sup>i</sup> /	<b>Shsh</b>	/ʃ/
<b>Uu</b>	/ʊ/ /u/ /ʌ/ /ə/	<b>Уу</b>	/u/	<b>Rr</b>	/z/
<b>Vv</b>	/v/	<b>Фф</b>	/f/ /f <sup>i</sup> /	<b>Yy</b>	/j/
<b>Ww</b>	/w/	<b>Хх</b>	/x/ /x <sup>i</sup> /	<b>Ww</b>	/w/
<b>Xx</b>	/j/	<b>Цц</b>	/ts/	<b>-ng</b>	/ŋ/
<b>Yy</b>	/j/	<b>Чч</b>	/tʃ <sup>i</sup> /	<b>Aa</b>	/a/
<b>Zz</b>	/z/	<b>Шш</b>	/ʃ/	<b>o</b>	/o/
<b>sh</b> <sup>20</sup>	/ʃ/	<b>Щщ</b>	/ʃ <sup>i</sup> :/	<b>e</b>	/ε/ /ə/
<b>ch</b>	/tʃ/	<b>ь</b>	silent	<b>i</b>	/i/
<b>ng</b>	/ŋ/	<b>Ьы</b>	/i/	<b>u</b>	/u/
<b>th</b>	/θ/ /ð/	<b>ь</b>	silent	<b>ü</b>	/y/
		<b>Ээ</b>	/ε/	<b>er</b>	/ɹ/
		<b>Юю</b>	/ju/		
		<b>Яя</b>	/ja/ /jə/ /ɪ/		

**Table 3.3** English, Russian, and Mandarin letter-phoneme relationships

<sup>19</sup> The offglides in each diphthong are transcribed with either a /j/ or /w/ since I assume that diphthongs are 2 segments comprised of a vowel plus offglide. See §4.2.2.1 for a discussion.

<sup>20</sup> This bold line separates the letters listed in the Roman alphabet from the English digraphs that are not part of the alphabet. In contrast, the Mandarin digraphs <sh zh ch ng> are listed in the Pinyin alphabet, and are, therefore not separated from the other letters in this list.

### ***3.4 Orthographic representation and the current project***

Now that we have explored the relevant previous research (Chapter 2) and outlined the language characteristics of English, Russian, and Mandarin (Chapter 3), we can discuss how these two chapters inform the current research project. Chapter 2 established that alphabetic experience shapes how individuals perceive phonemes. First, according to Ehri (1985), “the visual forms of words acquired from reading experiences serve to shape learner’s conceptualizations of the phoneme segments in those words” (p. 342). Second, research has also demonstrated that the ability to count phonemes only surfaces once children learn to read via an alphabet (e.g., Bertelson et al., 1989; Carroll, 2004; Morais et al., 1979; Read et al., 1986) and that after they make letter-phoneme associations, readers may have “difficulty focusing on phonemes and ignoring letters” (Gombert, 1996, p. 762). Finally, research has shown that learners interpret L2 orthographic input according to the L1 letter-phoneme correspondences (Bassetti, 2006; Erdener & Burnham, 2005). The research outlined in Chapters 2 suggests that at least four factors may shape native speakers’ abilities to count phonemes in their L1, L2 and an L0. These factors are: 1) L1 interference, 2) the strength of the connection between letter-phoneme correspondences, 3) orthographic depth, and 4) phoneme awareness.

If alphabetic knowledge overrides auditory information (i.e., what is heard) (Erdener & Burnham, 2005; Hallé et al., 2000), then a mismatch between the number of letters and the number of phonemes in a word should affect participant responses. Therefore, I predict that (reproduced from Chapter One):

- 1) L1 orthography *facilitates* L1 phoneme perception in consistent<sup>21</sup> English words where a match between number of phonemes and the number of letters occurs (i.e., consistent letter-phoneme correspondences) but *hinders* it in inconsistent English words where a mismatch between the number of phonemes and letter occurs (i.e., inconsistent correspondences).
- 2) L1 orthography *facilitates* L0 phoneme perception in consistent cross-language homophones because the associated L1 spellings help parse L0 phonemes, but L1 orthography does not affect perception in consistent nonhomophones because no spelling associations exist. In addition, L1 orthography *hinders* L0 phoneme perception in inconsistent cross-language homophones because the associated L1 spellings interfere with perception, but L1 orthography does not affect perception in inconsistent nonhomophones because, as with the consistent nonhomophones, no L1 spelling associations exist.
- 3) As with L1, L2 orthography *facilitates* L2 phoneme perception in consistent L2 nonhomophones but *hinders* it in inconsistent L2 nonhomophones. In contrast, for the cross-language L2 homophones, which have associated L1 spellings, L1 orthographic knowledge *overrides* L2 orthographic knowledge (due to L1 transfer effects) and influences L2 phoneme perception such that L1 orthography *facilitates* L2 phoneme perception in L2 words with

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<sup>21</sup> Recall that for the purposes of this research, *consistent* words are words where the number of letters equals the number of phonemes, and *inconsistent* words are words where the number of letters does not equal the number of phonemes.

consistent L1 associations but *hinders* it in L2 words with inconsistent L1 associations.

- 4) As native speakers, the listeners have many more years of experience with English than they do with their L2 and thus the L1 orthography is more entrenched and potentially exerts more influence on the L1 than the L2 orthography exerts on the L2. Therefore, the accuracy and response time differences between the consistent and inconsistent L1 words would be greater than the differences between the consistent and inconsistent L2 words, which in turn would be greater than the differences between the consistent and inconsistent L0 words (i.e., L1 differences >> L2 differences >> L0 differences).

Confirmation of these predictions will demonstrate that L1 alphabetic knowledge affects L1 speech processing *and* nonnative language speech processing, thereby suggesting that not only do learners perceive nonnative sounds (both L2 and L0 sounds) through the filter of their L1 sound system (Best, 2001; Flege, 1995, Kuhl, 2000) but also through the filter of their L1 writing system. Such results will identify another L1-related factor contributing to L2 speech processing that, up to now, has remained relatively unexplored: orthography. Indeed, the relationship between orthographic representation and phonemic representation in nonnative speech processing has been largely ignored. This research characterises and explores that relationship. Specifically, this research focuses on how orthographic representation influences sound perception in L2 learning and whether orthographic representation overrides phonemic information in L2 speech processing. It sheds light on how much influence (if any) orthographic representation exerts on

learners' perceptions of phonemes in their L1, their L2, and L0. Research of this kind contributes to the sparse body of research on orthography's relationship to nonnative sound processing, which, in turn, informs pedagogical practices in second language classrooms. That is, given that second languages are taught primarily through writing, it is essential to understand how using a writing system common to L1 in teaching L2 may affect learning correct L2 letter-phoneme correspondences and thus L2 phoneme awareness.

### ***3.5 Summary***

In sum, this chapter has provided orthographic background on four areas that are essential to understanding the current research. First, the chapter showed that writing systems can be created in one of three ways: from 1) a brand new idea, 2) stimulus diffusion, or 3) borrowing. Second, this chapter discussed the two broad types of writing systems: 1) morpheme-based systems (logographies), and 2) sound-based writing systems (syllabaries, consonantal scripts, or alphabets). Third, this chapter provided the necessary phonemic, syllabic, and orthographic background for English, Russian, and Mandarin. Finally, this chapter outlined the rationale behind and predictions of the current research project.

## Chapter Four

### METHODOLOGY

*“... to assume straightaway that an English spoken word such as bat consists of just three ‘individual sounds’ because its written form comprises just three letters is simply to put the alphabetic cart before the phonetic horse.”  
(Harris, 1986, p. 38)*

In order to determine how L1 orthography affects phoneme detection in not only a first language but also nonnative languages, a study was designed in which L1 English speakers counted phonemes in: 1) L1 words and 2) L0 (i.e., unfamiliar language) words. In addition, a subgroup of those L1 English speakers also counted phonemes in L2 words. The three languages under investigation are English, Russian, and Mandarin because they each employ different alphabetic orthographies and the last two are both taught at the University of Victoria as foreign languages. The following sections describes, in depth, the methodology employed in the current research—including the pilot study (§4.1), the primary data collection (§4.2), and the secondary data collection (§4.3). Both the primary and secondary data collection sections include subsections describing the participants, the experimental stimuli, the experimental materials, the experimental tasks, and the experimental procedure.

#### ***4.1 The pilot study***

As a step towards developing the experimental task for the current research, a pilot study (Pytlyk, to appear) was designed to test the hypothesis that native English speakers have more difficulty accurately perceiving phonemes in English words with *inconsistent* letter-phoneme correspondences (i.e., no one-to-one relationship between letters and

phonemes) than in English words with *consistent* letter-phoneme correspondences (i.e., one-to-one relationship). Twenty-one native English listeners counted phonemes in 60 monosyllabic English words: 30 *consistent* words (e.g., <bed> and /bed/) and 30 *inconsistent* words (e.g., <tax> and /tæks/). The results showed that participants were significantly less accurate at counting phonemes in *inconsistent* words (70%) than in *consistent* words (86%). Also, the analyses demonstrated that even when participants accurately count phonemes in *inconsistent* words, they were significantly slower (3.68 seconds) than when they accurately count phonemes in *consistent* words (2.75 seconds). The results confirm that, in the L1 at least, orthographic knowledge interferes with phoneme awareness and affects speech processing (e.g., Burnham, 2003; Glushko, 1979; Ziegler & Ferrand, 1998). In short, the pilot study results suggest that when letters equal phonemes, listeners do not receive conflicting orthographic and phonetic information, resulting in higher accuracy rates and faster processing times. In contrast, when letters do not equal phonemes, listeners must spend extra cognitive resources to reconcile the conflicting information, as reflected in their lower accuracy rates and slower processing times.

#### ***4.2 The primary study***

The primary study undertaken in this dissertation investigated the extent to which orthographic knowledge influences native and nonnative speech processing, namely phoneme perception. Via a phoneme counting task, data were collected and analysed to determine the effect of orthographic knowledge. This section outlines the methodology employed for this investigation, including the participants, stimuli, materials, tasks, procedure, and data analyses.

#### 4.2.1 Participants

Fifty-two participants who were all first language speakers of Canadian English participated in the primary. Participants were split into two groups, one of which heard Russian as the L0 (RNL0), and the other of which heard Mandarin as the L0 (MNL0). Of these 52 participants, 12 participants were learning Mandarin-as-an-second-language (MFL subgroup), and 13 participants were learning Russian-as-a-second-language (RFL subgroup). These two subgroups made it possible to not only assess listeners' perceptions of L1 and L0 phonemes but also their perceptions of L2 phonemes.

- 1) **Russian L0 (RNL0)** (26 participants) – All participants were unfamiliar with Russian (L0), and a subset of this group (12 participants) were MFL learners (Mandarin L2).
- 2) **Mandarin L0 (MNL0)** (26 participants) – All participants were unfamiliar with Mandarin (L0), and a subset of this group (13 participants) were RFL learners (Russian L2).

The Russian and Mandarin second language learners (i.e., the MFL and RFL subgroups) were recruited from University of Victoria language classes—specifically, from PAAS 111 (formerly CHIN 150) and RUSS 200B language classes.<sup>22</sup> All of the other participants were recruited from first year linguistics classes and posters placed around the university. Only those volunteers who reported no auditory or visual impairments were accepted for the study.

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<sup>22</sup> By the end of these classes, both groups of students had completed the equivalent of four semesters of language learning.

Table 4.1 below provides a summary of the participant characteristics within each experimental group.

group		number of participants	mean age	other languages learned	
primary data	Russian L0	overall	n = 26	21.0 years	<ul style="list-style-type: none"> <li>Japanese, French, Korean, Cantonese, German, Spanish, Italian, and Attic Greek</li> </ul>
		subgroup (MFL)	n = 12	21.3 years	<ul style="list-style-type: none"> <li>Japanese, French, Korean, Cantonese, German, Spanish, Italian, and Attic Greek</li> </ul>
	Mandarin L0	overall	n = 26	20.7 years	<ul style="list-style-type: none"> <li>French, Italian, Japanese, Spanish, Polish, German, Java<sup>23</sup>, Ainu<sup>24</sup>, Gaelic, Arabic, and Farsi</li> </ul>
		subgroup (RFL)	n = 13	20.8 years	<ul style="list-style-type: none"> <li>French, Italian, Japanese, Spanish, Polish, German, Java, Ainu, and Gaelic</li> </ul>

*n = total number, L0 = unfamiliar language, MFL = Mandarin-as-a-second-language, RFL = Russian-as-a-second-language*

**Table 4.1** Primary data participant demographics

In this table, the participant summaries are divided according to primary data groups (i.e., RNL0 and MNL0), and within each group, the participants are summarised according to the overall population in that group as well as the number of participants in the subgroup. For example, the RNL0 group had 26 overall participants, and a subgroup of 12 participants who were L2 learners of Mandarin. This table also contains information about the mean age of each group and subgroup as well as the other languages these participants had learnt. Henceforth, all primary data participants who belong to the subgroup data are referred to as the RFL and MFL participants, and all the other primary

<sup>23</sup> The participant considers Java, a programming language used for computer games and business applications, a language.

<sup>24</sup> Ainu is an indigenous language spoken in North-East Asia.

data participants who are not in the subgroup data are referred to as the non-L2 participants.

#### 4.2.2 *Experimental stimuli*

The following two subsections outline and describe the process and decisions made regarding the selection and creation of the experimental stimuli—including the target words (§4.2.1) and the stimuli creation process (§4.2.2).

##### 4.2.2.1 **Target words**

In order to assess the effect of orthographic knowledge on listeners' perception of L1, L2, and L0 phonemes, the stimuli in this project were English, Russian, and Mandarin Chinese words that contained between 1 and 5 letters and/or phonemes. These target words were organised according to two variables: *homophone*, and *match*. (See §4.2.6 for a more detailed discussion of all the independent and dependent variables.) The homophone variable refers to whether the nonnative words (Russian and Mandarin) had homophonous L1 (i.e., English) counterparts. The *homophone* variable has two levels, **nonhomophone** and **homophone**.

1. **NONHOMOPHONE (NH)** where the word does not have a homophonous counterpart in another language. For example, neither the Russian word *плащ* /plaf:/ (“raincoat”) nor the Mandarin *hē*<sup>25</sup> /xɤ/ (“to drink”) sound like any English word.

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<sup>25</sup> For ease of reading, all Mandarin words are given using the Pinyin orthography. See §3.1.4.3 for a discussion of the Pinyin alphabet.

2. **HOMOPHONE (H)** where the word has a (nearly) homophonous counterpart in another language. The homophone pairs were either L1–L0 pairs or L1–L2 pairs. For example, the English word *cart* /k<sup>h</sup>ɑ:t/ and the Russian word *карта* /kart/ (“map” GEN PL) are homophonous with each other. Similarly, the English word *May* /mej/ and the Mandarin *méi* /mej/ (“did not/have not”) are also homophonous with each other.

The match variable refers to whether the number of letters equalled the number of phonemes in the words. The *match* variable has two levels, **matched** or **mismatched**.

1. **MATCH (M)** where the number of letters in the word equals the number of phonemes. For example, the English word *big* /bɪg/, the Russian word *всё* /fsʲɔ/<sup>26</sup> (“everything”), and the Mandarin word *suān* /swan/ (“sour”) all have the same number of letters as the number of phonemes. The English word has 3 letters and 3 phonemes; the Russian word has 3 letters and 3 phonemes, and the Mandarin word has 4 letters and 4 phonemes.
2. **MISMATCH (MM)** where the number of letters in the word is either more or less than the number of phonemes. For example, the English word *sock* /sɒk/, the Russian word *звать* /zvətʲ/ (“to call”), and the Mandarin word *huáng* /xwɑŋ/ (“yellow”) do not have the same number of letters as the number of phonemes. The English word has 4 letters

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<sup>26</sup> The assumption here is that palatalisation is a characteristic of the consonant and not a phoneme itself (Unbegaun, 1957; Wade, 2011).

and 3 phonemes; the Russian word has 5 letters and 4 phonemes, and the Mandarin word has 5 letters and 4 phonemes.

Because this research also revolves around investigating whether L1 orthographic knowledge interferes with L2 orthographic knowledge and L0/L2 phonetic information, the MM-H conditions are of primary interest (highlighted bottom right quadrant in Table 4.2). It was impossible to find Russian and Mandarin words<sup>27</sup> with letter-phoneme mismatches that were homophonous with English words with letter-phoneme matches. In other words, because of their relative transparency, finding Russian and Mandarin words that had letter-phoneme mismatches *and* that were homophonous with English words that had a 1-to-1 letter-phoneme correspondence was almost impossible. For this reason, the mismatch was always in the L1. The homophone L0/L2 words therefore always had one-to-one letter to phoneme correspondence. For example, in the English-Russian homophone pair *stool–cmyл* (“chair”) and the English-Mandarin homophone pair *when–wèn* (“to ask”), the English words *stool* and *when* have mismatches (5 letters/4 phonemes and 4 letters/3 phonemes, respectively) while the Russian word *cmyл* and the Mandarin word *wèn* each have the same number of letters and phonemes in them (4 letters/4 phonemes and 3 letters/3 phonemes, respectively).

With respect to the target words, two other important considerations guided their selection. First, because the subgroup data analyses investigate a) the interaction between the L1 orthography and the L2 orthography and b) the effect of the L2 orthography on L2 phonology, the L2 subgroup participants needed to be familiar with the words—both

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<sup>27</sup> The Russian and Mandarin words were chosen in consultation with native speakers – Julia Rochtchina (Russian), Shu-min Huang (Mandarin), Xiaojuan Qian (Mandarin), and Yanan Fan (Mandarin). These native speakers intuitions contributed to the phonemic analyses of the Russian and Mandarin words.

orthographically and phonologically. Therefore, based on the vocabulary both the RFL and MFL learners learn in their language classes, there were a limited number of cross-language homophones that fit all the parameters (including the parameters that these target words be monosyllabic and contain between 1 to 5 phonemes). As a result, the matched homophone (M-H) conditions for the English, Russian, and Mandarin words only contained 10 target words as opposed to the 14 target words in the other conditions.

Second, due of the nature of Mandarin Chinese syllable structure (See §3.2.3.2.), it was impossible to avoid having target words containing diphthongs (i.e., a CVG syllable). Some examples of these types of Mandarin words include *gòu* /kow/ (*enough*), *mài* /maj/ (*to sell*), *tóu* /t<sup>h</sup>ow/ (*head*), and *nào* /naw/ (*noisy*). A diphthong is defined as a syllable nucleus that contains two target positions (Lehiste & Peterson, 1961) or as a sequence of a simple vowel and a glide (Rogers, 2000). While researchers generally agree that diphthongs are complex nuclei, there is still some debate surrounding the question of whether diphthongs should be classified as two units (Berg, 1986; Lehiste & Peterson, 1961) or one unit (Wiebe, 1998; Wiebe & Derwing, 1992, 1994). Based on the definitions given by Lehiste and Peterson (1961) and Rogers (2000) (see above), this research assumes all diphthongs in open syllables are two units—a vowel plus an offglide /j/ or /w/. For example, the word *go* (an open syllable) is phonemicised as /gow/ with the offglide /w/ while the word *pole* (a closed syllable) is phonemicised as /poʔ/.<sup>28</sup> Thus, accurate responses will be those responses where listeners count two phonemes for each diphthong heard. The decision to count diphthongs as two units obviously has an impact

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<sup>28</sup> In the two English target words *dome* and *pole*, which both have closed syllables, I assume that the vowel does not have an offglide. In *pole*, the offglide is subsumed under the /ʔ/, and in *dome*, there is no offglide to make the articulation of /m/ easier.

on the classification of the words into the match and mismatch categories. For example, when the diphthongs are counted as two phonemes the words *now* /naw/, *May* /mej/, and *toe* /tow/ are categorized as matched words (number of letters = the number of phonemes), and *my* /maj/ and *go* /gow/ are categorized as mismatched words (number of letters  $\neq$  number of phonemes). Consequently, this decision potentially affects the results. This issue is discussed further in §6.4.

Comparing the phoneme counting data for target words containing diphthongs with an orthographic mismatch (e.g., English *my* /maj/—has 2 letters but 3 phonemes) and target words containing diphthongs with no mismatch (e.g., Mandarin *mai* /maj/—has 3 letters and 3 phonemes) may shed additional light on orthographic influence. For example, if participants count 2 phonemes in English words like *go* and *my*, but 3 phonemes in words like *now* and *how*, this would suggest that listeners hear the diphthong as 1 phoneme when it is represented by one letter, but they hear diphthongs as 2 phonemes when it is represented by 2 letters. Similarly, if the MFL participants count 2 phonemes in English *go* and *my* but 3 phonemes in Mandarin *gòu* and *mai*, it would also suggest that the orthographic spelling of the diphthong dictates the number of phonemes heard. Moreover, this would also suggest that the influence of L2 orthography is stronger on L2 phoneme perception than the influence of the L1 orthography.

Each L0/L2<sup>29</sup> language condition consisted of **52 tokens** (14 M-NH + 14 MM-NH + 14 MM-H + 10 M-H). For example, in the M-H tokens, 10 were paired with English M-

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<sup>29</sup> Russian was the L2 for the subset of RFL learners, but the L0 for all other participants. Similarly, Mandarin was the L2 for the subset of MFL learners, but the L0 for all the other participants.

H words (like Russian *лифт* /lift/ (“elevator”) [4/4]<sup>30</sup> and English *lift* /lɪft/ [4/4]), and in the MM-H, 14 were paired with English MM-H words (like Mandarin *wèn* /wɛn/ (“to ask”) [3/3] and English *when* /wɛn/[4/3]). The English consisted of **76 tokens** (14 M-NH + 14 MM-NH + 20 M-H (10 paired with Russian / 10 paired with Mandarin) + 28 MM-H (14 paired with Russian / 14 paired with Mandarin). See Table 4.3 and Table 4.4 for the list of all the experimental words. In total, each participant was tested on 180 tokens (76 English + 52 Russian + 52 Mandarin). In Table 4.2, the words given in angled brackets are the cross-language counterparts of the example words. EN refers to English words; RN refers to Russian words, and MN refers to Mandarin words. For example, the English matched words have 14 nonhomophone tokens (e.g., *cup*), 10 homophones paired with Russian words (e.g., *brat*–*брат* (“brother”)), and 10 homophones paired with Mandarin words (e.g., *bow*–*bào* (“newspaper”)). Similarly, the English mismatched words have 14 nonhomophone tokens (e.g., *month*), 14 homophones paired with Russian words (e.g., *stool*–*стул* (“chair”)), and 14 homophones paired with Mandarin words (e.g., *my*–*mai* (“to buy”)). For clarity, Table 4.2 breaks down the types of stimuli according to the *homophone* and *match* variables. The shaded cells (MM) are the crucial tokens in terms of investigating cross-linguistic orthographic influence.

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<sup>30</sup> The pair of numbers in the square brackets outlines the number of letters and the number of phonemes for each word, respectively. For example, [4/4] indicates that the Russian word, *лифт* /lift/ has 4 letters and 4 phonemes. In contrast, [4/3] indicates that the English word, *when* /wɛn/ has 4 letters but only 3 phonemes.

			HOMOPHONE	
			no (NH)	yes (H)
MATCH	yes (M) [letter-phoneme correspondence]  (i.e., letters = phonemes)	EN	14 tokens  e.g., <i>cup</i> /kʌp/ (3 letters/3 phonemes)	10 tokens (paired with RN M-H) e.g., <i>brat</i> /bræt/ (4 letters/4 phonemes) *homophonous with RN <i>bram</i> /brat/ ( <i>brother</i> ) ----- 10 tokens (paired with MN M-H) e.g., <i>bow</i> /baw/ (3 letters/3 phonemes) * homophonous with MN <i>baò</i> /paw/ ( <i>newspaper</i> )
		RN	14 tokens  e.g., <i>ðpyz</i> /druk/ ( <i>friend</i> ) (4 letters/4 phonemes)	10 tokens (paired with EN M-H) e.g., <i>bram</i> /brat/ ( <i>brother</i> ) (4 letters/4 phonemes) *homophonous with EN <i>brat</i> /bræt/
		MN	14 tokens  e.g., <i>huān</i> /xwan/ ( <i>to like</i> ) (4 letters/4 phonemes)	10 tokens (paired with EN M-H) e.g., <i>baò</i> /paw/ ( <i>newspaper</i> ) (3 letters/3 phonemes) * homophonous with EN <i>bow</i> /baw/
	no (MM) [1 fewer or 1 more letter than phonemes]  (i.e., letters ≠ phonemes)	EN	14 tokens  e.g., <i>month</i> /mʌnθ/ (5 letters/4 phonemes)	14 tokens (paired with RN MM-H) e.g., <i>stool</i> /stuʔ/ (5 letters/4 phonemes) * homophonous with RN <i>cmʏl</i> /stul/ ( <i>chair</i> ) ----- 14 tokens (paired with MN MM-H) e.g., <i>my</i> /maj/ (2 letters/3 phonemes) * homophonous with MN <i>mai</i> /maj/ ( <i>to buy</i> )
		RN	14 tokens  e.g., <i>день</i> /dʲɛnʲ/ ( <i>day</i> ) (4 letters/3 phonemes)	14 tokens (paired with EN MM-H) e.g., <i>cmʏl</i> /stul/ ( <i>chair</i> ) (4 letters/4 phonemes) * homophonous with EN <i>stool</i> /stuʔ/
		MN	14 tokens  e.g., <i>huáng</i> /xwaŋ/ ( <i>yellow</i> ) (5 letters/4 phonemes)	14 tokens (paired with EN MM-H) e.g., <i>mai</i> /maj/ ( <i>to buy</i> ) (3 letters/3 phonemes) * homophonous with EN <i>my</i> /maj/

EN = English, RN = Russian, MN = Mandarin, NH = nonhomophone, H = homophone, M = match, MM = mismatch

Table 4.2 Breakdown of experimental stimuli for the primary study

The following two tables provide the complete word lists for all the experimental stimuli. These tables list each target token for each language according to the word’s 1) orthographic spelling, 2) phonemic representation, 3) English translation (where necessary), and 4) letter-phoneme relationship. Table 4.3 gives the matched and mismatched nonhomophonous words. In the first row of the table, the first Russian word is spelt (in the Cyrillic alphabet) as *два*; it is pronounced as /dva/; its English translation is “two”, and it contains 3 letters and 3 phonemes. Next, the English word is spelt (in the Roman alphabet) as *up*; it is pronounced as /ʌp/, and it has two letters and two phonemes. Finally, the Mandarin word is spelt as *bā*; it is pronounced as /pa/; its English translation is “eight”, and it has 2 letters and 2 phonemes. This table also lists (bottom 4 rows) the words used in the practice test—none of which were homophones.

Table 4.4 provides the homophonous word sets where the L0/L2 homophonous words are listed adjacent to their EN counterparts. In the first row of the MM-H stimuli in Table 4.4 (the lower section), the first Russian word is spelt as *май*; it is pronounced as /maj/; its English translation is *May*, and it contains 3 letters and 3 phonemes. Next in the row is the English word associated with the Russian word. This English word is spelt as *my*; it is pronounced as /maj/, and it has 2 letters and 3 phonemes. After that English word is a second English word; this word is homophonous with the following Mandarin word. The shaded and crossed out tokens indicate those tokens that were later removed from the data and were not analysed. See §4.2.6.3 for a more detailed discussion of the discarded tokens. **NOTE:** The transcriptions given in the word lists are phonemic transcriptions.

	Russian [28 tokens]	English [28 tokens]	Mandarin [28 tokens]
M-NH [14 per language]	<p>два /dva/ (<i>two</i>) 3-3</p> <p>лет /lʲet/ (<i>years GEN PL</i>) 3-3</p> <p>ваш /vaʃ/ (<i>your</i>) 3-3</p> <p>на /na/ (<i>on</i>) 2-2</p> <p>зонт /zont/ (<i>umbrella</i>) 4-4</p> <p>плащ /plaf:/ (<i>raincoat</i>) 4-4</p> <p>как /kak/ (<i>how</i>) 3-3</p> <p>вид /vit/ (<i>type</i>) 3-3</p> <p>душ /duʃ/ (<i>shower</i>) 3-3</p> <p>нет /nʲet/ (<i>no</i>) 3-3</p> <p>всё /fsʲɔ/ (<i>everything</i>) 3-3</p> <p>друг /druk/ (<i>friend</i>) 4-4</p> <p>что /ʃtɔ/ (<i>what</i>) 3-3</p> <p>их /ix/ (<i>their</i>) 2-2</p>	<p>up /ʌp/ 2-2</p> <p>big /bɪg/ 3-3</p> <p>set /set/ 3-3</p> <p>cup /kʌp/ 3-3</p> <p>yes /jes/ 3-3</p> <p>best /best/ 4-4</p> <p>risk /rɪsk/ 4-4</p> <p>help /help/ 4-4</p> <p>stop /stɒp/ 4-4</p> <p>hand /hænd/ 4-4</p> <p>if /ɪf/ 2-2</p> <p>print /prɪnt/ 5-5</p> <p>run /rʌn/ 3-3</p> <p>cost /kɒst/ 4-4</p>	<p>bā /pa/ (<i>eight</i>) 2-2</p> <p>huā /xwa/ (<i>flower</i>) 3-3</p> <p>duō /twɔ/ (<i>much . many</i>) 3-3</p> <p>nán /nan/ (<i>difficult</i>) 3-3</p> <p>dà /ta/ (<i>big</i>) 2-2</p> <p>huān /xwan/ (<i>to like</i>) 4-4</p> <p>hē /xɛ/ (<i>to drink</i>) 2-2</p> <p>gāo /kaw/ (<i>tall</i>) 3-3</p> <p>guàn /kwan/ (<i>accustomed</i>) 4-4</p> <p>lǜ /ly/ (<i>green</i>) 2-2</p> <p>duǎn /twan/ (<i>short</i>) 4-4</p> <p>fú /fu/ (<i>clothes</i>) 2-2</p> <p>yǎn /jan/ (<i>eye</i>) 3-3</p> <p>kuài /kʰwaj/ (<i>fast</i>) 4-4</p>
MM-NH [14 per language]	<p>я /ja/ (<i>I</i>) 1-2</p> <p>звать /zvatʲ/ (<i>to call</i>) 5-4</p> <p>альт /alʲt/ (<i>viola</i>) 4-3</p> <p>юг /juk/ (<i>south</i>) 2-3</p> <p>жить /ʒitʲ/ (<i>to live</i>) 4-3</p> <p>кровь /krofʲ/ (<i>blood</i>) 5-4</p> <p>дождь /doʃtʲ/ (<i>rain</i>) 5-4</p> <p>пять /pʲatʲ/ (<i>five</i>) 4-3</p> <p>семь /sʲemʲ/ (<i>seven</i>) 4-3</p> <p>весь /vʲɛsʲ/ (<i>whole</i>) 4-3</p> <p>здесь /zdʲesʲ/ (<i>here</i>) 5-4</p> <p>дать /datʲ/ (<i>to give</i>) 4-3</p> <p>шесть /ʃʲestʲ/ (<i>six</i>) 5-4</p> <p>день /dʲenʲ/ (<i>day</i>) 4-3</p>	<p>talk /tak/ 4-3</p> <p>box /bɒks/ 3-4</p> <p>long /lɒŋ/ 4-3</p> <p>fish /fɪʃ/ 4-3</p> <p>truth /truθ/ 5-4</p> <p>six /sɪks/ 3-4</p> <p>month /mʌnθ/ 5-4</p> <p>quick /kwɪk/ 5-4</p> <p>king /kɪŋ/ 4-3</p> <p>shot /ʃɒt/ 4-3</p> <p>tax /tæks/ 3-4</p> <p>speak /spi:k/ 5-4</p> <p>whom /hum/ 4-3</p> <p>give /gɪv/ 4-3</p>	<p>wàng /wan/ (<i>to forget</i>) 4-3</p> <p>yī /i/ (<i>one</i>) 2-1</p> <p>shān /ʃan/ (<i>mountain</i>) 4-3</p> <p>wǔ /u/ (<i>five</i>) 2-1</p> <p>huáng /xwan/ (<i>yellow</i>) 5-4</p> <p>shuō /ʃwɔ/ (<i>to speak</i>) 4-3</p> <p>yuè /ye/ (<i>month</i>) 3-2</p> <p>yòng /jɔŋ/ (<i>to use</i>) 4-3</p> <p>yīn /in/ (<i>reason</i>) 3-2</p> <p>péng /pʰɛŋ/ (<i>friend</i>) 4-3</p> <p>duì /twej/ (<i>correct</i>) 3-4</p> <p>máng /maŋ/ (<i>busy</i>) 4-3</p> <p>shéi /ʃej/ (<i>who</i>) 4-3</p> <p>tīng /tʰɪŋ/ (<i>listen</i>) 4-3</p>
PRAC-TICE [4 per language]	<p>пить /pitʲ/ (<i>to drink</i>) 4-3</p> <p>свой /svɔj/ (<i>one's self</i>) 4-4</p> <p>ты /tɨ/ (<i>you-SG</i>) 2-2</p> <p>кто /kto/ (<i>who-NOM</i>) 3-3</p>	<p>cat /kæt/ 3-3</p> <p>in /ɪn/ 2-2</p> <p>tough /tʌf/ 5-3</p> <p>skin /skɪn/ 4-4</p>	<p>shēng /ʃɛŋ/ (<i>student</i>) 5-3</p> <p>shū /ʃu/ (<i>book</i>) 3-2</p> <p>wǒ /wɔ/ (<i>I</i>) 2-2</p> <p>guài /kwaj/ (<i>to blame</i>) 4-4</p>

Table 4.3 English, Russian, and Mandarin nonhomophone wordlists

	Russian [24 tokens]	English [48 tokens]	Mandarin [24 tokens]	
<b>M-H:</b> 1-to-1 relation- ship in both L1 and L2 [10 per language]	<b>он</b> /an/ ( <i>he</i> ) 2-2 <del>кот</del> /kat/ ( <i>cat</i> ) 3-3 <b>лифт</b> /lift/ ( <i>elevator</i> ) 4-4 <b>дай</b> /daj/ ( <i>to give</i> ) 3-3 <del>год</del> /got/ ( <i>city</i> ) 3-3 <b>сад</b> /sat/ ( <i>garden</i> ) 3-3 <del>рад</del> /rat/ ( <i>glad</i> ) 3-3 <b>март</b> /mart/ ( <i>March</i> ) 4-4 <b>карт</b> /kart/ ( <i>map GEN.PL</i> ) 4-4 <b>брат</b> /brat/ ( <i>brother</i> ) 4-4	<b>on</b> /an/ 2-2 <del>eat</del> /kat/ 3-3 <b>lift</b> /lɪft/ 4-4 <b>die</b> /daj/ 3-3 <del>got</del> /gɒt/ 3-3 <b>sat</b> /sæt/ 3-3 <del>rat</del> /ræt/ 3-3 <b>mart</b> /mɑːt/ 4-4 <b>cart</b> /kɑːt/ 4-4 <b>brat</b> /bræt/ 4-4	<b>May</b> /mej/ 3-3 <b>now</b> /naw/ 3-3 <b>do</b> /du/ 2-2 <b>toe</b> /tʰow/ 3-3 <b>swan</b> /swan/ 4-4 <b>bow</b> /baw/ 3-3 <b>ban</b> /bæn/ 3-3 <b>how</b> /haw/ 3-3 <b>man</b> /mæn/ 3-3 <b>bun</b> /bʌn/ 3-3	<b>méi</b> /mej/ ( <i>did not have not</i> ) 3-3 <b>nào</b> /naw/ ( <i>noisy</i> ) 3-3 <b>dú</b> /tu/ ( <i>to read</i> ) 2-2 <b>tóu</b> /tʰow/ ( <i>head</i> ) 3-3 <b>suān</b> /swan/ ( <i>sour</i> ) 4-4 <b>bào</b> /paw/ ( <i>newspaper</i> ) 3-3 <b>bàn</b> /pan/ ( <i>half</i> ) 3-3 <b>hào</b> /xaw/ ( <i>number</i> ) 3-3 <b>màn</b> /man/ ( <i>slow</i> ) 3-3 <b>bèn</b> /pɛn/ ( <i>stupid</i> ) 3-3
<b>MM-H:</b> *mismatch in spelling for L1 *1-to-1 relation- ship in L2 [14 per language]	<b>май</b> /maj/ ( <i>May</i> ) 3-3 <b>дом</b> /dom/ ( <i>house</i> ) 3-3 <b>щи</b> /ʃ:i/ ( <i>cabbage soup</i> ) 2-2 <del>торт</del> /tɔːt/ ( <i>cake</i> ) 4-4 <b>стул</b> /stul/ ( <i>chair</i> ) 4-4 <del>стол</del> /stol/ ( <i>table</i> ) 4-4 <b>суп</b> /sup/ ( <i>soup</i> ) 3-3 <b>тут</b> <sup>31</sup> /tut/ ( <i>here</i> ) 3-3 <b>три</b> /tri/ ( <i>three</i> ) 3-3 <b>ну</b> /nu/ ( <i>well</i> ) 2-2 <b>сок</b> /sok/ ( <i>juice</i> ) 3-3 <b>пол</b> /pol/ ( <i>floor</i> ) 3-3 <del>глаз</del> /glas/ ( <i>eye</i> ) 4-4 <b>хит</b> /xit/ ( <i>hit</i> ) 3-3	<b>my</b> /maj/ 2-3 <b>dome</b> /dom/ 4-3 <b>she</b> /ʃi/ 3-2 <del>torte</del> /tɔːt/ 5-4 <b>stool</b> /stuːl/ 5-4 <del>stole</del> /stoːl/ 5-4 <b>soup</b> /sup/ 4-3 <b>toot</b> /tut/ 4-3 <b>tree</b> /tɹi/ 4-3 <b>(k)new</b> /nu/ 4-3 <b>sock</b> /sɒk/ 4-3 <b>pole</b> /poːl/ 4-3 <del>gloss</del> /glas/ 5-4 <b>heat</b> /hit/ 4-3	<b>my</b> /maj/ 2-3 <b>when</b> /wen/ 4-3 <b>coo</b> /ku/ 3-2 <del>lean</del> /lin/ 4-3 <del>sheen</del> /ʃin/ 5-4 <b>pea/pee</b> /pi/ 3-2 <b>sue</b> /su/ 3-2 <b>tea/tee</b> /ti/ 3-2 <b>who</b> /hu/ 3-2 <b>knee</b> /ni/ 4-2 <b>she</b> /ʃi/ 3-2 <b>go</b> /gow/ 2-3 <b>high</b> /haj/ 4-3 <b>rue</b> /ru/ 3-2	<b>mai</b> /maj/ ( <i>to sell</i> ) 3-3 <b>wèn</b> /wɛn/ ( <i>to ask</i> ) 3-3 <b>kū</b> /kʰu/ ( <i>to cry</i> ) 2-2 <del>lín</del> /lin/ ( <i>forest</i> ) 3-3 <del>xīn</del> /cin/ ( <i>heart</i> ) 3-3 <b>pí</b> /pʰi/ ( <i>skin</i> ) 2-2 <b>sù</b> /su/ ( <i>to tell</i> ) 2-2 <b>tí</b> /tʰi/ ( <i>to carry</i> ) 2-2 <b>hū</b> /xu/ ( <i>to call</i> ) 2-2 <b>nǐ</b> /ni/ ( <i>you</i> ) 2-2 <b>xī</b> /ci/ ( <i>west</i> ) 2-2 <b>gòu</b> /kow/ ( <i>enough</i> ) 3-3 <b>hái</b> /xaj/ ( <i>still / yet</i> ) 3-3 <b>rú</b> /zu/ ( <i>if / as if</i> ) 2-2

**Table 4.4** English, Russian, and Mandarin homophone wordlists

In addition to the homophone and nonhomophone lists in the above tables, Table 4.5 below outlines the letter-phoneme pairings of interest in the project.

<sup>31</sup> Unlike English, Russian voiceless stops (i.e., /p t k/) are not subject to aspiration (Unbegaun, 1957).

English		Russian		Mandarin	
letter(s)	phonemes(s)	letter(s)	phonemes(s)	letter(s)	phonemes(s)
y	/aj/	я	/ja/	ng	/ŋ/
e	silent	ю	/ju/	y	/j/
igh	/aj/	ь	silent	sh	/ʃ/
o	/o/			w	/w/
oo	/u/			ue	/ɛ/
ue	/u/			ui	/wej/
ou	/u/				
ee	/i/				
kn	/n/				
ew	/u/				
ck	/k/				
ea	/i/				
l	silent				
x	/ks/				
ng	/ŋ/				
sh	/ʃ/				
th	/θ/				
wh	/w/				
18		3		6	

**Table 4.5** List of English, Russian, and Mandarin letters that create the mismatched target words

Two main observations are apparent from the above three tables. First, the English words have a higher degree of letter-phoneme mismatch variability than either Russian or Mandarin. That is, in English, a greater variety of letter-phoneme correspondences (18) contribute to the mismatched tokens than in either Russian (3) or Mandarin (6). Indeed, 12 of the 14 Russian mismatched words result from the letter <ь>. This letter has not phonemic value itself; rather, its function is to indicate palatalisation of the preceding consonant. As for Mandarin, most mismatches result from borrowed digraphs like <sh> and <ng> as well as the reduced spelling of triphthongs like <ui>. (See §3.2.3.3 for a discussion of how Mandarin represents triphthongs orthographically.) The differences in the variety of mismatches across languages are a direct reflection of the depth (or

opacity) of their orthographies. The high number of mismatches in English reflects the fact that English has a much deeper (or more opaque) orthography than either Russian or Mandarin.

A second observation is that the letter-phoneme mismatches do not always come from the same type of orthographic inconsistency, suggesting subcategories of inconsistency. For example, inconsistency in words like *fish*, *month*, and *wàng* come from two consonant letters representing one phoneme; inconsistency in *speak*, and *stool* comes from two vowel letters representing one phoneme, inconsistency in *box*, *six*, and *юз* comes from one letter representing two phonemes, and inconsistency in *talk*, *уецмъ*, and *wǐ* comes from a silent letter.

As discussed above, selecting stimuli for this experiment was restricted by a number of considerations, such that creating mismatch categories that were more uniform within and across languages was not possible. This limitation, while unavoidable, must be kept in mind in understanding and interpreting the results. In terms of uniformity of the mismatch categories *across* languages, differences in orthographic transparency may affect participant responses. In particular for the L2 subgroups, listeners may have more difficulty ignoring mismatches in Russian and Mandarin (more transparent) than in English (less transparent)—resulting in larger accuracy and response time differences between the matched and mismatched words in Russian and Mandarin than in English. The increased difficulty would arise from readers/listeners of more transparent orthographies (i.e., Russian and Mandarin) relying more heavily on letter-phoneme correspondences than readers/listeners of less transparent languages (Frost & Katz, 1989; Katz & Frost, 1992; Liberman et al., 1980; Seymour et al., 2003). In terms of uniformity

of the mismatch category *within* languages, it is likely that not all types of mismatched tokens affect phoneme counting equally. This issue is taken up at length in Chapter 6 (§6.3.3).

#### **4.2.2.2 Creation of stimuli**

Three female native speakers (one from each language) recorded the target words for their L1s, either English (EN), Russian (RN), or Mandarin (MN). The speakers recorded the target words in the University of Victoria's Department of Linguistics Speech Research Lab. The words were presented to the speakers via Microsoft PowerPoint 2007. The speakers repeated each target word five times with a short pause between each repetition, and they took a short break every 25 words. The words were recorded in a sound-treated booth with Audacity [version 1.2.6] using a Grove Tubes GT57 large diaphragm microphone and a Mackie 1402-VLZ3 mixer. Each set of 25 words was saved as a *.wav* file.

Using the EN, RN, and MN target word recordings from the three native speakers, the stimuli tokens were created in the following four steps.

1. The third token in each series was segmented out to use as the experimental token. In some cases, either the second or fourth token were used when the third token was problematic.
2. Each token was saved as an individual *.wav* file.
3. The duration of each sound file was manually recorded to use for calculating response times (RTs) in E-prime Pro (version 2.0.1.97).

4. All the individual sound files were normalised for loudness using the software *WavNormalizer* (version 1.0).

Three native speakers for each language judged the *nativeness* of the chosen target words. That is, three native speakers of English judged the English words, three native speakers of Russian judged the Russian words, and three native speakers of Mandarin judged the Mandarin words. The native judgements were essential to ensure that the segmented words were indeed the chosen target words. Each native speaker listened to the target words via Sony MDR-7506 headphones and wrote the words they heard using the orthography of their particular language. The English speakers used the Roman alphabet. The Russian speakers used the Cyrillic alphabet, and the Mandarin speakers used the Pinyin alphabet. The Chinese educational system requires that teachers teach Pinyin in Grade One (DeFrancis, 1990). Therefore, although adult Mandarin speakers predominantly use Chinese characters, all three speakers stated that they were extremely comfortable with Pinyin and would have no difficulty in writing out the words using this alphabet. The speakers also indicated any tokens that were problematic (i.e., unclear, mispronounced, unnatural, etc.). All problematic tokens were discarded, rerecorded, and judged again. In addition, all three judges in each group of native speakers (i.e., English, Russian, and Mandarin) agreed on the “correct” spelling of each word. That is, none of the native speaker judges misspelled any of the target words in their languages.

#### *4.2.3 Experimental materials*

After all the stimuli were judged and confirmed to be good, natural representations of the target words, the software E-prime Pro (version 2.0.1.97) was used to create the perception test because E-prime records both accuracy and response times (RTs). As

mentioned above, the English language session consisted of 76 target words, and the Russian and Mandarin language sessions had 52 target words each. This means that each participant was tested on 180 target words. The perception test was organized into four sessions: Practice > L1 (native language) > L2 (second language for the subgroup participants but an L0 for the non-L2 participants) > L0 (unfamiliar language). For each participant group, the order of the languages varied depending on the L2 language learning experiences of the subgroup participants. For the MNL0 group, which contained the RFL subgroup, their counting task was organized as: Practice session > English session (L1) > Russian session (L2 for subgroup but L0 for others) > Mandarin session (L0). Conversely, for the RNL0 group, which contained the MFL subgroup, the task was organised as: Practice > English (L1) > Mandarin (L2 for subgroup but L0 for others) > Russian (L0).

#### *4.2.4 Experimental tasks*

This subsection outlines and discusses the experimental tasks employed for the primary experiment. For the MNL0 and the RNL0 participants (including the RFL and MFL subgroups), this research included two experimental tasks. First, the participants completed a **phoneme counting task** (e.g., Arnqvist, 1992; Bassetti, 2006; Cheung, 1999; Derwing, 1992; Ehri & Wilce, 1980; Gombert, 1996; Landerl et al., 1996; Lehtonen & Treiman, 2007; Liberman et al., 1974; Perin, 1983; Pytlyk, to appear; Spencer & Hanley, 2003; Treiman & Cassar, 1997) where they indicated the number of individual “sounds” they counted in a given auditorily presented word. Phoneme counting was first employed by Liberman et al. (1974) to test children’s *explicit* analysis of spoken utterances (i.e., metalinguistic analysis). The cognitive requirements for

phoneme counting include 1) perceiving separate phonemes, 2) holding the target in memory, and 3) segmenting sound units (Yopp, 1988). Based on these cognitive requirements, phoneme counting is commonly used as a measure of phoneme awareness. While Liberman et al. (1974) developed the phoneme counting task for testing children's phoneme awareness, it has since been used as a measure of adult's phoneme awareness and the influence of orthographic factors (Treiman & Cassar, 1997). Thus, because the current research seeks to determine the effects of L1 and L2 orthographic knowledge on L1, L2, and L0 phoneme awareness, a phoneme counting task is an appropriate method for measuring the L1 and L2 orthographic effects as it will provide evidence for how listeners hear phonemes.

With respect to the second task, half way through the RFL and MFL data collection, it became apparent that in order to strengthen any potential claims about L1 and L2 orthographic influence, I needed to first confirm that the participants did in fact know how to spell the L1 and L2 words. Therefore, the last 34 of the 52 participants also completed a **spelling dictation**. In this part of the experimental task, the participants listened to the L1 (and L2 for the MFL and RFL subgroups) cross-language homophones and wrote them out according to English (and Russian or Mandarin) spelling conventions. (See Appendix D for a sample dictation response sheet.) Specifically, the non-L2 participants (i.e., the participants not in an L2 subgroup) were tested on a total of 48 words in the dictation—all the English cross-language homophones (24 associated with Russian and 24 associated with Mandarin). The RFL and MFL were not only tested on the 48 English words but they were also tested on 52 words in their L2, i.e., all the L2 words (both nonhomophone and homophone). The spelling dictation task confirmed that

the speakers did, in fact, know how each word is spelt. Unfortunately, because this task was only added midway through the data collection when most of the subgroup data had already been collected, not all RFL and MFL participants completed this dictation task: only two RFL and five MFL participants completed the spelling dictation.

Table 4.6 below presents total number of accurate spellings (i.e., total) and the mean spelling accuracy (i.e., percentage) for each group across each language. The totals vary as the number of participants in each group varies. This table also provides the total number of participants who completed the spelling dictation in each group. For example, this table shows that 19 participants in the RNL0 group completed the spelling dictation for an overall total of 912 English words (19 participants x 48 tokens). The accurate total (given in bold) indicates that of the 912 tokens, these participants spelt 879 of them correctly for an accuracy of 96%. The high accuracy percentages confirm that the participants do know how to spell the L1 (and L2) target words.

group		# of participants	L1 (English)		L2 (Mandarin or Russian)	
			total*	percentage	total**	percentage
RNL0	overall	n = 19	<b>879/912</b>	96%	n.a.	n.a
	subgroup (MFL)	n = 5	<b>232/240</b>	97%	<b>238/260</b>	92%
MNL0	overall	n = 15	<b>702/720</b>	98%	n.a.	n.a
	subgroup (RFL)	n = 2	<b>94/96</b>	98%	<b>97/104</b>	93%

\* overall total = number of participants x 48 L1 words  
 \*\* overall total = number of participants x 52 L2 words

**Table 4.6** Overall results of the spelling dictation

After these mean accuracy rates were calculated, the incorrect spellings were analysed for any common spelling errors. For example, of the total 51 incorrect spellings for both

overall groups [(912-879) + (720-702) = 51], 41 (80%) of those spellings were of the words *cot* and *torte* (the incorrect spellings were *caught* and *tort*). While not technically incorrect spellings, these spellings provided by the participants deviated from the intended spellings/associations, which rendered their use in the data analyses impossible. Therefore, the data from these items were discarded. (See §4.2.6.3 for a more detailed discussion of discarded data.) The other 10 misspellings showed no similar pattern.

#### 4.2.5 Procedure

Each participant in the primary study completed nine separate tasks (See Table 4.7 below for a summary.) First, each participant read and signed a consent form (See Appendix E.). Second, after signing their consent forms, the participants received verbal instructions in their L1 (English) on how to complete their assigned tasks. Specifically, the participants were told that while all the words were one-syllable words, these words varied in the number of sounds (between 1 and 5 sounds) within each word. (Note that all participants were non-linguistically trained; therefore, to avoid confusion, the term *sound* (rather than the term *phoneme*) was used when explaining the tasks and speaking to the participants about the research project in general.) The researcher demonstrated that the words *at* and *milk* while both having only one syllable differed in the number of sounds—2 and 4 sounds, respectively. The participants were asked to “count the individual sounds that they heard in each particular word”.

The participants completed the “sound counting” task in 4 blocks:

- 1) a practice session (4 English words, 4 Mandarin words, and 4 Russian words),
- 2) the L1 session (the English words),

- 3) the L2 session (the Russian words for the MNL0/RFL participants and the Mandarin words for the RNL0/MFL participants),<sup>32</sup> and
- 4) the L0 session (Russian words for the RNL0/MFL participants and the Mandarin words for the MNL0/RFL participants).

Participants indicated their responses by pressing the number on a keyboard (1, 2, 3, 4, or 5) that corresponded to the number of sounds they heard in each word. They were asked to use their right hand and respond using the number pad on the keyboard. The participants were warned that they would only hear each word once. To force the participants to respond as quickly as possible, they only had 10 seconds within which to respond, and if they did not respond in that time, the program would record a “non-response” and move on to the next word. In cases where the participants were unsure, they were encouraged to make their best guess. E-prime recorded the number responses and response times (RTs) from each participant. The RTs were recorded as the time between the onset of the stimuli and the point at which the participants pressed one of the response keys.

The participants first completed the practice session. Then they had another opportunity to ask questions about their participation. Once any questions were answered and the participants felt they were comfortable with the task, the participants completed the actual counting task. The participants took short breaks between the L1 and L2/L0 sessions and between the L2/L0 and L0 sessions. During the short break between the L1 and L2/L0 sessions, the subgroup participants (i.e., the RFL and MFL participants) read

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<sup>32</sup> These data were only used for the L2 subgroup analyses. However, the non-L2 learners also completed this session to maintain the continuity and length of the task so that the L0 results in the final session (4 above) from all participants could be compiled and analysed together. These non-L2 learners were told that they would complete two L0 sessions; however, their L0 data from the first L0 session were discarded.

aloud a short passage called “The North Wind and Sun” in their L2 (See Appendix B). The participants’ readings of the “North Wind and the Sun” were not recorded and/or evaluated in anyway. Rather, the participants were told that the purpose of reading this fable aloud was to prepare the participants for thinking in their L2. The non-L2 did not do any passage reading. During the short break between the L2/L0 and L0 sessions, all participants completed a background questionnaire. The breaks were incorporated so that the participants would not find the counting task too long and tedious.

Once the participants completed the phoneme counting task, they answered three questions about their impressions of the task and its relative difficulty. These questions were as follows:

- 1) Which of the three sessions (English, Russian, and Mandarin) did you find the most difficult? Why?
- 2) What factors influenced you when counting sounds? Did any factors hinder you?
- 3) How easy or hard were the L0 words? Do you think that you listened to them differently?

Finally, after completing the counting task and answering the above questions, most (34 of 52) of the participants completed a spelling dictation task (See explanation on page 103.). The dictation task for the RFL and MFL participants involved listening to and writing out the spelling of all the L1 and L2 words. The dictation task for the non-L2 participants involved listening to and writing out the spelling of only the L1 words.

Table 4.7 below summarizes the experimental procedure for primary data collection by listing the order of tasks and briefly describing each task.

<b>TASKS</b>	<b>DESCRIPTION / RATIONALE</b>
<b>1) Consent forms</b>	<ul style="list-style-type: none"> <li>▪ Participants read and signed consent forms as per University of Victoria Ethics regulations.</li> </ul>
<b>2) Practice session</b>	<ul style="list-style-type: none"> <li>▪ Participants completed a practice session (with L1, L2 and L0) words.</li> <li>▪ None of the practice session tokens were used in the data analyses.</li> <li>▪ After the practice session, participants had an opportunity to ask questions about the task.</li> </ul>
<b>3) L1 session</b>	<ul style="list-style-type: none"> <li>▪ Participants counted phonemes in 76 English words.</li> </ul>
<b>4) Passage reading</b>	<ul style="list-style-type: none"> <li>▪ Only the L2 subgroups of participants did this activity.</li> <li>▪ The subgroup participants read aloud either the Russian or Mandarin translation of the “North Wind and the Sun.”</li> </ul>
<b>5) L2(L0) session</b>	<ul style="list-style-type: none"> <li>▪ The RFL and MFL participants counted phonemes in 52 words in their L2.</li> <li>▪ The L2 was Russian for the RFL learners and Mandarin for the MFL learners</li> <li>▪ The non-L2 participants also did this session (to maintain task continuity), but their data were not used in the overall analyses.</li> </ul>
<b>6) Background questionnaire</b>	<ul style="list-style-type: none"> <li>▪ Participants completed the background questionnaire about their previous and current language learning</li> </ul>
<b>7) L0 session</b>	<ul style="list-style-type: none"> <li>▪ Participants counted phonemes in 52 words in an L0.</li> <li>▪ The L0 was Mandarin for the RFL learners and Russian for the MFL learners</li> </ul>
<b>8) Interview</b>	<ul style="list-style-type: none"> <li>▪ The participants answered questions about the difficulty of the phoneme counting task.</li> </ul>
<b>9) L1 (and L2) dictation</b>	<ul style="list-style-type: none"> <li>▪ The participants completed a dictation task of the cross-language English homophones.</li> <li>▪ The subgroup participants also completed a L2 word dictation task to determine that they did in fact know how to spell each L2 word they counted phonemes for.</li> </ul>

**Table 4.7** Experimental procedure summary

#### 4.2.6 Data analyses

Now that the participants, stimuli, materials, task, and procedure, have been outlined, §4.2 concludes the methodological discussion of the primary study by considering and

discussing the analyses of the primary data. First, §4.2.6.1 and §4.2.6.2 identify and define both the independent and dependent factors in this research. Next, §4.2.6.3 discusses the discarded data, and §4.2.6.4 discusses the statistical analyses employed for analysing the data.

#### **4.2.6.1 Independent factors**

As mentioned above, this research examines two sets of data: 1) the overall data from the 52 participants (i.e., the L1–L0 comparisons), and 2) the subgroup data from 25 English L2 learners of Russian (12) and Mandarin (13) (i.e., the L1–L2–L0 comparisons).

The four independent factors (variables) for the *overall data* in this research are:

##### **I. Group (2 levels)**

1. Mandarin L0 (MNLO) – The participants in this experimental group were native speakers of Canadian English, and Mandarin Chinese was their unfamiliar language (L0).
2. Russian L0 (RNLO) – The participants in this experimental group were native speakers of Canadian English, and Russian was their unfamiliar language (L0).

##### **II. Language (2 levels)**

1. L1 – English for both experimental groups
2. L0 – Mandarin for the MNLO group and Russian for the RNLO group

##### **III. Homophone (2 levels)**

1. Nonhomophone (NH) – Words do not have a homophonous counterpart in one of the other test languages.

2. Homophone (H) – Words have a homophonous (or near homophonous) counterpart in one of the other test languages. The homophone pairs were L1-L0 pairs.

#### IV. **Match** (2 levels)

1. Match (M) – The number of letters in each word equals the number of phonemes.
2. Mismatch (MM) – The number of letters in each word is either more or less than the number of phonemes.

Like the overall data, the subgroup data in this research also have four independent factors. Here, the *homophone* and *match* factors were the same as for the overall data, but the *group* and *language* factors are different. All four factors are as follows:

##### I. **Group** (2 levels)

1. Russian-as-a-second-language learners (RFL) – The participants in this experimental group were native speakers of Canadian English; Russian was their L2, and Mandarin was their L0.
2. Mandarin-as-a-second-language (MFL) – The participants in this experimental group were native speakers of Canadian English, Mandarin Chinese was their L2, and Russian was their L0.

##### II. **Language** (3 levels)

1. L1 – English for both experimental groups
2. L2 – The L2 for the RFL group was Russian, and the L2 for the MFL group was Mandarin.

3. *L0* – The L0 for the RFL group was Mandarin, and the L0 for the MFL group was Russian.

### III. **Homophone** (2 levels)

1. *Nonhomophone (NH)* – Words do not have a homophonous counterpart in one of the other test languages.
2. *Homophone (H)* – Words have a homophonous (or near homophonous) counterpart in one of the other test languages. The homophone pairs were either L1-L2 pairs or L1-L0 pairs.

### IV. **Match** (2 levels)

1. *Match (M)* – The number of letters equals the number of phonemes.
2. *Mismatch (MM)* – The number of letters is either more or less than the number of phonemes.

#### 4.2.6.2 Dependent factors

Using the four independent factors for each set of data, this research investigates native English speakers' *phoneme awareness/perception* in the three languages (English, Russian, and Mandarin). Specifically, the role of four independent factors in determining phoneme awareness was measured through two dependent factors (i.e., variables): 1) accuracy rates (Acc) and 2) response times (RTs). To analyse the accuracy rates and response times, the average accuracy and response times for each condition were first calculated. Note that only *group* is a between-subjects factor, and because the other three factors are within-subjects factors, there is a condition for each combination of the within-subjects factors. Therefore, in the overall data, the levels of the three within-

factors, *language*, *homophone*, and *match* result in 8 conditions [2 x 2 x 2]. Specifically, the 8 conditions for the overall groups' data are outlined in Table 4.8.

		HOMOPHONE			
		NH		H	
		M	MM	M	MM <sup>33</sup>
LANGUAGE	L1	L1 matched nonhomophone e.g., <i>risk</i> /ɪrɪsk/	L1 mismatched nonhomophone e.g., <i>box</i> /bɒks/	L1 matched homophone e.g., <i>man</i> /mæn/	L1 mismatched homophone e.g., <i>knee</i> /ni/
	L0	L0 matched nonhomophone e.g., MN <i>duǎn</i> /twan/ or RN <i>əu</i> /vaɹ/	L0 mismatched nonhomophone e.g., MN <i>yǒng</i> /jɔŋ/ or RN <i>ɯz</i> /juk/	L0 matched homophone e.g., MN <i>nào</i> /naw/ or RN <i>əu</i> /daj/	L0 mismatched homophone e.g., MN <i>kū</i> /k <sup>h</sup> u/ or RN <i>cyn</i> /sup/

**Table 4.8** The 8 conditions for the overall data

Likewise, in the subgroup data, the levels of the three within-factors, *language*, *homophone*, and *match* result in 12 conditions [2 x 3 x 2]. These 12 conditions for the subgroups' data are outlined in Table 4.9.

<sup>33</sup> Recall that for the MM-H condition, the mismatch was always in the L1 (not the L0).

		HOMOPHONE			
		NH		H	
		M	MM	M	MM
LANGUAGE	L1	L1 matched nonhomophone e.g., <i>risk</i> /ɪsk/	L1 mismatched nonhomophone e.g., <i>box</i> /baks/	L1 matched homophone e.g., <i>man</i> /mæn/	L1 mismatched homophone e.g., <i>knee</i> /ni/
	L2	L2 matched nonhomophone e.g., MN <i>duǎn</i> /twan/	L2 mismatched nonhomophone e.g., MN <i>yòng</i> /jɔŋ/	L2 matched homophone e.g., MN <i>nào</i> /naw/	L2 mismatched homophone e.g., MN <i>kū</i> /k <sup>h</sup> u/
	L0	L0 matched nonhomophone e.g., RN <i>əau</i> /vaj/	L0 mismatched nonhomophone e.g., RN <i>ɯz</i> /juk/	L0 matched homophone e.g., RN <i>əəŋ</i> /daj/	L0 mismatched homophone e.g., RN <i>cyn</i> /sup/

**Table 4.9** The 12 conditions for the subgroup data

The first dependent factor is *accuracy rates*. The accuracy rate of each condition for each participant was calculated by adding the number of correct responses in that condition (i.e., when the participant response equalled the number of phonemes in a word) and dividing that number by the total number of tokens in that condition. Then, the accuracy rates for each condition were averaged over all the participants to calculate the overall mean accuracy rate for that condition.

The second dependent variable is *response times* (RTs). The RTs were calculated in milliseconds (ms) as the time between the offset of the stimulus token and the point at which the participants pressed one of the response keys. Because E-prime records RTs from the onset of the stimulus, the RT for each target word was first re-calculated by subtracting the duration of the sound file associated with the stimulus item from the RT recorded by E-prime. The revised RTs<sup>34</sup> were then used to calculate the mean RTs for each condition by averaging the RTs of the accurate responses only. The RTs for all the participants in each condition were then averaged for the overall mean RTs for that

<sup>34</sup> All subsequent references to RTs refer to these revised RTs.

condition. In sum, based on the data, phoneme awareness/perception was measured for the overall data (i.e., the L1–L0 comparisons) and the subgroup data (i.e., L1–L2–L0 comparisons) by using both accuracy rates and RTs.

#### **4.2.6.3 Discarded data**

Although the total number of tokens in the MM-H, M-NH, and MM-NH conditions was 14 tokens for each (See Table 4.3 and Table 4.4), information from the secondary data (see §4.3 below) identified eight problematic tokens, namely the Mandarin tokens *lin* (“forest”) and *xīn* (“heart”), the Russian tokens *глаз* (“eye”), *рад* (“glad”), and *город* (“city”), and the English tokens *torte* and *cot*. The Mandarin and Russian tokens were problematic because the secondary data participants did not identify these words as homophonous with their intended English counterparts, *lean*, *sheen*, *gloss*, *rat*, and *got*, respectively. As a result, it is relatively safe to assume that the primary data participants also did not perceive them as homophonous with the English words, and therefore, these tokens (and their English counterparts) were discarded from the data because they were not likely to show any L1 interference effect. The Russian token *стол* (“table”) and its English counterpart *stole* were also discarded because the secondary data indicated that perhaps the final /l/ in *стол* was relatively difficult to perceive, and participants may have heard /sto/ rather than /stol/. Additionally, over half of the secondary data participants spelt the English target words *torte* as *tort* and *cot* as *caught* (as did the primary data participants who completed the spelling dictation), effectively eliminating the word *torte*’s categorisation as a MM-H word and the word *cot*’s categorisation as a M-H word. Therefore, the English tokens *torte* and *cot* and their homophonous counterparts, the Russian tokens *мороженное* (“cake”) and *кот* (“cat”), were also discarded

from the data. While all these tokens were discarded from the data analyses, they remain listed in the *homophone* (i.e., Table 4.4) wordlists. (In this table, the shading and strikethrough for each indicate that they were later discarded and thus not used in the final data analysis.)

Finally, data with negative RTs were also discarded. Recall that the final RTs were calculated by subtracting the duration of the sound file from the overall RT value (since E-prime records RTs from the onset of the token rather than the offset of the token). Negative values were considered “accidental responses”: they resulted from participants responding before hearing the entire word, implying that they had not counted the phonemes in that word. All in all, for the overall data, 32 tokens with negative values were discarded (out of a total of 4553 tokens), and for the subgroup data, 19 tokens were discarded (out of a total of 3151 tokens).

In addition to the previously mentioned discarded data, the L2 session data and the corresponding L1 homophone data from the non-RFL and non-MFL (i.e., the non-subgroups) participants were discarded. That means, for the non-RFL participants in the MNL0 group, the Russian data and their English homophonous counterparts were removed. Similarly, for the non-MFL participants in the RNL0 group, the Mandarin data and their English homophonous counterparts were not used. These data were only used for the L2 subgroup analyses to compare the L1, L2, and L0. As mentioned previously, the non-L2 learners also completed this session to maintain the continuity and length of the task so that the L0 results from all participants could be compiled and analysed together. Therefore, although each participant was tested on 180 tokens, only 100 tokens from each MNL0 participant were analysed, and only 92 tokens from each RNL0

participant were analysed (because more Russian tokens than Mandarin tokens were discarded). More specifically, the MNL0 token data came from **i)** 22 L1 homophones (corresponding with the Mandarin L0), **ii)** 28 L1 nonhomophones, **iii)** 22 L0 homophones, and **iv)** 28 L0 nonhomophones while the RNL0 token data came from **i)** 18 L1 homophones (corresponding with the Russian L0), **ii)** 28 L1 nonhomophones, **iii)** 18 L0 homophones, and **iv)** 28 L0 nonhomophones. For the subgroup analyses, only 164 tokens from each participant were analysed. That is, the token data for the subgroup data analyses came from **i)** 43 L1 homophones (corresponding to both Russian and Mandarin homophones), **ii)**, 28 L1 nonhomophones, **iii)** 21 L2 homophones, **iv)** 28 L2 nonhomophones, **v)** 21 L0 homophones, and **vi)** 28 L0 nonhomophones. For clarity, Table 4.10 below breaks down the number of tokens analysed per participant in the overall data analyses (i.e., L1–L0 data) and the subgroup data analyses (i.e., L1–L2–L0) once the unusable data had been discarded. Notice that the L1 M-H and MM-H conditions differ in the token numbers for the overall data and the subgroup data.

	overall data		subgroup data	
	MNL0	RNL0	RFL	MFL
L1 match-homophone	<b>10</b> [with L0]	<b>7</b> [with L0]	<b>17</b> [with L2 & L0]	<b>17</b> [with L2 & L0]
L1 mismatch-homophone	<b>12</b> [with L0]	<b>11</b> [with L0]	<b>23</b> [with L2 & L0]	<b>23</b> [with L2 & L0]
L1 match-nonhomophone	14	14	14	14
L1 mismatch-nonhomophone	14	14	14	14
L2 match-homophone	–	–	7	10
L2 mismatch-homophone	–	–	11	12
L2 match-nonhomophone	–	–	14	14
L2 mismatch-nonhomophone	–	–	14	14
L0 match-homophone	10	7	10	7
L0 mismatch-homophone	12	11	12	11
L0 match-nonhomophone	14	14	14	14
L0 mismatch-nonhomophone	14	14	14	14
<b>Total tokens</b>	100	92	164	164

**Table 4.10** Breakdown of token numbers in each experimental condition after discarding data for the overall data and the subgroup data analyses

#### 4.2.6.4 Statistical analyses

Since this experiment incorporates four independent variables (*group*, *language*, *homophone*, and *match*) and two dependent variables (accuracy and response times), a four-way factorial analysis of variance (ANOVA) with repeated measures was conducted to calculate significance using the statistical package PASW 18.0 (formerly SPSS). The significance level was set at 0.05 such that any *p-value* less than 0.05 was considered statistically significant. By-subject analyses<sup>35</sup> (where the data are averaged over items) were conducted on the data. The following paragraphs outline the between- and within-

<sup>35</sup> By-items analyses were not performed on the data as the groups did not count phonemes in all the experimental items: the RNL0 group counted phonemes in the English and Russian items while the MNL0 groups counted phonemes in the English and Mandarin items. Therefore, by-items analyses could not compare all the items across all four independent variables.

subjects factors for the by-subjects analyses of the overall data (§4.6.4.1) and the subgroup data (§4.6.4.2).

To determine the effect of L1 orthography on the perception of phonemes in both L1 and L0 matched/mismatched words, the overall data were analysed using all four independent variables in by-subjects analyses. Moreover, in this analysis, because each listener participated in both *language* levels, both *homophone* levels, and both *match* levels, these 3 factors were within-subjects factors. In contrast, because individual listeners did not participate in both groups (only MNL0 or only RNL0), *group* was a between-subjects factor. In sum, the data were analysed using a by-subjects 4-way mixed factorial design ANOVA with one between-subjects factor, *group* (MNL0, RNL0) and 3 within-subjects factors: *language*<sup>36</sup> (L1, L0), *homophone* (homophone, nonhomophone), and *match* (match, mismatch). Table 4.11 below summarises these factors and their levels where the shaded columns indicate the within-subjects factors.

		<b>GROUP</b> (between-subjects)	<b>LANGUAGE</b> (within-subjects)	<b>HOMOPHONE</b> (within-subjects)	<b>MATCH</b> (within-subjects)
<b>LEVELS</b>	1	Mandarin L0 (MNL0)	first language (L1)	nonhomophone (NH)	match (M)
	2	Russian L0 (RNL0)	unfamiliar language (L0)	homophone (H)	mismatch (MM)

**Table 4.11** Between-subjects and within-subjects factors for the by-subjects analysis of the overall data (L1–L0 comparisons)

Because of the two dependent variables (accuracy and response times), 4-way repeated measures ANOVAs by-subjects were conducted for each dependent variable.

<sup>36</sup> Recall that the L0 for each experimental group was not the same. Specifically, the L0 for the MNL0 group was Mandarin, and the L0 for the RNL0 group was Russian.

As mentioned previously, the data were analysed according to two separate focuses: 1) the overall data for the L1–L0 comparisons, and 2) the subgroup data for the L1–L2–L0 comparisons. In addressing the second focus, we were only concerned with the L2 learners’ L1, L2, and L0 data (i.e., the subgroups). Still, as with the overall data, the subgroup data were analysed using a 4-way by-subjects ANOVA with one between-subjects factor, *group* (RFL, MFL) and three within-subjects factors: *language* (L1, L2, L0), *homophone* (homophone, nonhomophone), and *match* (match, mismatch). The between-subjects and within-subjects factors for the by-subjects analysis are identified and summarised below in Table 4.12. The shaded columns represent the within-subjects factors.

		<b>GROUP</b> (between-subjects)	<b>LANGUAGE</b> (within-subjects)	<b>HOMOPHONE</b> (within-subjects)	<b>MATCH</b> (within-subjects)
<b>LEVELS</b>	1	RFL	L1	nonhomophone	match
	2	MFL	L2	homophone	mismatch
	3	--	L0	--	--

**Table 4.12** Between-subjects and within-subjects factors for the by-subjects analysis of the subgroup data (L1–L2–L0 comparisons)

Again, as with the overall data, 4-way repeated measures ANOVAs by-subjects were conducted on the dependent variables, accuracy rates and RTs, for the subgroup data.

### ***4.3 The secondary study***

In addition to the primary data, secondary data were also collected to potentially help interpret the results from the primary experiment and, as it turned out, to discard inappropriate tokens from the analyses. This section outlines this secondary study—

including the participants (§4.3.1), the experimental stimuli (§4.3.2), and the experimental task and procedure (§4.3.3).

#### 4.3.1 Participants

Fourteen participants were recruited for the secondary study. All participants were native speakers of Canadian English, and all were unfamiliar with both Russian and Mandarin. These participants were recruited from first year linguistics classes and posters around the university. Only those volunteers who reported no auditory or visual impairments were accepted for the secondary study. Table 4.13 below provides a summary of the participants in this secondary data group. This table also contains information about mean the age of the participants in this group as well as the other languages these participants have learnt.

group	number of participants	mean age	other languages learned
secondary data	n = 14	26.8 years	<ul style="list-style-type: none"> <li>▪ Japanese, French, Latin, German, Classical Greek, Icelandic, Italian, Cantonese, and Spanish</li> </ul>

*n = total number, L0 = unfamiliar language, MFL = Mandarin-as-a-second-language, RFL = Russian-as-a-second-language*

**Table 4.13** Secondary data participant demographics

#### 4.3.2 Experimental stimuli

The stimuli for this secondary data collection were a subset of the stimuli used in the primary data collection. Specifically, the stimuli used were the English, Russian, and Mandarin homophones. The total number of stimuli was 96 stimuli: **24** English words and **24** Russian words that were homophonous with each other (e.g., EN *tree* /t<sup>h</sup>.i:/ and RN *mpu* /tri/), and **24** English words and **24** Mandarin words that were homophonous

with each other (e.g., EN *who* /hu/ and MN *hū* /xu/). See Table 4.4 for the complete list of English, Russian, and Mandarin homophones.

#### 4.3.3 *Experimental task and procedure*

For the secondary data group, the experimental task and procedure involved two components: an English dictation task and a nonnative language judgment task. For both these components, the researcher individually presented the target words via Windows 2007 Media Player to the participants who listened to these target words using Sony MDR-7506 headphones.

First, after reading and signing the consent form (See Appendix E.), the participants completed an English **spelling dictation**. The participants did this task to 1) confirm that the words they heard were in fact the intended target words and 2) parallel the English homophone priming reflected in the primary data collection. The participants listened to 48 words spoken by a native English speaker. They were told that they would hear each word twice, and they should listen to these words carefully. Once they had heard the word twice, they wrote down the word they heard in order to confirm that in fact, as assumed, other listeners would all hear the same word. The participants were also informed that the words might sound a bit strange since they were presented in isolation (i.e., without any context) and some of the words were not common (e.g., *toot* and *rue*). Finally, the participants were instructed that if more than one spelling was possible, then, they should write the first spelling that came to mind.

Second, participants completed an **accentedness judgment** task on the L2 and L0 cross-language homophones. In this component, they listened to each Russian and Mandarin homophone twice, wrote out the English homophonous word they heard (using

English orthography) and rated the “accentedness” of the non-L1 word on a scale from 1 to 9 where 1 equals native-like pronunciation and 9 equals highly accented pronunciation. (See Appendix C for the response sheet used to collect the native speaker judgements.) The goal of the cross-language judgements of accentedness was to confirm that native English speaking listeners did associate the MN and RN words with their intended EN counterparts and to help determine the degree of homophony between the English-Russian homophones and the English-Mandarin homophones. At no point during the instructions were the participants explicitly told that these words were English words nor were they told that the words were *not* English words. The description of the words was intentionally vague; the participants were led to assume the nonnative speakers’ words were English so that they would feel comfortable using English spelling to write out the words, which, in turn, would indicate whether those MN and RN words were associated with the intended EN counterparts. Also, the belief here was that if the participants were told that the words were not English words, then they would be likely to rate all the words as more accented than if they thought the words were English words. They were given the following instructions regarding the rating of accentedness:

- 1) If they felt a word was spoken like a native English speaker, then, they should circle one of the lower numbers (i.e., 1 or 2).
- 2) If they felt a word was spoken with a heavy accent (not native-like at all), then, they should circle one of the higher numbers (i.e., 8 or 9).
- 3) If they felt the word was spoken with an accent somewhere between a native speaker and a heavily accented speaker, then, they should circle a number in the middle.

Prior to rating the MN and RN cross-language homophones, the participants were also informed that they were to provide their intuitions as native speakers of English about the accentedness of the words and as such there were no right or wrong answers—only their impressions.

As mentioned above, these secondary data were used for two purposes: 1) to help determine how to analyse the primary study results, and 2) to identify any inappropriate token stimuli (which were then subsequently discarded). Because these data are secondary, they are not reported on (Chapter 5) nor discussed on their own (Chapter 6).

#### ***4.4 Summary***

In the search to determine if and how orthographic knowledge influences L1 and L0/L2 phoneme perception, this chapter has laid out in detail not only the primary research methodology (§4.2) but also the pilot study leading up to the primary research (§4.1) and the secondary study used to evaluate the stimuli tokens used in the primary (§4.3). Since the focus of this dissertation revolves around the orthographic effects, the following chapter—Chapter 5—reports on the results and analyses of the primary data only.

## Chapter Five

### ANALYSES AND RESULTS

***“In a phoneme counting task, a spelling strategy will back fire when the number of letters in a word’s spelling does not match the number of phonemes in its pronunciation.”  
(Treiman & Cassar, 1997, p. 771)***

Up to now, all the previous chapters (Chapters 1 through 4) of this dissertation have been dedicated to outlining and discussing all the necessary research, background, and methodology upon which the current research rests. The remainder of this dissertation reports on (Chapter 5), discusses (Chapter 6), and summarises (Chapter 7) the research findings. This chapter reports on the statistical analyses used to evaluate the primary study data and the results from those statistical analyses. Prior to exploring the statistical analyses, we must first briefly review the experimental groups and the four primary research questions. Therefore, the first section of this chapter, §5.1, outlines the questions and predictions driving this research and highlights the comparisons necessary for answering those questions. The remaining sections address each of the following questions.

#### ***5.1 Outline of research questions, comparisons, and predictions***

Recall that this research employed a phoneme counting task and collected data from two experimental groups to answer four primary research questions. The experimental task was one in which participants carefully listened to and counted phonemes in monosyllabic words from their native language (English) and 2 nonnative languages

(Russian and Mandarin). The experimental groups were comprised of native speakers of Canadian English, who were divided into two L0 (unfamiliar language) groups. One group counted phonemes in English and Mandarin (the MNL0 group) where English was the L1 and Mandarin was the L0, and the other group counted phonemes in English and Russian (the RNL0 group) where English was the L1 and Russian was the L0. In addition, each group contained a subgroup of participants who were L2 learners of one of the nonnative languages: the participant subgroup in the MNL0 group contained L2 learners of Russian, and the participant subgroup in the RNL0 group contained L2 learners of Mandarin.

The four primary questions stem from one general question: in an auditory task, does the orthographic representation (i.e., alphabetic knowledge) override the phonological representation and determine the number of phonemes individuals perceive in a word? Specifically, do literate native speakers of English rely on their knowledge of how words are spelt in order to count phonemes, and if so, how does this affect their perception of phonemes in other languages and the speed with which they identify those phonemes? The more specific questions investigated in this research were designed to not only determine the effect of orthography on the L1 but also its effect on an L2 and an L0.

The first primary research question asks: *does L1 orthographic knowledge affect how native English speakers count phonemes in L1 (Q1)?* Specifically, do they count phonemes more accurately in words with *consistent* letter-to-phoneme correspondences (i.e., the numbers of letters and phonemes are the same) than in words with *inconsistent* letter-phoneme correspondences (i.e., the numbers of letters and phonemes is not the same)? Also, are native English speakers faster at counting phonemes in consistent

words than in inconsistent words? An additional question here is: are native English speakers more successful at counting phonemes in orthographically *unfamiliar* words (from L0) with inconsistent letter-phoneme correspondences than in orthographically *familiar* (from L1) words with inconsistent correspondences because they are not affected by orthographic interference in the L0?

The second primary research question asks: ***does L1 orthographic knowledge affect how native English speakers count phonemes in L0 (Q2)?*** That is, when L0 words are homophonous with L1 words, does L1 orthographic knowledge affect participants' abilities to accurately perceive the phonemes in the L0 words. Specifically, do native English speakers more accurately count phonemes in L0 words that are homophonous with L1 words with *consistent* letter-phoneme correspondences than in L0 words that are homophonous with L1 words with *inconsistent* letter-phoneme correspondences?

With respect to the subgroup data, the third primary research question is a two-part question. ***First, does L2 orthographic knowledge affect how native English speakers count phonemes in L2? (Q3a)*** In parallel with L1, do language learners count phonemes more accurately in L2 words with *consistent* letter-to-phoneme correspondences than in L2 words with *inconsistent* letter-phoneme correspondences? ***Second, if so, how does L2 orthographic knowledge interact with L1 orthographic knowledge? (Q3b)*** Since “the nature of the L1 orthography influences the way L2 learners attend to the L2 orthographic units” (Wade-Woolley, 1999, p. 448), does L1 orthographic knowledge override L2 orthographic knowledge and affect phoneme perception in the L2? For example, when counting the sounds in the Russian word *стул* (which sounds like English *stool* /stuł/), do

listeners default to the L1 spelling of the homophonous word even if they are RFL learners?

Finally, the fourth primary research question asks: *does the strength of the orthographic effect vary depending on experience with the language (Q4)?*

Specifically, is the difference between the L1 matched and mismatched words greater than the L2 matched and mismatched difference because the listeners have more experience with the L1 than the L2? Similarly, is the L2 difference greater than the L0 matched and mismatched difference because the listeners have some experience with the L2 but no experience with the L0?

Table 5.1 below outlines the four primary research questions along with the specific data comparisons necessary to answer the questions. This table also includes the hypotheses for the accuracy rates and response times surrounding each comparison; these will be explained further in the relevant sections. In this table (and henceforth), the “>>” symbol indicates that one condition is either more accurate or faster than another condition, the “<<” symbol indicates that one condition is either less accurate or slower than another conditions, and the “=” symbol indicates that two conditions are equal. For example, the table shows that in the L1 matched and mismatched comparison (§5.3.1), L1 matched words are predicted to be more accurately and more quickly counted than the L1 mismatched words. **NOTE:** For the purposes of the analyses and results in this chapter, the MM tokens are analysed as a single group, because the research design does not allow otherwise. However, see §6.3.3 in Chapter 6 for an indepth discussion of mismatch subcategory effects.

§	research questions	comparisons		predictions
5.3	Q1: Does L1 orthographic knowledge affect how listeners count phonemes in their first language (L1)?	5.3.1	L1 matched vs. mismatched words (both NH and H)	1) L1 matched words >> L1 mismatched words
		5.3.2	L1 vs. L0 matched NH	1) L1 matched NH >> L0 matched NH
			L1 vs. L0 mismatched NH	2) L1 mismatched NH << L0 mismatched NH
			L0 matched vs. mismatched NH	3) L0 matched = L0 mismatched NH
5.4	Q2: Does L1 orthographic knowledge affect how listeners count phonemes in an unfamiliar language (L0)?	5.4.1	L0 matched vs. mismatched H	1) L0 matched H >> L0 mismatched H
		5.4.2	L0 matched NH vs. H	1) L0 matched NH << L0 matched H
				L0 mismatched NH vs. H
5.6	Q3a: Does L2 orthographic knowledge affect how listeners count phonemes in the L2?	5.6.1	L2 matched vs. mismatched NH	1) L2 matched NH >> L2 mismatched NH
	Q3b: If so, how does L2 orthographic knowledge interact with L1 orthographic knowledge?	5.6.1	L2 matched vs. mismatched H	1) L2 matched H >> L2 mismatched H
			L2 matched NH vs. mismatched H	1) L2 matched NH >> L2 mismatched H
5.7	Q4: Does the strength of the orthographic effect vary depending on experience with the language?		match-mismatch differences between L1, L2, and L0 NH	1) L1 NH >> L2 NH >> L0 NH

*L1 = first language, L0 = unfamiliar language, L2 = second language, NH = nonhomophone, H = homophone, RT = response time*

**Table 5.1** Outline of the primary research questions, the comparisons needed to answer the questions, and the hypotheses associated with the comparisons

The remainder of the chapter is divided into six sections. §5.2, §5.3, and §5.4 report on and evaluate the overall data with respect to the first and second research questions and their respective hypotheses: §5.2 provides the overall descriptive statistics for the mean accuracy rates and response times; §5.3 reports on the results and statistical analyses that answer the first primary research question, and §5.4 reports on the results and statistical analyses that answer the second primary research question. §5.5, §5.6, and §5.7 consider only the subgroup data with respect to the third and fourth research questions. §5.5 provides the descriptive statistics for the accuracy rates and RTs. §5.6 reports on the results and statistical analyses that answer the third primary research question, and §5.7 reports on the results and statistical analyses that answer the fourth primary research question. Finally, this chapter concludes with a general summary—outlining all the significant results discovered from the data comparisons (§5.8).

### ***5.2 Descriptive statistics for the overall data***

The overall data were analysed with the first two research questions in mind. As mentioned previously, the overall data were organised and analysed using four independent factors – *group*, *language*, *homophone*, and *match* – and two dependent factors – *accuracy rates* and *response times*. Exploration of the raw ACC and RT data showed that ACC data were negatively skewed (the frequent scores were clustered at the higher end and the tail points towards the lower scores) and the RT data were positively skewed (the frequent scores were clustered at the lower end and the tail points towards the higher scores) (Field, 2005). Therefore, square root transformations (ACC) and natural-log (RT) were applied to normalize the data. Via the transformation process, the ACC values were reversed such that the transformed values (henceforth “reflected

accuracy”) are interpreted as "error" not "accuracy". For this reason, in the following tables and figures, with respect to participant accuracy, higher numbers mean lower accuracy (= higher error). With respect to the participant RTs (henceforth “logged RTs”), logging the RTs brings extreme, long RT values in closer to the faster RT values. In other words, it pulls in the positive skew. In these calculations, the natural log "e" base is 2.718. As an additional manipulation, boxplots for each participant were used to identify RT outliers, which were not factored into the mean logged RTs values. (See Appendix I for the boxplots.)

Table 5.2 below provides the descriptive statistics for the MNL0 and RNL0 experimental groups. The table includes the mean reflected accuracy rates (RACC) and logged response times (LRT) for each group according to each experimental condition. In addition to the mean RACC and LRT, the table includes the standard deviations (given in parentheses) of these mean numbers. Also included in this table are the mean differences between the matched and mismatched words for each homophone type, language, and group. The match-mismatch accuracy differences were calculated by subtracting the mean *matched* values from the mean *mismatched* values. Similarly, the match-mismatch LRT differences were calculated by subtracting the mean *matched* LRT values from the mean *mismatched* LRT values. These calculations were conducted so that positive values would support the research predictions and negative values would contradict the research predictions: positive values represent higher accuracy and faster RTs for the matched words than the mismatched words (as predicted), and negative values represent lower accuracy and slower RTs.

For example, this table indicates that for the MNL0 group's L1 accuracy results, the mean square root of the reflected accuracy for the matched NH is 0.18 with a standard deviation of 0.23 and the mean for the mismatched NH is 0.54 with a standard deviation of 0.23. The reflected accuracy difference between these NH matched and mismatched words is +0.36, which demonstrates better accuracy with matched NH words than with mismatched NH words (as predicted). Similarly, the MNL0 group's L1 mean LRT value for the matched NH is 7.81 with a standard deviation of 0.21 and the mean LRT value for the mismatched NH is 8.10 with a standard deviation of 0.22. The LRT difference between the matched and mismatched NH is +0.29, which demonstrates faster response times for the matched NH words than the mismatched NH words (also as predicted). Impressionistically, the numbers in Table 5.2 hint that by and large the predictions surrounding the overall data are supported: the differences between the matched and mismatched words for each homophone condition show that matched words were generally counted more accurately and faster than mismatched words, as reflected by the positive difference values, particularly in L1.

		L1		L0	
group	condition	RACC (SD)	LRTs (SD)	RACC (SD)	LRTs (SD)
MNL0	NH-M	0.18 (0.23)	7.81 (0.21)	0.51 (0.15)	7.86 (0.25)
	NH-MM	0.54 (0.23)	8.10 (0.22)	0.60 (0.18)	7.99 (0.23)
	<b>difference</b>	<b>+0.36</b>	<b>+0.29</b>	<b>+0.09</b>	<b>+0.13</b>
	H-M	0.43 (0.18)	7.83 (0.21)	0.36 (0.24)	7.83 (0.27)
	H-MM	0.51 (0.12)	7.88 (0.23)	0.53 (0.16)	7.81 (0.26)
<b>difference</b>	<b>+0.08</b>	<b>+0.05</b>	<b>+0.17</b>	<b>-0.02</b>	
RNL0	NH-M	0.17 (0.22)	7.83 (0.30)	0.52 (0.12)	8.00 (0.29)
	NH-MM	0.52 (0.25)	8.15 (0.33)	0.54 (0.12)	8.06 (0.31)
	<b>difference</b>	<b>+0.35</b>	<b>+0.32</b>	<b>+0.02</b>	<b>+0.06</b>
	H-M	0.44 (0.15)	7.86 (0.31)	0.23 (0.23)	7.98 (0.32)
	H-MM	0.47 (0.15)	7.91 (0.36)	0.31 (0.21)	7.92 (0.37)
<b>difference</b>	<b>+0.03</b>	<b>+0.05</b>	<b>+0.08</b>	<b>-0.06</b>	

\* response times are in milliseconds  
(SD) = standard deviation

**Table 5.2** Mean nonhomophone (NH) and homophone (H) reflected accuracy (RACC) and logged response times (RTs) for the MNL0 and RNL0 experimental groups in the L1 and L0 across the matched (M) and mismatched conditions (MM)

Based on the experimental design outlined in Chapter 4, both the reflected accuracy rate data and the logged RT data were analysed using a 4-factor repeated measures ANOVA with a 2 x 2 x 2 x 2 design. In this design, *group* (MNL0, RNL0) was the between-subjects factor and *language* (L1, L0)<sup>37</sup>, *homophone* (nonhomophone, homophone), and *match* (match, mismatch) were the three within-subjects factors. For the overall reflected accuracy data, three main effects, five 2-way interactions, and two 3-way interaction were significant (language:  $F(1,50)=7.090$ ,  $p<0.05$ ; homophone:  $F(1,50)=5.722$ ,  $p<0.05$ ; match:  $F(1,50)=56.807$ ,  $p<0.001$ ; homophone by group:  $F(1,50)=5.557$ ,  $p<0.05$ ; language by homophone:  $F(1,50)=81.967$ ,  $p<0.001$ ; language by match:  $F(1,50)=12.492$ ,  $p<0.001$ ; homophone by match:  $F(1,50)=21.829$ ,  $p<0.001$ ; language by group:  $F(1,50)=6.829$ ,  $p<0.05$ ; language by homophone by match:

<sup>37</sup> Recall that the L2 data are relevant only for the subgroup data, discussed in §5.5, §5.6, and §5.7 below.

$F(1,50)=41.304$ ,  $p<0.001$ ; language by homophone by group:  $F(1,50)=5.743$ ,  $p<0.05$ ). None of the other interactions—including the 4-way interaction—was significant (group:  $F(1,50)=3.404$ <sup>38</sup>; match by group:  $F(1,50)=1.965$ ; language by match by group:  $F(1,50)=1.297$ ; homophone by match by group:  $F(1,50)=0.388$ ; language by homophone by match by group:  $F(1,50)=0.019$ ; all effects not significant at  $p>0.05$ ).

For the logged RT data, the main effects for *homophone* and *match*, three 2-way interactions, and one 3-way interaction were significant (homophone:  $F(1,50)=94.016$ ,  $p<0.001$ ; match:  $F(1,50)=66.409$ ,  $p<0.001$ ; language by match:  $F(1,50)=48.059$ ,  $p<0.001$ ; homophone by match:  $F(1,50)=92.644$ ,  $p<0.001$ ; language by group:  $F(1,50)=4.270$ ,  $p<0.05$ ; language by homophone by match:  $F(1,50)=19.194$ ,  $p<0.001$ ). None of the other main effects or interactions—including the 4-way interaction—were significant (language:  $F(1,50)=0.110$ ; group:  $F(1,50)=1.048$ ; match by group:  $F(1,50)=0.780$ ; homophone by group:  $F(1,50)=0.056$ ,  $p<0.05$ ; language by homophone  $F(1,50)=0.282$ ; language by homophone by group:  $F(1,50)=0.426$ ; language by match by group:  $F(1,50)=2.267$ ; homophone by match by group:  $F(1,50)=0.007$ ; language by homophone by match by group:  $F(1,50)=1.154$ ; all effects not significant at  $p>0.05$ ). The lack of a significant 4-way interaction tells us that the pattern of interaction of three factors does not differ significantly for each level of the fourth factor. Therefore, this allows us to divide and collapse the data to focus on and investigate the main effects and interactions that answer each specific research question.

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<sup>38</sup> This  $p$ -value approached significance ( $p=0.071$ ).

### ***5.3 Research question 1: L1 orthographic effect on L1 phoneme counting***

Regarding the first primary research question, the current research tested two hypotheses using the accuracy rates and response times. The first hypothesis states the L1 orthography should **a)** positively affect how native English speakers perceive phonemes in L1 words with consistent letter-phoneme correspondences (e.g., *cup* /kʰʌp/ – 3 letters and 3 phonemes) and **b)** negatively affect how they perceive phonemes in L1 words with inconsistent letter-phoneme correspondences (e.g., *box* /baks/ – 3 letters and 4 phonemes). Therefore, if the results support the hypothesis, native English listeners should count matched words *more accurately* and *faster* because the L1 orthography facilitates phoneme perception; in contrast, listeners should count mismatched words *less accurately* and *more slowly* because the L1 orthography interferes with how many phonemes listeners perceive.

In addition, when comparing the L1 data with the L0 data, a second hypothesis predicts that native speakers of Canadian English should count phonemes in L1 matched NH *more accurately* and *faster* than L0 matched NH because the L1 orthography facilitates counting in the L1 but not in the L0. Conversely, the hypothesis predicts that native speakers should count phonemes in L1 mismatched NH *less accurately* and *more slowly* than L0 mismatched NH because the conflict between the orthography and phonology hinders accurate phoneme perception in L1 but not L0. Finally, a third hypothesis predicts that because participants do not have any orthographic associations with either the L0 matched or mismatched NH, L1 orthographic knowledge will not interfere; thus, there should be no accuracy or RT differences between L0 matched vs. mismatched NH words.

### 5.3.1 Comparisons of L1 matched and mismatched words (both NH and H)

As mentioned previously, accuracy rates and response times are used as dependent measures of orthographic interference. These values were calculated to determine whether native speakers of Canadian English count phonemes more accurately and faster in English words with consistent one-to-one letter-phoneme correspondences than in words with inconsistent correspondences. Regarding the matched and mismatched L1 data comparisons, the predictions are as follows. (Recall that “>>” indicates higher accuracy and faster response times.)

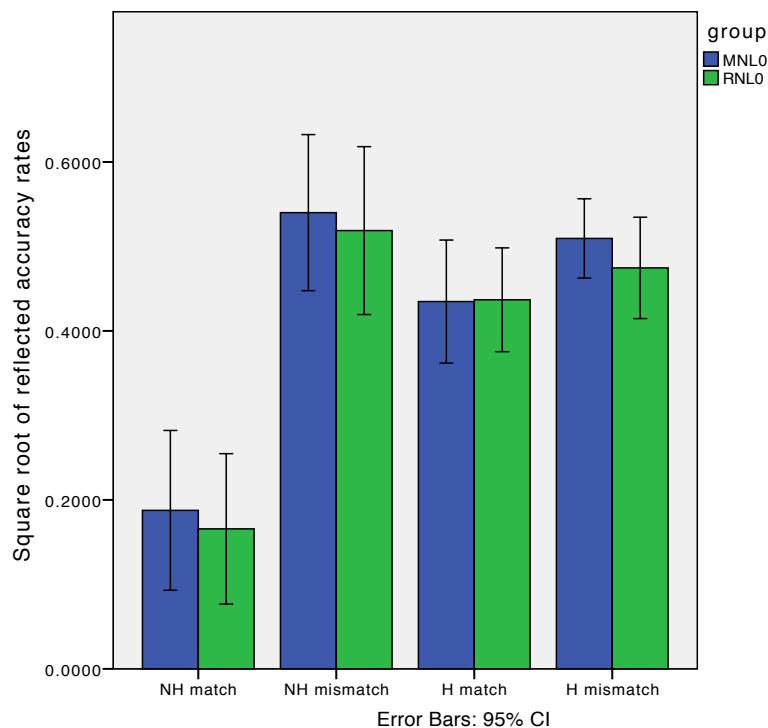
**Prediction:**

L1 **matched** NH and H

>>

L1 **mismatched** NH and H

In addition to the descriptive statistics given above in Table 5.2, Figure 5.1 below provides a visual representation of the MNL0 and RNL0 groups’ reflected accuracy rates for the L1 matched and mismatched words. The height of the bars in this figure indicates the square root of the reflected accuracy rates (i.e., lower bars = more accurate), and the error bars indicate a 95% confidence interval. This figure illustrates that both groups performed similarly on the matched and mismatched L1 NH and H although the RNL0 group appears to have performed slightly more accurately than the MNL0 group on all the conditions except the matched H condition. In addition, both groups were much more accurate at counting phonemes in the matched NH condition than the other three conditions. This figure also shows that both groups more accurately counted phonemes in matched NH and H than they did in mismatched NH and H.



**Figure 5.1** Mean MNL0 and RNL0 square root values of reflected accuracy rates for the L1 matched and mismatched conditions

The reflected accuracy rate data for the L1 words were analysed using a 3-factor repeated measures ANOVA with *group* (MNL0, RNL0) as the one between-subjects factor and *homophone* (nonhomophone, homophone) and *match* (match, mismatch) as the two within-subjects factors. The main effects for *homophone* and *match* as well as the interaction of *homophone* by *match* were significant (homophone:  $F(1,50)=28.983$ ,  $p<0.001$ ; match:  $F(1,50)=50.035$ ,  $p<0.001$ ; homophone by match:  $F(1,50)=51.644$ ,  $p<0.001$ ). All of the other main effects and interactions were not significant (group:  $F(1,50)=0.251$ ; match by group:  $F(1,50)=0.099$ ; homophone by group:  $F(1,50)=0.016$ ; homophone by match by group:  $F(1,50)=0.344$ ; all effects not significant at  $p>0.05$ ). Follow-up tests for the effects *match*, collapsed over *group* (since *group* did not participate in any significant interactions), for each homophone type (i.e., the NH and the

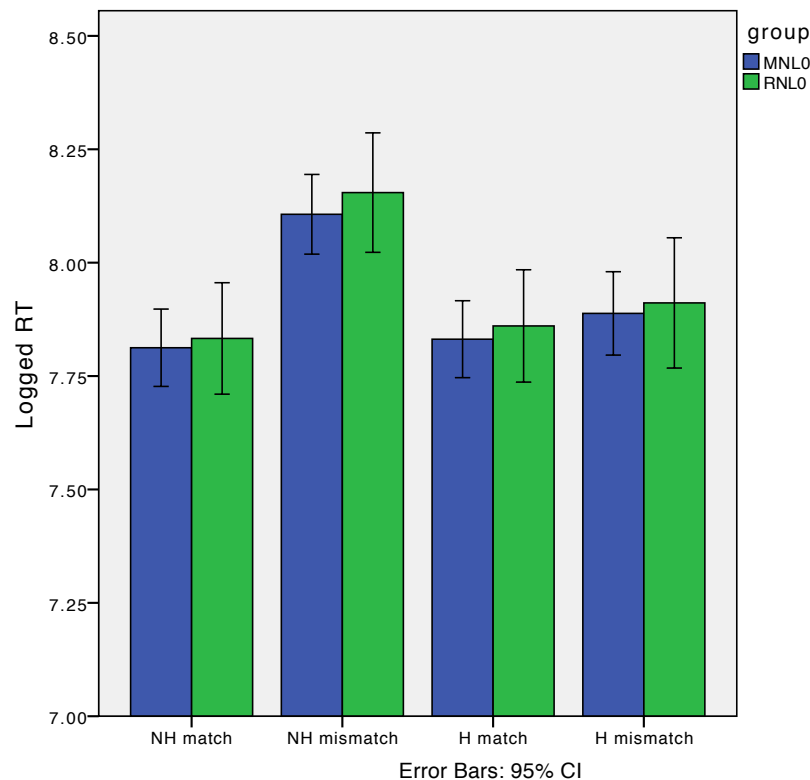
H) separately showed the main effect of *match* was significant for the NH ( $F(1,50)=78.289, p<0.001$ ), with participants more accurately counting phonemes in L1 matched NH than in L1 mismatched NH. The follow up tests also showed the main effect of *match* was significant for the H ( $F(1,50)=5.648, p<0.05$ ), with participants more accurately counting phonemes in L1 matched H than in L1 mismatched H. While the participants counted phonemes more accurately in both the matched NH and H than in the mismatched NH and H, the difference between the matched and mismatched words was greater for the NH than the H.

In sum, the statistical analyses indicate that the participants in both groups more accurately counted phonemes in matched words than in mismatched words. These results confirm previous findings that L1 orthography influences speech perception in the L1 such that it facilitates phoneme counting when there are consistent letter-phoneme correspondences but hinders phoneme counting when there are inconsistent correspondences. The analyses also show no significant difference in accuracy performance between the two groups for both the NH and the H words.

RT data provided an additional opportunity to determine possible L1 interference effects on performance differences between matched and mismatched L1 words. To determine the effect of L1 orthography on the speed of response, only the RT data for the accurate responses were analysed. In addition, the RTs were calculated from the offset of the word and only positive RTs were used since negative RTs indicated participants had answer before hearing the entire word (i.e., they had guessed). The prediction here was that reconciling mismatched letter-phoneme correspondences would require greater cognitive resources and processing, and thus would result in longer RTs. Therefore,

observing significant differences between matched and mismatched words would further support the hypothesis that orthography is co-activated with the speech signal and influences phoneme perception.

Figure 5.2 below presents the mean logged RTs for each group for each homophone and match condition. This figure shows three patterns of results. First, both groups are faster at counting phonemes in matched NH and H words than in the mismatched NH and H words. Second, the MNLO group appears to count phonemes in both L1 NH and H words faster than the RNL0 group does. Finally, the RT difference appears greater between the matched and mismatched NH words than between the matched and mismatched H words for both groups.



**Figure 5.2** Mean MNLO and RNL0 logged RTs for the L1 matched and mismatched conditions

Like the reflected accuracy data, the logged RT data for the L1 words were analysed using a 3-factor repeated measures ANOVA with *group* (MNL0, RNL0) as the one between-subjects factor and *homophone* (nonhomophone, homophone) and *match* (match, mismatch) as the two within-subjects factors. The main effects of *homophone* and *match* and the interaction of *homophone* by *match* were significant (homophone:  $F(1,50)=60.764$ ;  $p<0.001$ ; match:  $F(1,50)=143.131$ ;  $p<0.001$ ; homophone by match:  $F(1,50)=102.748$ ;  $p<0.001$ ). All other effects—including the 3-way interaction—were not significant (group:  $F(1,50)=0.173$ ; match by group:  $F(1,50)=0.122$ ; homophone by group:  $F(1,50)=0.090$ ; homophone by match by group:  $F(1,50)=0.446$ ; all effects not significant at  $p>0.05$ ). Follow-up tests for the effects *match*, collapsed over *group*, for each homophone type separately showed the main effect of *match* was significant for the NH ( $F(1,51)=255.599$ ,  $p<0.001$ ), with participants counting phonemes faster in L1 matched NH than in L1 mismatched NH. The follow up tests also showed that main effect of *match* was significant for the H ( $F(1,51)=7.448$ ,  $p>0.01$ ), with participants counting phonemes faster in L1 matched H than mismatched H. In other words, the both the NH and H matched words were counted faster than their NH and H mismatched counterparts, but the difference between the matched and mismatched words was greater for the NH than the H.

In sum, the analyses show that the logged RT results parallel the reflected accuracy data. That is, the statistical analyses show that both groups were significantly faster at counting phonemes in matched NH and H words than in the mismatched NH and H words although the matched-mismatched difference was greater for the NH than the H.

In addition, the analyses show no significant difference in speed between the two groups for the both the NH and H words.

### 5.3.2 Comparisons of L1 and L0 matched and mismatched NH

To further investigate L1 orthography's effect on phoneme perception in the L1, the current research also compared 1) the L1 matched NH with the L0 matched NH, 2) the L1 mismatched NH with the L0 mismatched NH, and 3) the L0 matched and mismatched NH. If L1 orthography does affect phoneme perception in the L1, we should observe an important difference in accuracy and RTs in the first two comparisons. First, in the L1 and L0 *matched* NH comparison, the prediction is that both the MNL0 and the RNL0 groups should count phonemes *more accurately* in the matched L1 NH than in matched L0 NH because orthography facilitates the perception of sound in the L1 but not in the L0 since L0 spellings are not known, and therefore cannot facilitate perception. Second, in the L1 and L0 *mismatched* comparison, the prediction is that both groups would count phonemes *less accurately* in the L1 mismatched NH than in the L0 mismatched NH because the orthography interferes with how many phonemes listeners perceive in the L1 but not in the L0 since these words have no orthographic association. Finally, in the matched and mismatched L0 NH comparison, the prediction is that the accuracy and speed for the matched and mismatched NH should be the same since the listeners do not have any orthographic knowledge that will impede their success.

**Predictions:**

L1 matched

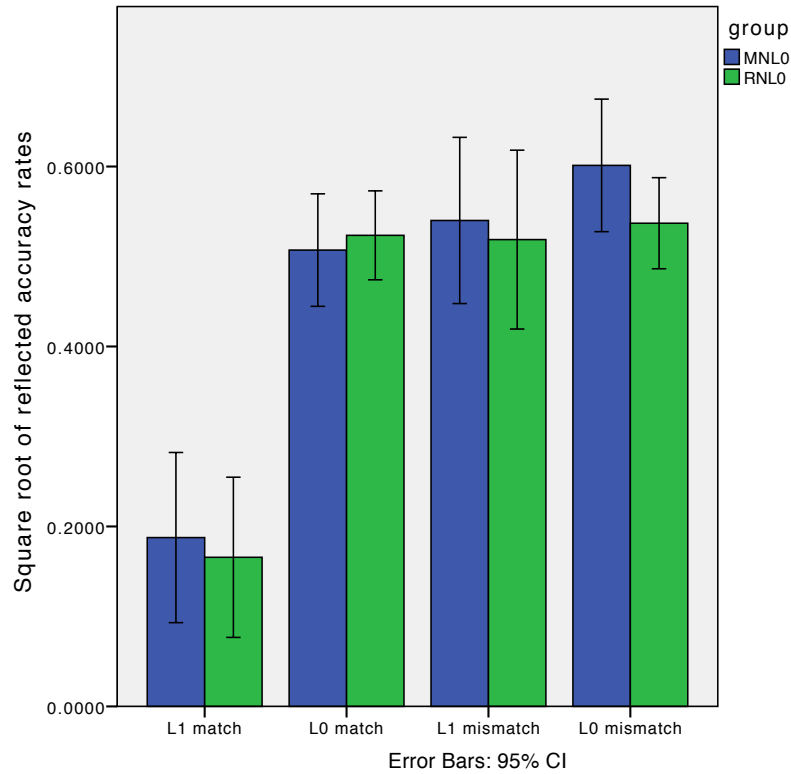
>>

L0 matched, L0 mismatched

>>

L1 mismatched

In addition to the descriptive statistics given above in Table 5.2, Figure 5.3 below provides a visual representation of the MNL0 and RNL0 groups' reflected accuracy rates of the L1 and L0 matched and mismatched NHs. The height of the bars in this figure indicates the mean reflected accuracy (higher bars = lower accuracy), and the error bars indicate a 95% confidence interval. This figure illustrates that the MNL0 group and the RNL0 group performed similarly with respect to accuracy for the L1 (i.e., English) matched NHs and the L1 mismatched NHs, and that both groups performed more accurately counted phonemes in L1 matched NHs (0.91 and 0.93, respectively) than in L1 mismatched NHs (0.66 for both groups) (as previously shown in Figure 5.1). With respect to the L0 accuracy, Figure 5.3 shows that neither group was as accurate at counting phonemes in the L0 matched NHs as it was at counting phonemes in the L1 matched NHs. In fact, for both groups, their L0 matched NH reflected accuracy rates were about the same as their mean reflected accuracy for the L1 mismatched NHs and for the L0 mismatched NHs.



**Figure 5.3** Mean square root values of reflected accuracy rates for the L1 and L0 matched and mismatched *nonhomophones*

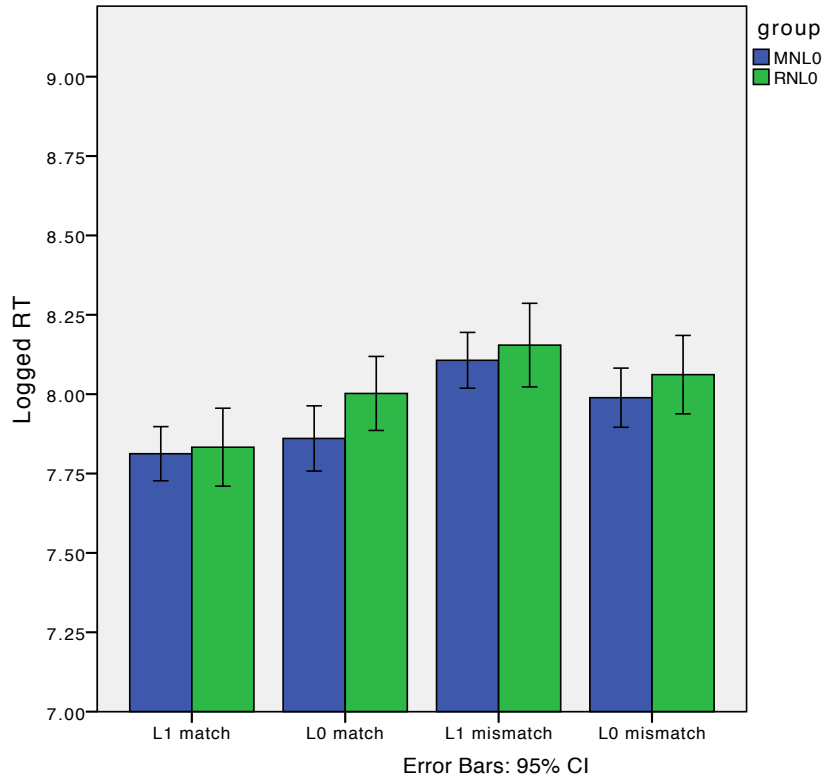
The reflected accuracy data for the L1 and L0 NH were analysed using a 3-factor repeated measures ANOVA with *group* (MNL0, RNL0) as the one between-subjects factor and *language* (L1, L0) and *match* (match, mismatch) as the two within-subjects factors. The main effects of *language* and *match* as well as the interaction of *language* and *match* were significant (language:  $F(1,50)=60.169$ ,  $p<0.001$ ; match:  $F(1,50)=72.513$ ,  $p<0.001$ ; language by match:  $F(1,50)=39.779$ ,  $p<0.001$ ). All other effects were not significant (group:  $F(1,50)=0.433$ ; language by group:  $F(1,50)=0.002$ ; match by group:  $F(1,50)=0.702$ ; language by match by group:  $F(1,50)=0.736$ ; all effects not significant at  $p>0.05$ ). Tests for the effects of *language* for each match, collapsed over *group*, show that participants more accurately count phonemes in L1 matched NH than in L0 matched

NH ( $F(1,51)=111.459, p<0.001$ ); however, the effect of *language* was not significant for the mismatched NH ( $F(1,51)=1.256, p>0.05$ ). Finally, the effects of *match*, collapsed over *group*, were tested for the L0 NH words. In this test, the main effect of *match* was significant ( $F(1,51)=4.378, p<0.05$ ), with participants counting phonemes more accurately in L0 matched NH than in L0 mismatched NH.

In short, the statistical analyses show no significant accuracy difference between groups. They also show that both groups are significantly more accurate at counting phonemes in the L1 matched NHs than in the L0 matched NHs (as predicted). This result suggests that L1 orthographic knowledge facilitates phoneme counting in L1 words with consistent letter-phoneme correspondences. However, the analyses also show that no difference exists between the L1 and L0 mismatched NHs (not predicted). Also, contrary to the prediction, the analyses also show that listeners were significantly more accurate at counting phonemes in L0 matched NH than in L0 mismatched NH, suggesting perhaps an effect of the words themselves within the matched and mismatched NH (However, as illustrated later in §5.4.2, word effect cannot possibly be the only factor influencing performance.).

With respect to the RTs, the hypotheses predict that both groups of participants will **a)** count phonemes faster in the L1 matched NH than in the L0 matched NH, **b)** count phonemes slower in the L1 mismatched NH than in the L0 mismatched NH, and **c)** count equally as fast in the L0 matched NH words as in the L0 mismatched NH words. Figure 5.4 below indicates that the participants were faster at counting phonemes in the L1 matched NH than in the L0 matched phonemes. This figure also indicates that participants were slower at counting phonemes in the L1 mismatched NH than in the L0

mismatched NH. Finally, both groups appear to count phonemes in the L0 matched NH slightly faster than in the L0 mismatched NH.



**Figure 5.4** Mean logged RTs for the L1 and L0 matched and mismatched *nonhomophones*

The logged RT data for the L1 and L0 NH were also analysed using a 3-factor repeated measures ANOVA with *group* (MNL0, RNL0) as the one between-subjects factor and *language* (L1, L0) and *match* (match, mismatch) as the two within-subjects factors. The main effects for *match* and the interaction of *language* and *match* were significant (match:  $F(1,50)=172.148$ ,  $p<0.001$ ; language by match:  $F(1,50)=61.398$ ,  $p<0.001$ ). All other effects were not significant (group:  $F(1,50)=1.057$ ; language:  $F(1,50)=0.006$ ; language by group:  $F(1,50)=2.736$ ; match by group:  $F(1,50)=0.467$ ;

language by match by group:  $F(1,50)=0.3.114^{39}$ ; all effects not significant at  $p>0.05$ ). Tests of the effect of *language* on each match type, collapsed over *group*, show that participants counted phonemes in L1 matched NH significantly faster than in L0 matched NH ( $F(1,51)=16.193$ ,  $p<0.001$ ). In contrast, participants counted phonemes in L1 mismatched NH significantly slower than in L0 mismatched NH ( $F(1,51)=16.693$ ,  $p<0.01$ ). Finally, the effects of *match*, collapsed over *group*, were tested for the L0 NH words. The main effect of *match* was significant ( $F(1,51)=18.255$ ,  $p<0.001$ ), with participants counting phonemes faster in L0 matched NH than in L0 mismatched NH.

In sum, the statistical analyses on LRT support and even go beyond the RACC results, showing that participants counted phonemes in the L1 matched NH *faster* than in the L0 matched NH, but they counted phonemes in the L1 mismatched NH *slower* than in the L0 mismatched NH. As with accuracy results, LRT results show that participants also counted phonemes faster in L0 matched NH than in L0 mismatched NH, which is contrary to the predictions surrounding the L0 NH words. Again, this suggests an effect of the words in each match type.

### 5.3.3 Summary for primary research question 1

The previous subsections have reported on the results and statistical analyses of the overall data regarding the first primary research question (Q1). Three-way repeated measures ANOVAs and subsequent tests for effects were conducted to analyse the effect of L1 orthography on phoneme perception in listeners' first language (L1) and an unfamiliar language (L0) in terms of two dependent measures – accuracy and RTs. Table 5.3 summarises the accuracy and RT results below according to the matched and

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<sup>39</sup> This  $p$ -value approached significance,  $p=0.084$ .

mismatched L1 NH comparison as well as the L1 and L0 comparisons. This table also indicates whether each result confirms the research hypotheses (✓) or not (✗). All differences indicated in the table are significant.

question	comparisons	results	hyp.
<b>Q1:</b> Does L1 orthographic knowledge affect how listeners count phonemes in their first language (L1)?	all L1 matched vs. mismatched words (Figures 5.1 & 5.2)	1) both groups <i>more accurate</i> with matched NH and H than mismatched NH and H 2) both groups <i>faster</i> in matched NH and H than in mismatched NH and H 3) no accuracy or RT differences between groups	✓ ✓ ✓
	L1 vs. L0 matched NH (Figures 5.3 & 5.4)	1) both groups <i>more accurate</i> in L1 matched NH than in L0 matched NH 2) both groups <i>faster</i> at counting in L1 matched NH than in L0 matched NH 3) no accuracy or RT differences between groups	✓ ✓ ✓
	L1 vs. L0 mismatched NH (Figures 5.3 & 5.4)	4) no accuracy difference between L1 and L0 mismatched NH 5) both groups <i>slower</i> at counting L1 mismatched NH than L0 mismatched NH 6) no accuracy or RT difference between groups	× ✓ ✓
	L0 matched vs. mismatched NH (Figures 5.3 & 5.4)	5) L0 matched NH <i>more accurate</i> than mismatched NH 6) L0 matched NH <i>faster</i> than mismatched NH 7) no accuracy or RT difference between groups	× × ✓

*L1 = first language, L0 = unfamiliar language, NH = nonhomophone, H = homophone, RT = response time, hyp. = hypotheses, ✓ = supported, × = not supported, n/a = no hypothesis predicted*

**Table 5.3** Summary of overall data results addressing the first primary research question, the comparisons, and the predictions

These results suggest that for accuracy, L1 orthography has a *facilitative* effect but not an inhibitory one: the matched L1 NH words were counted more accurately than the mismatched L1 NH, the matched L0 NH, and the mismatched L0 NH. In contrast, the mismatched L1 NH were *not* counted less accurately than the matched and mismatched L0 NH, suggesting that L1 orthography does not hinder counting any more than not knowing the language does. Conversely, the results suggest that L1 orthography has both a facilitative *and* inhibitory effect with respect to counting speed: L1 NH were counted faster than the matched and mismatched L0 NH (facilitation), but the mismatched L1 NH were counted more slowly than the L0 NH words (inhibition). Finally, the analyses show one unexpected result: contrary to the hypothesis, both groups of listeners counted phonemes in matched L0 NH more accurately and faster than they did in mismatched L0 NH, suggesting that something about the words themselves (i.e., a word effect) may also have influenced how listeners perceived and counted L0 phonemes.

Given that L1 orthography appears to facilitate phoneme counting in L1 words with consistent correspondences and, to a lesser extent, hinder phoneme counting in L1 words with inconsistent correspondences, the next important question here is: does L1 orthography affect perception of L0 phonemes? If so, does it affect L0 phoneme perception in the same way as it affects L1 phoneme perception? The following subsection addresses the second primary research question to investigate L1 orthography's effect on the L0.

#### ***5.4 Research question 2: L1 orthographic effect on L0 phoneme counting***

As mentioned above in §5.1, the second primary research question asks: ***does L1 orthographic knowledge affect how native English speakers count phonemes in an***

*unfamiliar language (L0)?* Specifically, when L0 words are homophonous with L1 words, does L1 orthographic knowledge intrude on L0 perception and affect participants' abilities to accurately perceive the phonemes in the L0 words. In concrete terms: do native English speakers more accurately count phonemes in L0 words that are homophonous with L1 words with consistent letter-phoneme correspondences (e.g., Mandarin *méi* /mej/ and English *May* /mej/) than in L0 words that are homophonous with L1 words with inconsistent letter-phoneme correspondences (e.g., Mandarin *hū* /xu/ and English *who* /hu/)?

Regarding these questions, the first hypothesis predicts that listeners should tap into their L1 orthographic knowledge to help them count phonemes in the L0. This strategy should facilitate phoneme counting (both in accuracy and speed) when the L0 words are homophonous with L1 words that have consistent letter-phoneme correspondences, but it should hinder counting when the L0 words are homophonous with L1 words that have inconsistent correspondences. This should be reflected in significantly higher accuracy rates and faster RTs for the L0 matched H than for L0 mismatched H. Also, a second hypothesis predicts that if L1 orthographic knowledge intrudes on L0 phoneme perception, we should observe significant differences in accuracy and speed between the L0 NH and H words. First, listeners should *more accurately* count phonemes and respond *faster* for L0 matched H than L0 matched NH because listeners tap into their L1 orthographic knowledge to help them with matched H, but they have no orthographic associations for the matched NH, and therefore, receive no such boost from the L1. In contrast, listeners should *less accurately* count phonemes and respond *slower* for L0 mismatched H words than L0 mismatched NH because again they tap into their L1

orthographic knowledge, but the inconsistent correspondences prevent the same degree of success for the mismatched H words.

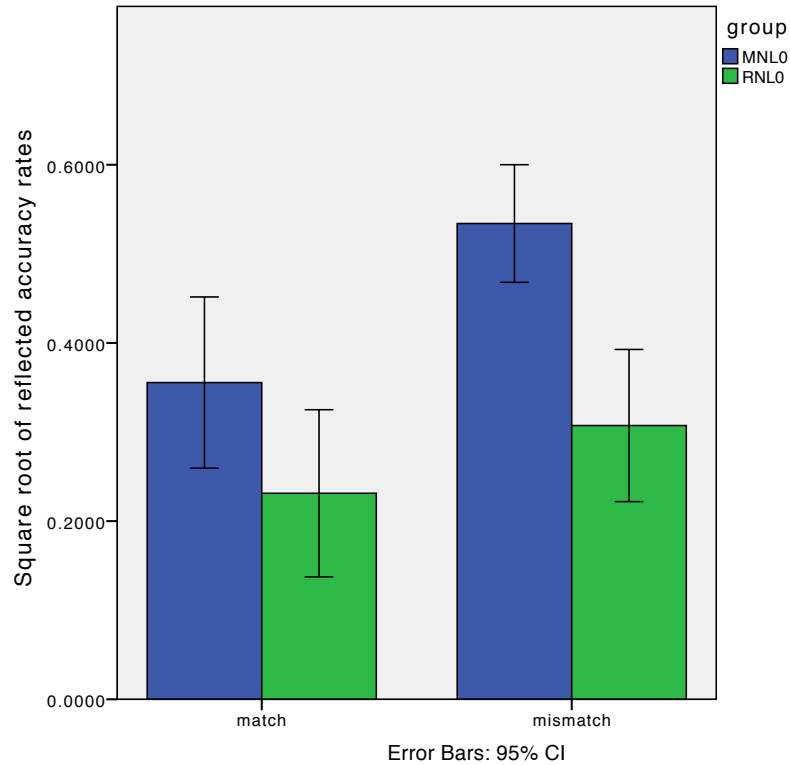
#### *5.4.1 Comparison of L0 matched and mismatched H*

To test the hypothesis that the L1 orthography would facilitate counting in L0 words with consistent L1 letter-phoneme associations and hinder counting in the L0 words with inconsistent L1 letter-phoneme associations, this subsection analyses and compares the L0 matched and mismatched H data. As mentioned above, the hypothesis predicts that listeners should count phonemes more accurately and faster in the L0 matched H than mismatched H because when they use their L1 orthographic knowledge to help them with the matched H words, there is no conflict between the number of letters and phonemes.

**Prediction:**

L0 <b>matched</b> H
>>
L0 <b>mismatched</b> H

Figure 5.5 below indicates two major trends in the L0 H words. First, the RNL0 group appears to count phonemes in both the matched H and mismatched H conditions more accurately than the MNL0 group does. Second, regardless of the group differences, L0 matched H words appear to be counted more accurately than the L0 mismatched H.

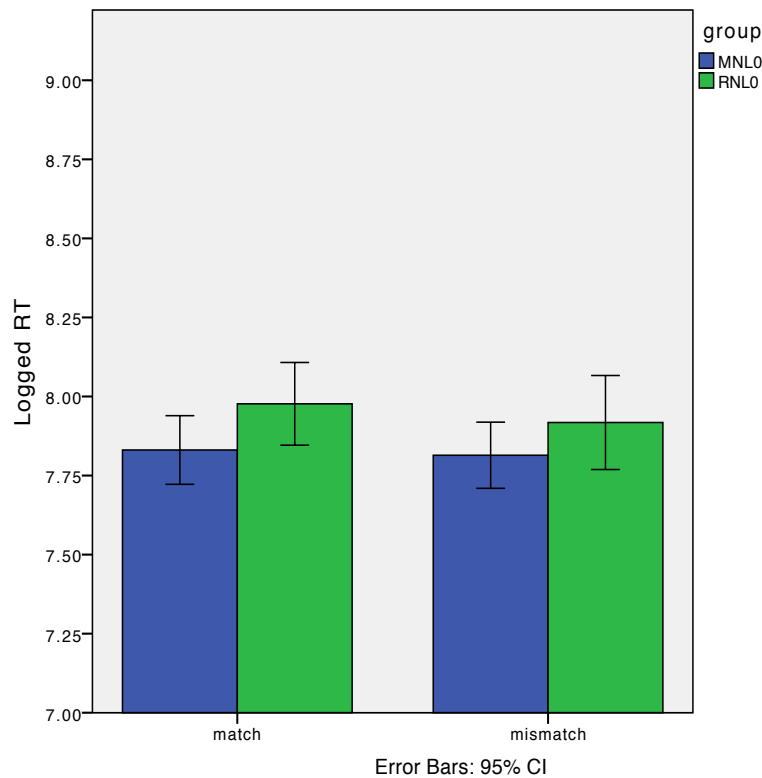


**Figure 5.5** Mean square root values of reflected accuracy rates comparing the L0 matched and mismatched cross-language *homophones*

These data were analysed with a 2-way repeated measures ANOVA with *group* (MNLO, RNLO) as a between-subjects factor and *match* (match, mismatch) as a within-subjects factor. The main effects for *match* and *group* were significant (match:  $F(1,50)=14.179$ ,  $p<0.001$ ; group:  $F(1,50)=13.085$ ,  $p<0.05$ ); however, the interaction of *match* and *group* was not significant ( $F(1,50)=2.3$ ,  $p>0.05$ ). In other words, both groups were significantly more accurate at counting phonemes in L0 matched H than in mismatched H. Also, the RNLO group was significantly more accurate at counting phonemes in the L0 matched and mismatched H than the MNLO group was.

With respect to the RT data, the hypothesis predicts that listeners should count phonemes faster in the L0 matched H because when they tap into their L1 orthographic

knowledge for help, they do not need extra time to reconcile a conflict between the number of letters and phonemes. Figure 5.6 below indicates two trends with the data. First, the MNL0 group appears to count phonemes in the matched and mismatched conditions faster than the RNL0 group does. Second, both groups appear to count L0 mismatched H slightly faster than L0 matched H.



**Figure 5.6** Mean logged RTs comparing the L0 matched and mismatched cross-language *homophones*

These RT data were also analysed using the 2-way repeated measures ANOVA with *group* (MNL0, RNL0) as the between-subjects factor and *match* (match, mismatch) as the within-subjects factor. Contrary to the trends observed above in Figure 5.6 all of the effects—including the interaction of *group* and *match*—were not significant (match:  $F(1,50)=2.856$ ; group:  $F(1,50)=2.290$ ; match by group:  $F(1,50)=0.903$ ; all effects not

significant at  $p > 0.05$ ). That means neither group was faster than the other in counting phonemes. Also, the listeners did not count phonemes in one condition (either the matched or mismatched) faster than the other condition.

In sum, the statistical analyses of the reflected accuracy rates indicate that overall the RNL0 group was more accurate than the MNL0 group at counting phonemes (not predicted). As predicted, the analyses also indicate that both groups were significantly more accurate with the L0 matched H words than with the mismatched H words. The reflected accuracy results suggest that L1 orthographic knowledge is also a factor in L0 phoneme perception. Specifically, the L1 orthography facilitates phoneme perception in L0 words when they are homophonous with L1 words that have consistent correspondences but hinders perception when the L0 are homophonous with L1 words that have inconsistent correspondences. In short, participants appear to employ the L1 orthography to help them count phonemes in the L0, but that strategy is not as successful when the number of letters does not match the number of phonemes in the associated L1 cross-language H words. However, the RT data here do not show the same facilitative effect of L1 orthography. In fact, the analyses show no significant differences exist not only between the two groups but also between the L0 matched and mismatched H words.

#### *5.4.2 Comparison of L0 NH and H*

This subsection reports on the results and statistical analyses of the accuracy rates for the L0 NH and H comparison. While reading the following, keep in mind that the phoneme counting task was a purely auditory task and that neither group knew the L0 words, and thus by extension nor did they know how to spell the L0 words in the L0 orthography. However, the groups were familiar with the L1 spellings of the cross-language H;

therefore, differences in performance between the L0 NH and L0 H would suggest an effect of L1 orthography. While the previous section focuses exclusively on comparing L0 matched and mismatched *homophones*, we must also compare the NH and H data to confirm that the H effects found in the previous section are due to L1 interference. If L1 orthographic knowledge intrudes on L0 phoneme perception, listeners should count phonemes *more accurately* for L0 matched H than for L0 matched NH because listeners tap into their L1 orthographic knowledge to help them with the Hs. In contrast, they have no orthographic associations for the matched NH and, therefore, receive no such boost from the L1. In addition, listeners should count phonemes *less accurately* for L0 mismatched H words than L0 mismatched NH because again they tap into their L1 orthographic knowledge for the Hs, but in this case, the inconsistent correspondences prevent them from counting phonemes as accurately in the mismatched H words. Finally, listeners should count phonemes as accurately for the L0 matched NH as for the L0 mismatched NH (already reported in §5.3.2) because they have no orthographic knowledge for these words.

**Predictions:**

L0 matched H

>>

L0 matched NH, L0 mismatched NH

>>

L0 mismatched H

Figure 5.7 shows three patterns of behaviour. (Note that this figure is the same as Table 5.5 but with the addition of the matched and mismatched NH data.) First, both the MNL0 and the RNL0 groups count phonemes more accurately in L0 matched NH and H

words than in L0 mismatched NH and H words. Second, the RNL0 group is generally more accurate than the MNL0 group—with the exception of the matched NH condition (mentioned previously in §5.3.2). Finally, both groups are more accurate at counting phonemes with matched H than with matched NH, and they are more accurate with mismatched H than with mismatched NH.



**Figure 5.7** Mean square root values of reflected accuracy rates for MNL0 and RNL0 comparing the L0 *nonhomophones* with the cross-language *homophones* across the matched and mismatched conditions

The overall reflected accuracy rates data for the L0 NH and H were analysed using *group* (MNL0, RNL0) as the one between-subjects factor and *homophone* (nonhomophone, homophone) and *match* (match, mismatch) as the two within-subjects factors. All main effects and the interactions of *match* and *group* and *homophone* and

*group* were significant (group:  $F(1,50)=8.970$ ,  $p<0.01$ ; homophone:  $F(1,50)=57.883$ ,  $p<0.001$ ; match:  $F(1,50)=18.211$ ,  $p<0.001$ ; homophone by group:  $F(1,50)=9.694$ ,  $p<0.01$ ; match by group:  $F(1,50)=4.658$ ,  $p<0.05$ ); however, all the other interactions were not significant (homophone by match:  $F(1,50)=3.054$ <sup>40</sup>; homophone by match by group:  $F(1,50)=0.068$ ; all effects not significant at  $p>0.05$ ). Follow up analyses of the effects of *homophone* and *group* were conducted for match and mismatch separately. For the matched words, the main effects of *homophone* and *group* as well as the interaction of *homophone* by *group* were all significant (homophone:  $F(1,50)=46.432$ ,  $p<0.001$ ; group:  $F(1,50)=4.661$ ,  $p<0.05$ ; homophone by group:  $F(1,50)=4.661$ ,  $p<0.05$ ). Subsequent tests of the effects of *homophone* for each group separately showed a significant main effect of *homophone* for both the MNL0 group ( $F(1,50)=10.417$ ,  $p<0.01$ ) and the RNL0 group ( $F(1,50)=41.943$ ,  $p<0.001$ ), with both groups of participants counting matched H more accurately than matched NH. However, the difference between the matched NH and H was greater for the RNL0 group than the MNL0 group. Similarly, the follow up tests for the mismatched words showed the main effects of *homophone* and *group* as well as the interaction of *homophone* by *group* were all significant (homophone:  $F(1,50)=21.853$ ,  $p<0.001$ ; group:  $F(1,50)=6.547$ ,  $p<0.05$ ; homophone by group:  $F(1,50)=6.547$ ,  $p<0.05$ ). Subsequent tests of the effects of *homophone* for each group separately showed a significant main effect of *homophone* for both the MNL0 group ( $F(1,50)=4.024$ ,  $p=0.05$ ) and the RNL0 group ( $F(1,50)=18.123$ ,  $p<0.001$ ), with both groups of participants counting mismatched H more accurately than mismatched NH. However, the difference

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<sup>40</sup> The  $p$ -value approached significance,  $p=0.087$ .

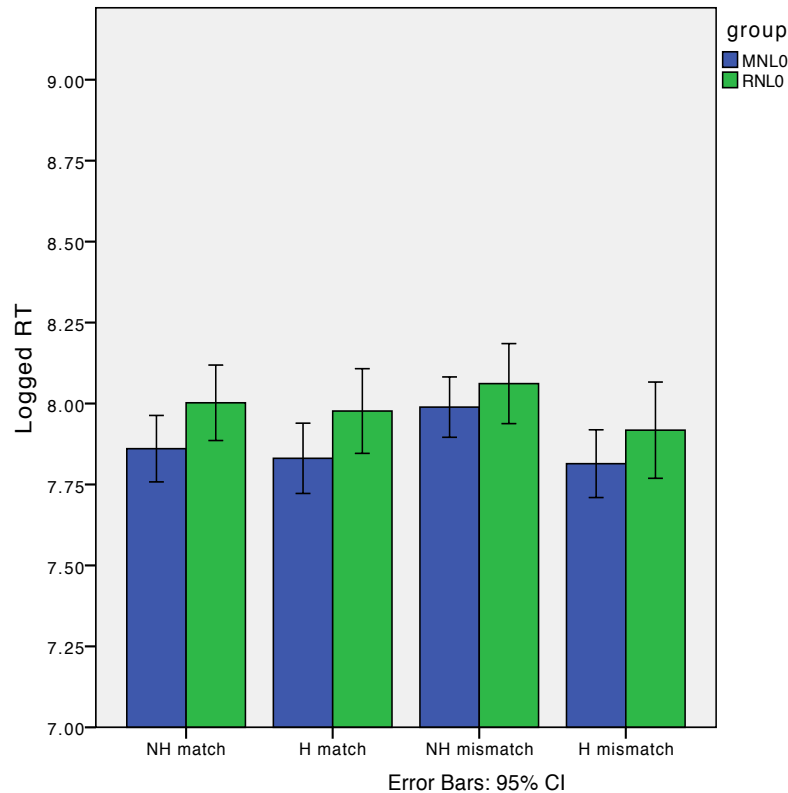
between the mismatched NH and H was greater for the RNL0 group than the MNL0 group.

In addition to the analyses of the effects of *match* and *group* on the L0 homophone data (reported above in §5.4.1), follow-up analyses of the effects of *match* and *group* were also conducted on the L0 nonhomophone data. These analyses showed a significant main effect of *match* ( $F(1,50)=4.510$ ,  $p<0.05$ ), but the main effect of *group* and the interaction of *match* and *group* were not significant (group:  $F(1,50)=0.547$ ; match by group:  $F(1,50)=2.534$ ; both effects not significant at  $p>0.05$ ). In other words, neither group was more accurate at counting phonemes than the other group, and both groups were more accurate at counting phonemes in matched NH than they were at counting phonemes in mismatched NH.

In sum, the statistical analyses show that both groups of participants more accurately count phonemes in homophones than in nonhomophones, with the RNL0 group showing a greater difference between H and NH words than the MNL0 group for both matched and mismatched words. In addition, both groups of participants more accurately count phonemes in matched words than in mismatched words with the RNL0 group demonstrating a greater accuracy difference between matched and mismatched words than the MNL0 group. These two results suggest that two effects are at play: 1) a familiarity effect and 2) L1 an orthographic knowledge effect. First, performing better on both sets of homophonous words (i.e., the matched and mismatched) than nonhomophonous words suggests that homophony with English words make L0 words more familiar to participants thus making them more successful regardless of whether the words have consistent letter-phoneme correspondences or not. Second, performing better

on matched words than mismatched words suggests that while familiarity helps them count phonemes in general, the inconsistent letter-phoneme correspondences in the L0 mismatched words do interfere with their abilities to count the phonemes accurately.

In addition to the previous comparisons made with the L0 data, comparing the L0 NH and H response times further provide insight into L1 orthography's influence on phoneme perception in L0 words. Here, the hypotheses predict 1) participants should be faster at counting phonemes in matched H than in matched NH because the associated L1 orthography facilitates counting, and 2) participants should be slower at counting phonemes in the mismatched H than in the mismatched NH because the associated L1 orthography hinders phoneme perception in the mismatched H. Figure 5.8 presents three observations about the L0 data comparisons. First, the MNL0 group appears to be faster at counting phonemes in all the L0 words than the RNL0 group is (as reported previously in §5.3.2). Second, both groups appear to be faster at counting phonemes in matched H than in matched NH. Finally, both groups appear to be faster at counting phonemes in mismatched H than in mismatched NH.



**Figure 5.8** Mean MNL0 and RNL0 logged RTs comparing the L0 *nonhomophones* with the cross-language *homophones* across the matched and mismatched conditions

The overall logged RT data for the L0 NH and H were analysed using *group* (MNL0, RNL0) as the between-subjects factor and *homophone* (nonhomophone, homophone) and *match* (match, mismatch) as the within-subjects factors. The main effect for *homophone* and the interaction between *homophone* and *match* were significant (homophone:  $F(1,50)=39.374, p<0.001$ ; homophone by match:  $F(1,50)=30.644, p<0.001$ ). All of the other main effects and interactions were not significant (match:  $F(1,50)=2.280$ ; group:  $F(1,50)=2.328$ ; homophone by group:  $F(1,50)=0.350$ ; match by group:  $F(1,50)=2.273$ ; homophone by match by group:  $F(1,50)=0.313$ ; all effects not significant at  $p>0.05$ ). The simple effect of *homophone* was tested for each match type separately, collapsed over *group* (since *group* did not participate in any significant interactions). These tests show

that participants were significantly faster at counting L0 mismatched H than L0 mismatched NH ( $F(1,51)=57.450, p<0.001$ ); however they were not significantly faster at counting matched H than matched NH ( $F(1,51)=2.722, p>0.05$ ).

Like the accuracy data, follow up analyses of *match* and *group* were conducted on the RT data for each homophone type separately. The results for the H data are reported in §5.4.1. For the NH data, the analyses showed a significant main effect of *match* ( $F(1,50)=18.813, p<0.001$ ), but neither the main effect of *group* nor the interaction of *match* and *group* was significant (group:  $F(1,50)=2.557$ ; match by group  $F(1,50)=2.557$ ; both effects not significant at  $p>0.05$ ). That is, both groups were as equally as fast at counting phonemes in both matched and mismatched NH; however, both groups were significantly faster at counting phonemes in matched NH than they were at counting phonemes in mismatched NH.

In sum, although Figure 5.8 suggests that the MNL0 group is faster than the RNL0 group at counting phonemes, the statistical analyses show that there was no significant difference between the two groups. In addition, the analyses show that participants are faster at counting the L0 matched and mismatched H than they are at counting in the L0 matched and mismatched NH, again suggesting a familiarity effect of L1 orthography. In addition, the RT difference was significant between the mismatched Hs and NHs but not significant between the matched Hs and NHs. Also, unlike the L1 RT results (§5.3.2), L1 orthographic knowledge does not appear to exert the same inhibitory effect for the L0 mismatched H. Rather, the results suggest that the familiarity effect outweighs any inhibitory effect such that familiarity allows listeners to respond faster with mismatched

H than mismatched NH even though they must still reconcile the letter-phoneme conflict associated with the mismatched H.

#### *5.4.3 Summary for primary research question 2*

The previous subsections have reported on the results and statistical analyses of the overall data regarding the second primary research question (Q2). Three-way repeated measures ANOVAs were conducted to analyse the effect of L1 orthography on phoneme perception in listeners' unfamiliar language (L0) in terms of accuracy rates and response times. Table 5.4 below summarises the accuracy and RT results according to the L0 matched and mismatched comparisons and the L0 NH and H comparisons. This table also indicates whether each result confirms the research hypotheses (✓) or not (✗). All differences indicated in the table are significant. The analyses of the L0 data thus far suggest three effects are potentially at play in this phoneme monitoring task. First, an L1 orthographic effect can account for why the L0 matched Hs are more accurate than the L0 mismatched Hs. Second, a familiarity effect accounts for why the L0 Hs are more accurate and faster than the NHs, regardless of match or mismatch. Finally, a word effect can account for why the L0 matched NHs are more accurate than the L0 mismatched NHs (as reported in §5.3.2). Therefore, while the results do suggest an effect of L1 orthographic knowledge, the effect of L1 orthographic knowledge interacts with the other two effects (i.e., the familiarity effect and the word effect) and this interaction mitigates the effects of L1 orthography alone such that its influence is not as strong in the L0 as it is in the L1.

questions	comparisons	results	hyp.
<b>Q2:</b> Does L1 orthographic knowledge affect how listeners count phonemes in an unfamiliar language (L0)?	L0 matched vs. mismatched H  (Figures 5.5 & 5.6)	1) RNL0 group demonstrates a greater accuracy difference between the matched and mismatched words than MNL0 group	×
		2) both groups more accurate in L0 matched H than in mismatched H	✓
		3) no RT difference between groups	✓
		4) no RT difference between L0 matched and mismatched H	×
	L0 matched NH vs. H  (Figures 5.7 & 5.8)	1) RNL0 group demonstrates a greater accuracy difference between the matched and mismatched words than RNL0 group	×
		2) matched H more accurate than matched NH	✓
		3) no RT difference between groups	✓
		4) no RT difference between matched H and NH	×
	L0 mismatched NH vs. H  (Figures 5.7 & 5.8)	5) RNL0 group demonstrates a greater accuracy difference between the matched and mismatched words than RNL0 group	×
		6) No RT difference between groups	✓
		7) mismatched H more accurate than mismatched NH	×
		8) mismatched H faster the mismatched NH	×

*L1 = first language, L0 = unfamiliar language, NH = nonhomophone, H = homophone, RT = response time, hyp. = hypotheses, ✓ = supported, × = not supported*

**Table 5.4** Summary of overall data results addressing the second primary research question, the comparisons, and the predictions

Given that the previous two sections (§5.3 and §5.4) have established that orthographic knowledge affects phoneme perception in both the native language and the unfamiliar language, albeit to a lesser extent in the L0, the next logical question is: how does orthographic knowledge affect phoneme perception in an L2 (i.e., a language that the listeners are already familiar with)? Does the strength of its influence fall somewhere between its effect on the L1 and its effect on the L0? Therefore, to investigate orthography's effect on L2 phoneme perception, the following sections report on and analyse the L2 subgroup data.

### ***5.5 Descriptive statistics for the subgroup data***

The subgroup<sup>41</sup> data were analysed to answer the third primary research question and test the research hypotheses surrounding that question. (See the subsections below for a reminder of these hypotheses.) Like the overall data, the subgroup data were also organised and analysed using 4 independent factors – *group*, *language*, *homophone*, and *match* – and 2 dependent factors – *accuracy rates* and *response times*. Table 5.5 provides the descriptive statistics for the Russian-as-a-second-language (RFL) and Mandarin-as-a-second-language (MFL) experimental subgroups' data. The table contains the mean reflected accuracy rates (RACC) and logged response times (LRT) for each group according to each experimental condition as well as the standard deviations of these mean numbers, which are given in parentheses (See §5.2 for the rationale behind the reflected accuracy and logged RTs.).

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<sup>41</sup> Recall that the RFL subgroup was part of the MNL0 overall group, and the MFL subgroup was part of the MFL overall group.

Also included in this table are the mean differences between the matched and mismatched words for each of homophone type, language, and group. Again, as with the overall data, the match-mismatch accuracy and RT differences were calculated by subtracting the mean *matched* values from the mean *mismatched* values. These calculations were conducted so that positive values would support for the research predictions and negative values would contradict the research predictions. Therefore, positive values represent higher accuracy and faster RTs for the matched words than the mismatched words, and negative values represent lower accuracy and slower RTs.

		L1		L2		L0	
group	condition	RACC (SD)	LRTs (SD)	RACC (SD)	LRTs (SD)	RACC (SD)	LRTs (SD)
RFL	NH-M	0.23 (0.27)	7.54 (0.30)	0.23 (0.21)	7.57 (0.29)	0.47 (0.16)	7.60 (0.39)
	NH-MM	0.54 (0.26)	7.93 (0.25)	0.38 (0.17)	7.79 (0.19)	0.61 (0.22)	7.72 (0.32)
	<b>difference</b>	<b>+0.31</b>	<b>+0.39</b>	<b>+0.15</b>	<b>+0.22</b>	<b>+0.14</b>	<b>+0.12</b>
	H-M	0.39 (0.22)	7.59 (0.28)	0.23 (0.30)	7.56 (0.38)	0.30 (0.23)	7.51 (0.42)
	H-MM	0.50 (0.14)	7.69 (0.32)	0.18 (0.21)	7.58 (0.29)	0.49 (0.19)	7.42 (0.39)
<b>difference</b>	<b>+0.11</b>	<b>+0.10</b>	<b>-0.05</b>	<b>+0.02</b>	<b>+0.19</b>	<b>-0.09</b>	
MFL	NH-M	0.13 (0.258)	7.59 (0.45)	0.40 (0.28)	7.56 (0.42)	0.57 (0.14)	7.81 (0.43)
	NH-MM	0.53 (0.31)	8.01 (0.49)	0.63 (0.17)	7.86 (0.50)	0.60 (0.08)	7.89 (0.46)
	<b>difference</b>	<b>+0.40</b>	<b>+0.42</b>	<b>+0.13</b>	<b>+0.30</b>	<b>+0.03</b>	<b>+0.08</b>
	H-M	0.42 (0.16)	7.61 (0.49)	0.41 (0.32)	7.46 (0.61)	0.31 (0.23)	7.78 (0.49)
	H-MM	0.50 (0.15)	7.72 (0.54)	0.42 (0.23)	7.54 (0.66)	0.36 (0.20)	7.77 (0.57)
<b>difference</b>	<b>+0.08</b>	<b>+0.11</b>	<b>+0.01</b>	<b>+0.08</b>	<b>+0.05</b>	<b>-0.01</b>	

\* response times are in milliseconds  
(SD) = standard deviation

**Table 5.5** Mean nonhomophone (NH) and homophone (H) reflected accuracy (RACC) and logged response times (LRTs) for the RFL and MFL experimental groups in the L1, L2, and L0 across the matched (M) and mismatched conditions (MM)

For example, this table indicates that for the RFL's L1 accuracy results, the mean reflected accuracy for the matched NH is 0.23 with a standard deviation of 0.27 and the mean reflected accuracy for the mismatched NH is 0.54 with a standard deviation of 0.26.

The accuracy difference between these NH matched and mismatched words is +0.31, which demonstrates higher accuracy in the matched NHs than in the mismatched NHs. Similarly, the RFL's L1 RT results are a mean logged RT for the matched NH of 7.54 with a standard deviation of 0.30 and a mean logged RT for the mismatched NH of 7.93 with a standard deviation of 0.25. The RT difference between the matched and mismatched NH is +0.39, which demonstrates faster response time in the matched NHs than in the mismatched NHs. Overall, the numbers in Table 5.5 suggest that the predictions surrounding the subgroup data are supported. The positive differences between the matched and mismatched words for the L1, L2, and L0 homophones and nonhomophones show that matched words were generally counted more accurately and faster than mismatched words (as reflected by more positive values).

As outlined in Chapter 4, both the reflected accuracy data and the logged RT data for the subgroups were analysed using a 4-factor repeated measures ANOVA with a 2 x 3 x 2 x 2 design. In this design, *group* (RFL, MFL) was the one between-subjects factor and *language* (L1, L2, L0), *homophone* (nonhomophone, homophone), and *match* (match, mismatch) were the three within-subjects factors. For the subgroup reflected accuracy data, Mauchly's test indicated the assumption of sphericity had been violated for the main effect of *language* ( $\chi^2(2)=9.355$ ,  $p<0.01$ ); therefore, the degrees of freedom were corrected using Greenhouse-Geisser estimates of sphericity ( $\epsilon=0.748$ ). The main effects for *language*, *homophone* and *match* as well as the 2-way interactions for *language* by *group*, *language* by *homophone*, *language* by *match*, and *homophone* by *match*, and the 3-way interaction of *language* by *homophone* by *match* were all significant (*language*:  $F(1.485,34.166)=6.077$ ,  $p=0.01$ ; *homophone*:  $F(1,23)=11.028$ ,  $p<0.01$ ; *match*:

$F(1,23)=24.078$ ,  $p<0.001$ ; language by group:  $F(2,46)=9.293$ ,  $p<0.001$ ; language by homophone:  $F(2,46)=15.902$ ,  $p<0.001$ ; language by match:  $F(2,46)=4.310$ ,  $p<0.05$ ; homophone by match:  $F(1,23)=22.159$ ,  $p<0.001$ ; language by homophone by match  $F(2,46)=8.617$ ,  $p<0.001$ ). All other main effects and interactions, including the 4-way interaction, were not significant (group:  $F(1,23)=1.231$ ; homophone by group:  $F(1,23)=0.085$ ; match by group:  $F(1,23)=0.024$ ; language by homophone by group:  $F(2,46)=0.1395$ ; homophone by match by group:  $F(1,23)=0.833$ ; language by homophone by match by group:  $F(2,46)=0.373$ ; all effects not significant at  $p>0.05$ ).

For the subgroup RT data, Mauchly's test indicated no violations of sphericity. The main effects for *language*, *homophone* and *match*, the 2-way interactions of *language* by *group*, *language* by *match*, and *homophone* by *match*, and the 3-way interactions of *language* by *homophone* by *match* and *language* by *homophone* by *group* were all significant (language:  $F(2,46)=4.003$ ,  $p<0.05$ ; homophone:  $F(1,23)=27.715$ ,  $p<0.001$ ; match:  $F(1,23)=40.179$ ,  $p<0.001$ ; language by group:  $F(2,36.732)=7.957$ ,  $p<0.001$ ; language by match:  $F(2,46)=21.028$ ,  $p<0.001$ ; homophone by match:  $F(1,23)=29.587$ ,  $p<0.001$ ; language by homophone by match:  $F(2,46)=3.026$ ,  $p=0.05$ ; language by homophone by group:  $F(2,46)=4.774$ ,  $p<0.05$ ). All other main effects and interactions, including the 3-way interactions and the 4-way interaction, were not significant (group:  $F(1,23)=0.361$ ; homophone by group:  $F(1,23)=0.001$ ; match by group:  $F(1,23)=0.635$ ; language by homophone:  $F(2,46)=0.662$ ; language by match by group:  $F(1,23)=0.227$ ; homophone by match by group:  $F(1,23)=0.119$ ; language by homophone by match by group:  $F(2,46)=0.664$ ; all effects not significant at  $p>0.05$ ).

### **5.6 Primary research question 3: Orthographic effect on L2 phoneme counting**

As mentioned above in §5.1, with respect to the L1–L2–L0 subgroup data, the third primary research question asks: *does L2 orthographic knowledge affect how native English speakers count phonemes in their second language (L2)?* That is, as predicted with the L1, do language learners count phonemes more accurately in L2 words with consistent L2 letter-to-phoneme correspondences than in L2 words with inconsistent L2 letter-phoneme correspondences? Subsequently, if L2 orthography does affect L2 phoneme perception, *how does L2 orthographic information interact with L1 orthographic information?* In other words, do L1 orthographic representations of L2 cross-language H also influence native speakers? Specifically, does L1 orthographic knowledge override L2 orthographic knowledge and affect phoneme perception in the L2?

With respect to the first question, specifically concerned with L2, the prediction is that listeners should employ their L2 orthographic knowledge to help them count phonemes in the nonhomophonous L2 words. (Recall that these subgroup participants were intermediate learners of either Russian or Mandarin, and they were familiar with the spelling of the L2 target words.) As with the L1 words in the overall data, this strategy should facilitate phoneme counting—both in accuracy and speed—when the L2 NH words contain consistent letter-phoneme correspondences (ex. Russian *зонт* /zont/—4 letters and 4 phonemes), but it should hinder counting when the L2 NH words have inconsistent correspondences (ex. Russian *юк* /juk/—2 letters and 3 phonemes). Therefore, significantly higher accuracy and faster RTs for the L2 matched NH than for

L2 mismatched NH would suggest that L2 orthography impacts phoneme counting in the L2.

With respect to the second question above, concerning the interaction between L1 and L2 orthographies, the prediction is not as clear. Since the research suggests that L1 orthographic knowledge is co-activated with L1 phonology (e.g., Perreman et al., 2009; Castles et al., 2008; Ziegler & Ferrand, 1998) and that the L1 affects L2 learning in a general sense (e.g., Archibald, 1998; Brown, 2000; Major, 2001, 2002), then logically, we can propose that L1 orthographic knowledge will affect L2 phoneme perception. The question is whether L1 orthographic knowledge will override L2 orthographic knowledge and affect L2 phoneme perception? Remember that in the L2 mismatched H words, the L2 spellings have consistent letter-phoneme correspondences; the mismatches are in the associated L1 homophones. If L1 orthography intrudes, listeners should count phonemes relatively accurately and quickly for L2 matched Hs because listeners tap into their L1 orthographic knowledge to help them. In contrast, listeners should count phonemes relatively inaccurately and slowly for L2 mismatched H words because again they tap into their L1 orthographic knowledge, but the inconsistent correspondences prevent the same degree of success for the mismatched H words. In addition, if L1 orthography overrides L2 orthography, L2 matched NH words (where no L1 orthographic associations exist) should be counted more accurately and faster than L2 mismatched H words (where the L1 associations contain inconsistent correspondences).

As mentioned above, the subgroup data were collected to investigate the effect of L2 orthography and the L1-L2 interaction of orthographic effects on L2 phoneme perception. Three comparisons for both the accuracy rates and the response times were conducted to

**1)** determine the effect of L2 orthography on L2 phoneme perception (the matched and mismatched NH word comparison), **2)** determine the effect of L1 orthography on L2 phoneme perception (the matched and mismatched H word comparison), and **3)** tease apart the effects of the L1 orthography and the L2 orthography on L2 phoneme perception (the matched NH and mismatched H comparison). The predictions relating to these comparisons are

**Prediction 1:**

L2 <b>matched</b> NH
>>
L2 <b>mismatched</b> NH

**Prediction 2:**

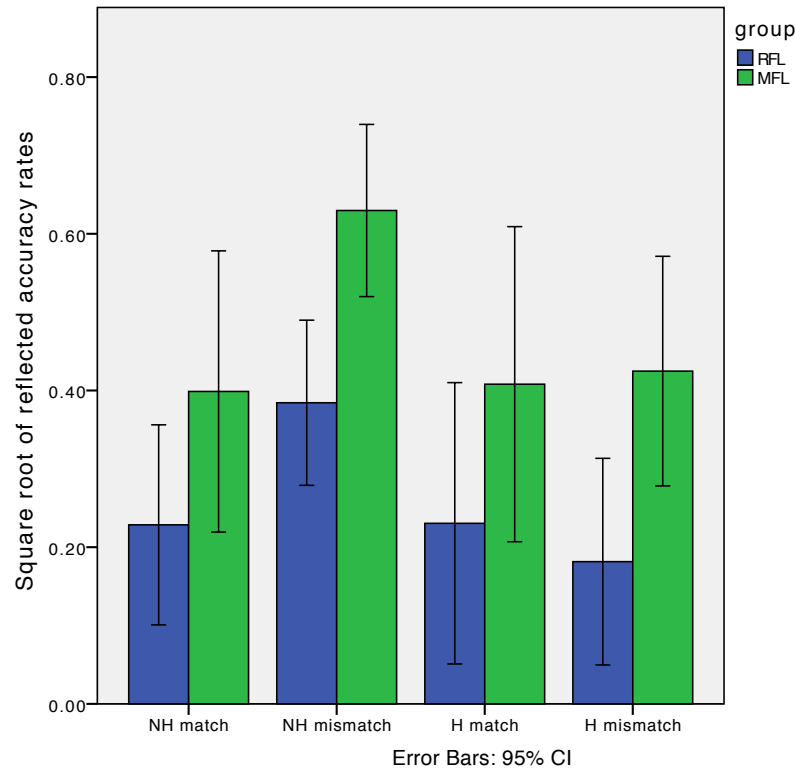
L2 <b>matched</b> H
>>
L2 <b>mismatched</b> H

**Prediction 3:**

L2 <b>matched</b> NH
>>
L2 <b>mismatched</b> H

When comparing the L2 matched and mismatched NH and H words, Figure 5.9 below shows four trends in the L2 data. First, overall, the RFL group was more accurate at counting L2 phonemes than the MFL group. Second, both groups more accurately counted phonemes in L2 matched NH words than in L2 mismatched NH words. Third, while the MFL group more accurately counted phonemes in matched H than in

mismatched H, the RFL group is more accurate at counting phonemes in the mismatched H than in the matched H. Finally, both the MFL and RFL learners count L2 phonemes in the matched NH words roughly to the same degree that they count phonemes in the mismatched H words.



**Figure 5.9** Mean square root values of reflected accuracy rates comparing the L2 matched and mismatched *nonhomophones* and *homophones*

To determine the effects L2 orthography on L2 phoneme perception and the interaction of the L1 and the L2 orthography, the accuracy rates of the subgroup L2 NH and H data were analysed using a 3-factor repeated measures ANOVA with *group* (RFL, MFL) as the one between-subjects factor and *homophone* (nonhomophone, homophone) and *match* (match, mismatch) as the within-subjects factors. The main effects of *homophone*, *match* and *group*, and the 2-way interaction of *homophone* and *match* were

significant (homophone:  $F(1,23)=5.269$ ,  $p<0.05$ ; match:  $F(1,23)=4.814$ ,  $p<0.05$ ; group:  $F(1,23)=8.395$ ,  $p<0.01$ ; homophone by match:  $F(1,23)=14.348$ ,  $p<0.001$ ). All other effects were not significant (homophone by group:  $F(1,23)=0.001$ ; match by group:  $F(1,23)=0.767$ ; homophone by match by group:  $F(1,23)=0.007$ ; not significant at  $p>0.05$ ). The effects of *match* and *group* were tested separately for each homophone type. For the NH words, the tests indicate significant main effects of *match* and *group* (match:  $F(1,23)=17.977$ ,  $p<0.001$ ; group:  $F(1,23)=8.211$ ,  $p<0.01$ ), but no significant interaction of *match* and *group* ( $F(1,23)=0.677$ ,  $p>0.05$ ). Thus, as Figure 5.9 suggests, the RFL group is significantly more accurate at counting phonemes than the MFL group in the NH words and both groups are significantly more accurate at counting phonemes in matched words than in mismatched words. For the H words, the follow-up tests indicate a significant main effect for *group* ( $F(1,23)=2.812$ ,  $p<0.05$ ), with the RFL group more accurately counting phonemes than the MFL group. Neither the main effect of *match* nor the interaction of *match* by *group* were significant (match:  $F(1,23)=0.097$ ; match by group:  $F(1,23)=0.402$ ; all effects not significant at  $p>0.05$ ), which means that the groups show the same degree of accuracy on the L2 matched and mismatched H words, suggesting L1 orthographic knowledge has no effect on phoneme counting in L2.

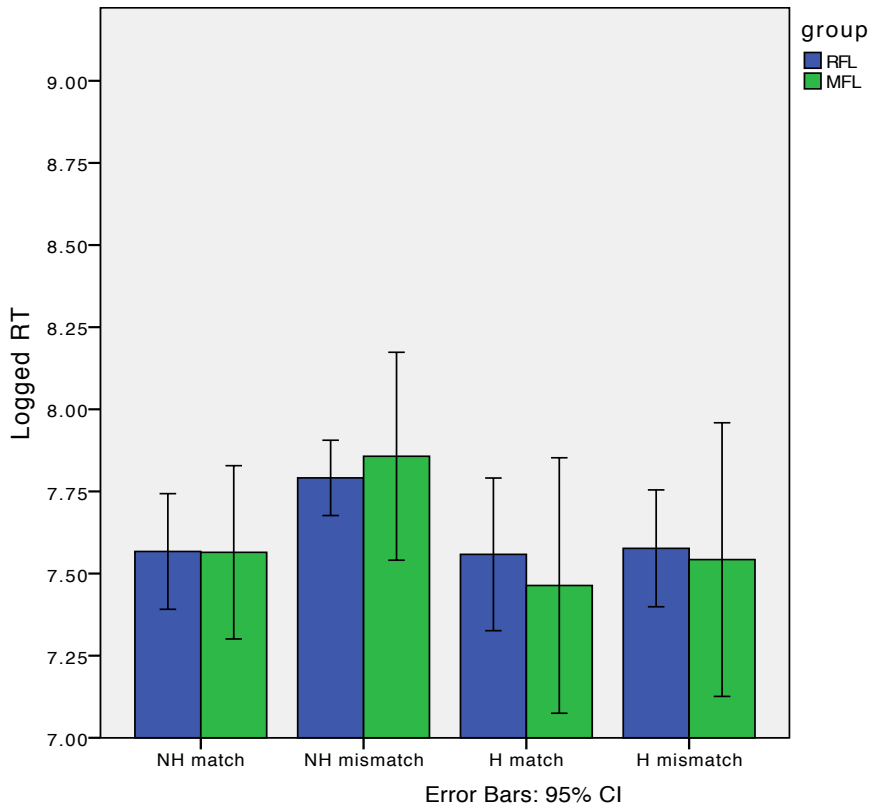
Finally, to confirm the lack of L1 effect and further test for any L1 and L2 interaction effects, an additional analysis was conducted comparing the L2 matched NH and the L2 mismatched H word data. This analysis tested the effects of *match* and *group* for the L2 matched NH words and the L2 mismatched H words. This test indicated a significant main effect of *group* ( $F(1,23)=7.089$ ,  $p<0.05$ ) such that the RFL group counted phonemes more accurately than the MFL group. However, the test indicated no

main effect for *match* or interaction of *match* and *group* (match:  $F(1,23)=0.030$ ; match by group:  $F(1,23)=0.454$ ; both effects not significant at  $p>0.05$ ) such that there was no accuracy difference between the matched NH words and the mismatched H words for either group, again suggesting that L1 orthography does not have an effect on L2 phoneme perception.

In sum, the subgroup L2 data were compared and analysed in three ways. First, the statistical analyses of the L2 matched and mismatched NH show that the RFL group is significantly more accurate at counting phonemes in Russian NH than the MFL group is at counting phonemes in Mandarin NH. This is possibly due to the linguistic nature of Russian versus Mandarin (See §6.3.2 for a discussion.). Also, the analyses show that both groups more accurately counted phonemes in L2 matched NH than in L2 mismatched NH, suggesting that L2 orthographic knowledge was present in the auditory phoneme counting task and influenced L2 phoneme perception and counting. Second, the statistical analyses of the L2 matched and mismatched H comparisons show that while the RFL learners counted phonemes more accurately overall than the MFL learners, neither group was more accurate at counting phonemes in the matched H than in the mismatched H. Since the mismatches in the mismatched H were always in the L1 associations and the L2 orthographic spellings of the mismatched H were always consistent, these results suggest that the L1 orthography does NOT negatively impact L2 phoneme perception (as previously predicted). These results are supported by the third and final comparison, which show no significant difference between the matched NH words and the mismatched H words. These results further suggest that L1 orthography does not negatively affect L2 phoneme perception. The combination of a) the matched and

mismatched NH results, b) the matched and mismatched H results, and c) the matched NH and mismatched H results suggest that L1 orthography does not have as strong an impact on L2 phoneme perception as L2 orthography does at the intermediate stage of L2 learning. In fact, L2 orthographic knowledge appears to override entrenched L1 orthographic knowledge for both RFL and MFL learners. On the other hand, the fact that participants counted mismatched H as accurately as matched NH suggest that familiarity has a positive impact on L2 phoneme perception, so L1 DOES have an effect, just not an orthographic one.

As with first two research questions, RTs provide an additional opportunity to investigate the effects of L1 and L2 orthography on L2 phoneme perception. Figure 5.10 shows four trends in the L2 logged RT data. First, the RFL group appears faster at counting phonemes in NH words than the MFL group. Second, for both groups, the matched NH words were counted faster than the mismatched NH words. Third, there are no apparent RT differences between the RFL and MFL groups or between the L2 matched and mismatched H words. Finally, the figure shows no apparent RT difference between the matched NH words and the mismatched H for either group.



**Figure 5.10** Mean RFL and MFL response times comparing the L2 matched and mismatched *nonhomophones* and *homophones*

To further determine the effects of L1 and/or L2 orthography on L2 phoneme perception, the logged RTs of the subgroup L2 NH data were analysed using a 3-factor repeated measures ANOVA with *group* (RFL, MFL) as the one between-subjects factor and *homophone* (nonhomophone, homophone) and *match* (match, mismatch) as the within-subjects factors. The main effects of *homophone* and *match* as well as the interaction of *homophone* and *match* were significant (homophone:  $F(1,23)=15.054$ ,  $p<0.001$ ; match:  $F(1,23)=18.929$ ,  $p<0.001$ ; homophone by match:  $F(1,23)=8.736$ ,  $p<0.01$ ). All other effects were not significant (group:  $F(1,23)=0.010$ ; homophone by group:  $F(1,23)=1.362$ ; match by group:  $F(1,23)=0.838$ ; homophone by match by group:  $F(1,23)=0.003$ ; effects not significant at  $p>0.05$ ). Tests for the effects of *match* for each

homophone type separately, collapsed over *group*, indicate a significant effect of *match* for NH words, with participants counting phonemes faster in matched NH than in mismatched NH ( $F(1,23)=34.613, p<0.001$ ), but the effect was not significant for the H words ( $F(1,23)=0.755, p>0.05$ ). Like the accuracy data, the effects of *match*, collapsed over *group*, on the matched NH data and mismatched H data were conducted to tease apart the effects of the L1 and L2 orthographies. This analysis indicates no significant effect of *match* ( $F(1,23)=0.016, p>0.05$ ) such that neither match type was significantly faster than the other.

In sum, these RT analyses indicate that neither group counted phonemes faster in their L2 than the other group. The analyses also indicate that both groups count phonemes faster in L2 matched NH than in L2 mismatched NH. In contrast, the analyses show 1) no significant RT difference between the matched H and the mismatched H words, and 2) no significant RT difference between the matched NH and mismatched H words. These results parallel and support the accuracy rate results. They suggest that L2 orthographic knowledge is present in an auditory phoneme counting task and influences L2 phoneme perception and counting more so than L1 orthographic knowledge does. However, unlike the accuracy results, there was no group effect. In other words, the RFL group was neither faster nor slower than the MFL group at counting L2 phonemes.

This section has reported on the results and statistical analyses of the subgroup data regarding the third primary research question (Q3). Three-way repeated measures ANOVAs were conducted to analyse the effect of both the L2 and L1 orthography on phoneme perception in listeners' second language (L2) in terms of accuracy and RT. Table 5.6 summarises the accuracy and RT results according to the L2 matched and

mismatched NH comparisons, and L2 matched and mismatched H comparisons. This table also indicates whether each result confirms the research hypotheses (✓) or not (✗). All differences indicated in the table are significant. In short, the results from the three L2 comparisons suggest that not only does L2 orthographic knowledge influence L2 phoneme perception (L2 matched > mismatched NH) but it also overrides any potential L1 orthographic effect (L2 matched H = L2 mismatched H and L2 matched NH = L2 mismatched NH).

question	comparisons	results	hyp.
<b>Q3a:</b> Does L2 orthographic knowledge affect how listeners count phonemes in their second language (L2)?	L2 matched vs. mismatched NH  (Figures. 5.9 & 5.10)	1) RFL group more accurate than MFL group	×
		2) L2 matched NH counted more accurately than L2 mismatched NH	✓
		3) no RT difference between the RFL and MFL groups	✓
		4) L2 matched NH counted faster than L2 mismatched NH	✓
<b>Q3b:</b> If so, how does L2 orthographic knowledge interact with L1 orthographic knowledge?	L2 matched vs. mismatched H  (Figures. 5.9 & 5.10)	1) RFL group more accurate than MFL group	×
		2) no accuracy difference between matched and mismatched H	×
		3) no RT difference between groups	✓
		4) no RT difference between matched and mismatched H	×
	L2 matched NH vs. L2 mismatched H  (Figures. 5.9 & 5.10)	1) RFL group more accurate than MFL group	×
		2) no accuracy difference between matched NH and mismatched H	×
		3) no RT difference between groups	✓
		4) no RT difference between matched NH and mismatched H	×

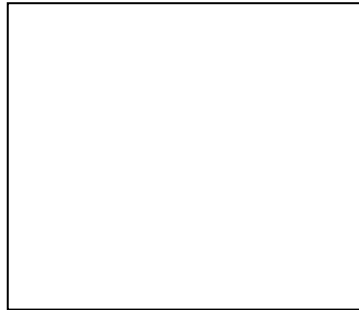
*L1 = first language, L2 = second language, L0 = unfamiliar language, NH = nonhomophone, H = homophone, RT = response time, hyp. = hypotheses, ✓ = supported, × = not supported, n/a = no hypothesis predicted*

**Table 5.6** Summary of subgroup data results addressing the third primary research question, the comparisons, and the predictions

#### **5.7 Primary research question 4: strength of orthographic effect**

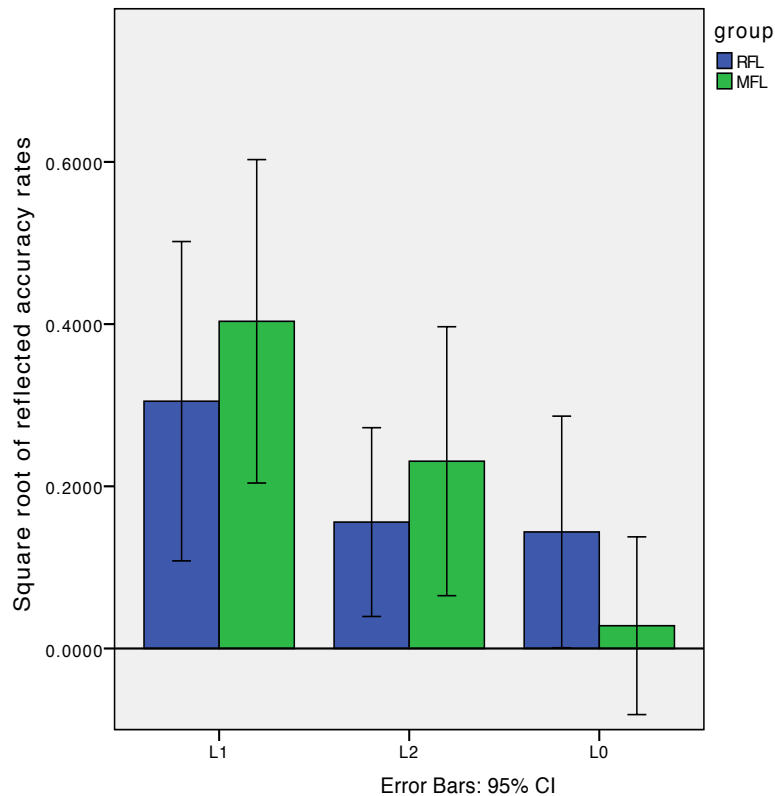
Considering the previous results suggest that L1 orthography affects L1 phoneme perception (§5.3) and L2 orthography affects L2 phoneme perception (§5.6), the next logical question is: does the strength of the orthographic effect vary depending on experience with the language? The hypothesis here predicts that the difference between the matched and mismatched L1 NH would be greater than the difference between the matched and mismatched L2 NH, which in turn would be greater than the difference between the matched and mismatched L0 NH. That is,

**Prediction:**



As native English speakers, the participants have many more years of experience with English than they do with their L2. Thus, the L1 orthography is more entrenched and should exert more influence on L1 perception than the L2 orthography does on L2 perception. The mean reflected accuracy and logged RT differences were calculated by subtracting the matched value from the mismatched value for each condition. **Positive** values indicate higher accuracy rates and faster RTs in the matched conditions than in the mismatched conditions, and **negative** values indicate lower accuracy and faster RTs in the matched conditions than in the mismatched conditions. (See Table 5.5 for a summary of the mean reflected accuracy and logged RT differences for each homophone type and across each language.)

Figure 5.11 represents the match-mismatch accuracy differences for the RFL and MFL groups across each language (i.e., L1, L2, and L0). In this figure, all mean reflected accuracy differences have positive values, indicating higher accuracy in the matched NHs than in the mismatched NHs. This figure also shows that the degree and pattern of the RFL group's differences appear to diverge from the MFL group's differences. That is, while both groups exhibit a greater difference between the matched and mismatched NH in the L1 than in the L2 and L0, the RFL group appears to exhibit the same degree of difference in the L2 and L0. In contrast, the MFL group appears to exhibit the predicted pattern of L1 difference > L2 difference > L0 difference.

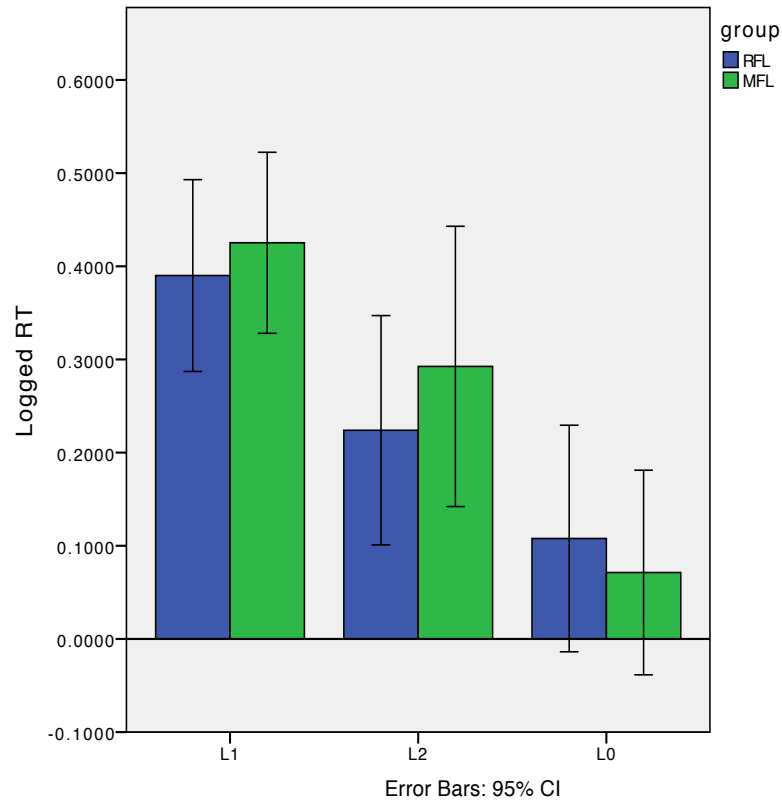


**Figure 5.11** Mean square root values of the reflected accuracy rates comparing the match-mismatch differences between the L1, L2 and L0 nonhomophones for the RFL and MFL groups

The reflected accuracy differences between the matched and mismatched NH were analysed using a 2-factor repeated measures ANOVA with *group* (RFL, MFL) as a between-subjects factor and *language* (L1, L2, L0) as a within-subjects factor. Mauchly's test indicated no violations of the assumption of sphericity. The main effect of *language* was significant ( $F(2,46)=11.552, p<0.005$ ), but neither the effect of *group* nor the interaction of *language* and *group* was significant (group:  $F(1,23)=0.085$ ; language by group:  $F(2,46)=1.841$ ; all effects not significant at  $p>0.05$ ). Subsequent analyses, collapsed over *group*, indicated that the L1 difference was significantly greater than both the L2 difference ( $F(1,24)=6.433, p<0.05$ ) and the L0 difference ( $F(1,24)=10.825, p<0.005$ ), but the L2 difference was not significantly greater than the L0 difference ( $F(1,24)=2.924, p>0.05$ ).

With respect to the match-mismatch RT differences, Figure 5.12 reflects the pattern predicted by the hypothesis, namely that the L1 differences would be greater than the L2 differences, which in turn, would be greater than the L0 differences. In this figure, the positive values indicate that participants responded faster for the matched NHs than for the mismatched NHs. This figure also shows that the MFL group appears to have greater match-mismatch differences for each language than the RFL group does. These RT differences between the matched and mismatched NH were analysed using a 2-factor repeated measures ANOVA with *group* (RFL, MFL) as a between-subjects factor and *language* (L1, L2, L0) as a within-subjects factor. The main effect of *language* was significant ( $F(2,46)=46.144, p<0.001$ ), but neither the effect for *group* nor the interaction of *language* and *group* was significant (group:  $F(1,23)=0.215$ ; language and group:  $F(2,46)=0.586$ ; not significant at  $p>0.05$ ). Follow up tests, collapsed over *group*, indicate

that the match-mismatch L1 RT difference is significantly greater than the L2 difference ( $F(1,24)=11.961, p<0.01$ ) and the L0 difference ( $F(1,24)=46.606, p<0.001$ ). In addition, the L2 difference is greater than the L0 difference ( $F(1,24)=7.311, p<0.05$ ).



**Figure 5.12** Mean logged RT comparing the match-mismatch differences between the L1, L2 and L0 *nonhomophones* for the RFL and MFL groups

In sum, the statistical analyses for the L1, L2, and L0 NH differences indicate that while both Figure 5.11 and Figure 5.12 suggest differences between the RFL group and MFL group overall, there is, in fact, no statistically significant difference between them. Moreover, the analyses of accuracy do not completely reflect the hypothesised pattern of differences. In fact, the analyses indicate that the L1 accuracy difference is greater than the L2 difference, but that the L2 accuracy difference is not greater than the L0 difference. Conversely, the analyses of RTs do reflect the hypothesised pattern.

Specifically, the RT analyses indicate that the L1 RT difference is greater than the L2 difference, and the L2 RT difference is greater than the L0 difference. These results and analyses suggest that the L1 orthographic effect is stronger in the L1 than the L2 orthographic effect is in the L2. In fact, the L2 orthography appears weaker than the L1 orthography at this stage of L2 learning as evidenced by the lack of a significant difference between the L2 and L0 in accuracy rates, but the presence of a significant difference between the L2 and the L0 in RTs.

question	comparisons	results	hyp.
<p><b>Q4:</b> Does the strength of the orthographic effect vary depending on experience with the language?</p>	<p>match-mismatch differences for the L1, L2, and L0 NH  (Figures 5.11 &amp; 5.12)</p>	<p>1) L1 accuracy difference greater than both L2 and L0  2) L2 accuracy difference not greater than L0  3) L1 RT difference greater than L2, which is greater than L0</p>	<p>✓  ×  ✓</p>

*L1 = first language, L2 = second language, L0 = unfamiliar language, NH = nonhomophone, H = homophone, RT = response time, hyp. = hypotheses, ✓ = supported, × = not supported, n/a = no hypothesis predicted*

**Table 5.7** Summary of subgroup data results addressing the third primary research question, the comparisons, and the predictions

## 5.8 General summary

This chapter has presented and analysed the primary data collected in this research. The data were analysed according to reflected accuracy rates and logged RTs in order to investigate the effects of orthographic knowledge on phoneme perception in listeners' first language, second language, and unfamiliar language. To determine this effect, 4-way repeated measures ANOVAs analysed the data along four independent factors (group, language, homophone, and match) to answer four primary research questions:

1. Does L1 orthographic knowledge affect how native English speakers count phonemes in their first language (L1)?
2. Does L1 orthographic knowledge affect how native English speakers count phonemes in an unfamiliar language (L0)?
3. Does L2 orthographic knowledge affect how native English speakers count phonemes in their second language (L2), and if so how does L2 orthography interact with L1 orthography?
4. Does the strength of the orthographic effect vary depending on language experience?

The results of the analyses overall confirm the hypotheses that L1 orthographic knowledge influences both L1 and L0 phoneme perception and that L2 orthographic knowledge influences L2 phoneme perception. Specifically, for L1 phoneme perception, L1 orthography has a *facilitative* effect on accuracy such that L1 orthographic knowledge helps listeners count phonemes when the words have consistent (one-to-one) letter-phoneme correspondences. In addition, L1 orthography has both a facilitative *and* inhibitory effect on RTs such that the L1 orthography allows participants to count

consistent L1 words faster than inconsistent L1 words and prevents them from counting phonemes in inconsistent L1 words as fast as they count phonemes in unknown L0 words. For L2 phoneme perception, the results show that not only does L2 orthographic knowledge influence L2 phoneme perception, but it also overrides any potential L1 orthographic effect.

However, the analyses also indicated that the picture is much more complex than simple orthographic interference. In fact, and perhaps not so surprisingly, the results show that the orthographic effect interacts with at least three other effects – 1) familiarity, 2) word, and 3) experience – to influence phoneme perception. First, familiarity allows listeners to count phonemes in L0 words that are homophonous with L1 words more accurately and faster than in L0 words that are *not* homophonous with L1 words even if the H words are mismatched. Second, a word effect (i.e., an unanticipated difference between the L0 matched and mismatched NH) makes counting L0 matched NHs more accurate than the L0 mismatched NHs. These first two effects attenuate the effects of L1 orthography such that its influence does not appear as strong in the L0 as it is in the L1. Third, L1, L2, and L0 differences between the matched and mismatched conditions suggest that the orthographic effect is directly related to the amount of experience the listeners have with the target language. That is, the orthographic effect is the strongest for the L1 (the most experience), followed by the L2, and then the L0 (the least experience).

Finally, the results and analyses reported on in this chapter point towards two major findings surrounding the effect of orthographic knowledge.

1. *Orthographic knowledge facilitates and hinders phoneme perception in both native and nonnative languages*, which explains why the matched words were counted more accurately and faster than the mismatched words, and
2. *The effect of orthographic knowledge appears to be language specific*, which explains why L2 orthography has a greater influence over L2 perception than L1 orthography has over L2 perception.

These two effects and findings (as well as the other interesting findings) are explored and discussed at length in the next chapter, Chapter 6.

## Chapter Six

### DISCUSSION

*“The visual forms of words acquired from reading experiences serve to shape learners’ conceptualizations of the phoneme segments in those words.”  
(Ehri, 1985, p. 342)*

The previous chapter has reported on and analysed the overall and subgroup data according to the four primary research questions, which were designed to ascertain the effect of orthographic knowledge on phoneme perception. Many interesting findings and subsequent questions have come to the fore in light of the data analyses. This chapter discusses each of these findings and questions in depth. To facilitate the discussion, this chapter is divided into three major sections. The first section (§6.1) provides an overview of the research project itself and the results—including the experimental groups, the experimental task, research questions, hypotheses, rationales supporting the hypotheses, and the results. The second section is the General Discussion of orthographic effects with reference to phoneme awareness (§6.2.1), language-specificity (§6.2.2), the Bipartite Model of Orthographic Knowledge and Transfer (§6.2.3), and experience-dependency (§6.2.4). The third section (§6.3) discusses three unanticipated (albeit very interesting) results stemming from the research, including familiarity and word effects (§6.3.1), phonological effects (§6.3.2), and mismatch subcategory effects (§6.3.3). The fourth section (§6.4) explores the phonemicisation of the diphthongs. Finally, the fifth section (§6.5) concludes the chapter by summarising the main findings and discussions.

### 6.1 Research overview

As outlined and discussed in Chapter 2, previous research suggests that alphabetic literacy is the foundation upon which phoneme awareness rests (e.g., Carroll, 2004; Cheung, 2004; Cheung & Chen, 1999; Ehri, 1985) and speech processing is not independent of written language (Ziegler & Ferrand, 1998). Therefore, this project contributes to the body of research on orthographic influence by determining and investigating how orthographic knowledge affects phoneme detection not only in a first language (L1) but also in a second language (L2) and an unfamiliar language (L0). For this project, each set of stimuli was created and organised according to two parameters: *match* and *homophony*. That is, within each language, the stimuli set had four types of words:

- 1) M-NH – nonhomophonous words with consistent letter-phoneme correspondences (e.g., *big* /bɪg/, *ɔ̄yu* /duʃ/, and *huā* /xwa/),
- 2) MM-NH – nonhomophonous words with inconsistent correspondences (e.g., *fish* /fɪʃ/, *ɲɔ* /juk/, and *yòng* /jɔŋ/)
- 3) M-H – cross-language homophonous words with consistent L1 and L2/L0 associations (e.g., *brat* /bræt/–*ōpam* /brat/ and *bow* /baw/–*bào* /paw/), and
- 4) MM-H – cross-language homophonous words with inconsistent L1 (but not L2/L0) associations (e.g., *tree* /ti/–*mpu* /tri/ and *rue* /ru/–*rú* /zu/).

The assumption here was that accuracy and response time differences between matched and mismatched words, as well as between homophones and nonhomophones, would indicate an effect of orthographic knowledge on phoneme perception.

In this research, 52 native speakers of Canadian English counted phonemes in words from their L1 (English) and an L0 (either Russian or Mandarin). The MNL0 group counted phonemes in English (L1) and Mandarin (L0) words while the RNL0 group counted phonemes in English (L1) and Russian (L0) words. In addition, two subgroups of participants also counted phonemes in their L2. The L2 for the subgroup within the MNL0 was Russian (the RFL subgroup), and the L2 for the subgroup within the RNL0 was Mandarin (the MFL subgroup). Via a phoneme counting task, which assesses the influence of orthographic factors and measures phoneme awareness (Treiman & Cassar, 1997), the participants listened to the target stimuli and counted the number of “sounds” they heard in the each word.

The data were analysed according to accuracy rates and response times in order to investigate the effects of orthographic knowledge on L1, L2, and L0 phoneme perception. Four-factor repeated measures ANOVAs analysed the data along four independent factors (*group*, *language*, *homophone*, and *match*) to answer four primary research questions designed to investigate the orthographic effects (See Table 6.1 for a review.). Overall, the results of the analyses show that L1 orthographic knowledge influences both L1 and L0 phoneme perception and that L2 orthographic knowledge influences L2 phoneme perception. Specifically, L1 orthography has a *facilitative* effect on accuracy in L1 phoneme perception and both a *facilitative* and *inhibitory* effect on response times in L1 phoneme perception. For L2 phoneme perception, the results show that L2

orthographic knowledge influences L2 phoneme perception, and it overrides any potential L1 orthographic effect. These L2 results suggest that orthographic effects are language-specific and experience-dependent. In terms of L0 phoneme perception, the results suggest that orthographic knowledge interacts with familiarity, the words themselves, and language experience. The interaction of these effects reduces the effects of L1 orthography such that its influence is not as strong in the L0 as it is in the L1.

As a reminder, Table 6.1 summarises the four primary research questions, their predictions, the rationales behind the predictions, and the results (✓ indicates results that support the predictions, and where the predictions are not supported, the results are provided.). For example, with respect to the L1 consistent and inconsistent<sup>42</sup> words (column 2, row 1), the hypothesis predicts that matched words should be counted more accurately and faster than the mismatched words because L1 orthography helps listeners perceive and segment phonemes in consistent words but misdirects listeners in inconsistent words. As indicated by the “✓”, both the accuracy rates and response times support the L1 predictions. In contrast, with respect to the L2 matched and mismatched H, the hypothesis predicts that L2 matched H should be counted more accurately and faster than mismatched H (column 2, row 9) because L1 orthography would interfere and affect how many phonemes are perceived. The table indicates that this prediction is not supported; the results, in fact, show no difference between the L2 matched and mismatched H words. The subsequent sections address and discuss the effects of orthography and other observed effects in more depth.

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<sup>42</sup> Recall that consistent words (i.e., matched) words refer to words **with** one-to-one letter-phoneme correspondences while inconsistent words (i.e., mismatched) words refer to words **without** one-to-one letter-phoneme correspondences.

questions	rationale	predictions	results	
<b>Q1:</b> Does L1 orthographic knowledge affect how listeners count phonemes in their first language (L1)?	- L1 orthography <i>facilitates</i> L1 phoneme perception in matched words but <i>hinders</i> in mismatched words	2) L1 matched words <i>more</i> accurate than L1 mismatched words 3) L1 matched words <i>faster</i> than L1 mismatched words	✓ ✓	
	- L1 orthography <i>facilitates</i> L1 phoneme perception in L1 matched NH and does <i>not</i> affect L0 phoneme perception in L0 matched NH because spelling is unknown	4) matched L1 NH <i>more</i> accurate than matched L0 NH 5) matched L1 NH <i>faster</i> than matched L0 NH	✓ ✓	
	- L1 orthography <i>hinders</i> L1 phoneme perception in L1 mismatched NH and does <i>not</i> affect L0 phoneme perception in L0 mismatched NH because spelling is unknown	6) L1 mismatched NH <i>less</i> accurate than L0 mismatched NH 7) L1 mismatched NH <i>slower</i> than L0 mismatched NH	L1 NH = L0 NH ✓	
	- L1 orthography does not affect L1 phoneme perception when spelling is NOT known	8) no accuracy difference between L0 matched and mismatched NH 9) no RT difference between L0 matched and mismatched NH	M-NH >> MM-NH M-NH >> MM-NH	
	<b>Q2:</b> Does L1 orthographic knowledge affect how listeners count phonemes in an unfamiliar language (L0)?	- L1 orthography <i>facilitates</i> L0 phoneme perception in matched H but <i>hinders</i> in mismatched H	2) L0 matched H <i>more</i> accurate than L0 mismatched H 3) L0 matched H <i>faster</i> than L0 mismatched H	✓ M-H = MM-H
		- L1 orthography <i>facilitates</i> L0 phoneme perception in matched H but does not affect matched NH because spelling is unknown	3) L0 matched H <i>more</i> accurate than matched L0 NH 4) L0 matched H <i>faster</i> than matched L0 NH	✓ MM-H = M-NH
		- L1 orthography <i>hinders</i> L0 phoneme perception in mismatched H but does not affect mismatched NH because spelling is unknown	5) L0 mismatched H <i>less</i> accurate than mismatched NH 6) L0 mismatched H <i>slower</i> than mismatched NH	MM-H >> MM-NH MM-H >> MM-NH

**Table 6.1** Primary research questions, predictions, and results revisited

<b>Q3a:</b> Does L2 orthographic knowledge affect how listeners count phonemes in their second language (L2)?	- L2 orthography <i>facilitates</i> L2 phoneme perception in matched NH but <i>hinders</i> in mismatched NH	2) L2 matched NH <i>more</i> accurate than L2 mismatched NH 3) L2 matched NH <i>faster</i> than mismatched NH	✓ ✓
<b>Q3b:</b> If so, how does L2 orthographic knowledge interact with L1 orthographic knowledge?	- L1 orthographic knowledge <i>hinders</i> L2 phoneme perception because it overrides L2 orthographic knowledge - L1 orthography <i>facilitates</i> L2 phoneme perception in L2 words with matched L1 associations but <i>hinders</i> in L2 words with mismatched L1 associations	1) matched H <i>more</i> accurate than mismatched H 2) matched H <i>faster</i> than mismatched H ----- 3) L2 matched NH <i>more</i> accurate than L2 mismatched H 4) L2 matched NH <i>faster</i> than L2 mismatched H	M-H = MM-NH M-H = MM-NH ----- M-NH = MM-H M-NH = MM-H
<b>Q4:</b> Does the strength of the orthographic effect vary depending on the language experience?	- greater language experience results in greater differences between matched and mismatched words	1) L1 NH <i>greater</i> accuracy and RT differences than L2 NH, and L2 NH <i>greater</i> accuracy and RT differences than L0 NH	A: L1 > L2 = L0 RT: ✓

*L1 = first language, L0 = unfamiliar language, L2 = second language, NH = nonhomophone, H = homophone, M = match, MM = mismatch, RT = response time, A = accuracy*

**Table 6.1** Continued ...

## **6.2 General Discussion**

The following subsections discuss in depth the effects of orthography as suggested by the results. The first section discusses the overall orthographic effects on phoneme perception in all three languages, the L1, L2, and L0 (§6.2.1); the second section focuses on the language-specific aspect of orthographic effects (§6.2.2). Next, to account for the language-specific effect and other previous findings, the third subsection proposes the Bipartite Model of Orthographic Knowledge and Transfer (§6.2.3). Finally, the fourth section (§6.2.4) discusses how language experience affects the influence of orthographic knowledge.

### *6.2.1 Orthographic knowledge's influences on phoneme perception*

The first step of this research project was to confirm—as claimed by previous research (e.g., Burnham, 2003; Castles et al., 2003; Ehri & Wilce, 1980; Perin, 1983; Pytlyk, to appear; Treiman & Cassar, 1997)—that L1 orthography influences listeners' abilities to perceive L1 phonemes. This part of the research analysed the overall data from native Canadian English-speaking participants who counted phonemes in English words with consistent letter-phoneme correspondences (e.g., *run* /ɹʌn/ has 3 letters and 3 phonemes) and with inconsistent letter-phoneme correspondences (e.g., *truth* /truθ/ has 5 letters and only 4 phonemes). Indeed, the results confirm that participants' orthographic knowledge interferes with their phoneme awareness of words: the statistical analyses indicate that the participants were significantly more accurate and faster at counting phonemes with consistent words than with inconsistent words (given in (1) below):<sup>43</sup>

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<sup>43</sup> Henceforth, all discussed comparisons and differences are statistically significant unless otherwise indicated.

(1) L1 M-NH and M-H >> L1 MM-NH and MM-H.

In general, these L1 findings suggest that L1 orthography influences speech perception in L1 such that it *facilitates* phoneme counting when the words contain consistent letter-phoneme correspondences but *hinders* phoneme counting when the words contain inconsistent correspondences, although see the discussion below for further details. In other words, because listeners receive conflicting orthographic and phonetic information, inconsistent letter-phoneme correspondences inhibit speech processing, which results in lower accuracy rates and longer processing times (e.g., Glushko, 1979; Jared et al., 1990; Lacruz & Folk, 2004; Stone et al., 1997; Ziegler et al., 2004).

When comparing the L1 NH (i.e., nonhomophone) data with the L0 NH data, we gain even more insight into the effects of L1 orthography on phoneme perception. First, in terms of accuracy, recall the L1 matched NH words were counted more accurately than not only the L1 mismatched NH but also the L0 matched and mismatched NH (as expected). However, the L1 mismatched NH words were counted as accurately as the L0 mismatched NH (not as expected). In short, we can represent the results as:

(2) L1 M-NH >> L0 M-NH >> L1 MM-NH = L0 MM-NH.

This suggests that, in terms of accuracy, L1 orthography actually has a *facilitative* effect but not an inhibitory one on accuracy. That is, the lack of accuracy differences between the L1 mismatched NHs and the L0 NHs suggest that L1 orthography does not hinder counting any more than not knowing the language does. If orthography did hinder counting, we would expect listeners to more accurately count phonemes in the L0 NHs than in the L1 mismatched NHs.

In addition, the analyses comparing L0 H data indicate that both groups were significantly more accurate with the L0 matched H words than with the mismatched H words, as given below in (3).

(3) L0 M-H >> L0 MM-H

The accuracy rates results suggest that L1 orthographic knowledge is also a factor in L0 phoneme perception. Specifically, the L1 orthography facilitates phoneme perception in L0 words when they are homophonous with L1 words that have consistent correspondences but hinders perception when the L0 are homophonous with L1 words that have inconsistent correspondences. In short, participants appear to employ the L1 orthography to help them count phonemes in the L0, a strategy that helps with counting phonemes in matched words but not with mismatched words.

In terms of speed, while the phonemes in the L1 matched NH were counted faster than the L1 mismatched NH and all the L0 NH (as with the accuracy rates), the L1 mismatched NH were counted slower than the L0 NH. Compare the representation in (2) with the following one in (4).

(4) L1 M-NH >> L0 M-NH = L0 MM-NH >> L1 MM-NH.

These RT results suggest that L1 orthography has both a facilitative *and* inhibitory effect with respect to counting *speed* as the L1 orthography allowed participants to count matched L1 NH faster than the matched and mismatched L0 NH but made them count the mismatched L1 NH slower than the L0 NH words. The response time data here do not show the same facilitative effect of L1 orthography as with accuracy (given in (2) above). In fact, the analyses show no significant differences exist either between the MNL0 and RNL0 groups or between the L0 matched and mismatched H words.

While previous research has established—rather convincingly—that L1 orthographic knowledge exerts an unavoidable influence on L1 phonology, little research has investigated the effect of orthography on nonnative language phoneme awareness—both unfamiliar (L0) and familiar (L2) nonnative languages. After investigating the effects of orthographic knowledge on L0, this research also investigated what effect orthography exerts on phoneme awareness in the listeners' second language. Does L2 orthography affect L2 phoneme awareness? This part of the research analysed L2 nonhomophone word data (i.e., the L2 words without L1 orthographic associations) from two subgroups of participants. One subgroup contained L2 learners of Russian (RFL) who counted phonemes in Russian words with consistent letter-phoneme correspondences (e.g., *друк* /druk/ has 4 letters and 4 phonemes) and with inconsistent letter-phoneme correspondences (e.g., *кровь* /krofi/ has 5 letters but only 4 phonemes). The other subgroup contained L2 learners of Mandarin (MFL) who counted phonemes in Mandarin words with consistent letter-phoneme correspondences (e.g., *huān* /xwan/ has 4 letters and 4 phonemes) and with inconsistent letter-phoneme correspondences (e.g., *shūo* /ʃwɔ/ has 4 letters but only 3 phonemes).

The analyses of the subgroup data suggest that L2 orthographic knowledge does influence L2 phoneme perception. That is, the analyses show that both groups more accurately count phonemes in L2 matched NH than in L2 mismatched NH. In addition, the analyses indicate that both groups count phonemes faster in L2 matched NH than in L2 mismatched NH. That is, for both accuracy and RTs,

(5) L2 M-NH >> L2 MM-NH.

These results suggest that L2 orthographic knowledge is a contributing factor for performance in an auditory phoneme counting task: as with the effect of L1 orthography on L1 words, L2 orthography facilitates L2 phoneme perception and counting in L2 words with consistent letter-phoneme correspondences and hinders L2 phoneme perception and counting in L2 words with inconsistent correspondences.

As this research employed a strictly auditory task, these L1 and L2 results support other findings on letter-phoneme inconsistencies. Previous research has shown that even in absence of visual stimulation, orthographic knowledge influences auditory processing (Ziegler & Ferrand, 1998; Ziegler et al., 2003; Ziegler et al., 2004). The current findings support the theory that orthographic knowledge is co-activated with auditory information, and once it is activated, orthographic knowledge influences how and what phonemes are perceived even when visual stimulation is absent (Blau et al., 2008; Chéreau et al., 2007; Taft et al., 2008). Because “the orthographic code cannot be suppressed even when it hinders performance” (Perin, 1983, p. 138), orthographic interference is unavoidable (e.g., Burnham, 2003; Treiman & Cassar, 1997). Dijkstra et al. (1995) propose that when completing phoneme-monitoring tasks such as phoneme detection, listeners may keep both the orthographic representation and the phonological representation in mind even if it is detrimental to performance. In fact, the automatic co-activation makes separating orthographic knowledge and phonological representation virtually impossible (Treiman & Cassar, 1997), and as a result, individuals are more “susceptible to unwanted interference” from the orthographic code (Landerl et al., 1996, p.12), and have “difficulty focusing on phonemes and ignoring the letters” (Gombert, 1996, p. 262). The L1 results in this current research confirm that individuals are susceptible to interference from their

L1 orthographic code, and more importantly, the L2 results demonstrate that individuals are also susceptible to interference from their L2 orthographic code.

This research has demonstrated that due to pervasiveness of orthographic interference, orthographic knowledge facilitates phoneme perception in words with consistent letter-phoneme correspondences but hinders phoneme perception in words with inconsistent correspondences. One possible explanation for why L1 and L2 orthographic knowledge both facilitates and hinders phoneme perception may lie in the assumptions listeners make about the relationship between letters and phonemes. Recall that two or more single letters that are used to represent individual phonemes (e.g., <s> and <h>) are sometimes combined (e.g., <sh>) to represent a different phoneme (e.g., /ʃ/). In general, speakers of languages with alphabetic representations function under the assumption that one letter represents one phoneme and “take for granted that letters correspond to individual phonemes” (Cook, 2004; p. 8). Therefore, in situations where the number of letters does not match the number of phonemes in a word, listeners are faced with conflicting information (orthographic and phonetic), and they must reconcile their underlying assumption about the relationship between letters and phonemes with the phonetic information they hear. To do this, listeners must spend extra cognitive resources reconciling the letter-phoneme contradictions, and trying to reconcile these contradictions results in processing difficulties which, in turn, results in lower accuracy rates and longer processing times. In contrast, when the number of letters equals the number of phonemes, listeners do not receive any conflicting information and as such are extremely accurate at counting phonemes. In fact, the orthographic information supports the phonetic information and the listeners do not experience processing difficulties.

In short, the results from the current project further corroborate that, as predicted, orthographic knowledge affects how listeners perceive phonemes. The L1 results here are consistent with previous findings on L1 phoneme perception and awareness (e.g., Ehri & Wilce, 1980; Perin, 1983; Pytlyk, to appear), namely that L1 orthographic knowledge plays a pivotal role in L1 speech perception. In addition, this research expands on the previous research by also demonstrating that L2 orthographic knowledge is factor in L2 phoneme perception. However, additional questions remain about the interaction between L1 and L2 orthographic knowledge. Does L1 orthographic knowledge 1) transfer into L2 speech perception, 2) override the influence of L2 orthographic knowledge, and 3) affect L2 phoneme awareness? These questions are addressed in the following subsection.

### *6.2.2 The language-specific nature of orthographic effects*

The statistical analyses of the L2 matched and mismatched homophone (i.e., the H data) comparisons—as well as the L0 matched and mismatched homophone comparisons—further demonstrate the effects of orthography and provide answers for those questions asked in the paragraph above. Indeed, the results from this research suggest that for alphabetic languages in which listeners are literate (i.e., L1 and L2), the ***effect of orthographic knowledge is language-specific***. In other words, the results suggest that once an L2 orthography is learnt, it exerts its own effect on L2 speech perception and in fact replaces the effect of L1 orthography.

The analyses show that while the RFL learners counted phonemes more accurately overall than the MFL learners (discussed below in §6.3.3), neither the RFL nor the MFL

group was more accurate or faster at counting phonemes in L2 matched H words than in the mismatched H words. We can represent these L2 H accuracy and RT results as

$$(6) \quad \text{L2 M-H} = \text{L2 MM-H.}$$

In contrast, the L1 matched and mismatched H accuracy and RT results are

$$(7) \quad \text{L1 M-H} \gg \text{L1 MM-H.}$$

Recall that for the L2 mismatched H, the mismatches were always in the L1 homophones and the L2 orthographic spellings of the mismatched H were always consistent. For example, the Russian mismatched H word *уу* /ʃ:i/ has 2 letters and 2 phonemes while its associated English counterpart *she* /ʃi/ has 3 letters but only 2 phonemes. Similarly, the Mandarin mismatched H word *nǐ* /ni/ has 2 letters and 2 phonemes while the associated English word *knee* /ni/ has 4 letters but only 2 phonemes. Thus, the finding that L2 MM-H = L2 M-H suggests (contrary to the prediction) that the L1 orthography does **not** intrude on L2 phoneme perception. If L1 orthographic information did override L2 orthographic information, the results would have shown the same kind of difference in accuracy and RTs between the matched and mismatched H as was observed with the L1 matched and mismatched H (i.e., L2 M-H >> L2 MM-H). When we consider these results in conjunction with the L2 NH results (See (4) above.), L2 listeners do not appear to fall back on their L1 orthographic knowledge to help them count phonemes in their L2. Rather, the difference between the L2 matched and mismatched NH (i.e., L2 words with no L1 associations) and the lack of difference between the matched and mismatched H (i.e., L2 words with L1 associations where the mismatch was in the L1) indicate that the L2 listeners rely more heavily on their L2 orthographic knowledge than they do on their L1 orthography knowledge.

To be certain that the L2 orthographic information overrides the L1 orthographic information, L2 words without L1 associations were also compared to L2 words with L1 associations in one additional test: the L2 matched NH word data were compared with the L2 mismatched H word data. This comparison teases apart the potential orthographic effects of L1 (mismatched H) and L2 (matched NH). If L1 orthography did intrude, we would expect the L2 M-NH to be more accurately counted than the L2 MM-H since the listeners would have been positively influenced by the consistent L2 letter-phoneme correspondences of the L2 matched nonhomophones, and they would have been negatively influenced by the inconsistent L1 letter-phoneme correspondences of the L2 mismatched homophones. However, this comparison yielded no significant accuracy or RT differences between the L2 matched NH words (no L1 association) and the L2 mismatched H words (L1 association):

$$(8) \quad L2 \text{ M-NH} = L2 \text{ MM-H}$$

This final comparison supports the above results suggesting that L2 orthographic knowledge is paramount in L2 speech processing, and further suggesting that L1 orthography does not negatively affect L2 phoneme perception.

In sum, the combination of a) the matched and mismatched NH results, b) the matched and mismatched H results, and c) the matched NH and mismatched H results suggest that L1 orthography does not have as strong an impact on L2 phoneme perception as L2 orthography does, at least at an intermediate stage of L2 learning. In fact, L2 orthographic knowledge appears to override the more established L1 orthographic knowledge for both RFL and MFL learners. These language-specific findings raise two very important questions. First, how do the L2 orthographic and phonological systems

become so closely connected? In other words, how does L2 phonology become linked with L2 orthography? Second, what promotes (or prevents) the formulation of the orthography-phonology link?

Regarding the first question, researchers have suggested that orthography and phonology are co-activated in the native language because learning orthographic representations of phonemes serves to reorganise and restructure the L1 phonological system (e.g., Burnham, 2003; Frith, 1998; Perre et al., 2009; Ziegler & Muneaux, 2007; Ziegler et al., 2003). Burnham (2003) claims that once children start to acquire an alphabet, the orthographic knowledge reorganises the L1 phonological system and the two systems become interdependent. Ziegler et al. (2003) suggest that orthographic knowledge “provides an additional constraint in driving segmental restructuring” (p. 790). In addition to research on offline metalinguistic phonological processing, research using event-related potentials (ERPs) has measured online activation of phonological codes. This research too supports the restructuring hypothesis by demonstrating that orthographic knowledge influences the functional organization of the temporal-parietal junction (Perre et al., 2009). After reorganising and restructuring the phonological system, orthographic knowledge is so intimately linked to the phonological system that readers cannot avoid thinking about the letters even when specifically instructed not to do so (Landerl et al., 1996) and in the absence of visual stimulation (e.g., Ziegler & Ferrand, 1998; Ziegler et al., 2004; Ziegler et al., 2003).

Can we extrapolate from the L1 orthographic and phonological co-activation to L2 orthographic and phonological co-activation? If L1 orthographic learning does indeed force a reorganisation of L1 phonology, can we posit that L2 orthography forces an

organisation of L2 phonology? In L1, native speakers learn phonology *before* orthography, but in L2, learners generally learn phonology and orthography concurrently. Therefore, learning L2 phonology cannot “reorganise” the L2 phonology. However, does learning L2 orthography help to *organize* L2 phonology? The L2 results suggest that perhaps learning L2 orthography dictates the organisation of the L2 phonology thus making these two systems interconnected, which in turn, means that they are co-activated in L2 speech processing. This reduces the influence and impact L1 orthography has on the L2. Indeed, Coutougera (2007) maintains that “beginner learners are *forced* [original emphasis] into reaching some kind of phonological awareness [in L2] so that they are able to start reading and writing” and that “learners urgently need to establish letter-phoneme correspondences in order to decode writing” (pp. 3–4). As a result of this urgency, L2 learners build the L2 letter-phoneme correspondences upon the foundation of L1 orthographic assumptions and principles. The question then becomes how (or at what point) does L2 orthography organise L2 phonology?

Other avenues of first language acquisition may provide answers to the questions surrounding the acquisition of L2 orthography and the organisation of L2 phonology. In general, previous research indicates that L1 phonology is sharpened and reorganised at two important junctures of L1 acquisition: 1) in infancy with exposure to the ambient/oral language (Kuhl, 2000; Werker & Tees, 1987) and 2) in childhood with the onset of learning to read (e.g., Burnham, 1986, 2003; Burnham, Earnshaw, & Clark, 1991; Carroll, 2004; Castro-Caldas et al., 1998; Flege, 1991; Olson, 1996; Treiman & Cassar, 1997; Ziegler et al., 2004). With respect to the second juncture, Olson argues that learning to read results in “learning to hear speech in a new way” (p. 95) because it

provides an abstract conceptual model that creates speech categories and brings those categories into consciousness. Similarly, Castro-Caldas et al. (1998) propose that learning to read modifies the phonological system by adding a “visuographic” dimension and opens the door for new language-processing possibilities such that different and more areas of the brain are activated in literates than in non-literates. Furthermore, Burnham (2003) maintains that children’s heightened language-specific speech perception is related to the onset of reading. For these researchers, the onset of reading is a critical developmental step in L1 phonological acquisition because (as mentioned above) learning to read forces a reorganisation of the L1 phonology, which in turn, creates a co-dependency between the two systems whereby they are co-activated, and they reciprocally influence each other. More importantly, orthographic effects are not limited to skilled readers; in fact, orthographic knowledge affects speech perception and awareness as soon as children *begin* to learn how speech is represented in print (Treiman & Cassar, 1997).

If learning to read is a critical juncture in L1 phonological development (e.g., Burnham, 2003; Carroll, 2004; Castro-Caldas et al., 1998; Flege, 1991; Olson, 1996; Treiman & Cassar, 1997; Ziegler & Muneaux, 2007; Ziegler et al., 2004), then, we can reasonably speculate that learning to read in the L2 is also a critical juncture in L2 phonological development. Recall that the current research found L2 orthographic knowledge exerts a greater influence on L2 phoneme perception than L1 orthographic knowledge does, at least for intermediate learners of Russian and Mandarin Chinese. According to Burnham (2003), language-specific speech perception is heightened following and significantly related to the onset of reading instruction. Therefore, one

possible explanation is that as in L1, learning to read in L2 may organise the L2 phonology and lead learners to develop a similar co-dependency between the L2 orthography and L2 phonology. As a result of the new co-dependency, L2 learners are able to disassociate themselves from L1 orthographic knowledge and use L2 orthographic information as a new crutch when performing L2 phoneme awareness tasks. Moreover, if learning to read in L2 parallels learning to read in L1, then, orthographic effects will not be limited to advanced learners but will also affect L2 learners as soon as they begin to learn to read in the L2 orthography (Treiman & Cassar, 1997).

Regarding the second question—what promotes the link between orthography and phonology—orthographic transparency and active engagement appear to dictate the formulation and strength of the link. The new L2 co-dependency may be strengthened by the degree of orthographic transparency of the L2 orthographic system. Again, we need to turn to L1 acquisition research to provide us with some insight. In L1 acquisition research, the general consensus is that children who learn more transparent orthographies (like Greek, Spanish, and Welsh) acquire orthography-phonology relations rapidly in the first year of reading instruction, while children who learn less transparent orthographies (like English and French) acquire these relations slowly over the course of many years (e.g., Goswami et al., 1998; Goswami, et al., 1997; Landerl, 2000; Seymour et al., 2003; Spencer & Hanley, 2003, 2004). In addition, Goswami and colleagues (Goswami et al., 1998; Goswami et al., 1997) found that children who learn transparent orthographies like Spanish and Welsh develop orthographic representations that encode individual letter-phoneme correspondences; in contrast, children who learn opaque orthographies like

English and French develop orthographic representations that encode sequences of letter-phoneme correspondences (i.e., rimes).

In other studies investigating orthographic transparency, Spencer and Hanley (2003, 2004) discovered Welsh children consistently outperformed their English counterparts in both reading and phoneme detection skills. Interestingly, not only did the Welsh children perform better on Welsh words than English children performed on English words, but the Welsh children also performed better on the English words than the English children performed on the English words. Spencer and Hanley (2003) conclude that “the critical factor at play here is the transparent nature of the alphabetical orthography” (p. 24). In other words, learning a transparent orthography allowed the Welsh children to successfully perform tasks in Welsh and generalize from Welsh to English, and learning an opaque orthography created difficulty for the English children in English and prevented them from generalizing from English to Welsh. Orthographic transparency does indeed appear to be the critical factor in dictating the development of orthographic-phonological associations in L1.

Could orthographic transparency have also been the factor in the relatively rapid development and strength of L2 orthographic and phonological associations observed in the current research? As discussed in §3.2, both the Russian and Mandarin orthographies are more transparent than the English orthography. If learning transparent orthographies facilitates rapid development of letter-phoneme correspondences, this would explain the current results, which suggest that L2 learners gathered enough experience in their language classes to create and foster L2 orthographic and phonological associations that

were strong enough to withstand any potential interference from L1 orthographic knowledge.

The second aspect that appears to promote the formulation of the orthography-phonology link is active engagement. Research in the area of nonnative language speech perception indirectly suggests that not only learning to read but also actively engaging in reading activities are necessary for orthographic knowledge to have an impact on L2 speech processing. Two very recent studies (Pytlyk, 2011; Simon, Chambless, & Alves, 2010) sought to improve nonnative phoneme perception via orthographic training. Both studies posited that using novel letter-to-phoneme correspondences may aid nonnative speakers in distinguishing between difficult non-phonemic sounds. Non-phonemic sounds refer to sounds that do not participate in a phonemic distinction in the L1 and as such do not have their own phonemic category at the outset of L2 acquisition/exposure. These sounds may be involved in an L2 contrast where only one phoneme belongs to L1 phoneme inventory (e.g., /u/–/y/ contrast in French; /u/ is an English phoneme but /y/ is not), or individual L2 phonemes sound similar to L1 phonemes but are not contrastive with the L1 (e.g., /x/ in Mandarin is similar to /h/ in English). As a result, nonnative speakers often fail to distinguish between these non-phonemic sounds and similar sounding phonemes. Interestingly, neither study found evidence that novel orthographic representations promote L2 phoneme distinctions (at the outset of L2 learning at least).

In their study of American English listeners, Simon et al. (2010) investigated whether orthographic training would help the listeners distinguish between two similar sounding contrastive French vowels, /u/–/y/—a contrast that does not exist in American English. The question asked was whether or not representing each vowel with a different novel

letter in a pre-test training phase facilitated establishment of separate phoneme categories for these vowels. Specifically, the participants were divided into two groups and were told they would learn words from an unfamiliar language. Half the participants learnt nonsense words in the “sound only” group where they were saw pictures and heard the words, and half learnt nonsense words in the “sound-spelling” group where they were not only saw pictures and heard the words, but they also saw the spelling of the words. For the spelling, the researchers used <ou> to represent /u/ (e.g., douge /duʒ/) and <û> to represent /y/ (e.g., dûge /dyʒ/). Then, Simon et al. used an AXB discrimination task to determine if orthographic support assisted in the creation of distinct phonological categories for the two sounds. They discovered (contrary to the predictions) that those participants trained on new words *with* orthographic support did not outperform those participants trained on new words *without* orthographic support. In other words, we could interpret Simon et al.’s results as indicating that initial orthographic training in the L2 does not promote separate category creation. Most likely, the participants did not have enough exposure and experience with the orthography at this point for it to have a positive impact on their /u/-/y/ distinction.

Similarly, Pytlyk (2011) sought to determine if learners’ abilities to distinguish new L2 sounds from similar sounding L1 sounds could be enhanced by training in an unfamiliar orthography. Specifically, the research investigated whether English speakers who learn Mandarin Chinese via a familiar orthography (i.e., the alphabetic system Pinyin) differ from those who learn via a non-familiar orthography (i.e., the syllabic system Zhuyin) in their perception of English–Mandarin sound pairs. Pytlyk found no significant perceptual differences between the two groups and concluded that Mandarin

instruction via the non-familiar orthography did not appear to provide an advantage over instruction via the familiar orthography (at the very beginning stages of learning at least). Pytlyk suggested that 1) conflict between the L1 orthographic system and the unfamiliar L2 orthographic system (i.e., Zhuyin) may neutralize any potential benefits of learning novel letter associations, and 2) lack of orthographic engagement (i.e., active reading) does not allow listeners to develop strong L2 letter-phoneme associations.

What these previous two studies show is that a short orthographic training period is insufficient for creating strong reciprocal relationships between L2 orthography and phonology. In fact, these findings suggest that before L2 orthography exerts any measurable influence, the listeners/learners may have to possess some experience reading in the target language's orthography—much like when children learn to read in their first language. However, as the current results suggest, the L2 learners are sophisticated enough to realise that the L1 correspondences do not apply to the L2 correspondences once they do have experience with an L2 orthography.

Finally, another possible explanation for the language-specificity of the orthographic effects may come from the nature of the experimental design itself (Dijkstra, Grainger, & van Heuven, 1999; Dijkstra, van Jaarsveld, & ten Brinke, 1998; Schulpen, Dijkstra, Schriefers, & Hasper, 2003). That is, L1 interference is dependent on whether participants are presented with stimuli from both languages or just one. When homophonous stimuli from both languages are presented, the homophone representations from both languages are activated and suppress each other thereby creating phonological inhibition effects—competition between two phonological representations of homophones. However, when presented with stimuli from only one language, only

representations from the target language are activated and non-target language interference is reduced. While the current research did present both stimuli in both languages, the L1 and L2 stimuli were presented in separate blocks (not intermingled with each other) and the blocks were separated by a short break and a L2 reading activity. Thus, when counting phonemes in the L2 block, the participants were presented with stimuli from only the L2, which may have limited the amount of L1 interference.

In addition, the L2 listeners may have been more susceptible to L2 orthographic knowledge than L1 orthographic knowledge because they were primed with the L2 orthography prior to completing the phoneme counting task (Jared & Kroll, 2001; Jared & Szucs, 2002; Lukatela, Turvy, & Todorović, 1991). Recall that the participants read aloud a short passage called “The North Wind and the Sun” in their L2 to prepare them for thinking in their L2. Other work has found that orthographic priming strongly affects accuracy and RT performances in adult speakers. In a very interesting study, Lukatela et al. (1991) investigated native Serbo-Croatian speakers’ identification of phonologically ambiguous words. Serbo-Croatian is a bi-alphabetic language: it uses both the Roman and Cyrillic alphabets. These alphabets share a number of letters that represent different phonemes (e.g., <B> represents the phoneme /v/ in the Cyrillic alphabet and /b/ in the Roman alphabet). Some words in Serbo-Croatian are made entirely up of shared letters—hence the ambiguity. For example, the letter string <BETAP> can be pronounced as either /vetar/ (Cyrillic), /betap/ (Roman), /vetap/ (mixed), or /betar/ (mixed). Using masked and unmasked orthographic priming, Lukatela et al. discovered that their participants pronounced and identified the target words more accurately and faster when the phonologically ambiguous target was preceded by a same-alphabet context than when

it was preceded by an other-alphabet context. Based on these results, they concluded that the alphabet specific context “adjust[s] temporarily the states of the letter-phoneme connections, biasing processing in favor of the letter-phoneme correspondencies of one alphabet rather than those of another” (p. 660).

Similarly, Jared and colleagues (Jared & Kroll, 2001; Jared & Szucs, 2002) also discovered an effect of orthographic priming. In their studies of English–French and French–English bilinguals in Canada, they found that bilinguals are significantly faster at naming target words after reading in the target language than after reading in the non-target language. For example, for the French word *grand*, bilinguals are more likely to encounter conflicting pronunciations (i.e., /grã/ vs. /gɹænd/) after reading in English than after reading in French, and vice versa. With these previous findings in mind, it is possible that in the current project, the L2 passage reading biased the listeners towards L2 orthography, thus helping L2 orthographic knowledge override L1 orthographic knowledge and emphasizing the language-specific effect of orthography.

### *6.2.3 Bipartite Model of Orthographic Knowledge and Transfer*

Taking the view that L2 orthography exerts its own influence on L2 phoneme perception once it is learnt, the next question is how—if at all—does L1 orthographic knowledge affect L2 orthographic knowledge’s influence on L2? Currently, researchers are debating the issue of L1 orthographic transfer. On one hand, some researchers provide evidence that L1 orthographic knowledge does transfer into and affect nonnative speech processing (Bassetti, 2006; Ben-Dror et al., 1995; Holm & Dodd, 1996; Sun-Alperin & Wang, 2011, Vokic, 2011; Wade-Woolley, 1999). On the other hand, other researchers provide evidence that L1 orthographic knowledge does not, in fact, transfer into and affect

nonnative speech processing (Wang, Park, & Lee, 2006; Wang, Perfetti, & Liu, 2005). The findings in the current study appear to support both sides of the debate. The L0 results suggest that L1 orthographic knowledge is transferred into and affects the nonnative language. However, the L2 results suggest the contrary: L2 orthographic knowledge appears to supersede L1 orthographic knowledge and affects L2 processing. How can we account for these conflicting results (not only within the current findings but between previous findings)?

On the side of the debate advocating L1 orthographic transfer, previous researchers have argued that L1 orthographic knowledge shapes L2 orthographic knowledge, which, in turn, shapes L2 phoneme perception (Bassetti, 2006; Erdener & Burnham, 2005; Holm & Dodd, 1996; Vokic, 2011). Holm and Dodd (1996) claim that L2 learners draw on their L1 literacy skills and strategies and apply them to their L2 orthography. In other words, once literate in their L1 alphabet and when learning an L2 alphabet, L2 learners transfer their L1 knowledge of the orthographic mapping principle<sup>44</sup> and assumptions about the function of the orthography and its relationship to phonology. These assumptions are learnt via the L1 orthography acquisition, and they are transferred and applied to the L2 orthographic relationships. That is, the abstract ideas about the function of orthographic representation are acquired when people/children become literate in their first language, and the mapping principle and its assumptions are then transferred into their L2 learning and applied to the L2 orthographic-phonological associations.

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<sup>44</sup> A mapping principle refers to what sound units (i.e., morphemes, syllables, or phonemes) graphemes map onto (e.g., Perfetti, 2003; Wang et al., 2005). For example, alphabetic orthographies like English or Korean map graphemes onto phonemes while logographic orthographies like Chinese map graphemes onto syllabic morphemes (DeFrancis, 1989).

In a study to determine the effect of orthographic transfer, Bassetti (2006) used a phoneme counting task and a phoneme segmentation task to investigate learners' mental representations of Mandarin Chinese rimes. Here, Bassetti studied beginning English learners of Chinese-as-a-foreign-language (CFL). Via the phoneme counting task, she discovered that the CFL learners counted one fewer vowel in Mandarin rimes that do not represent the main vowel orthographically than they did in Mandarin rimes that do represent the main vowel orthographically. In Mandarin consonant-glide-vowel-glide (CGVG) syllables, the main vowel is not represented in the orthography. For example, in the word *tui* /dweɨj/, the main vowel is /e/, but there is no graphemic representation of this sound in the Pinyin spelling; only the pre-vocalic glide /w/ and post-vocalic glide /j/ are encapsulated in the spelling, the <u> and <i>, respectively. In contrast, in Mandarin GVG syllables, the main vowel is represented in the orthography. For example, in *wei* /weɨj/, the main vowel is also /e/, which is represented in the spelling by the letter <e> (along with the pre- and post-vocalic glides). Via a phoneme segmentation task (where learners pronounced all the phonemes in a Mandarin syllable one by one), Bassetti discovered that the CFL learners failed to pronounce the main vowel as a separate segment when the spelling did not include a letter for it. In short, Mandarin rimes were most often counted and segmented as they are spelt. Based on these results, Bassetti argues that English CFL learners interpret Pinyin orthography in terms of English letter-phoneme conversion rules rather than the L2 orthographic conventions. She concludes then that L1 orthographic knowledge transfers into L2 and shapes the mental representations of Mandarin Chinese rimes.

Vokic (2011) agrees with Bassetti (2006) in that she too argues that learners interpret their L2 orthography through the “prism” of their L1 orthography. Studying native Spanish speakers producing the English flap /ɾ/, Vokic investigated how much difficulty these speakers had recovering phonological information from the graphemic representation. She found that Spanish speakers’ access to the English flapping rule was blocked by their reliance on Spanish orthographic rules. The native Spanish speakers failed to produce /ɾ/ when faced with words like *city* and *lady* where the <t> and <d> orthographically represent the flap. Rather, these speakers produced /t/ and /ð/ for <t> and <d>, respectively—based on the Spanish letter-phoneme associations. From these results, Vokic concludes that because Spanish has highly *regular* orthographic-phonological mappings, native Spanish speakers cannot easily recover the English phonology from the highly *irregular* orthographic-phonological mappings in English despite the fact that /ɾ/ is also part of the Spanish consonant inventory. Therefore, according to Vokic, L2 learners interpret L2 graphs “through the prism of L1 graphs, much like L2 phonemes are interpreted in light of L1 phonemic categories” (p. 412).

In addition, Erdener and Burnham’s (2005) research also supports the argument that the nonnative language is interpreted through L1 orthographic knowledge. Specifically, they discovered L1 orthography impacts native Turkish speakers’ production of Spanish (L0) phonemes. Although the letter <j> exists in both the Turkish and Spanish alphabets, it represents entirely different phonemes in Turkish and Spanish, /ʒ/ and /x/ respectively. They found that when given only auditory information, the Turkish participants had 0% error rates for reproduction of the L0 Spanish phonemes. However, when given both auditory and orthographic information, the Turkish participants’ error rates increased to

46%. Erdener and Burnham conclude that these increased error rates result from the participants substituting the L1 phoneme /ɜ/ associated with the letter <j> they saw. These results provide additional evidence that in the absence of nonnative orthographic knowledge, listeners transfer their L1 orthographic operational knowledge into their speech processing of a nonnative language.

As mentioned above, the current L0 finding provides support for Bassetti (2006), Erdener and Burnham (2005), and Vokic's (2011) side of the L1 orthographic transfer debate. These results suggest that without any experience in a nonnative language, learners do transfer their L1 orthographic knowledge to help them parse nonnative phonemes. However, the L2 finding (i.e., L2 orthographic knowledge overrides L1 orthographic knowledge to influence L2 phoneme perception) appears to contradict their claims of L1 orthographic transfer. In fact, the current finding suggests that L1 orthographic knowledge does not transfer into L2 phoneme perception.

Researchers on the other side of the debate have found that orthographic skills do not transfer from L1 to L2. In a series of experiments involving biliteracy, Wang and colleagues (Sun-Alperin & Wang, 2011; Wang et al., 2006; Wang et al., 2005) sought to determine whether orthographic skills transfer from L1 to L2 in learning to read. In the first study, Wang et al. (2005) investigated Chinese (L1)–English (L2) bilingual children. Using combined phonological and orthographic tasks and regression analyses, Wang et al. found that while phonological skills transfer from L1 to L2, orthographic skills do not. Specifically, Chinese orthographic skills (with characters) could not predict reading skills in English. From this, they concluded that orthographic skills “may be language-specific with little facilitation from one to the other” (p. 83). One possible explanation they offer

for this lack of facilitation is that the Chinese and English orthography do not share the same mapping principle: Chinese maps graphemes to morphemes while English maps graphemes (i.e., letters) to phonemes. Therefore, Wang et al. speculate that this disparity in mapping principles does not lend itself to L1–L2 transfer.

A subsequent study by Wang et al. (2006) asked the same question—do orthographic skills transfer from the L1 to L2 in learning to read? However, in this study, they investigated Korean (L1)–English (L2) bilingual children. Unlike the different mapping principles between the Chinese and English orthographies, Korean and English orthographies share the same mapping principle, even though the systems are different: both are alphabetic systems that map letters onto phonemes. Through similar tasks and analyses as in Wang et al. (2005), Wang et al. (2006) again found that phonological skills transferred from L1 to L2, but orthographic skills did not; Korean L1 orthographic skills did not predict English L2 word reading. Again, Wang and colleagues concluded that in learning to read, there is little facilitation of orthographic skills from L1 to L2, and thus, orthographic skills appear to be language-specific, even when the two languages share the same mapping principle (i.e., an alphabetic principle).

From these two studies, Wang et al. (2005, 2006) suggest that the visual orientations of graphemes may contribute to the language-specificity of their respective orthographies. That is, while the Korean writing system, Hangul, is alphabetic, its representation is non-linear (similar to Chinese characters) and creates a “square-like syllable block” (Wang et al., 2006, p. 149). As a result, the non-linear Korean Hangul representations visually resemble Chinese characters more than the linear Roman alphabet letter representations. Because of the drastically different visual orientations of

their respective L1 orthographies, learners did not transfer their L1 orthographic knowledge.

More recently, Sun-Alperin and Wang (2011) sought to investigate orthographic transfer in two languages where the orthographic representation not only shares the same mapping principle but also resembles each other, Spanish (L1) and English (L2). They hypothesised since the two orthographies were closely related, the Spanish orthography (L1) may facilitate English reading and spelling. The results here showed that when closely related, the orthographic skills are transferred into and facilitate L2 reading but not L2 spelling, indicating “an independence of orthographic processing as it relates to spelling” (p. 612). Like Wang and colleagues, the L2 NH and H results and L1 NH and H results imply that orthographic effects are language-specific (as discussed above) thereby suggesting that L2 orthographic knowledge overrides L1 orthographic knowledge.

How can we reconcile the findings from Bassetti (2006) and Vokic (2011) with those from Wang and colleagues (Wang et al., 2006; Wang et al., 2005; Sun-Alperin & Wang, 2011)? The current results suggest that L1 orthographic knowledge is comprised of at least two types of knowledge: *abstract* and *operational*. When we consider the notion of orthographic knowledge not as a single entity but rather as a combination of components—the abstract and operational—the findings from this and previous research no longer contradict each other. The following paragraphs outline the proposal; further details and validation await future research.

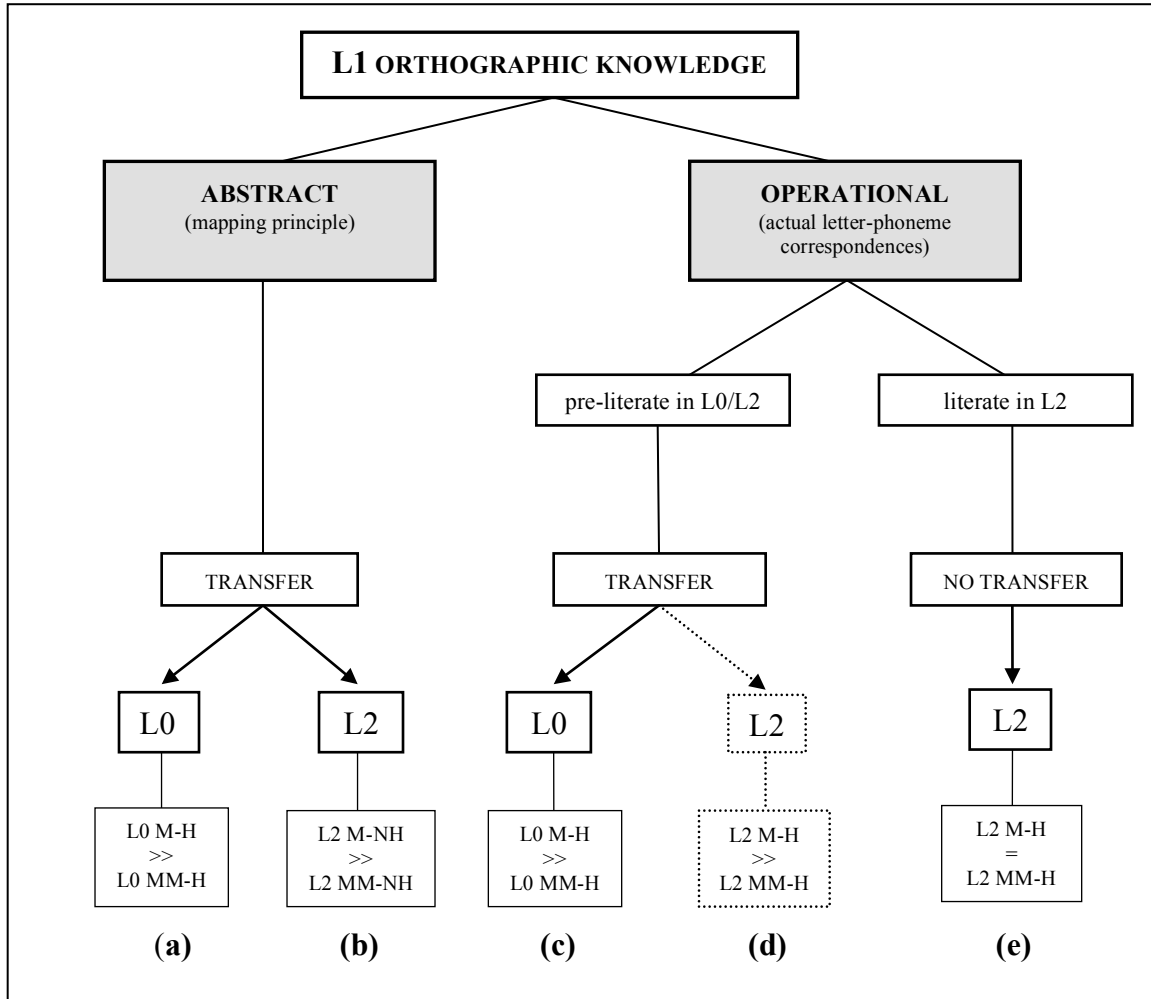
**Abstract** orthographic knowledge refers to the assumptions literates have about the function of orthographic representation and its relationship to the phonological

representation. Children/learners acquire abstract knowledge through the process of becoming literate in their L1, which creates a set of assumptions upon which all other orthographic effects rest. The general assumption surrounding alphabets (like the Roman and Cyrillic alphabets) is that individual letters represent individual phonemes (Cook, 2004; Coutsougera, 2007). In contrast, the general assumption surrounding logographies (like the Chinese characters) is that individual letters represent individual morphemes (Cook, 2004; Coulmas, 2003). That is, alphabetic literates generally assume that graphemes (i.e., letters) map onto phonemes while logographic literates generally assume that graphemes (i.e., characters) map onto morphemes.

In the case of alphabetic systems, literates use their abstract knowledge about the function of orthographic representation to interpret the operational letter-phoneme correspondences. **Operational** orthographic knowledge refers to the actual letter-phoneme correspondences in any given language. For example, English literates know that the letter <t> corresponds to the phoneme /t/, <x> corresponds to the phonemes /ks/, <c> corresponds to either /k/ or /s/, and so on. Similarly, Russian literates know that the letter <y> corresponds to the phoneme /u/, <r> corresponds to the phonemes /g/ or /gʲ/, <io> corresponds to the phonemes /ju/, and so on. In L1, operational orthographic knowledge is also acquired as children become literate in their L1 orthography.

The abstract and operational components of orthographic knowledge proposed here can be unified as in Figure 6.1, in what is termed here the *Bipartite Model of Orthographic Knowledge and Transfer* (henceforth the *Bipartite Model*). Included in Figure 6.1 are the current findings (found in the lettered boxes) that provide support for

the predictions of the Bipartite Model. Also included (in the box with dashed lines) is an additional prediction made by the model for which no data exists yet (See §7.4).



*L1 = native language, L0 = unfamiliar language, L2 = second language*

**Figure 6.1** Bipartite Model of Orthographic Knowledge and Transfer

While both abstract and operational knowledge are acquired concurrently in L1 acquisition, the proposal is that this is not always the case for L2 orthographic

<sup>45</sup> The current model represents literacy as a pre-literate-literate dichotomy. However, one alternative (as suggested by Dr. Patrick Bolger) is to represent literacy along a continuum from pre-literate to literate, which may also allow us to include orthographic depth and time course in the model. I leave the questions of how to expand the model to include orthographic depth and time for future research.

knowledge. For example, in L2 learning, when both L1 and L2 orthographies share visual orientation (i.e., a linear alphabetic orientation), abstract L1 orthographic knowledge transfers into L2 and contributes to a perceived relationship between L2 orthography and phonology. Specifically, the L1 assumptions about the function of orthography transfer into L2 letter-phoneme associations such that learners assume that the L2 orthography functions in relation to the L2 phonology in much the same way that the L1 orthography functions in relation to the L1 phonology. Then, through this perceived relationship (whether accurate or not), learners acquire new operational orthographic knowledge about L2 letter-phoneme correspondences. Once this new L2-specific operational knowledge is acquired, it supercedes L1 operational knowledge.

The Bipartite Model makes a number of predictions regarding the transfer of orthographic knowledge. First, in this model, abstract knowledge transfers into both L2 and L0 (assuming the same broad type of alphabetic system) such that the L1 assumptions about the function of orthographic representations are applied to the nonnative language regardless of whether L0/L2 literacy exists. This is shown on the previous page in Figure 6.1. In the current study, the L1 results showed that native English speakers are strongly influenced by orthographic representation such that they were significantly more accurate at counting phonemes in matched L1 words than they were in mismatched L1 words. This finding is interpreted as evidence that native English speakers assume individual letters represent individual phonemes in English, which is the key characteristic in abstract knowledge. The model proposes that this assumption is then transferred (regardless of literacy) into nonnative speech processing and is reflected

in both the higher accuracy of L0 matched H (given above in (a)) and L2 matched NH (given in (b)) than of the L0 mismatched H and L2 mismatched NH.

Second, the model proposes that transfer of operational knowledge depends on the existence of literacy in the nonnative language. Although literate L2 learners/listeners do transfer L1 abstract knowledge, this knowledge facilitates the formation of L2-specific operational knowledge, which overrides L1 operational knowledge. Recall that in the MM-H tokens, the mismatch was always in the L1 not the L2; therefore, any difference between the L0/L2 matched-mismatched words would indicate an L1 transfer effect. The lack of difference between the L2 matched and mismatched H (given in (e)) suggest the L2 listeners employ L2 letter-phoneme associations rather than L1 associations. In contrast, without any L0 orthographic knowledge, L0 listeners transfer their L1 operational orthography into L0 phoneme processing, which is reflected in the difference between the L0 matched and mismatched H (given in (c)). This model also proposes that non-literate L2 learners would also experience L1 operational transfer. That is, using a similar research methodology, the model predicts that non-literate L2 listeners would more accurately count phonemes in L2 matched H than they would in L2 mismatched H (given in (d)).

Third, operational transfer entails abstract transfer because operational knowledge is built on the foundation of abstract knowledge; however, abstract transfer does not entail operational transfer. Therefore, it is possible to transfer abstract knowledge without transferring operational knowledge (as is the case for L2 learners), but it is *not* possible to transfer operational knowledge without also transferring abstract knowledge (as is the case for L0 in the current study).

By means of the Bipartite Model, the current research adds insight into L1 orthographic transfer and facilitation, namely with respect to L2 speech perception. It provides evidence that abstract orthographic knowledge behaves differently from operational orthographic knowledge. First, the L2 NH data parallel the L1 NH data. Specifically, for both L1 NH and L2 NH, the matched words (i.e., the *consistent* words) were counted more accurately and faster than the mismatched words (i.e., the *inconsistent* words). These differences suggest that learners apply their assumptions about the function of orthography and its relationship to phonology (i.e., abstract knowledge) that they learn in L1 orthographic acquisition to their L2. Second, the L2 H data indicates that once learners become literate in their L2, they do not transfer L1 operational knowledge; rather, they employ their L2 operational knowledge to aid them in phoneme awareness tasks. As with L2 reading (Sun-Alperin & Wang, 2011; Wang et al., 2006; Wang et al., 2005) and L2 spelling (Sun-Alperin & Wang, 2011), the L2 findings here suggest that *abstract* orthographic knowledge transfers when L1 and L2 share same visual orientations (i.e., alphabetic letters). That is, listeners rely on their L1 assumptions about how letters are mapped onto phonemes and apply those assumptions to the relationship between L2 letters and phonemes (e.g., Ben-Dror et al., 1995; Wade-Woolley, 1999). In addition, *operational* orthographic knowledge appears to be language-specific for L2 speech perception; once L2 learners are literate in their L2, they rely on actual L2 letter-phoneme associations. In other words, the results here provide little evidence for operational L1 orthographic transfer in L2 speech perception once learners have learnt an L2 orthography; in fact, the results suggest that L2 orthographic knowledge takes over and influences L2 phoneme perception. Finally, the L0 H data

indicate that listeners do transfer their L1 operational knowledge (in addition to abstract knowledge) to the unfamiliar language because they have no other orthographic associations (i.e., other operational knowledge) to aid them (Erdener & Burnham, 2005).

In support of the non-transfer of operational knowledge, listeners in the current research appeared to use a language-specific spelling strategy in the phoneme counting task. As mentioned above, Sun-Alperin and Wang (2011) have suggested that L1 orthographic processing is independent from L2 spelling. In the current study, of the 52 participants, 39 participants mentioned spelling in their debrief interviews. Many participants commented that spelling was a strategy for counting (whether helpful or not) and that they often “saw” the words in their heads before counting. For example, some general comments about the task include

*... visualized English spelling*

*... saw the spelling*

*... automatically saw the word*

*... started seeing letters not sounds...*

*... I could see the words*

*... you could see the word in your head*

*... heard letters*

*... knowing words and spelling helped recognize sounds*

Indeed, many participants recognised that spelling was a distraction and hindered their counting, but they also found it difficult to put aside. They had to remind themselves that spelling was not the focus. For example, some of the participants’ responses included

*... letters did not help counting ... had to put them aside*

*... danger of going by the letter rather than the sound*

*... could visualize spelling although sometimes misleading*

*... spelling was a distraction, especially in English*

*... I had to remind myself not to spell*

*... spelling got in the way*

*... had to remind myself not to count letters*

Therefore, even when spelling was not explicitly mentioned at any time during the perception task, it appears that listeners could not help but think of spelling, suggesting that, as previous research has also suggested (discussed above in §6.2.1), orthography and phonology are co-activated in an auditory task (e.g., Blau et al., 2008; Chéreau et al., 2007; Perreman et al., 2009; Taft et al., 2008; Ventura et al., 2008; Ventura et al., 2007; Ziegler & Ferrand, 1998; Ziegler et al., 2004; Ziegler, Muneaux, & Grainger, 2003).

In addition to the general comments about spelling, listeners' debrief comments suggest that in the absence of nonnative orthographic knowledge (i.e., the L0), listeners ascribe English orthographic knowledge to nonnative phoneme awareness. For example,

*... pictured how the word would be spelt in English and transliterate into  
Mandarin and Russian*

*... tried not to spell L0[words] in English terms*

*... I spelt out the words how they would be in English*

In contrast, in the presence of nonnative orthographic knowledge (i.e., L2 orthographic knowledge), listeners no longer rely on L1 orthography, but rather, fall back on the L2 orthography to aid their L2 phoneme perception.

*... pictured Russian and English letters*

*...when I heard a sound, immediately thought about how to spell it in Pinyin*

The results and listeners' comments in this research add further support to the idea that once an L2 orthography is learnt in conjunction with an L2 phonology, L2 orthographic knowledge appears to be co-activated with L2 phonology—much like the L1 orthography is co-activated with L1 phonology.

While this new Bipartite Model is still in its infancy and has yet to be thoroughly tested, it does provide us with a new way of thinking about orthographic knowledge and

allows us to unify the seemingly conflicting accounts of L1 orthographic transfer into L2 and/or L0. For example, the model accounts for Bassetti's (2006) findings nicely. Bassetti herself states "the orthographic representation is interpreted in terms of the first language letter-phoneme conversion rules" (p. 107)—abstract transfer. (I interpret conversion rules here to refer to the general rules governing letter-phoneme mapping, not the actual letter-phoneme correspondences.) The CFL results also contain evidence of lack of L1 operational transfer. When participants were asked to segment (by pronouncing each segment) the sounds in a word, Bassetti reports that words were segmented as they are spelt (abstract transfer again), but they were segmented with Mandarin pronunciations of each individual letter, suggesting operational knowledge of Mandarin Pinyin letter-phoneme associations (i.e., no L1 operational transfer). If L1 operational transfer had occurred as well as abstract transfer, Bassetti would have observed English pronunciations of Pinyin spelt words; however, the Pinyin spellings were pronounced with Mandarin phonemes, i.e., *you* was segmented with a Mandarin pronunciation as /jow/ rather than with an English pronunciation as /ju/.

While the model can account for Bassetti's (2006) findings rather nicely, Vokic's (2011) findings are a little trickier to account for. Recall that Vokic discovered native Spanish speakers failed to produce the English flap when represented by the letters <t> and <d> in words like *city* and *lady*. She attributes this failure to L1 transfer of actual Spanish letter-phoneme associations (what the Bipartite Model would call L1 operational transfer). However, the model proposes that once learners acquire an L2 orthography, the L2 operational knowledge overrides L1 operational knowledge. So why would L1 operational knowledge still transfer Vokic's research? Vokic's findings indicate that

orthographic knowledge and transfer effects involve more complexity than has been considered here. In particular, for example, Vokic's findings suggest that L1 operational transfer may be mediated by orthographic transparency. Perhaps L2 operational knowledge of less transparent languages (i.e., English) takes longer to acquire because of its inconsistency than L2 operational knowledge of more transparent languages (i.e., Russian and Mandarin Pinyin). In fact, Seymour et al. (2003) have shown that L1 English children take at least twice as much time to develop decoding skills as L1 children with a transparent orthography. (See also Spencer & Hanley, 2003, 2004). The delayed mastery of decoding skills has also been observed in Danish—another less transparent orthography (Juil & Sigurdsson, 2005). This delay for less transparent languages possibly explains why the current results show L2 operational effects but Vokic's (2011) results show L1 operational effects: the current study went from a deep L1 to a shallow L2 while Vokic's study went from a shallow L1 to a deep L2. Maybe the English operational knowledge had yet to take hold of the native Spanish speakers' English letter-phoneme associations. Thus, future research needs to establish if transparency is a factor affecting operational knowledge and, if so, what its role is in determining at what point L2 operational knowledge takes over from L1 operational knowledge.

#### *6.2.4 The experience-dependency of orthographic effects*

In light of the previous discussion, the additional finding that *orthographic effects are experience-dependent* is perhaps not so surprising. These results were determined by analysing the accuracy and RT differences between the matched and mismatched NH for the L1, L2, and L0 subgroup data. For this analysis, the mean mismatch NH accuracy and RT values were subtracted from the mean NH accuracy and RT values for each

language condition. Positive values indicated higher accuracy rates and shorter RTs from the matched to mismatched NH conditions (See §5.7.). In general, the accuracy and RT difference results can be summarised as

$$(9) \quad L1 \gg L2 \gg L0.$$

In other words, the effects are the largest for L1, the smallest for L0 and between the L1 and L0 for L2. However, the accuracy results do not directly reflect this pattern. In fact, the analyses indicate that the L1 accuracy difference is greater than the L2 difference, but that the L2 accuracy difference is not significantly greater than the L0 difference. Conversely, the analyses of RTs do reflect the pattern: the RT analyses indicate that the L1 RT difference is greater than the L2 difference, and the L2 RT difference is greater than the L0 difference. These results and analyses suggest that the L1 orthographic effect is stronger in the L1 than the L2 orthographic effect is in the L2. In fact, the strength of the L2 orthography appears tenuous at this stage of learning as evidenced by the lack of a significant difference between the L2 and L0 in accuracy rates, but the presence of a significant difference between the L2 and the L0 in RTs. Still while not entirely cut and dried, the results do suggest an experience-dependent trend whereby the more experience listeners have with the target language's orthography and phonology, the greater the effects of the orthography. To be clear, while orthographic knowledge affects phoneme perception from the beginning of learning to read, these effects get stronger as the readers/learners gain more and more experience with the language.

These results run parallel to other linguistic research that has demonstrated the effect of language experience influences speech processing. According to Burnham (2003), as a component of language-specific speech perception, linguistic experience facilitates the

perception of speech sounds. In addition, age-related differences in performance and perception have been interpreted as evidence of language experience-dependency. For example, in a classic study, McGurk and MacDonald (1976) investigated the “McGurk effect”<sup>46</sup> in children and adults. They demonstrated that children aged 3–5 and 7–8 were influenced to a lesser extent by visual cues than adults were. Subsequent research also showed similar age-related effects (i.e., experience effects) of visual influence (e.g., Chen & Hazan, 2009; Massaro, Thompson, Barron, & Laren, 1986; Sekiyama, Burnham, Tam, & Erdener, 2003). Research has even reported a developmental increase of visual influence across ages—from age 5 to adulthood (Hockley & Polka, 1994; Sekiyama et al. 2003). In short, the previous research has shown that the use of visual information increases as age increases (i.e., as experience with the language increases).

The results here suggest that reliance on orthographic information also increases as experience increases. While the current study used only an auditory task, many participants commented that they “saw” the words in their heads. Thus, even though they did not receive any direct visual information from orthography, the listeners appear to rely on their existing mental visualisations of the words’ spellings. In this research, the different target languages (i.e., L1, L2, and L0) represent different levels of language experience: listeners had the most experience with their L1, less experience in their L2, and no experience with the L0. Therefore, the listeners experienced the largest influence from visual information (i.e., the orthographic knowledge) in their L1, the second largest influence from their L2, and the smallest visual influence from the L0. Extending the language experience parallel, we can liken the L0 language perception with the very

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<sup>46</sup> The “McGurk effect” refers to a phenomenon observed by McGurk and MacDonald (1976) whereby when a visual /ga/ syllable is presented concurrently with an auditory /ba/ syllable, listeners typically report hearing a /da/ syllable.

beginning stages of nonnative language learning where learners have little to no experience with the nonnative language, and we can liken L2 language perception with more advanced stages of nonnative language learning where the learners do have some experience in the nonnative language but not as much as the native language.

### ***6.3 Unanticipated Effects***

In addition to the findings discussed above, other effects also surfaced during the course of this research. These effects are 1) familiarity and word effects (§6.3.1), 2) phonological effects (§6.3.2), and 3) MM subcategory effects (§6.3.3).

#### *6.3.1 Familiarity and word effects*

The analyses of the L0 data suggest two other effects—*familiarity* and *word* effects— influence the perception of phonemes in words from an unfamiliar language. While an L1 orthographic effect can account for why the L0 matched Hs were counted more accurately and faster than the L0 mismatched Hs, a familiarity effect accounts for why the L0 matched Hs were counted more accurately and faster than the matched NHs. That is, performing better on both sets of H (i.e., the matched and mismatched) suggests that homophony with English words make L0 H words more familiar to participants, and that this familiarity facilitated performance, regardless of whether the familiar words had consistent letter-phoneme correspondences. Related to the facilitative effect of familiarity, Russak and Saigh-Haddad (2011) discovered that native Hebrew speakers exhibited higher levels of phoneme awareness in their L1 (Hebrew) than in their L2 (English). They argue that higher levels of language proficiency as well as the degree of experience with the language facilitate phoneme awareness and that awareness is

enhanced by language familiarity (This also accounts for the experience-dependency of orthographic effects discussed above in (§6.2.4.). Thus, although the participants had no previous knowledge of the L0s in the current research, the very nature of the L0 cross-language homophones made them familiar to a certain degree thereby increasing the participants' phonemic awareness in the L0 homophones.

Other research on cross-language homophones has also shown a phonological facilitation effect such that both L1 and L2 phonological codes are activated simultaneously when reading in the L2, and phonological information from both codes contribute to word recognition (Brysbaert, Van Dyck, & Van de Poel, 1999; Carrasco-Ortiz, Midgley, & Frenck-Mestre, 2012; Haigh & Jared, 2007; Lemhöfer & Dijkstra, 2004). In other words, L2 cross-language homophones benefit from the co-activation of their nonpresented L1 cross-language counterparts. For example, Lemhöfer and Dijkstra (2004) found phonological overlap facilitates lexical decisions such that Dutch-English bilinguals identified cross-language homophones more accurately and faster than the control words, which did not share a phonological overlap. Similarly, Haigh and Jared (2007) found that French-English bilinguals made more accurate and faster lexical decisions on cross-language homophones than control words. Haigh and Jared also discovered that the phonological facilitation effect was greater when participants were reading in their L2 than when they were reading in their L1.

In addition to research involving metalinguistic awareness, other research—specifically research involving ERPs—provide further evidence for the facilitatory effect of phonological overlap. For example, Carrasco-Ortiz et al. (2012) compared the cortical responses to cross-language homophones and control words of English monolinguals

with French-English biliguals. The monolinguals showed no variation in N400 amplitude between the cross-language homophones and control words, suggesting no advantage of one stimulus type over another. In contrast, the bilinguals showed a significant reduction in N400 amplitude in response to the homophones compared with the control words, which Carrasco-Ortiz et al. interpret as a processing advantage for the homophones. Taken together, these studies all suggest that familiarity (via the phonological overlap inherent in cross-language homophones) facilitates speakers' abilities to process a nonnative language.

Conversely, it is likely that with the nonhomophones, the listeners were more distracted by the “strangeness” of the unfamiliar words thereby resulting in lower accuracy rates and longer response times. In fact, when asked which language was the most difficult to count, most participants identified the L0 as the most difficult. They claimed the “unfamiliarity” with the words and the L0 language was a barrier to successful phoneme parsing. For example, some comments include

- ... not familiar with the sound combinations*
- ... wasn't sure about what is an individual sound*
- ... not used to some sounds*
- ... sounds were really different*
- ... less familiar sound combinations*
- ... couldn't recognise most sounds and sound combinations*
- ... Russian sounds were weird ... difficult to pick out sounds*
- ... Russian sound combinations were hard to separate*
- ... a lot of unfamiliar sounds—hard to determine whether 1 or 2 sounds*
- ...very foreign*
- ... not sure about some sounds—were they sounds?*
- ... sounds so much more different—not recognisable*

If many of the L0 words sounded strange or foreign, then these comments suggest that participants may have found the H easier than NH because they were not so foreign or “weird” sounding. Thus, the homophony allowed listeners to more easily hear the words. Therefore, the L0 results strongly suggest that familiarity with phonemes and phoneme sequences play a large role in listeners’ abilities to distinguish individual phonemes.

An interesting question worth asking is whether the familiarity effect is due to *whole words* sounding familiar or to their internal phonotactics sounding familiar. Previous research has shown that listeners’ knowledge/familiarity with “legal” L1 phonotactic patterns affects auditory L2 speech processing (Dupoux, Kakehi, Hirose, Pallier, & Mehler, 1999; Kabak & Idsardi, 2007). For example, Dupoux et al. (1999) discovered that Japanese listeners hear illusory epenthetic vowels in French consonantal sequences that violate the legal phonotactic patterns of Japanese. Dupoux et al. interpret these findings as evidence that L1 listeners “may invent or distort [L2] segments so as to conform to the typical phonotactics of their language (p. 1577). In the Carrasco-Ortiz et al. (2012), Lemhöfer and Dijkstra (2004) and Haigh and Jared (2007) studies outlined above, the L1 representations were real (homophonous) words. Would they have found the same results if the L1 representations were nonsense words with similar and familiar phonotactic structures as the L2 target representations? The participant comments above clarify to some extent what “counts” as familiar. Specifically, they indicate that it is not necessarily familiarity with the homophonous words themselves that matters, but rather familiarity with the phonetic quality of their component sounds and their phonotactic rules. Indeed, comparing the accuracy rates of the Russian L0 and Russian L2 listeners (See Table 6.4 on page 241.) further suggests that phonotactic familiarity plays an

important role in listeners' abilities to parse nonnative phonemes. Russian MM-NHs containing the consonant combinations of /zv/ and /zd/, which are not licenced combinations in either English or Mandarin, were more difficult to parse for speakers with Russian as the L0 (no experience with Russian phonotactics) than for speakers with Russian as the L2 (experience with Russian phonotactics). The Russian L2 listeners had 0.85 accuracy for both *здесь* /zɗʲɛsʲ/ and *звать* /zvətʲ/ compared with the Russian L0 listeners' accuracy of 0.50 for both. In other words, the Russian L2 listeners were highly successful at parsing these combinations because although these combinations do not exist in English, they are familiar with them from learning of Russian. Conversely, the Russian L0 listeners were relatively unsuccessful at parsing /zv/ and /zd/ because neither their L1 nor their L2 (Mandarin) provide any phonotactic familiarity with the combinations.

In addition to orthographic and familiarity effects, the results suggest a word effect also influenced L0 phoneme perception. A word effect can account for why the L0 matched NHs were counted more accurately and faster than the L0 mismatched NHs (as reported in §5.3.2). The hypothesis predicted that participants would count phonemes in the matched and mismatched NH equally accurately because the listeners had neither orthographic knowledge nor any L1 orthographic associations with these words. The results, however, did not support this prediction: participants were better at counting the matched NH than the mismatched NH. While the reasons for the accuracy difference between the matched and mismatched NH are not clear, most likely something about the words themselves in the mismatched condition made them more difficult to count.

Thus, although the results do suggest an effect of L1 orthographic knowledge on L0 phoneme counting, it interacts with the other two effects, the familiarity effect and the word effect, and this interaction mitigates the effects of L1 orthography alone such that its influence is not as strong in the L0 as it is in the L1. While both effects interact with L1 orthographic knowledge, the familiarity effect is likely a “real” effect, whereas the word effect is likely an artifact of the stimuli selection (See §7.2 for a discussion of research limitations.).

### 6.3.2 Phonological Effects

The second unanticipated effect discovered in this research project is a *phonological* effect. Here, the phonological effect refers to phonological characteristics of a particular language that make it easier or harder to process. The analyses showed that in four comparisons, listeners counted phonemes in the Russian words more accurately than in the Mandarin words. Specifically,

1. The RNL0 group counted Russian H, regardless of match, more accurately than the MNL0 group counted Mandarin H (§5.4.1).
2. The RNL0 group counted Russian L0 matched H and NH more accurately than the MNL0 group counted Mandarin L0 matched H and NH (§5.4.2).
3. The RFL subgroup counted Russian NH more accurately than the MFL subgroup counted Mandarin NH (§5.6).
4. The RFL subgroup counted Russian matched NH and mismatched H more accurately than the MFL subgroup counted Mandarin matched NH and mismatched H (§5.6).

This raises a very interesting question: in what ways do the Russian and Mandarin words differ such that the phonemes in Russian words are easier to perceive (and therefore count) than the phonemes in the Mandarin words?

One reasonable explanation for the asymmetry in Russian and Mandarin performance has to do with the different phonological structure of the Russian and Mandarin words. According to Saiegh-Haddad et al. (2010), the phonological structure of a word affects the ease with which listeners can access phonemes in different positions (i.e., onset and coda positions) and in different linguistic contexts. As discussed in (§3.2), the Russian and the Mandarin syllable structures differ significantly. Russian syllable structure (§3.2.2.2) allows many different syllable types—(C)(C)(C)(C)V(C)(C)(C)(C)—which results in many closed syllables (i.e vowel–obstruent sequences). In contrast, Mandarin syllable structure (§3.2.3.2) is much more limited—(C)(G)V(G) or (n) or (ŋ)—which results in many open syllables ending in a diphthong (i.e vowel–glide sequences). In taking a closer look at the word stimuli, we see that no Russian words contained diphthongs while 12 Mandarin words containing diphthongs. (See Table 4.4.) When we consider the raw accuracy rates of words containing diphthongs in comparison to words without diphthongs, we see a dramatic difference in accuracy—44% versus 80% (regardless of letter-phoneme consistency). This difference suggests that the phonological ambiguity of diphthongs, which were particularly common in the Mandarin stimuli (12 Mandarin words had diphthongs compared with zero Russian words with diphthongs), creates confusion and makes these sequences harder to count. In fact, some listeners commented on the difficulty of separating the vowel sounds. For example,

*... sounds blended together ... not sure if 1 or 2 sounds*

*... unsure about what constitutes a sound ... not sure if 1 sound or 2*

*... Mandarin vowel combinations were hard to distinguish*  
*... hard to separate vowel sounds*

Section 6.4 provides a more detailed discussion on the debate surrounding diphthongs and how they are counted.

Another possible explanation for the differences in accuracy between the RFL and MFL groups may lie in the differences between the Cyrillic and Pinyin alphabets. Specifically, the Pinyin orthography is based on the Roman alphabet, which makes it very similar to the English orthography. Conversely, the Russian orthography uses the Cyrillic alphabet, which makes it less similar to the English orthography than the Pinyin alphabet. Therefore, a greater difference between the L1 and L2 (i.e., Russian) orthographies may encourage greater disassociation between the L1 and L2, which may in turn lead to greater success (or less interference from the L1 orthography) and/or greater reliance on the L2 rather than the L1.

### *6.3.3 Subcategory effects*

The most important unanticipated effect, and one that deserves a relatively lengthy discussion here, involves internal inconsistency within the MM category. The question is: do different words within the MM category exert different effects on the perception of phonemes, depending on nature of the MM? That is, does a continuum of difficulty exist for different types of inconsistent words? The present study was not designed to answer this question; however, it has become apparent that some of the overall differences between M and MM categories may be due to a subset (or subsets) of words in the MM category<sup>47</sup>. Therefore, some preliminary analyses are included here in an attempt to shed

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<sup>47</sup> Thank you to Dr. Bruce Derwing for pointing this out and encouraging me to explore the issue further.

light on the issue and provide us with some direction for future research. The following three tables provide the raw accuracy rates by item of the mismatched nonhomophones (Table 6.2) and mismatched homophones (Table 6.3) for the overall data as well as the mismatched nonhomophones (Table 6.4) for the subgroup data.

	Russian (L0)		English (L1)		Mandarin (L0)	
	word	mean	word	mean	word	mean
MM- NH	альт /alʲɪt/	0.96	fish /fɪʃ/	0.88	shān /ʃan/	0.88
	дать /datʲ/	0.92	shot /ʃɑt/	0.88	yī /i/	0.85
	юг /juk/	0.92	give /gɪv/	0.85	máng /maŋ/	0.69
	я /ja/	0.88	whom /hum/	0.83	huáng /xwaŋ/	0.62
	дождь /doʃtʲ/	0.85	speak /spɪk/	0.81	wàng /waŋ/	0.62
	жить /ʒɪtʲ/	0.73	month /mʌnθ/	0.79	yòng /jɔŋ/	0.62
	день /dʲɛnʲ/	0.73	truth /truθ/	0.75	yuè /yɛ/	0.62
	здесь /zdʲɛsʲ/	0.69	talk /tɑk/	0.67	tīng /tʰɪŋ/	0.58
	шесть /ʃʲɛstʲ/	0.58	quick /kwɪk/	0.65	shūo /ʃwɔ/	0.58
	звать /zvʌtʲ/	0.58	king /kɪŋ/	0.65	wǔ /u/	0.58
	кровь /krofʲ/	0.54	long /lɑŋ/	0.62	yīn /in/	0.58
	семь /sʲɛmʲ/	0.50	six /sɪks/	0.33	péng /pʰɛŋ/	0.54
	пять /pʲʌtʲ/	0.42	tax /tæks/	0.29	shéi /ʃej/	0.42
	весь /vʲɛsʲ/	0.42	box /bɑks/	0.25	duì /tweɨ/	0.31

**Table 6.2** Mean accuracy rates by mismatched item for English (L1), Russian (L0), and Mandarin (L0) *nonhomophones*

	Russian (L0)		English (L1)				Mandarin (L0)	
	word	mean	mean	word	mean	mean	word	
MM-H	три /tri/	0.88	0.96	tree /tɹi/	when /wɛn/	0.92	0.92	wèn /wɛn/
	дом /dom/	0.92	0.92	dome /dom/	coo /ku/	0.88	0.88	kū /kʰu/
	суп /sup/	0.92	0.92	soup /sup/	she /ʃi/	0.88	0.81	xī /çi/
	пол /pol/	0.81	0.92	pole /pɔɫ/	sue /su/	0.85	0.81	sù /su/
	щи /ʃ:i/	0.88	0.88	she /ʃi/	tea/tee /ti/	0.81	0.92	tí /tʰi/
	тут /tut/	0.96	0.85	toot /tut/	who /hu/	0.81	0.88	hū /xu/
	стул /stul/	0.88	0.85	stool /stuɫ/	knee /ni/	0.81	0.54	nǐ /ni/
	хит /xit/	0.88	0.85	heat /hit/	rue /ru/	0.81	0.85	rú /zu/
	сок /sok/	0.88	0.73	sock /sɔk/	pea/pee /pi/	0.77	0.85	pí /pʰi/
	ну /nu/	1.00	0.50	(k)new /nu/	my /maj/	0.21	0.46	mai /maj/
	май /maj/	0.42	0.21	my /maj/	high /haj/	0.19	0.31	hái /xaj/
				go /gow/	0.00	0.04	gòu /kow/	

**Table 6.3** Mean item accuracy rates for English (L1), Russian (L0), and Mandarin (L0) *homophones*

From the raw data in Table 6.2 and Table 6.3, five observations are apparent. First, not all types of mismatched tokens exhibit the same level of difficulty. Specifically, with respect to English (the only language in the overall data where spelling is known), the stimuli with <sh>, <wh>, silent <e>, and multiple vowel letters (e.g., <oo> and <ea>) pose little difficulty, stimuli with <ng>, <th>, and silent <l> pose moderate difficulty, and stimuli with <x> and diphthongs pose great difficulty. Second, for the Russian MM-NH the 3 most difficult tokens contained 2 palatalized consonants each. Third, for the L0 MM-H, 9 of the 11 Russian tokens and 9 of the 12 Mandarin tokens had the same accuracy as or greater accuracy than their English counterparts.<sup>48</sup> Fourth, in the Russian MM-NH, stimuli with unfamiliar phoneme combinations (e.g., /zd/ and /zv/) appear to be harder than familiar phoneme combinations, suggesting that phonotactic familiarity may

<sup>48</sup> Recall that for the L0 and L2 MM-H, the mismatch was only in their English counterparts.

be a factor (See §6.2.1 above.). Finally, diphthongs have lowest accuracy in all conditions (regardless of whether spelling is known or not).

Like the mismatched tokens for the overall data, Table 6.4 below reports the raw accuracy rates of the mismatched nonhomophones for the subgroup data, and these data suggest that the aforementioned observations for the overall data also hold for the subgroup data. In addition, the raw subgroup data here provide even more support for and insight into two of the observations made in Tables 6.2 and 6.3. First, as with <x> in English, words containing single letters (i.e., <ю> and <я> in Russian) that represent 2 phonemes have low accuracy when the listeners possess orthographic knowledge of the language (the L2) but have high accuracy when the listeners do not possess orthographic knowledge of the language (L0). Notice that listeners for whom Russian was the L2 had accuracies of 0.62 and 0.54 for the Russian words *юг* /juk/ and *я* /ja/, respectively; in contrast, listeners for whom Russian was the L0 had much higher accuracies of 0.92 and 0.83 for *юг* /juk/ and *я* /ja/, respectively. These differing results suggest that L2 listeners experience more difficulty in parsing phonemes when those phonemes are represented together via one letter (Castles et al., 2003).

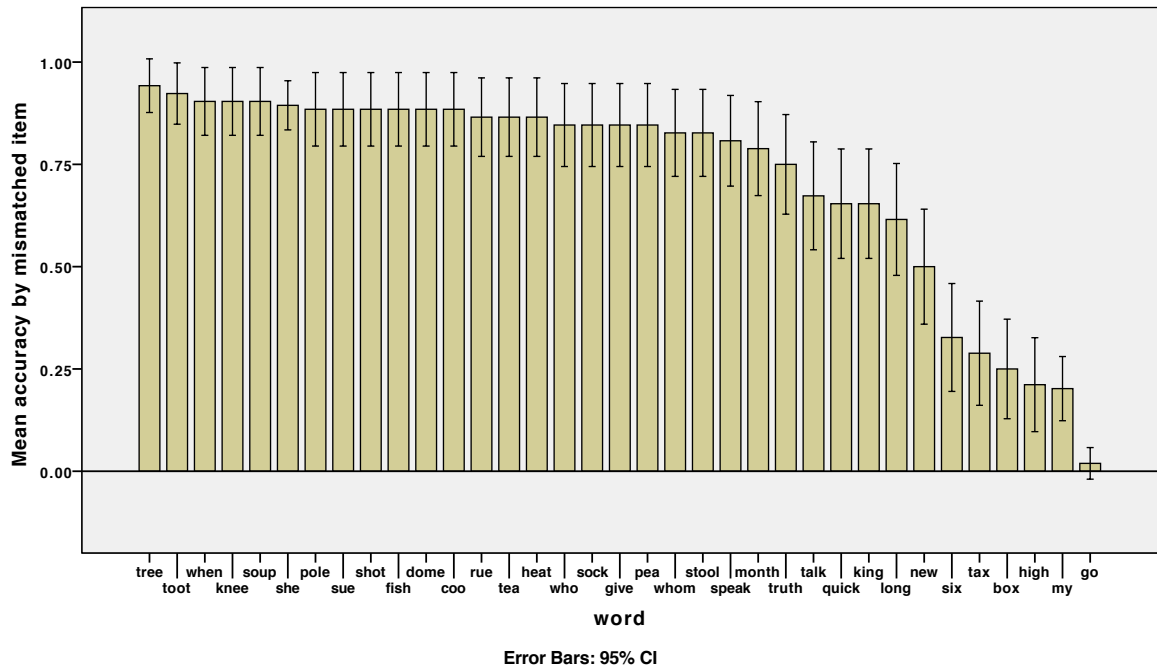
	L1		L2		L0	
	word	mean	word	mean	word	mean
RFL	whom /hum/	0.92	дать /datʲ/	1.00	yuè /yɛ/	0.85
	shot /ʃat/	0.85	дождь /doʃtʲ/	0.92	shān /ʃan/	0.77
	fish /fiʃ/	0.77	жить /ʒitʲ/	0.92	yī /i/	0.77
	give /gɪv/	0.77	альт /alʲt/	0.92	máng /maŋ/	0.77
	speak /spɪk/	0.77	шесть /ʃjɛstʲ/	0.92	yòng /jɔŋ/	0.77
	month /mʌnθ/	0.77	кровь /krofʲ/	0.92	wǔ /u/	0.54
	truth /truθ/	0.77	день /dʲɛnʲ/	0.85	yīn /in/	0.54
	talk /tak/	0.69	здесь /zdʲɛsʲ/	0.85	wàng /waŋ/	0.54
	quick /kwɪk/	0.69	звать /zvətʲ/	0.85	péng /pʰɛŋ/	0.54
	long /lɔŋ/	0.69	семь /sʲɛmʲ/	0.85	shūo /ʃwɔ/	0.54
	king /kɪŋ/	0.46	весь /vʲɛcʲ/	0.85	huáng /xwaŋ/	0.46
	tax /tæks/	0.38	юг /juk/	0.62	tīng /tʰɪŋ/	0.46
	six /sɪks/	0.31	пять /pʲatʲ/	0.54	shéi /ʃɛj/	0.38
box /bɒks/	0.23	я /ja/	0.54	duì /twej/	0.23	
MFL	fish /fiʃ/	0.92	shān /ʃan/	0.92	альт /alʲt/	0.92
	shot /ʃat/	0.83	yòng /jɔŋ/	0.83	юг /juk/	0.92
	give /gɪv/	0.75	péng /pʰɛŋ/	0.75	дать /datʲ/	0.83
	whom /hum/	0.75	wàng /waŋ/	0.75	я /ja/	0.83
	speak /spɪk/	0.75	máng /maŋ/	0.67	дождь /doʃtʲ/	0.83
	quick /kwɪk/	0.67	shūo /ʃwɔ/	0.67	день /dʲɛnʲ/	0.58
	king /kɪŋ/	0.67	tīng /tʰɪŋ/	0.58	весь /vʲɛcʲ/	0.50
	month /mʌnθ/	0.67	shéi /ʃɛj/	0.58	жить /ʒitʲ/	0.50
	truth /truθ/	0.67	yī /i/	0.58	здесь /zdʲɛsʲ/	0.50
	long /lɔŋ/	0.58	yuè /yɛ/	0.50	шесть /ʃjɛstʲ/	0.50
	talk /tak/	0.50	wǔ /u/	0.42	звать /zvətʲ/	0.50
	six /sɪks/	0.33	huáng /xwaŋ/	0.33	кровь /krofʲ/	0.50
	tax /tæks/	0.25	yīn /in/	0.25	семь /sʲɛmʲ/	0.50
box /bɒks/	0.25	duì /twej/	0.17	пять /pʲatʲ/	0.42	

**Table 6.4** RFL and MFL subgroups item accuracy for L1, L2, and L0 mismatched *nonhomophones*

Second, while not a factor related to letter-phoneme inconsistency, these accuracy data further demonstrate that phonotactic unfamiliarity results in lower accuracy rates (as discussed above in §6.2.1.). Consider the L2 and L0 accuracy rates for the Russian words *здесь* /zdʲɛsʲ/ and *звать* /zvətʲ/. With Russian as the L2, listeners are relatively accurate at counting the phonemes—0.85 accuracy for both. In contrast, with Russian as the L0,

listeners' abilities to accurately count the phonemes greatly decrease to 0.50 for both words. In short, similar to the overall data (Table 6.2), Russian MM-NH words containing the consonant combinations of /zv/ and /zd/, which are not licenced in English (or Mandarin), were more difficult to parse for speakers with Russian as the L0 than for speakers with Russian as the L2.

When further exploring different possible subcategories of inconsistent words and their potential varying degrees of difficulty, the question becomes: what are the different subcategories? Figure 6.2 visually presents the raw accuracy for each of the English mismatched items, arranged from the most accurately counted word, *tree*, to the least accurately counted word, *go*. This figure suggests at least four subcategories of inconsistent words: words containing 1) multiple consonant letters <sh> and <wh>, 2) multiple vowel letters (including silent <e>), 3) multiple consonant letters <th> and <ng>, and 4) <x> and diphthongs. (Note: The subcategories are partly based on the characteristics of the inconsistent representation, i.e., whether the inconsistency represents consonants or vowels, thus the separate categorization of subcategory 1 and subcategory 2, although the data suggest they pose the same level of ease.)

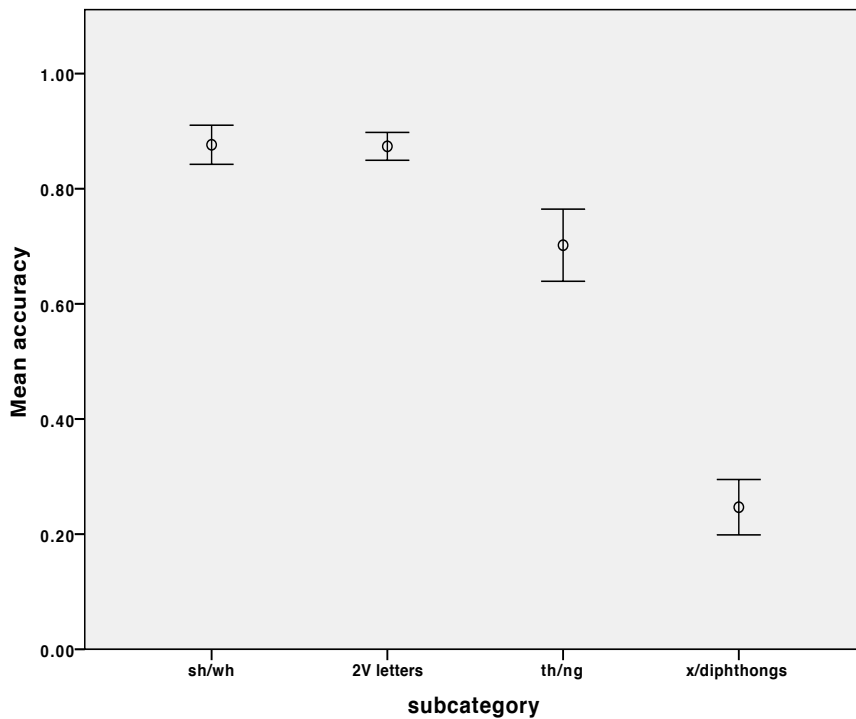


**Figure 6.2** Mean accuracy of the English mismatched items

To further explore subcategory differences in accuracy, the word items in Figure 6.2 were grouped into the four subcategories outlined above. Six items (*talk*, *go*, *knew*, *sock*, *quick*, and *knee*) were not included in the analysis because either they a) were single instances of an inconsistency (e.g., *talk* was the only token with a silent <l>), b) were ambiguous tokens (both *knee* and *knew* contained two inconsistencies—a silent <k> and multiple vowel letters), or c) did not pattern together even though they contained the same inconsistency (*sock* patterned with the multiple vowel letter items, and *quick* patterned with the <th> and <ng> items.). Each subcategory was analysed using a one-factor ANOVA with *item* as the between-subjects factor to determine whether there were any significant differences between the items in that subcategory. There were no statistically significant differences between the items in any of the subcategories (subcat1:  $F(5,358)=0.464$ ; subcat2:  $F(14,765)=0.677$ ; subcat3:  $F(3,204)=1.631$ ; subcat4:

$F(4,307)=0.936$ ; all effects not significant at  $p>0.05$ ). In other words, the accuracy performance of each item within a subcategory was not significantly different from any of the other items in that subcategory.

Figure 6.3 below represents the mean accuracy for each of the four subcategories. From this figure, we can see that subcategory 1 (i.e., sh/wh) and subcategory 2 (i.e., multiple vowel letters) exhibit roughly the same high level of accuracy followed by subcategory 3 (i.e., th/ng) with a moderate level of accuracy followed by subcategory 4 (i.e., x/diphthongs) with a low level of accuracy.



**Figure 6.3** Mean accuracy of the English mismatched items

Once internal consistency within each subcategory was confirmed (see above), differences between the four subcategories were analysed using one-factor ANOVA with *subcategory* as the between-items factor. The main effect of *subcategory* was significant

( $F(3, 25)=246.232, p<0.001$ ), which indicates a significant difference between at least two of the subcategories. Post hoc comparisons using the Tukey test indicate that the mean accuracy of subcategory 1 ( $M=0.87, SD=0.03$ ) was not significantly different from the mean accuracy of subcategory 2 ( $M=0.87, SD=0.04$ ). However, mean accuracy of subcategories 1 and 2 did differ significantly from the mean accuracies of both subcategory 3 ( $M=0.70, SD=0.08$ ) and subcategory 4 ( $M=0.26, SD=0.05$ ), and the mean accuracy of subcategory 3 differed significantly from mean accuracy of subcategory 4. In other words, while the words in subcategories 1 and 2 were not different from each other, both of these groups of words were significantly more accurate than the words in subcategory 3, which, in turn, were significantly more accurate than the words in subcategory 4. Taken together, these results indicate that not all inconsistent words exhibit the same degree of difficulty for listeners. Specifically, when counting phonemes, listeners find inconsistent words containing <sh>, <wh>, and multiple vowel letters relatively unproblematic, inconsistent words containing <th> and <ng> moderately problematic, and inconsistent words containing <x> and diphthongs highly problematic.

The findings here are, for the most part, in line with other previous research. With respect to multiple letters representing single phonemes, listeners usually ignore “silent letters” (e.g., the <h> in *when* and the <e> in *home*) and interpret the digraphs <th>, <sh>, and <ch> as single units (Derwing, 1992; Derwing, Nearey, & Dow, 1986). Using an eye-tracking paradigm, Hayes-Harb, Nicol, and Barker (2010) too discovered that silent letters did not negatively impact listeners’ judgements. Lehtonen and Treiman (2007) discovered that <ng> is more often counted as two phonemes than <th> and <sh>, possibly because (other than at the end of a word) /ŋ/ can only appear before a velar stop

as in *tank* /tæŋk/ and *finger* /fɪŋgəɪ/ where only the <n> represents /ŋ/. Lehtonen and Treiman suggest that listeners analogize this pattern to other <ng> words like *hang* and come to believe that the <n> spells /ŋ/ and the <g> spells /g/. With respect to single letters representing multiple phonemes, other research has shown that both children and adults are more likely to say a two-sound sequence such as /ɛm/ and /ɑɪ/ consists of only one sound when that sequence is a letter name—<m> and <r>, respectively (Treiman & Cassar, 1997). Castles et al. (2003) also found that multiple phonemes associated with a single letter are very difficult for native speakers to parse; specifically, their participants had great difficulty deleting the phoneme /s/ in words like *fix* because it is represented along with /k/ by the single phoneme <x>.

In sum, the analysis of the MM subcategories suggest that not all types of letter-phoneme inconsistency hinder phoneme monitoring, and that the overall differences observed between M and MM categories were possibly due to a subset of the MM tokens rather than the MM tokens as a whole. Given that the current experiment was not meant to tease apart different types of letter-phoneme inconsistencies, the methodological design did not allow us to compare each MM subcategory condition against the matched condition. Indeed, this would have entailed 5 levels of the *match* variable (i.e., matched, subcategory 1, subcategory 2, subcategory 3, and subcategory 4), which would have required many more tokens per subcategory than were available for analysis (and equal numbers across subcategories). In light of the findings of the preliminary analyses presented above, further investigation of this issue is clearly warranted, using an experiment specifically designed to compare different types of letter-phoneme inconsistencies.

#### ***6.4 Phonemicisation of diphthongs***

As mentioned previously, researchers are still debating whether diphthongs should be considered two separate units (Berg, 1986; Lehiste & Peterson, 1961; Rogers, 2000) or one cohesive unit (Wiebe, 1998; Wiebe & Derwing, 1992, 1994). On the 2 unit-side of the debate, Lehiste and Peterson (1961) argue that diphthongs should be classified as two segments because they contain two target positions. In contrast, on the 1 unit-side of the debate, Wiebe and Derwing (1992, 1994) and Wiebe (1998) argue that diphthongs form a cohesive unit because they are most often counted and perceived as one unit rather than two.<sup>49</sup> Why would listeners tend to perceive diphthongs as one unit? One possible explanation is that vowel-obstruent sequences might very well be more perceptible and easier to parse than vowel-glide sequences as the sonority distance between a vowel and an obstruent is greater than between a vowel and a glide. This speculation is not unreasonable given the multitude of research surrounding sonority sequencing (e.g., Clements, 1990; Selkirk, 1984) and perceptibility (e.g., Blevins, 2003; Steriade, 1999). If the hypothesis that the sonority distance between a vowel and its following consonant determines the perceptibility of that consonant as an individual segment is in fact correct, this might explain why the listeners more accurately counted phonemes in Russian words than in Mandarin words: fewer Russian words had vowels followed by glides (only 2 words) than Mandarin words (12 words). However, the limited and uneven number of tokens prevents us from arriving at any firm accounts of the performance differences between the Russian and Mandarin tokens at this stage. No doubt, future research must

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<sup>49</sup> Interestingly, as the literature suggests, the 1-unit side is primarily based on acoustic evidence whereas the 2-unit side is based on psycho-linguistic evidence.

explore the connection between the sonority of segments and their effects on phoneme counting tasks, and more generally on phoneme perception.

Given the controversy surrounding the number of segments in diphthongs, some questions have arisen about the proper phonemicisation of the diphthong stimuli in the current project. Should the English and Mandarin diphthongs have been coded as one unit rather than two? If so, would that coding effectively change the results? To shed light on these questions, I investigated the raw accuracy rates of the diphthongs and reanalysed the data with the reverse phonemecisation of the diphthongs.

Table 6.5 below lists the raw accuracy rates for the English and Mandarin diphthongs and orders them from the most accurately counted to the least accurately counted (when the diphthongs are counted as 2 phonemes). This table also includes the accuracy rates for each of the diphthongs if they were re-phonemecised as 1 phoneme. The raw accuracy rates suggest that coding diphthongs as one unit is not necessarily the answer. Rather, the accuracy suggests that the cohesiveness of diphthongs depends on the diphthong and that not all diphthongs are the same. For example, /aw/ diphthongs appear to be more often counted as two units (e.g. *how*=0.81, *hào*=0.85), while /ow/ and /aj/ diphthongs appear to be more often counted as one unit (*my*=0.21, *toe*=0.19, *hái*=0.31). The question then is: do speakers parse diphthongs as one or two units depending on the compatibility of their component sounds? According to Reetz and Jongman (2009), /aw/ and /ɔj/ as in *plow* and *toy* are true diphthongs with much more substantial articulatory movement from the vowel to the glide than in diphthongised vowels such as /ej/ and /ow/ as in *way* and *grow*. This substantial difference in articulatory movement and

consequently in acoustic movement may explain why /aw/ was counted as two segments while /ej/ and /ow/ were counted as one.

<b>word</b>	<b>language</b>	<b>2 phonemes</b>	<b>1 phoneme<sup>50</sup></b>
<b>hào</b> /xaw/	Mandarin	<b>0.85</b>	<b>0.12</b>
<b>how</b> /haw/	English	<b>0.81</b>	<b>0.19</b>
<b>bào</b> /paw/	Mandarin	<b>0.81</b>	<b>0.19</b>
<b>nào</b> /naw/	Mandarin	<b>0.77</b>	<b>0.23</b>
<b>now</b> /naw/	English	<b>0.69</b>	<b>0.31</b>
<b>gāo</b> /kaw/	Mandarin	<b>0.69</b>	<b>0.31</b>
<b>bow</b> /baw/	English	<b>0.62</b>	<b>0.31</b>
<b>méi</b> /mej/	Mandarin	<b>0.62</b>	<b>0.35</b>
<b>mài</b> /maj/	Mandarin	<b>0.46</b>	<b>0.54</b>
<b>May</b> /mej/	English	<b>0.46</b>	<b>0.48</b>
<b>shéi</b> /ʃej/	Mandarin	<b>0.42</b>	<b>0.54</b>
<b>tóu</b> /t <sup>h</sup> ow/	Mandarin	<b>0.42</b>	<b>0.58</b>
<b>kuài</b> /k <sup>h</sup> waj/	Mandarin	<b>0.31</b>	<b>0.62</b>
<b>duì</b> /twej/	Mandarin	<b>0.31</b>	<b>0.54</b>
<b>hái</b> /xaj/	Mandarin	<b>0.31</b>	<b>0.65</b>
<b>my</b> /maj/	English	<b>0.21</b>	<b>0.78</b>
<b>high</b> /haj/	English	<b>0.19</b>	<b>0.75</b>
<b>toe</b> /tow/	English	<b>0.19</b>	<b>0.73</b>
<b>die</b> /daj/	English	<b>0.15</b>	<b>0.81</b>
<b>gòu</b> /kow/	Mandarin	<b>0.04</b>	<b>0.96</b>
<b>go</b> /gow/	English	<b>0.00</b>	<b>0.96</b>

**Table 6.5** Raw accuracy rates for English and Mandarin diphthongs

In addition to investigating the raw accuracy rates, I also reanalysed the L1 and L0 homophone data<sup>51</sup> with the diphthongs re-phonemecised as 1 phoneme and re-categorised into the appropriate M and MM categories to determine whether the choice of

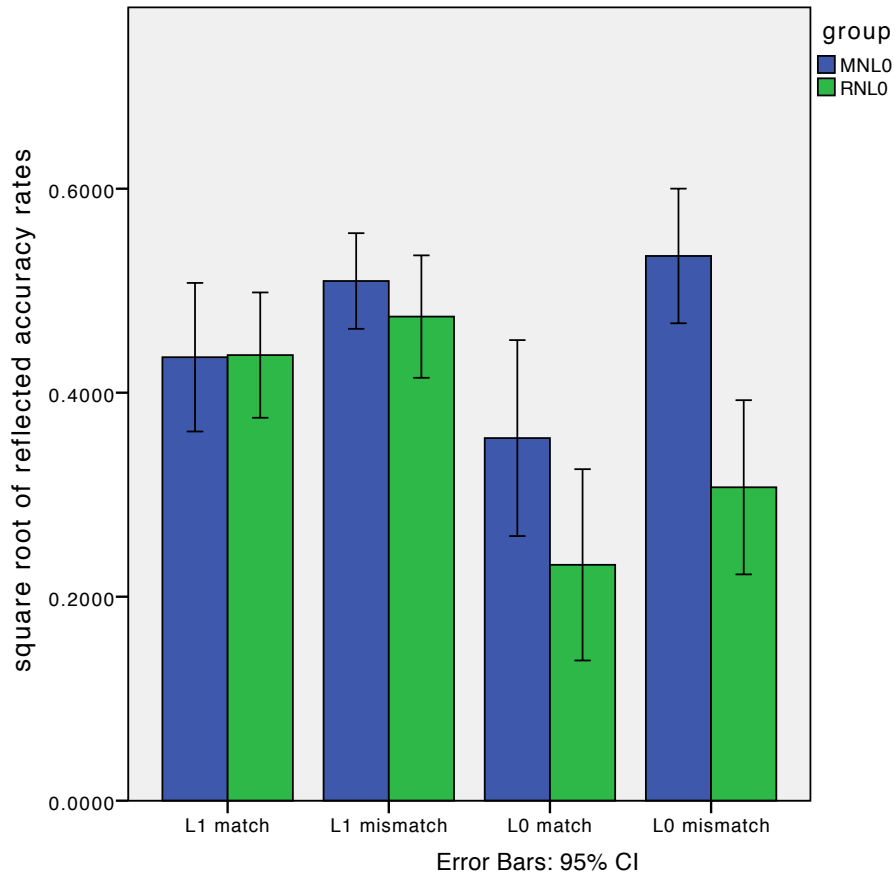
<sup>50</sup> In the cases where the 2 phoneme accuracy and 1 phoneme accuracy do not add up to 100%, the missing percentages result from instances where participants counted the words with diphthongs as neither 2 phonemes nor 1 phoneme.

<sup>51</sup> I could not reanalyse the L2 data because the diphthongs could not be re-phonemecised in a way that did not also introduce other confounding factors. That is, the L2 MM-H condition would have contained both matched and mismatched tokens rather than matched tokens. The match-mismatch mix, however, is not problematic for the L0 data as the participants had no knowledge of the spellings of the L0 words.

phonemicisation had a bearing on the results. Table 6.6 and Figure 6.4 reproduce the categorisation of the diphthongs (highlighted in grey) and the results from the original analysis, respectively.

	Russian [24 tokens]	English [48 tokens]	Mandarin [24 tokens]	
<b>M-H:</b> 1-to-1 relation- ship in both L1 and L2 [10 per language]	он /an/ ( <i>he</i> ) 2-2 лифт /lift/ ( <i>elevator</i> ) 4-4 дай /daj/ ( <i>to give</i> ) 3-3 сад /sat/ ( <i>garden</i> ) 3-3 март /mart/ ( <i>March</i> ) 4-4 карт /kart/ ( <i>map GEN.PL</i> ) 4-4 брат /brat/ ( <i>brother</i> ) 4-4	он /an/ 2-2 lift /lift/ 4-4 die /daj/ 3-3 sat /sæt/ 3-3 mart /maɪt/ 4-4 cart /kɑ:ɪt/ 4-4 brat /bræt/ 4-4	May /mej/ 3-3 now /naw/ 3-3 do /du/ 2-2 toe /tow/ 3-3 swan /swan/ 4-4 bow /baw/ 3-3 ban /bæn/ 3-3 how /haw/ 3-3 man /mæn/ 3-3 bun /bʌn/ 3-3	méi /mej/ ( <i>did not have not</i> ) 3-3 nào /naw/ ( <i>noisy</i> ) 3-3 dú /tu/ ( <i>to read</i> ) 2-2 tóu /tʰow/ ( <i>head</i> ) 3-3 suān /swan/ ( <i>sour</i> ) 4-4 bào /paw/ ( <i>newspaper</i> ) 3-3 bàn /pan/ ( <i>half</i> ) 3-3 hào /xaw/ ( <i>number</i> ) 3-3 màn /man/ ( <i>slow</i> ) 3-3 bèn /pɣn/ ( <i>stupid</i> ) 3-3
<b>MM-H:</b> *mismatch in spelling for L1 *1-to-1 relation- ship in L2 [14 per language]	май /maj/ ( <i>May</i> ) 3-3 дом /dom/ ( <i>house</i> ) 3-3 щи /ʃ:i/ ( <i>cabbage soup</i> ) 2-2 стул /stul/ ( <i>chair</i> ) 4-4 суп /sup/ ( <i>soup</i> ) 3-3 тут /tut/ ( <i>here</i> ) 3-3 три /tri/ ( <i>three</i> ) 3-3 ну /nu/ ( <i>well</i> ) 2-2 сок /sok/ ( <i>juice</i> ) 3-3 пол /pol/ ( <i>floor</i> ) 3-3 хит /xit/ ( <i>hit</i> ) 3-3	my /maj/ 2-3 dome /dom/ 4-3 she /ʃi/ 3-2 stool /stu:/ 5-4 soup /sup/ 4-3 toot /tut/ 4-3 tree /tri/ 4-3 (k)new /nu/ 4-3 sock /sak/ 4-3 pole /pɒl/ 4-3 heat /hit/ 4-3	my /maj/ 2-3 when /wɛn/ 4-3 coo /ku/ 3-2 pea/pee /pi/ 3-2 sue /su/ 3-2 tea/tee /ti/ 3-2 who /hu/ 3-2 knee /ni/ 4-2 she /ʃi/ 3-2 go /gow/ 2-3 high /haj/ 4-3 rue /ru/ 3-2	mai /maj/ ( <i>to sell</i> ) 3-3 wèn /wɣn/ ( <i>to ask</i> ) 3-3 kū /ku/ ( <i>to cry</i> ) 2-2 pí /pʰi/ ( <i>skin</i> ) 2-2 sù /su/ ( <i>to tell</i> ) 2-2 tí /tʰi/ ( <i>to carry</i> ) 2-2 hū /xu/ ( <i>to call</i> ) 2-2 nǐ /ni/ ( <i>you</i> ) 2-2 xī /ci/ ( <i>west</i> ) 2-2 gòu /kow/ ( <i>enough</i> ) 3-3 hái /xaj/ ( <i>still / yet</i> ) 3-3 rú /zu/ ( <i>if / as if</i> ) 2-2

**Table 6.6** Original categorisation of target words with diphthongs phonemicised as 2 segments



**Figure 6.4** Original analyses of L1 and L0 H with the diphthongs phonemicised as 2 phonemes

The data here show that for the L1 data, the matched Hs were more accurately counted than the mismatched Hs but that there was no difference between the RNLO and MNLO groups. In contrast, for the L0 data, the results suggest that while both groups counted matched L0 Hs more accurately than mismatched L0 Hs, the RNLO was more accurate than the MNLO overall. (See §5.3 for the complete statistical analyses of these original data.)

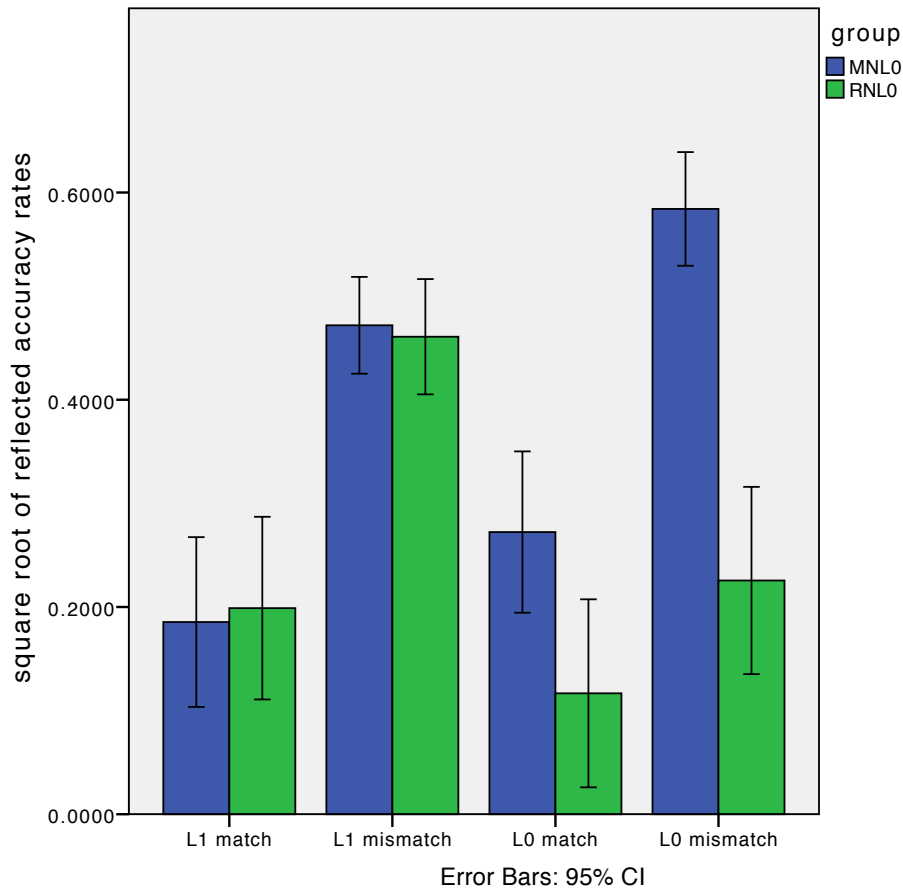
Table 6.7 and Figure 6.5 below present the re-categorised and re-analysed data results for the diphthongs phonemicised as 1 phoneme (rather than 2 as in the original analysis).

	Russian [24 tokens]	English [48 tokens]	Mandarin [24 tokens]	
<b>M-H:</b> 1-to-1 relationship in both L1 and L2 [10 per language]	он /an/ ( <i>he</i> ) 2-2 лифт /lift/ ( <i>elevator</i> ) 4-4 дай /daj/ ( <i>to give</i> ) 3-3 сад /sat/ ( <i>garden</i> ) 3-3 март /mart/ ( <i>March</i> ) 4-4 карт /kart/ ( <i>map GEN.PL</i> ) 4-4 брат /brat/ ( <i>brother</i> ) 4-4	on /an/ 2-2 lift /lift/ 4-4 die /daj/ 3-2 sat /sæt/ 3-3 mart /mɑ:rt/ 4-4 cart /kɑ:rt/ 4-4 brat /bræt/ 4-4	my /ma <sup>l</sup> / 2-2 <sup>52</sup> go /go <sup>w</sup> / 2-2 do /du/ 2-2 swan /swan/ 4-4 ban /bæn/ 3-3 man /mæn/ 3-3 bun /bʌn/ 3-3	mai /ma <sup>l</sup> / ( <i>to sell</i> ) 3-2 gòu /ko <sup>w</sup> / ( <i>enough</i> ) 3-2 dú /tu/ ( <i>to read</i> ) 2-2 suān /swan/ ( <i>sour</i> ) 4-4 bàn /pan/ ( <i>half</i> ) 3-3 màn /man/ ( <i>slow</i> ) 3-3 bèn /pɛn/ ( <i>stupid</i> ) 3-3
<b>MM-H:</b> *mismatch in spelling for L1 *1-to-1 relationship in L2 [14 per language]	май /maj/ ( <i>May</i> ) 3-3 дом /dom/ ( <i>house</i> ) 3-3 щи /ʃ:i/ ( <i>cabbage soup</i> ) 2-2 стул /stul/ ( <i>chair</i> ) 4-4 суп /sup/ ( <i>soup</i> ) 3-3 тут /tut/ ( <i>here</i> ) 3-3 три /tri/ ( <i>three</i> ) 3-3 ну /nu/ ( <i>well</i> ) 2-2 сок /sok/ ( <i>juice</i> ) 3-3 пол /pol/ ( <i>floor</i> ) 3-3 хит /xit/ ( <i>hit</i> ) 3-3	my /ma <sup>l</sup> / 2-2 dome /dom/ 4-3 she /ʃi/ 3-2 stool /stu:/ 5-4 soup /sup/ 4-3 toot /tut/ 4-3 tree /tri/ 4-3 (k)new /nu/ 4-3 sock /sok/ 4-3 pole /poł/ 4-3 heat /hit/ 4-3	May /me <sup>l</sup> / 3-2 now /na <sup>w</sup> / 3-2 toe /to <sup>w</sup> / 3-2 bow /ba <sup>w</sup> / 3-2 how /ha <sup>w</sup> / 3-2 when /wɛn/ 4-3 coo /ku/ 3-2 pea/pee /pi/ 3-2 sue /su/ 3-2 tea/tee /ti/ 3-2 who /hu/ 3-2 knee /ni/ 4-2 she /ʃi/ 3-2 high /ha <sup>l</sup> / 4-2 rue /ru/ 3-2	méi /me <sup>l</sup> / ( <i>did not/have not</i> ) 3-2 nào /na <sup>w</sup> / ( <i>noisy</i> ) 3-2 tóu /t <sup>h</sup> o <sup>w</sup> / ( <i>head</i> ) 3-2 bào /pa <sup>w</sup> / ( <i>newspaper</i> ) 3-2 hào /xa <sup>w</sup> / ( <i>number</i> ) 3-2 wèn /wɛn/ ( <i>to ask</i> ) 3-3 kū /ku/ ( <i>to cry</i> ) 2-2 pí /p <sup>h</sup> i/ ( <i>skin</i> ) 2-2 sù /su/ ( <i>to tell</i> ) 2-2 tí /t <sup>h</sup> i/ ( <i>to carry</i> ) 2-2 hū /xu/ ( <i>to call</i> ) 2-2 nǐ /ni/ ( <i>you</i> ) 2-2 xī /ci/ ( <i>west</i> ) 2-2 hái /xa <sup>l</sup> / ( <i>still /yet</i> ) 3-2 rú /zu/ ( <i>if/as if</i> ) 2-2

**Table 6.7** Re-categorised L1 and L0 H data with the diphthongs phonemicised as 1 phoneme

Interestingly, in Figure 6.5 below, we can see a very similar pattern of results to the original analyses, except the accuracy difference between the matched and mismatched L1 H appears to be much greater than in the original analyses.

<sup>52</sup> When phonemicised as 2 phonemes the diphthongs are represented as VG sequences as in /aw/, /ej/, /aj/ and /ow/. In contrast, when phonemicised as 1 phoneme the diphthongs are represented as V<sup>G</sup> sequences as in /a<sup>w</sup>/, /e<sup>l</sup>/, /a<sup>l</sup>/ and /o<sup>w</sup>/



**Figure 6.5** Re-analysed L1 and L0 H data with the diphthongs phonemicised as 1 phoneme

The reflected accuracy data for the L1 and L0 H were analysed using a 3-factor repeated measures ANOVA with *group* (MNLO, RNL0) as the between-subjects factor and *language* (L1, L0) and *match* (match, mismatch) as the two within-subjects factors. The main effects of *match* and *group*, the 2-way interactions of *language* and *group*, and *match* and *group*, and the 3-way interaction of *language* and *match* and *group* were significant (match:  $F(1,50)=102.212$ ,  $p<0.001$ ; group:  $F(1,50)=16.873$ ,  $p<0.001$ ; match by group:  $F(1,50)=5.687$ ,  $p<0.05$ ; language by group:  $F(1,50)=41.480$ ,  $p<0.001$ ; language by match by group:  $F(1,50)=4.049$ ,  $p=0.05$ ). All other effects were not significant (language:  $F(1,50)=2.208$ ; language by match:  $F(1,50)=2.133$ ; all effects not

significant at  $p > 0.05$ ). Tests for the effects of *match* and *group* for each language show a significant main effect of *match* for the L1 H ( $F(1,50)=66.936$ ,  $p < 0.001$ ) such that all participants more accurately counted phonemes in L1 matched H than mismatched H.

In addition, the effects of *match* and *group* were tested separately for each language. For the L1 H words, the tests indicate a significant main effect of *match* ( $F(1,50)=66.936$ ,  $p < 0.001$ ), but no significant main effect for *group* ( $F(1,50)=0.021$ ,  $p > 0.05$ ) or interaction of *match* and *group* ( $F(1,50)=0.099$ ,  $p > 0.05$ ). Thus, both groups are significantly more accurate at counting phonemes in matched L1 H than in mismatched L1 H. For the L0 H words, the follow-up tests indicate significant main effects of *match* and *group* as well as the interaction of *match* and *group* (match:  $F(1,50)=40.246$ ,  $p < 0.001$ ; group:  $F(1,50)=238.289$ ,  $p < 0.001$ ; match by group:  $F(1,50)=9.955$ ,  $p < 0.01$ ). Subsequent tests for the effects of *match* for each *group* separately indicate a significant effect of *match* for the RNL0 ( $F(1,50)=4.894$ ,  $p < 0.05$ ) and MNL0 ( $F(1,50)=46.943$ ,  $p < 0.001$ ) groups. That is, both groups more accurately counted phonemes in the matched L0 Hs than the mismatched L0 Hs, but the difference was greater for the MNL0 group than the RNL0 group.

Re-phonemicising the diphthongs did not bring all the diphthongs into one inclusive category. Rather, by changing the phonemicisation from 2 phonemes to 1 phoneme, the originally matched words and mismatched words swapped categories so that the matched words became mismatched words and vice versa. By swapping categories, there were still diphthongs in each reorganised category, except that now the /e<sup>j</sup>/ and /o<sup>w</sup>/ diphthongs were accurately counted while the /a<sup>w</sup>/ diphthongs were not. In other words, the diphthongs still may have balanced each other out—just in the opposite way from the

original data—thus possibly explaining why the pattern of results remained the same. Also, the greater difference between the reanalysed L1 M and MM might be explained by the /aw/ words (phonemicised as 1 phoneme /a<sup>w</sup>/) moving into the MM condition. These /aw/ words were accurately counted as 2 phonemes in the original analysis, so they would have been counted inaccurately in the re-analysis, adding to the inaccuracy of the MM category and widening the gap between the L1 M and MM conditions and the Mandarin L0 M and MM conditions (The Russian L0 conditions had no diphthongs.). In short, simply categorising diphthongs as either 1 or 2 phonemes across the board is not the answer; instead, when phonemising diphthongs, it appears that each diphthong must be analysed individually on its own terms.

### **6.5 Summary**

This chapter has discussed the two major findings regarding orthographic effects. The first major finding here supports previous research findings that participants' orthographic knowledge influences their phoneme awareness of words (e.g., Bassetti, 2006; Burnham, 2003; Castles et al., 2003; Ehri & Wilce, 1980; Perin, 1983; Pytlyk, to appear; Treiman & Cassar, 1997). In short, listeners count phonemes more accurately in words with consistent letter-phoneme correspondences than in words with inconsistent letter-phoneme correspondences. The results demonstrate that L1 orthographic knowledge influences phoneme awareness in the first language and an unfamiliar language and that L2 orthographic knowledge influences phoneme perception in a second language. We can conclude from the results that when a match exists between the number of letters and the number of phonemes in a word, the orthography aids listeners in perceiving the correct number of phonemes in a word. In contrast, when a mismatch

exists between the number of letters and the number of phonemes, the orthography prevents listeners from perceiving the correct number of phonemes because they receive conflicting orthographic and phonological information. These results provide further evidence that orthographic and phonological information are co-activated in L1 and L2 speech processing even in the absence of visual stimuli (Blau et al., 2008; Chéreau et al., 2007; Taft et al., 2008; Ziegler & Ferrand, 1998; Ziegler et al., 2003; Ziegler et al., 2004). Moreover, these results provide evidence that listeners are sensitive to orthographic information, which can trigger unwanted interference when the two systems provide conflicting information (Burnham, 2003; Landerl et al., 1996; Perin, 1983; Treiman & Cassar, 1997). Most importantly, the results from this current project reveal that not only are listeners susceptible to L1 orthographic interference, but they are also susceptible to L2 orthographic interference.

The second major finding stemming from this research is that orthographic effects appear to be language-specific. Comparisons of subgroups' homophone data show that the listeners were equally accurate and as fast at counting phonemes in L2 matched H words (i.e., L2 words with consistent L1 associations) as they were in counting the mismatched H words (i.e., L2 words with inconsistent L1 associations). The lack of any significant performance differences between these two types of L2 words suggest that L2 listeners rely on the L2 orthographic information rather than the L1 orthographic information when counting phonemes in their L2. These results suggest that L2 orthographic effects override L1 orthographic effects by the intermediate stages of second language learning, at least for Russian and Mandarin. Apparently, by the time L2 learners become intermediate learners, they are able to transcend L1 orthographic

influence, but they do have to contend with L2 orthographic influence as evidenced by the significant differences in performance between the L2 NH matched and mismatched words. As with L2 reading and spelling (Sun-Alperin & Wang, 2011; Wang et al., 2006; Wang et al., 2005), these results indicate that L1 orthographic effects may not transfer into L2 speech perception when the L2 orthography is known. Rather, L2 listeners appear to dissociate themselves from L1 orthographic knowledge and employ their L2 orthographic knowledge to aid them in speech perception. While the reasons why L2 orthographic knowledge overrides the more entrenched L1 orthographic knowledge are not entirely clear at this point, it is possible that—as has been suggested for L1 orthography and phonology (e.g., Burnham, 1986, 2003; Burnham et al., 1991; Carroll, 2004; Castro-Caldas et al., 1998; Flege, 1991; Olson, 1996; Treiman & Cassar, 1997; Ziegler et al., 2004)—learning to read forces the organisation of L2 phonology such that the two systems become inseparably linked and thus are co-activated in L2 speech processing. In addition to the language-specific nature of orthographic effects, the degree of orthographic influence also appears to be directly correlated to the degree of experience listeners have in the target language. The more experience listeners have with the language the greater the orthographic effects are.

This chapter has also proposed the Bipartite Model, which accounts for the seemingly contradictory findings discovered in this and previous research. The model identifies two types of L1 orthographic knowledge: abstract and operational. Abstract knowledge refers to the assumptions and principles children/learners have about the function of orthography and its relationship to phonology. Based on the current and previous findings, the model proposes that this aspect of L1 orthographic knowledge

appears to transfer into nonnative language processing regardless of whether the listeners/speakers are familiar with the nonnative language (e.g., Bassetti, 2006; Vokic, 2011). In contrast, operational knowledge in this model refers to the actual letter-phoneme correspondences created in any given language. Here, the model predicts that this aspect of L1 orthographic knowledge transfers into the nonnative language processing in the absence of nonnative orthographic knowledge (i.e., the L0), but does not transfer in the presence of nonnative orthographic knowledge (i.e., the L2).

In addition to the major findings, this chapter outlined and discussed three unanticipated findings from the data analyses. First, listeners also demonstrate familiarity and word effects, which interact with orthographic knowledge and attenuate orthographic effects. Second, a phonological effect accounts for the performance asymmetry between the Russian and Mandarin words. This phonological effect is likely due to the differing phonological structures of Russian and Mandarin. Third, preliminary analyses of the mismatched stimuli suggest at least four different subcategories of inconsistency that vary in terms of their influence on L1 and L2 speech perception. Finally, this chapter addresses the question of the proper phonemicisation of the diphthongs and reanalysed the data to determine whether rephonemising the diphthongs as 1 phoneme would impact the results. Interestingly, the pattern of results remained the same; likely due to the fact that the diphthongs varied in accuracy from 85% to 0% and re-phonemising them simply swapped their categories but maintained the balance.

## Chapter Seven

### CONCLUSION

*“The nature of the L1 orthography influences the way L2 learners attend to the L2 orthographic units”  
(Wade-Woolley, 1999, p. 448)*

This final chapter completes this dissertation with four closing sections. The first section summarises the entire project from the research questions and hypotheses to the conclusions stemming from the major findings (§7.1). The second section (§7.2) discusses the limitations of the research. The third section (§7.3) suggests some potential future research endeavours. The final section (§7.4) completes this dissertation by outlining the contributions this research makes to the growing body of literature surrounding the effects of orthographic knowledge on speech processing not only in native languages but also in nonnative languages.

#### ***7.1 Summary of research***

This research investigated how orthographic knowledge affects phoneme detection in listeners’ first language (L1), second language (L2) and an unfamiliar language (L0).

This study sought to

1. confirm that L1 orthographic knowledge influences L1 phoneme perception,
2. determine if L1 orthographic knowledge affects L0 phoneme perception,
3. discover whether L2 orthographic knowledge influences L2 phoneme perception and if so how it interacts with L1 orthographic knowledge, and

- ascertain whether amount of language experience dictates the strength of orthographic effects.

The project studied the effect of orthographic knowledge on phoneme awareness in English (L1), Russian (L2 or L0), and Mandarin (L2 or L0). The stimuli for each language were created and organised according to two parameters: *match* and *homophony*. The assumption here was that accuracy and response time differences between the different types of target words would indicate an effect of orthographic knowledge on phoneme perception.

In the research project, participants listened to the target stimuli and counted the number of “sounds” they heard in each word via a phoneme counting task, which assesses the influence of orthographic factors and measures phoneme awareness (Treiman & Cassar, 1997). Fifty-two native speakers of Canadian English participated and counted phonemes in words from their L1 (English) and L0 (either Russian or Mandarin). The MNL0 group counted phonemes in English (L1) and Mandarin (L0) words while the RNL0 group counted phonemes in English (L1) and Russian (L0) words. In addition, two subgroups of participants also counted phonemes in their L2. The L2 for the subgroup within the MNL0 was Russian (the RFL subgroup), and the L2 for the subgroup within the RNL0 was Mandarin (the MFL subgroup).

Once collected from the participants, the data were analysed according to accuracy rates and response times in order to investigate the effects of orthographic knowledge on L1, L2, and L0 phoneme perception. Four-way repeated measures ANOVAs analysed the data along four independent factors (*group*, *language*, *homophone*, and *match*) to answer the four primary research questions outlined above. Overall, the results of the analyses

confirm the hypotheses that L1 orthographic knowledge influences both L1 and L0 phoneme perception (Questions 1 and 2), that L2 orthographic knowledge influences L2 phoneme perception (Question 3), and that the degree of language experience determines the strength of orthographic effects such that orthographic effects are strongest in L1 followed by L2 and are the weakest in L0 (Question 4). Specifically, L1 orthographic knowledge facilitates L1 and L0 phoneme perception when the number of letters equals the number of phonemes in a word, and conversely, L1 orthographic knowledge hinders L1 and L0 phoneme perception when the number of letters does not equal the number of phonemes. The results also show a parallel pattern of influence with L2 orthographic knowledge facilitating L2 phoneme perception in consistent words but hindering L2 perception in inconsistent words. These L1, L0, and L2 results provide further evidence that orthographic and phonological information are co-activated in speech processing even in the absence of visual stimuli (Blau et al., 2008; Chéreau et al., 2007; Taft et al., 2008; Ziegler & Ferrand 1998; Ziegler et al. 2003; Ziegler et al. 2004). In addition, these results provide evidence that listeners are sensitive to orthographic information, which may trigger unwanted interference when the orthographic and phonological systems provide conflicting information (Burnham, 2003; Landerl et al., 1996; Perin, 1983; Treiman & Cassar, 1997). Finally and most interestingly, the results reveal that listeners are susceptible to L2 orthographic interference as well as L1 orthographic interference.

Not only does L2 orthographic knowledge appear to influence L2 phoneme perception, but it also appears to override any potential L1 orthographic effects thereby suggesting that orthographic effects are language-specific. Comparisons of subgroups' homophone data show that the listeners were as accurate and as fast at counting

phonemes in L2 matched homophones words (i.e., L2 words with consistent L1 associations) as they were in counting the mismatched homophones (i.e., L2 words with inconsistent L1 associations). The lack of any significant performance differences between these two types of L2 words suggest that L2 listeners rely on the L2 orthographic information rather than the L1 orthographic information when counting phonemes in their L2. These results imply that by the intermediate stage of learning, L2 listeners appear to dissociate themselves from L1 orthographic knowledge and employ their L2 orthographic knowledge to aid them in speech perception. The reasons why L2 orthographic knowledge overrides the more entrenched L1 orthographic knowledge are not entirely clear at this point. However, it is possible that—as with L1 acquisition—learning to read forces the organisation of L2 phonology such that the two systems become inseparably linked and thus are co-activated in L2 speech processing.

As a way of synthesising the findings here and the findings from previous research, this dissertation proposes two components of orthographic knowledge: abstract and operational. Abstract knowledge refers to the general assumptions and principles children and/or learners have about the function of orthography and its relationship to phonology (e.g., letters map onto phonemes or letters map onto morphemes). It predicts that this aspect of L1 orthographic knowledge transfers into nonnative language processing regardless of whether the listeners/speakers are familiar with the nonnative language (e.g., Bassetti, 2006; Vokic, 2011). In contrast, operational knowledge refers to the actual letter-phoneme correspondences created in any given language (i.e., what letters map to what phonemes). Here, the proposal predicts that this aspect of L1 orthographic knowledge transfers into the nonnative language processing in the absence nonnative

orthographic knowledge (i.e., the L0), but does not transfer in the presence of nonnative orthographic knowledge (i.e., the L2). Rather, L2-specific operational knowledge is created based partly on the transferred abstract knowledge. These two aspects of orthographic knowledge are encapsulated in what is termed the Bipartite Model of Orthographic Knowledge and Transfer.

In addition to the major findings regarding the effects of orthographic knowledge, the results suggest a number of other effects and interactions. First, the results indicate that orthographic knowledge interacts with familiarity and with the nature of the words themselves to influence L0 phoneme perception. The interaction of these effects reduces the effects of L1 orthography on L0 phoneme counting, such that its influence is not as strong in the L0 as it is in the L1. Second, the phonological structure of the target languages appears to influence the ease of phoneme perception. Finally, investigation into the internal consistency of the mismatched tokens suggest that not all mismatched words pose the same level of difficulty for listeners, and that the observed difference between the M and MM words may be due to a subset of MM words rather than the MM words as a whole.

## ***7.2 Limitations***

While every aspect and decision was carefully considered, this research is not without its limitations. This research contains two types of limitations. The first type includes the limitations that were unavoidable due to the differences between the target languages. As mentioned in Chapter 4, because the L2 subgroup participants needed to be orthographically and phonologically familiar with the target words, there were a limited number of cross-language homophones available that fit all the parameters. This resulted

in certain unavoidable limitations with respect to stimuli selection. First, only 10 target words could be found for the matched homophone conditions, in contrast to the 14 target words of each of the other conditions. Second, not all the Russian nonhomophone words followed English phonotactic rules, although particularly difficult consonant clusters in Russian were avoided. Third, the relatively simple syllable structure of Mandarin (See §3.2.3.2.) meant that diphthongs (and tone) were impossible to avoid. Some of the L0 listeners commented on the “strange” or “weird” sound combinations in the L0 words. The unlicensed combinations (Russian) and the contour pitch (Mandarin) may have thrown off the participants from the task at hand, especially with the nonhomophone targets where they did not have any orthographic support in parsing phonemes. In addition, cross-linguistic differences in syllable structure and phonotactics may have contributed the word effects discussed in §6.3.2 above. Finally, the limited stimuli available prevented controlling for the internal consistency of the mismatched words. That is, to have enough tokens in the MM conditions, these conditions were populated with different types of inconsistency, which, as it turned out, were not all equal in terms of their effect on phoneme counting. Potential solutions to these limitations might include 1) choosing target languages that are more phonotactically similar and with fewer restrictions on phonological structure, 2) investigating potential differences between subcategories of mismatched tokens and comparing them with the matched tokens, and 3) studying more advanced learners so that it is possible to draw the homophones from a more extensive L2 vocabulary.

The second type of limitations includes the unforeseen and unanticipated limitations with the methodological design. First, half way through the L2 data collection, it became

apparent that knowing whether the participants knew how to spell the L1 words (and the L2 words in case of the RFL and MFL subgroups) was extremely important. Unfortunately, 18 of the 52 participants did not complete a spelling dictation. Fortunately, those participants whose spelling was tested indicated that they could spell the vast majority of the words. While we may assume that the first 18 participants would have been equally adept at spelling, still we cannot be absolutely certain that those whose spelling was not tested also knew how to spell the L1 (and L2 words). Second, the order of the data collection (i.e., primary data then secondary data) was a methodological limitation. The secondary data should have been collected and analysed *before* the primary data so that the problematic tokens (which were discarded) would have been identified prior to the primary data collection, and other stimuli could have been chosen in their places thereby equalising the number of tokens in each condition. The secondary data collection came after the primary data because it was envisioned to help interpret the primary results not to evaluate the stimuli. While this is not an exhaustive list, these limitations outlined here are the major limitations discovered within the research.

### ***7.3 Future research***

The Bipartite Model proposed in Chapter 6 is clearly still in its infancy; much research is required to support and refine its claims and predictions. For example, future research needs to determine to what extent orthographic transparency affects L2 orthographic learning, and if transparency does exert a strong influence, the model needs to be adapted to reflect this influence. Also, future research needs to test the model's prediction that non-literate L2 learners would transfer L1 operational knowledge as well as L1 abstract knowledge into their L2 speech processing. Indeed, the model predicts that non-literate

L2 learners would behave like the L0 listeners in this research because they do not have any L2 orthographic knowledge. These non-literates should therefore rely on both their abstract and operational L1 orthographic knowledge. In addition, other interesting research possibilities would test and help refine the Bipartite Model. These include investigating and comparing:

1. L2 groups that vary according to proficiency/experience (i.e., beginner, intermediate, and advanced) to determine/confirm that the degree of language experience is, indeed, a factor in the strength of orthographic effects and to see when L2 specific operational knowledge takes hold,
2. L2 learners from a transparent L1 orthography learning an opaque L2 orthography (e.g., Spanish L1 and English L2) and L2 learners from a opaque L1 orthography learning a transparent L2 orthography (e.g., English L1 and Spanish L2) to determine whether learning an opaque L2 orthography requires more time and exposure in order to develop L2 decoding skills and operational knowledge than learning a transparent L2 orthography does,
3. the strength of orthography-phonology connections between L2s with differing transparency to determine whether the connections are stronger between orthography and phonology when the L2 is more transparent than when the L2 is less transparent.
4. “Good” vs. “bad” spellers to determine whether “good” spellers rely more on L2 operational knowledge than “bad” spellers do, to determine if degree of literacy is also a factor in the model, and

One of the most interesting and important issues raised here involves internal inconsistency within the MM words. Future research must delve into the question of whether different types of MM exert different effects on the perception of phonemes. That is, does a continuum of difficulty exist for subcategories of inconsistent words? While the present study was not designed to answer this question, the preliminary analysis of the MM words suggests that not all MM words influence listeners' abilities to parse phonemes to the same degree. Thus, future research is required to test these preliminary findings and determine how many subcategories of inconsistency exist and which subcategories hinder phoneme perception.

The suggestions listed here are only a few of the possibilities for future research. Because the effect of orthographic knowledge on L2 and L0 phoneme awareness remains relatively unexplored, the research possibilities are seemingly endless.

#### ***7.4 Contributions***

This project contributes to the body of literature on orthographic knowledge by investigating and determining how orthographic knowledge affects phoneme perception not only in an L1 but also in an L2 and an L0. Specifically, the research here contributes to the body of literature in three ways. First, the current research supports previous findings and claims regarding orthographic knowledge and native language speech processing. Second, the L2 findings provide insight into the relatively sparse—but growing—understanding of the relationship between L1 and L2 orthography and nonnative speech perception. In fact, the research suggests that L2 learners can transcend L1 transfer effects, at least for operational orthographic knowledge. Finally, this research proposes an alternative view of orthographic knowledge, one that views orthographic

knowledge not as a single homogeneous entity but rather an entity comprised of at least two components, abstract knowledge and operational knowledge. If true, this division of orthographic knowledge will redefine and shape our future understanding of how orthography influences speech processing in native and nonnative languages, specifically as it relates to perception, orthographic depth, and literacy.

Pedagogically, this research is valuable for language instructors in that it identifies orthographic knowledge as a potential barrier to L2 speech perception, a barrier they may not have previously considered. Although language instructors may not always view orthographic knowledge as an obvious barrier to nonnative speech processing, this research demonstrates that L1 and L2 orthographic knowledge exert very real effects on L0 and L2 phoneme perception. First, the L0 results suggest that at the initial stages of learning (=L0), L1 orthographic knowledge may provide a visual crutch with which beginners use to help them parse nonnative phonemes. Second, while the L2 results suggest that L2 learners can overcome the effects of L1 operational knowledge after they gain more experience in the language, the results also caution language instructors that L2 orthographic knowledge too can influence how learners hear and parse L2 phonemes. That is, these findings can raise instructors' awareness about how firmly learners rely on their orthographic knowledge to aid them in L2 speech processing. More specifically, the current findings suggest that instructors may find it worthwhile to explicitly discuss with their students the relationship between orthography and phonology in the L2. Such a discussion would be the most beneficial for learners who are accustomed to a vastly different orthography-phonology relationship in their L1. For example, knowing that learners transfer abstract knowledge into L2, English language instructors would be wise

at the outset to draw attention to the high degree of inconsistency in letter-phoneme correspondences, especially for their students whose L1 employs a more transparent orthography than English, such as Spanish and Greek.

## REFERENCES

- Alegria, J., Pignot, E., & Morais, J. (1982). Phonetic analysis of speech and memory codes in beginning readers. *Memory & Cognition*, 10 (5), 451–456. [http:// www.springerlink.com/content/0090-502x/10/5/](http://www.springerlink.com/content/0090-502x/10/5/)
- Archibald, J. (1998). *Second Language Phonology*. Amsterdam: John Benjamins Publishing Company.
- Arnqvist, A. (1992). The impact of consonant clusters on preschool children's phonemic awareness: A comparison between readers and nonreaders. *Scandinavian Journal of Psychology*, 33 (1), 29–35. doi: 10.1111/j.1467-9450.1992.tb00810.x
- Aronoff, M. (1992). Segmentalism in linguistics: The alphabetic basis of phonological theory. In P. Downing, S. D. Lima, & M. Noonan (Eds.), *The Linguistics of Literacy* (pp. 71–82). Amsterdam: John Benjamins.
- Bassetti, B. (2005). Effects of writing systems on second language awareness: Word awareness in English learners of Chinese as a foreign language. In V. Cook & B. Bassetti (Eds), *Second Language Writing Systems* (pp. 335–356). North York, ON: Multilingual Matters Ltd.
- Bassetti, B. (2006). Orthographic input and phonological representations in learners of Chinese as a foreign language. *Written Language and Literacy*, 9 (1), 95–114. Print
- Ben-Dror, I., Frost, R., & Bentin, S. (1995). Orthographic representation and phonemic segmentation in skilled readers: A cross-language comparison. *Psychological Science*, 6 (3), 176–181. Retrieved from <http://www.jstor.org/stable/40063011>
- Berg, T. (1986). The monophonematic status of diphthongs revisited. *Phonetica*, 43, 198–205. Print
- Bertelson, P., & de Gelder, B. (1991). The emergence of phonological awareness: Comparative approaches. In I. G. Mattingly & M. Studdert-Kennedy (Eds.), *Modularity and the Motor Theory of Speech Perception* (pp. 393–412). Hillsdale, NJ: Erlbaum.
- Bertelson, P., de Gelder, B., Tfouni, L. V. Morais, J. (1989). Metaphonological abilities of adult illiterates: New evidence of heterogeneity. *European Journal of Cognitive Psychology*, 1 (3), 239–250. doi: 10.1080/09541448908403083
- Best, C. (1995). A direct realist view of cross-language speech perception. In W. Strange (Ed.), *Speech Perception and Linguistic Experience: Issues in Cross Language Research* (p. 171–204). Baltimore, MD: York Press.

- Best, C. (2001). Discrimination of non-native consonant contrasts varying in perceptual assimilation to the listener's native phonological system. *Journal of the Acoustical Society of America*, 109 (2), 775–794. doi: 10.1121/1.1332378
- Blau, V., van Atteveldt, N., Formisano, E., Goebel, R., & Blomert, L. (2008). Task-irrelevant visual letters interact with the processing of speech sounds in heteromodal and unimodal cortex. *European Journal of Neuroscience*, 28, 500–509. doi: 10.1111/j.1460-9568.2008.06350.x
- Blevins, J. (2003). The independent nature of phonotactic constraints. In Féry, C. and R. van de Vijver (eds.) *The Syllable in Optimality Theory*. Cambridge, UK: University Press. 375–403.
- Bloomfield, L. (1933). *Language*. New York, NY: Holt.
- Boberg, C. (2004). English in Canada: Phonology. In E. W. Schneider, K. Burrige, B. Kortmann, R. Mesthrie, & C. Upton, *A Handbook of Varieties of English: Volume 1 Phonology*, (pp. 351–365). New York, NY: Mouton de Gruyter.
- Bohn, O. S., & Flege, J. E. (1992). The production of new and similar vowels by adult German learners of English. *Studies in Second Language Acquisition*, 14 (2), 131–158. Print
- Bonfante, L. (1996). The scripts of Italy. In P. T. Daniels and W. Bright (eds.) *The World's Writing Systems* (pp. 297–311). New York, NY: Oxford University Press.
- Bowey, J. A. (1994). Phonological sensitivity in novice readers and nonreaders. *Journal of Experimental Child Psychology*, 58, 134–159. doi: 10.1006/jecp.1994.1029
- Brown, C. (2000). The interrelation between speech perception and phonological acquisition from infant to adult. In J. Archibald (Ed.), *Second Language Acquisition and Linguistic Theory* (pp. 4–63). Malden, MA: Blackwell Publishers Ltd.
- Bruck, M., Treiman, R., & Caravolas, M. (1995). Role of the syllable in the processing of spoken English: Evidence from a nonword comparison task. *Journal of Experimental Psychology: Human Perception and Performance*, 21 (4), 469–479. doi: 10.1037/0096-1523.21.3.469
- Brysbaert, M., Van Dyck, G., & Van de Poel, M. (1999). Visual word recognition in bilinguals: Evidence from masked phonological priming. *Journal of Experimental Psychology: Human Perception and Performance*, 25 (1), 137–148. doi: 10.1037/0096-1523.25.1.137
- Burnham, D. K. (1986). Developmental loss of speech perception: Exposure to and experience with a first language. *Applied Psycholinguistics*, 7, 207–240. doi: 10.1017/S0142716400007554

- Burnham, D. K., Earnshaw, L. J., & Clark, J. E. (1991). Development of categorical identification of native and non-native bilabial stops: Infants, children and adults. *Journal of Child Language*, 18 (2), 231–260. doi: 10.1017/S0305000900011041
- Burnham, D. K. (2003). Language specific speech perception and the onset of reading. *Reading and Writing*, 16 (6), 573–609. doi: 10.1023/A:1025593911070
- Caravolas, M., & Bruck, M. (1993). The effect of oral and written language input on children's phonological awareness: a cross-linguistic study. *Journal of Experimental Child Psychology*, 55 (1), 1–30. doi: 10.1006/jecp.1993.1001
- Carrasco-Ortiz, H., Midgley, K. J., & Frenck-Mestre, C. (2012). Are phonological representations in bilinguals language-specific? An ERP study on interlingual homophones. *Psychophysiology*, 49, 531–543. doi: 10.1111/j.1469-8986.2011.01333.x
- Carroll, J. M. (2004). Letter knowledge precipitates phoneme segmentation, but not phoneme invariance. *Journal of Research in Reading*, 27 (3), 212–225. doi: 10.1111/j.1467-9817.2004.00228.x
- Carroll, J. M., Snowling, M., Hulme, C., & Stevenson, J. (2003). The development of phonological awareness in preschool children. *Developmental Psychology*, 39 (5), 913–923. doi: 10.1037/0012-1649.39.5.913
- Castles, A., Coltheart, M., Wilson, K., Valpied, J., & Wedgwood, J. (2009). The genesis of reading ability: What helps children learn letter-sound correspondences? *Journal of Experimental Child Psychology*, 104, 68–88. doi: 10.1016/j.jecp.2008.12.003
- Castles, A., Holmes, V. M., Neath, J., & Kinoshita, S. (2003) How does orthographic knowledge influence performance on phonological awareness tasks? *The Quarterly Journal of Experimental Psychology: Section A*, 56 (3), 445–467. doi: 10.1080/02724980244000486
- Castro-Caldas, A., Petersson, K. M., Reis, A., Stone-Elander, S., & Ingvar, M. (1998). The illiterate brain: Learning to read and write during childhood influences the functional organization of the adult brain. *Brain*, 121, 1053–1063. doi: 10.1093/brain/121.6.1053
- Chen, Y., & Hazan, V. (2009). Developmental factors and the non-native speaker effect in auditory-visual speech perception. *Journal of the Acoustical Society of America*, 126 (2), 858–865. doi: 10.1121/1.3158823
- Ch'en, T. T., Link, P., Tai, Y. J., & Tang, H. T. (1994). *Chinese Primer: Lessons*. Princeton, NJ: Princeton University Press.

- Ch'en, T. T., Link, P., Tai, Y. J., & Tang, H. T. (1994). *Chinese Primer: Notes and Exercises*. Princeton, NJ: Princeton University Press.
- Chéreau, C., Gaskell, M. G., & Dumay, N. (2007). Reading spoken words: Orthographic effects in auditory priming. *Cognition*, 102, 341–360. doi: 10.1016/j.cognition.2006.01.001
- Cheung, H. (1999). Improving phonological awareness and word reading in a later learned alphabetic script. *Cognition*, 70 (1), 1–26. doi: 10.1016/S0010-0277(98)00074-2
- Cheung, H., & Chen, H. C. (2004). Early orthographic experience modifies both phonological awareness and on-line speech processing. *Language and Cognitive Processes*, 19 (1), 1–28. doi: 10.1080/01690960344000071
- Clements, G. N. (1990). The role of the sonority cycle in core syllabification. In J. Kingston and M. E. Beckman (eds.) *Papers in Laboratory Phonology I: Between the grammar and the physics of speech*. Cambridge, UK: Cambridge University Press. 283–333.
- Cook, V. (2002). Background to the L2 user. In V. Cook (Ed.), *Portraits of the L2 User* (pp. 1–28). North York, ON: Multilingual Matters.
- Cook, V. (2004). *The English Writing System*. London, UK: Hodder Education.
- Cook, V., & Bassetti, B. (2005). An introduction to researching second language writing systems. In V. Cook & B. Bassetti (Eds.), *Second Language Writing Systems* (pp. 1–67). Toronto, ON: Multilingual Matters Ltd.
- Cossu, G., Shankweiler, D., Liberman, I. Y., & Gugliotta, M. (1995) Visual and phonological determinants of misreading in a transparent orthography. *Reading and Writing*, 7 (3), 237–256. doi: 10.1007/BF02539523
- Cossu, G., Shankweiler, D., Liberman, I. Y., Tola, G., & Katz, L. (1988). Awareness of phonological segments and reading ability in Italian children. *Applied Psycholinguistics*, 9, 1–16. doi: 10.1017/S0142716400000424
- Coulmas, F. (1989). *The Writing Systems of the World*. New York, NY: Basil Blackwell Ltd.
- Coulmas, F. (1999). *The Blackwell Encyclopedia of Writing Systems*. Hoboken, NJ: John Wiley & Sons.
- Coulmas, F. (2003). *Writing Systems: An Introduction to their Linguistic Analysis*. Cambridge, UK: Cambridge University Press.
- Coutsougera, P. (2007). The impact of orthography on the acquisition of L2 phonology: Inferring the wrong phonology form print. In the *Proceedings of the Phonetics*

- Teaching and Learning Conference 2007* (pp. 1–5). London, UK: University College London.
- Cubberley, P. (1996). The Slavic alphabets. In P. T. Daniels and W. Bright (eds.) *The World's Writing Systems* (pp. 346–355). New York, NY: Oxford University Press.
- Cutler, A., Treiman, R., & van Ooijen, B. (1998). Orthografik inkoncistensy ephekts in foneme detektion? In R. Mannell, & J. Robert-Ribes (Eds.), *Proceedings of the Fifth International Conference on Spoken Language Processing: Vol. 6* (pp. 2783–2786). Sydney: ICSLP.
- Cutler, A., Treiman, R., & van Ooijen, B. (2010). Strategic deployment of orthographic knowledge in phoneme detection. *Language and Speech*, 53 (3), 307–320. doi: 10.1177/0023830910371445
- Daniels, P. T. (1996). The first civilizations. In P. T. Daniels and W. Bright (eds.) *The World's Writing Systems* (pp. 21–32). New York, NY: Oxford University Press.
- Danielsson, K. (2003). The relationship between grapheme-phoneme correspondences and reading errors in Swedish beginners' oral reading. *Scandinavian Journal of Educational Research*, 47 (5), 511–528. doi: 10.1080/0031383032000122435
- Davenport, M., & Hannahs, S. J. (2010). *Introducing Phonetics and Phonology Third Edition*. New York, NY: Oxford University Press.
- DeFrancis, J. (1989). *Visible speech: The diverse oneness of writing systems*. Honolulu, HI: University of Hawaii Press.
- DeFrancis, J. (1990). The why of Pinyin grapheme selection. *The Journal of the Chinese Language Teachers Association*, 25 (3), 1–14. Print
- DeFrancis, J. (2006). The prospects for Chinese writing reform. *Sino-Platonic Papers*, 171 (June), 1–24. Print
- Derwing, B. L. (1992). Orthographic aspects of linguistic competence. In P. Downing, S. D. Lima, & M. Noonan (Eds.), *The Linguistics of Literacy* (pp. 193–210). Amsterdam: Benjamins.
- Derwing, B. L., Nearey, T. M., & Dow, M. L. (1986). On the phoneme as the unit of the 'second articulation'. *Phonology Yearbook*, 3, 45–69. <http://www.jstor.org/stable/4615392>
- Detey, S., & Nespoulous, J. L. (2008). Can orthography influence second language syllabic segmentation? Japanese epenthetic vowels and French consonantal clusters. *Lingua*, 118, 66–81. doi: 10.1016/j.lingua.2007.04.003

- Dijkstra, T., Grainger, J., & van Heuven, W. (1999). Recognition of cognates and interlingual homographs: The neglected role of phonology. *Journal of Memory and Language*, 41 (4), 496–518. doi: 10.1006/jmla.1999.2654
- Dijkstra, T., Roelofs, A., & Fieuws, S. (1995). Orthographic effects on phonemic monitoring. *Canadian Journal of Experimental Psychology*, 49 (2), 264–271. doi: 10.1037/1196-1961.49.2.264
- Dijkstra, T., van Jaarsveld, H., & ten Brinke, S. (1998). Interlingual homograph recognition: Effects of task demands and language intermixing. *Bilingualism: Language and Cognition*, 1 (1), 51–66. doi: [10.1017/S1366728998000121](https://doi.org/10.1017/S1366728998000121)
- Duanmu, S. (2000). *The Phonology of Standard Chinese*. Oxford, UK: Oxford University Press.
- Dumbreck, J. C. (1964). *Forbes' Russian Grammar (3<sup>rd</sup> ed)*. Oxford, UK: Oxford University Press.
- Dupoux, E., Kakehi, K., Hirose, Y., Pallier, C., & Mehler, J. (1999). Epenthetic vowels in Japanese: A perceptual illusion? *Journal of Experimental Psychology: Human Perception and Performance*, 25 (6), 1568–1578. doi: [10.1037/0096-1523.25.6.1568](https://doi.org/10.1037/0096-1523.25.6.1568)
- Ehri, L. C. (1984). How orthography alters spoken language competencies in children learning to read and spell. In J. Downing & R. Valtin (Eds.), *Language Awareness and Learning to Read* (pp. 119–147). New York, NY: Springer.
- Ehri, L. C. (1985). Effects of printed language acquisition on speech. In D. Olsen, N. Torrence, & A. Hildyard (Eds.), *Literacy, Language, and Learning: The Nature and Consequences of Reading and Writing* (pp. 333–367). New York, NY: Cambridge University Press.
- Ehri, L. C., & Wilce, L. S. (1980). The influence of orthography on readers' conceptualization of the phonemic structure of words. *Applied Psycholinguistics*, 1 (4), 371–385. doi: 10.1017/S0142716400009802
- Ellis, N. (2002). Frequency effects in language processing. *Studies in Second Language Acquisition*, 24 (2), 143–188. doi: 10.1017/S0272263102002024
- Ellis, N., & Hooper, A. M. (2001). It is easier to learn to read in Welsh than in English: Effects of orthographic transparency demonstrated using frequency-matched cross-linguistic reading tests. *Applied Psycholinguistics*, 22 (4), 571–590. doi: 10.1017/S0142716401004052
- Ellis, N., Natsume, M., Stavropoulou, K., Hoxhallari, L., Van Daal, V. H. P., Polyzoe, N., Tsipa, M., & Petalas, M. (2004). The effects of orthographic depth on learning to read alphabetic, syllabic, and logographic scripts. *Reading Research Quarterly*, 39 (4), 438–468. doi: 10.1598/RRQ.39.4.5

- Erdener, V. D., & Burnham, D. K. (2005). The role of audiovisual speech and orthographic information in nonnative speech production. *Language Learning*, 55 (2) June, 191–228. doi: 10.1111/j.0023-8333.2005.00303.x
- Escudero, P., & Wanrooij, K. (2010). The effect of L1 orthography on non-native vowel perception. *Language and Speech*, 53 (3), 343–365. doi: 10.1177/0023830910371447
- Everson, M. E. (1998). Word recognition among learners of Chinese as a foreign language: Investigating the relationship between naming and knowing. *Modern Language Journal*, 82 (ii), 194–203. Retrieved from <http://www.jstor.org/stable/329208>
- Field, A. (2005). *Discovering Statistics Using SPSS 2<sup>nd</sup> Edition*. London, UK: Sage Publications.
- Flege, J. E. (1987). The production of new and similar phones in a foreign language: evidence for the effect of equivalence classification. *Journal of Phonetics*, 15, 47–65. Print
- Flege, J. E. (1991). Interlingual identification of Spanish and English vowels: Orthographic evidence. *Quarterly Journal of Experimental Psychology Section A: Human Experimental Psychology*, 43(3), 701–731. Print.
- Flege, J. E. (1995). Second language speech learning theory, findings and problems. In W. Strange (Ed.), *Speech Perception and Linguistic Experience: Issues in Cross Language Research* (p. 233–277). Baltimore, MD: York Press.
- Fletcher-Flinn, C. M., Thompson, G. B., Yamada, M., & Naka, Makiko. (2011). The acquisition of phoneme awareness in children learning the hiragana syllabary. *Reading and Writing*, 24 (6), 623–633. doi: 10.1007/s11145-010-9257-8
- Frauenfelder, U. H., Segui, J., & Dijkstra, T. (1990). Lexical effects in phonemic processing: Facilitatory or inhibitory? *Journal of Experimental Psychology: Human Perception and Performance*, 16 (1), 77–91. doi: 10.1037/0096-1523.16.1.77
- Frith, U. (1998). Editorial: Literally changing the brain. *Brain*, 121, 1011–1012. doi: 10.1093/brain/121.6.1011
- Frost, R. (1998). Toward a strong phonological theory of visual word recognition: True issues and false trails. *Psychological Bulletin*, 123 (1), 71–99. doi: 10.1037/0033-2909.123.1.71
- Frost, R., & Katz, L. (1989). Orthographic depth and the interaction of visual and auditory processing in word recognition. *Memory & Cognition*, 17 (3), 302–310. doi: 10.3758/BF03198468

- Gelb, I. J. (1963). *A Study of Writing (2<sup>nd</sup> Edition)*. Chicago, IL: The University of Chicago Press.
- Glushko, R. (1979). The organization and activation of orthographic knowledge in reading aloud. *The Journal of Experimental Psychology: Human Perception and Performance*, 5 (4), 674–691. doi: 10.1037/0096-1523.5.4.674
- Gombert, J. E. (1996). What do children do when they fail to count phonemes? *International Journal of Behavioral Development*, 19 (4), 757–772. Print
- Goswami, U. (1999). The relationship between phonological awareness and orthographic representation in different orthographies. In M. Harris & G. Hatano (Eds.), *Learning to Read and Writing: A Cross-Linguistic Perspective* (pp. 134–156). New York, NY: Cambridge University Press.
- Goswami, U., & Bryant, P. E. (1990). *Phonological Skills and Learning to Read*. Hove, East Sussex, UK: Psychology Press.
- Goswami, U., Gombert, J. E., & De Barrera, L. F. (1998). Children's orthographic representations and linguistic transparency: Nonsense word reading in English, French, and Spanish. *Applied Psycholinguistics*, 19 (1), 19–52. doi: 10.1017/S0142716400010560
- Goswami, U., Porpodas, C., & Wheelwright, S. (1997). Children's orthographic representations in English and Greek. *European Journal of Psychology of Education*, 12 (3), 273–292. doi: 0.1007/BF03172876
- Grigorenko, E. L. (2006). If John were Ivan, would he fail in reading? In M. Malatesha Joshi & P. G. Aaron (Eds.), *Handbook of Orthography and Literacy* (pp. 303–320). Mahwah, NJ: Lawrence Erlbaum Associates.
- Haigh, C., & Jared, D. (2007). The activation of phonological representations by bilinguals while reading silently: Evidence from interlingual homophones. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 33 (4), 623–644. doi: 10.1037/0278-7393.33.4.623
- Hallé, P. A., Chéreau, C., & Segui, J. (2000). Where is the /b/ in “absurde” [apsyrd]? It is in French listeners' minds. *Journal of Memory and Language*, 43 (4), 618–639. doi: 10.1006/jmla.2000.2718
- Hammond, M. (1999). *The Phonology of English: A Prosodic Optimality-Theoretic Approach*. New York, NY: Oxford University Press.
- Hancin-Bhatt, B. (1994). Segment transfer: A consequence of a dynamic system. *Sound Language Research*, 10 (3), 241–269. Print
- Harris, R. (1986). *The Origin of Writing*. London, UK: Gerald Duckworth & CO. Ltd.

- Hayes-Harb, R., Nicol, J., & Barker, J. (2010). Learning the phonological forms of new words: Effect of orthographic and auditory input. *Language and Speech*, 53 (3), 367–381. doi: 10.1177 /0023830910371460
- He, T., & Wang, W. (2009). Invented spelling of EFL young beginning writers and its relation with phonological awareness and grapheme-phoneme principles. *Journal of Second Language Writing*, 18, 44–56. doi: 10.1016/jslw.2008.06.001
- Henderson, L. (1982). *Orthography and Word Recognition in Reading*. Toronto, ON: Academic Press.
- Høien, T., Lundberg, L., Stanovich, K. E., & Bjaalid, I. K. (1995). Components of phonological awareness. *Reading and Writing*, 7 (2), 171–188. doi: 10.1007/BF 01027184
- Hockley, N., & Polka, L. (1994). A developmental study of audiovisual speech perception using the McGurk paradigm. *Journal of the Acoustical Society of America*, 96, 3309. doi: 10.1121/1.410782
- Holm, A., & Dodd, B. (1996). The effect of first written language on the acquisition of English literacy. *Cognition*, 59 (2), 119–147. doi: [10.1016/0010-0277\(95\)00691-5](https://doi.org/10.1016/0010-0277(95)00691-5)
- Hu, C-F. (2008). Use orthography in L2 auditory word learning: Who benefits? *Reading and Writing*, 21 (8), 823–841. doi: 10.1007/s11145-007-9094-6
- Istrin, V. A. (1965). *Возникновение и развитие письменности [The Origin and Development of Writing]*. Moscow, Russia: Academy of Science Publishing.
- Jared, D., McRae, K., & Seidenberg, M. S. (1990). The basis of consistency effects in word naming. *The Journal of Memory and Language*, 29 (6), 687–715. doi: 10.1016/0749-596X(90)90044-Z
- Jared, D., & Kroll, J. F. (2001). Do bilinguals activate phonological representations in one or both of their languages when naming words? *Journal of Memory and Language*, 44 (1), 2–31. doi: 10.1006/jmla.2000.2747
- Jared, D., & Szucs, C. (2002). Phonological activation in bilinguals: Evidence from interlingual homograph naming. *Bilingualism: Language and Cognition*, 5 (3), 225–239. doi: 10.1017/S1366728902003024
- Juul, H., & Sigurdsson, B. (2005). Orthography as a handicap? A direct comparison of spelling acquisition in Danish and Icelandic. *Scandinavian Journal of Psychology*, 46 (3), 263–272. doi: 10.1111/j.1467-9450.2005.00456.x
- Kabak, B., & Idsardi, W. J. (2007). Perceptual distortions in the adaption of English consonant clusters: Syllable structure or consonantal contact constraints? *Language and Speech*, 50 (1), 23–52. doi: 10.1177/00238309070500010201

- Katz, L., & Frost, R. (1992). The reading process is different for different orthographies. In R. Frost & L. Katz (Eds.), *Orthography, Phonology, Morphology, and Meaning. Advances in Psychology*, 94, 67–84.
- Kerek, E., & Niemi, P. (2009). Russian orthography and learning to read. *Reading in a Foreign Language*, 21 (1), 1–21. Retrieved from <http://nflrc.hawaii.edu.ezproxy.library.uvic.ca/rfl/April2009/>
- Killingley, S. Y. (1998). *Learning to Read Pinyin Romanization and its Equivalent in Wade-Giles: A Practical Course for Students of Chinese*. Newcastle, UK: LINCOM Europa.
- Knight, S. (1996). The Roman alphabet. In P. T. Daniels and W. Bright (eds.) *The World's Writing Systems* (pp. 312–332). New York, NY: Oxford University Press.
- Koda, K. (1989). Effects of L1 orthographic representation on L2 phonological coding strategies. *Journal of Psycholinguistic Research*, 18 (2), 201–222. doi: 10.1007/BF01067782
- Kolnibalozky, J. (1938). *A Progressive Russian Grammar*. London, UK: Sir Isaac Pitman & Sons, Ltd.
- Kuhl, P. K. (1993). Early linguistic experience and phonetic perception: implications for theories of developmental speech perception. *Journal of Phonetics*, 21, 125–139. Print
- Kuhl, P. K. (2000). A new view of language acquisition. *Proceedings of the National Academy of Sciences of the United States of America*, 97 (22) October, 11850–11857. Retrieved from <http://www.pnas.org/content/97/22/11850.full>
- Lacruz, I., & Folk, J. R. (2004). Feedforward and feedback consistency effects for high- and low-frequency words in lexical decision and naming. *The Quarterly Journal of Experimental Psychology*, 57A (7), 1261–1284. doi: 10.1080/02724980.34300.0756
- Ladefoged, P. (1999). American English. In *Handbook of the International Phonetic Association: A Guide to the Use of the International Phonetic Alphabet* (pp. 41–44). New York, NY: Cambridge University Press.
- Lado, R. (1957). *Linguistics Across Cultures*. Ann Arbor, MI: University of Michigan Press.
- Landerl, K. (2000). Influences of orthographic consistency and reading instruction on the development of nonword reading skills. *European Journal of Psychology of Education*, 15 (3), 239–257. doi: 10.1007/BF03173177

- Landerl, K., Frith, U., & Wimmer, H. (1996). Intrusion of orthographic knowledge on phoneme awareness: Strong in normal readers, weak in dyslexic readers. *Applied Psycholinguistics*, 17 (1), 1–14. doi: 10.1017/S0142716400009437
- Lehiste, I., & Peterson, G. E. (1961). Transitions, glides, and diphthongs. *The Journal of the Acoustical Society of America*, 33 (3), 268–277.
- Lehtonen, A., & Treiman, R. (2007). Adults' knowledge of phoneme-letter relationships is phonology based and flexible. *Applied Psycholinguistics*, 28 (1), 95–114. doi: 10.1017/S0142716406070056
- Lemhöfer, K., & Dijkstra, T. (2004). Recognizing cognates and interlingual homographs: Effects of code similarity in language-specific and generalized lexical decision. *Memory & Cognition*, 32 (4), 533–550. doi: 10.3758/BF03195845
- Lieberman, A. (1980). Orthography and phonemics in present-day Russia. In J. Kavanagh & R. Venezky (Eds.), *Orthography, Reading and dyslexia* (pp. 51–55). Baltimore, MD: University Park Press.
- Lieberman, I. Y. (1971). Basic research in speech lateralization of language: Some implications for reading disability. *Bulletin of the Orton Society*, 21, 71–87.
- Lieberman, I. Y., Cooper, F. S., Shankweiler, D., & Studdert-Kennedy, M. (1967). Perception of the speech code. *Psychological Review*, 74 (5), 431–461. doi: 10.1037/h0020279
- Lieberman, I. Y., Liberman, A. M., Mattingly, I. G., & Shankweiler, D. L. (1980). Orthography and the beginning reader. In J. Kavanagh & R. Venezky (Eds.), *Orthography, Reading and dyslexia* (pp. 137–153). Baltimore, MD: University Park Press.
- Lieberman, I. Y., Shankweiler, D., Fischer, F. W., & Carter, B. (1974). Explicit syllable and phoneme segmentation in the young child. *Journal of Experimental Child Psychology*, 18, 201–212. doi: 10.1016/0022-0965(74)90101-5
- Lin, H. (2001). *A Grammar of Mandarin Chinese*. Munich: LINCOM Europa.
- Lukatela, G., & Turvey, M. T. (1994). Visual lexical access is initially phonological: 1. Evidence from associative priming by words, homophones, and pseudo-homophones. *Journal of Experimental Psychology: General*, 123 (2), 107–128. doi: 10.1037/0096-3445.123.2.107
- Lukatela, G., Turvey, M. T., & Todorović, D. (1991). Is alphabet biasing in bialphabetical word perception automatic and prelexical. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 17 (4), 653–663. doi: 10.1037/0278-7393.17.4.653

- Mair, V. H. (1996). Modern Chinese Writing. In P. T. Daniels and W. Bright (eds.) *The World's Writing Systems* (pp. 200–208). New York, NY: Oxford University Press.
- Major, R. (2001). *Foreign Accent: The Ontogeny and Phylogeny of Second Language Phonology*. Mahwah, NJ: Lawrence Erlbaum Associates, Inc.
- Major, R. (2002). The phonology of the L2 user. In V. Cook (Ed.), *Portraits of the L2 User* (pp. 7–92). Clevedon, UK: Multilingual Matters Ltd.
- Mann, V. A. (1986). Phonological awareness: The role of reading experience. *Cognition*, 24 (1–2), 65–92. doi: [10.1016/0010-0277\(86\)90005-3](https://doi.org/10.1016/0010-0277(86)90005-3)
- Massaro, D. W., Thompson, L. A., Barron, B., & Laren, E. (1986). Developmental changes in visual and auditory contribution to speech perception. *Journal of Experimental Child Psychology*, 41 (1), 93–113. doi: [10.1016/0022-0965\(86\)90053-6](https://doi.org/10.1016/0022-0965(86)90053-6)
- McMahon, A. (2002). *An Introduction to English Phonology*. New York, NY: Oxford University Press.
- McGurk, H., & MacDonald, J. (1976). Hearing lips and seeing voices. *Nature*, 264, 746–748. Print
- Morais, J. (1991). Constraints on the development of phonemic awareness. In S. A. Brady & D. P. Shankweiler (Eds.), *Phonological Processes in Literacy: A Tribute to Isabelle Y. Liberman* (pp. 5–27). Hillsdale, NJ: Lawrence Erlbaum Associates.
- Morais, J., Bertelson, P., Cary, L., Alegria, J. (1986). Literacy training and speech segmentation. *Cognition*, 24 (1), 45–64. Print
- Morais, J., Cary, L., Alegria, J., & Bertelson, P. (1979). Does awareness of speech as a sequence of phones arise spontaneously? *Cognition*, 7 (4), 323–331. Print
- Morris, D. (1983). Concept of word and phoneme awareness in the beginning reader. *Research in the Teaching of English*, 17 (4), 359–373. <http://www.jstor.org/stable/40170971>
- Muneaux, M., & Zeigler, J. C. (2004). Locus of orthographic effects in spoken word recognition: Novel insights for the neighbour generation task. *Language and Cognitive Processes*, 19 (5), 641–660. doi: [10.1080/01690960444000052](https://doi.org/10.1080/01690960444000052)
- Oller, J. W., & Ziahosseiny, S. M. (1970). The contrastive analysis hypothesis and spelling errors. *Language Learning*, 20 (2), 183–189. doi: [10.1111/j.1467-1770.1970.tb00475.x](https://doi.org/10.1111/j.1467-1770.1970.tb00475.x)
- Olson, D. R. (1993). How writing represents speech. *Language & Communication*, 13 (1), 1–17. doi: [10.1016/0271-5309\(93\)90017-H](https://doi.org/10.1016/0271-5309(93)90017-H)

- Olson, D. R. (1996). Towards a psychology of literacy: On the relations between speech and writing. *Cognition*, 60 (1), 83–104. doi: 10.1016/0010-0277(96)00705-6
- Padgett, J., & Tabain, M. (2005). Adaptive dispersion theory and phonological vowel reduction in Russian. *Phonetica*, 62, 14–54. doi: 10.1159/000087223
- Peereman, R., Dufour, S., & Burt, J. S. (2009). Orthographic influences in spoken word recognition: The consistency effect in semantic and gender categorization tasks. *Psychonomic Bulletin & Review*, 16 (2), 363–368. doi: 10.3758/PBR.16.2.363
- Peng, T. H. (1984). *Hanyu Pinyin*. Singapore: Times Books International.
- Perfetti, C. (2003). The universal grammar of reading. *Scientific Studies of Reading*, 7 (10), 3–24. doi: 10.1207/S1532799XSSR0701\_02
- Perin, D. (1983). Phonemic segmentation and spelling. *British Journal of Psychology*, 74 (1), 129–144. Retrieved from <http://ezproxy.library.uvic.ca/login?url=http://search.ebscohost.com/login.aspx?direct=true&db=byh&jid=BJP&site=ehost-live>
- Perre, L., Pattamadilok, C., Montant, M., & Ziegler, J. C. (2009). Orthographic effects in spoken language: On-line activation phonological restructuring? *Brain Research*, 1275, 73–80. doi: 10.1016/j.brainres.2009.04.018
- Perre, L., & Ziegler, J. C. (2008). On-line activation of orthography in spoken word recognition. *Brain Research*, 1188, 132–138. doi: 10.1016/j.brainres.2007.10.084
- Press, I. (2000). *What's in a Russian Word? From Sounds to Structures*. London: Bristol Classical Press.
- Pytlyk, C. (2008). Interlanguage prosody: Native English speakers' production of Mandarin yes-no questions. In *The Proceedings of the 2008 Annual Conference of the Canadian Linguistics Association*, ed. Susie Jones. Canadian Linguistics Association.
- Pytlyk, C. (2011). Shared orthography: Do shared written symbols influence the perception of L2 sounds? *Modern Language Journal*, 95 (4), 541–557.
- Pytlyk, C. (to appear). Orthographic representation and phoneme awareness: Does alphabetic knowledge affect how individuals perceive phoneme in English words? *Toronto Working Papers in Linguistics*.
- Randal, M. (2005). Orthographic knowledge and first language reading: Evidence from single word dictation from Chinese and Malaysian users of English as a foreign language. In V. Cook & B. Bassetti (Eds), *Second Language Writing Systems* (pp. 122–146). North York, ON: Multilingual Matters Ltd.

- Read, C. (1983). Orthography. In M. Martlew (Ed.), *The Psychology of Written Language Development and Educational Perspectives* (pp. 143–162). Toronto, ON: John Wiley & Sons.
- Read, C., Zhang, Y. F., Nie, H. Y., Ding, B. Q. (1986). The ability to manipulate speech sounds depends on knowing alphabetic writing. *Cognition*, 24, 31–44. doi: 10.1016/0010-0277(86)90003-X
- Reetz, H., & Jongman, A. (2009). *Phonetics: Transcription, Production, Acoustics, and Perception*. Malden, MA: Wiley-Blackwell.
- Reformatsky, A. A. (1996). *Введение в языковедение [Introduction to Linguistics]*. Moscow, Russia: Accent Press.
- Robin, R., Evans-Romaine, K., Shatalina, G., & Robin, J. (2007). *Голоса: A Basic Course in Russian Book 1 (4<sup>th</sup> Edition)*. Upper Saddle River, NJ: Pearson Education, Inc.
- Rogers, H. (2000). *The Sounds of Language: An Introduction to Phonetics*. Essex, UK: Pearson Education Limited.
- Rogers, H. (2005). *Writing Systems: A Linguistic Approach*. Malden, MA: Blackwell Publishing.
- Russak, S., & Saiegh-Haddad, E. (2011). Phonological awareness in Hebrew (L1) and English (L2) in normal and disabled readers. *Reading and Writing*, 24 (4), 427–442. doi: 10.1007/s11145-010-9235-1
- Saiegh-Haddad, E. (2007). Linguistic constraints on children's ability to isolate phonemes in Arabic. *Applied Psycholinguistics*, 28 (4), 605–625. doi: 10.1017/S0142716407070336
- Saiegh-Haddad, E., Kogan, N., & Walters, J. (2010). Universal and language-specific constraints on phonemic awareness: Evidence from Russian-Hebrew bilingual children. *Reading and Writing*, 23, 359–384. doi: 10.1007/s11145-009-9204-8
- Schulpen, B., Dijkstra, T., Schriefers, H. J., & Hasper, M. (2003). Recognition of interlingual homophones in bilingual auditory word recognition. *Journal of Experimental Psychology: Human Perception and Performance*, 29 (6), 1155–1178. doi: 10.1037/0096-1523.29.6.1155
- Seidenberg, M. S., Waters, G. S., Barnes, M. A., & Tanenhaus, M. K. (1984). When does irregular spelling of pronunciation influence word recognition? *The Journal of Verbal Learning and Verbal Behavior*, 23, 383–440. Print
- Sekiyama, K., Burnham, D. K., Tam, H., & Erdener, D. (2003). Auditory-visual speech perception development in Japanese and English speakers. In J.-L. Schwartz, F.

- Berthommier, M.-A. Cathiard, & D. Sodoyer (Eds.), *Proceedings of AVSP [Audio Visual Speech Processing] 2003* (pp. 43–47). Grenoble, France: Université Stendhal, Institute de la Communication Parlée.
- Selinker, L. (1972). Interlanguage. *International Review of Applied Linguistics*, 10, 209–231. Print
- Selkirk, E. (1984). The major class features and syllable theory. In Aronoff, M. et al. (eds.) *Language Sound Structure* (pp. 107–136). Cambridge, MA: MIT Press.
- Seymour, P. H. K., Aro, M., & Erskine, J. M. (2003). Foundation literacy acquisition in European orthographies. *British Journal of Psychology*, 94 (2), 143–174. doi: 10.1348/000712 603321661859
- Silva, C., Almeida, T., Martins, M. A. (2010). Letter names and sounds: Their implication for the phonetisation process. *Reading and Writing*, 23, 147–172. doi: 10.1007/s11145-008-9157-3
- Simon, E., Chambless, D., & Alves, U. K. (2010). Understanding the role of orthography in the acquisition of a non-native vowel contrast. *Language Sciences*, 32, 380–394. doi: 10.1016/j.langsci.2009.07.001
- Spencer, L. H., & Hanley, J. R. (2003). Effects of orthographic transparency on reading and phoneme awareness in children learning to read in Wales. *British Journal of Psychology*, 94 (1), 1–28. doi: 10.1348/000712603762842075
- Spencer, L. H., & Hanley, J. R. (2004). Learning a transparent orthography at five years old: Reading development of children during their first year of formal reading instruction in Wales. *Journal of Research in Reading*, 27 (1), 1–14. doi: 10.1111/j.1467-9817.2004.00210.x
- Steriade, D. (1999). Alternatives to syllable-based accounts of consonantal phonotactics. *Proceedings of the 1998 Linguistics and Phonetics Conference*. The Karolinum Press. 205–242.
- Stone, G. O., Vanhoy, M., & Van Orden, G. (1997). Perception is a two-way street: Feedforward and feedback phonology in visual word recognition. *The Journal of Memory and Language*, 36 (3), 337–359. doi: 10.1006/jmla.1996.2487
- Sun-Alperin, M. K., & Wang, M. (2011). Cross-language transfer of phonological and orthographic processing skills from Spanish L1 to English L2. *Reading and Writing*, 24 (5), 591–614. doi: 10.1007/s11145-009-9221-7
- Swiggers, P. (1996). Transmission of the Phoenician scrip to the West. In P. T. Daniels and W. Bright (eds.) *The World's Writing Systems* (pp. 261–270). New York, NY: Oxford University Press.

- Taft, M., Castles, A., Davis, C., Lazendic, G., & Nguyen-Hoan, M. (2008). Automatic activation of orthography in spoken word recognition: Pseudohomograph priming. *Journal of Memory and Language*, 58, 366–379. doi: 10.1016/j.jml.2007.11.002
- Threatte, L. (1996). The Greek alphabet. In P. T. Daniels and W. Bright (eds.) *The World's Writing Systems* (pp. 271–280). New York, NY: Oxford University Press.
- Treiman, R., & Cassar, M. (1997). Can children and adults focus on sound as opposed to spelling in a phoneme counting task? *Developmental Psychology*, 33 (5), 771–780. doi: 10.1037/0012-1649.33.5.771
- Treiman, R., & Zukowski, A. (1991). Levels of phonological awareness. In S. A. Brady & D. P. Shankweiler (Eds.), *Phonological Processes in Literacy: A Tribute to Isabelle Y. Liberman* (pp. 67–83). Hillsdale, NJ: Lawrence Erlbaum Associates.
- Tyler, M. D., & Burnham, D. K. (2006). Orthographic influences on phoneme deletion response times. *The Quarterly Journal of Experimental Psychology*, 59 (11), 2010–2031. doi: 10.1080/174702 10500521828
- Unbegaun, B. O. (1957). *Russian Grammar*. Oxford, UK: Clarendon Press.
- Venezky, R. L. (1970). *The Structure of English Orthography*. The Hague, The Netherlands: Mouton.
- Ventura, P., Kolinsky, R., Pattamadilok, C., & Morais, J. (2008). The developmental turnpoint of orthographic consistency effects in speech recognition. *Journal of Experimental Child Psychology*, 100, 135–145. doi: 10.1016/j.jecp.2008.01.003
- Ventura, P., Morais, J., & Kolinsky, R. (2007). The development of the orthographic consistency effect in speech recognition: From sublexical to lexical involvement. *Cognition*, 105 (3), 547–576. doi:10.1016/j.cognition.2006.12.005
- Visceglia, T., & Fodor, J. D. (2006). Fundamental frequency in Mandarin and English: Comparing first- and second-language speakers. In C. Lleoa (Ed.), *Interfaces in Multilingualism: Acquisition and Representation*, (pp. 27–59). Amsterdam: John Benjamins.
- Vokic, G. (2011). When alphabets collide: Alphabetic first-language speakers' approach to speech production in an alphabetic second language. *Second Language Research*, 27 (3), 391–417. doi: 10.1177/0267658310396627
- Wade, T. (2011). *A Comprehensive Russian Grammar (3<sup>rd</sup> Edition)*. West Sussex, UK: Wiley-Blackwell.

- Wade-Woolley, L. (1999). First language influences on second language word reading: All roads lead to Rome. *Language Learning*, 49 (3), 447–471. doi: 10.1111/0023-8333.00096
- Wallach, L., Wallach, M. A., Dozier, M. G., & Kaplan, N. E. (1997). Poor children learning to read do not have trouble with auditory discrimination but do have trouble with phoneme recognition. *Journal of Educational Psychology*, 69 (1), 36–39. doi: 10.1037/0022-0663.69.1.36
- Wang, M., Park, Y., & Lee, K. (2006). Korean-English biliteracy acquisition: Cross language and orthographic transfer. *Journal of Educational Psychology*, 98 (1), 148–158. doi: 10.1037/0022-0663.98.1.148
- Wang, M., Perfetti, C. A., & Liu, Y. (2005). Chinese-English biliteracy acquisition: Cross language writing system transfer. *Cognition*, 97 (1), 67–88. doi: 10.1016/j.cognition.2004.10.001
- Wang, W. S-Y. (1973). The Chinese language. *Scientific American*, 228 (2), 53–62.
- Werker, J., & Tees, R. (1984). Phonemic and phonetic factors in adult cross-language speech perception. *Journal of the Acoustical Society of America*, 75, 1866–1878. Print.
- Werker, J., & Tees, R. (1987). Speech perception in severely disabled and average reading children. *Canadian Journal of Psychology*, 41, 48–61. doi: 10.1037/h0084150
- Widmann, A., Kujala, T., Tervaniemi, M., Kujala, A., & Schroger, E. (2004). From symbols to sounds: Visual symbolic information activates sound representations. *Psychophysiology*, 41 (5), 709–715. doi: 10.1111/j.1469-8986.2004.00208.x
- Wiebe, G. E. (1998). The syllabic status of postvocalic resonants: Evidence from global sound similarity judgements. In S. Embleton (Ed.), *LACUS Forum XXIV* (pp. 66–76). Chapel Hill, NC: Linguistic Association of Canada and the United States.
- Wiebe, G. E., & Derwing, B. (1992). The syllabic status of postvocalic resonants in an unwritten Low German dialect. In J. J. Ohala, T. M. Nearey, B. L. Derwing, M. M. Hodge, & G.E. Wiebe, (eds.) *ICSLP 1992*, 1, 293–296.
- Wiebe, G. E., & Derwing, B. (1994). Rime embeddedness in an unwritten language. In S. Hargus, G.R. McMenamin & V. Samiian (eds.) *Proceedings of the 23rd WECOL* (pp. 490–502). Fresno, CA: CSU Fresno, Department of Linguistics.
- Williams, J. P. (1980). Teaching decoding with an emphasis on phoneme analysis and phoneme blending. *Journal of Educational Psychology*, 72 (1), 1–15. PsycARTICLES

- Wimmer, H., & Hummer, P. (1990). How German speaking first graders read and spell: Doubts on the importance of the logographic stage. *Applied Psycholinguistics*, 11 (4), 349–368. doi: 10.1017/S0142716400009620
- Wimmer, H., Landerl, K., & Schneider, W. (1994). The role of rhyme awareness in learning to read a regular orthography. *British Journal of Developmental Psychology*, 12, 469–484. Print
- Wode, H. (1983). Phonology in L2 acquisition. In H. Wode (Ed.), *Papers on Language Acquisition, Language Learning and Language Teaching* (p. 175–187). Heidelberg, Germany: Groos.
- Yopp, H. K. (1988). The validity and reliability of phonemic awareness tests. *Reading Research Quarterly*, 23 (2), 159–177. <http://www.jstor.org/stable/747800>
- Young-Scholten, M. (1995). The negative effects of ‘positive’ evidence on L2 phonology. In L. Eubank, L. Selinker, & M. Sharwood Smith (Eds.), *The Current State of Interlanguage: Studies in Honor of William E. Rutherford* (pp. 107–121). Philadelphia, PA: John Benjamins Publishing Company.
- Zhou, M. (2001). Language policy and reforms of writing systems for minority languages in China. *Written Language & Literacy*, 4 (1), 31–65. Print
- Ziegler, J. C., & Ferrand, L. (1998). Orthography shapes the perception of speech: The consistency effect in auditory word recognition. *Psychonomic Bulletin & Review*, 5 (4), 683–689. doi: 10.3758/BF03208845
- Ziegler, J. C., Ferrand, L., & Montant, M. (2004). Visual phonology: The effects of orthographic consistency on different auditory word recognition tasks. *Memory & Cognition*, 32 (5), 732–741. doi: 10.3758/BF03195863
- Ziegler, J. C., & Muneaux, M. (2007). Orthographic facilitation and phonological inhibition in spoken word recognition: A developmental study. *Psychonomic Bulletin & Review*, 14 (1), 75–80. doi: 10.3758/BF03194031
- Ziegler, J. C., Muneaux, M., & Grainger, J. (2003). Neighborhood effects in auditory word recognition: Phonological competition and orthographic facilitation. *Journal of Memory and Language*, 48 (4), 779–793. doi: 10.1016/S0749-596X(03)00006-8

## APPENDIX A: Glossary

**Abecedary:** An abecedary is an inventory of letters for an alphabet (Rogers, 2005).

**Accessibility:** Accessibility refers to the availability of a unit (e.g., a word, syllable, or phoneme) such that speakers/listeners are aware of and can manipulate that unit (Read, 1983).

**Allograph:** Allographs are “non-contrastive variants of a grapheme” (Rogers, 2005, p. 10). For example, a cursive <g>, an upper case <G>, and a lower case <g> are all allographs.

**Alphabet:** An alphabet is “a writing system characterized by a systematic mapping relation between its signs (graphemes) and the minimal units of speech (phonemes)” (Coulmas, 1999). Letters of an alphabet are used to represent consonants (Hebrew and Arabic) or consonants and vowels (Greek and Cyrillic). Alphabets represent speech segments that are unpredictable.

**Character:** *Character* is the term for a single symbol in logographic writing systems like Chinese and Japanese (Cook, 2004). For example, the Chinese graphemes <人> (‘person’), <眠> (‘sleep’), and <國> (‘country’) are all individual characters.

**Coda:** The coda is the part of the syllable that follows the nucleus (Rogers, 2000). For example, in the word /post/, the consonants /s/ and /t/ – which come after the nucleus /o/ – form the coda /st/.

**Correspondence rules:** Correspondence rules are the means by which we relate written letters and sounds (Cook, 2004). For example, in the word *hand*, each letter – <h>, <a>, <n>, and <d> – corresponds with a single phoneme /h/, /æ/, /n/, and /d/, respectively.

**Diagraph:** “A sequence of two graphemes which represents a linguistic unit normally represented by one grapheme” (Rogers, 2005, p. 292). For example, in English, the diagraph <th> represents both the voiced /ð/ and voiceless /θ/ dental fricatives.

**Deep orthography (opaque):** Deep orthographies have a high degree of irregular letter-to-sound correspondences. That means, that some letters can have more than one sound attached to it, and some phonemes can have more than one graphemic representation. English and Hebrew are examples of languages with deep orthographies. (Katz & Frost, 1992; Liberman et al., 1980)

**Dual-route model:** “A dual-route model of reading aloud has two processes or ‘routes’: the *phonological route*, which converts letters into sounds through rules, and the *lexical route*, which matches words as wholes in the mental lexicon” (Cook, 2004, p. 16).

**First language (L1):** An L1 refers to a speaker's native language (Archibald, 1998; Cook, 2002; Major, 2001).

**Grapheme:** A grapheme is a “contrastive unit in a writing system, parallel to phoneme or morpheme” (Rogers, 2005, p. 10). Graphemes can be represented by letters, characters, numerals, and/or other symbols. For example, in English, the grapheme <z> is a letter that contrasts with other letter graphemes like <p t h g l>.

**Homography:** Homographs are words where the “phonemic distinctions are neutralized graphemically” (Rogers, 2005, p. 16). For example, in English, the words read /ɪd/ and read /ɪəd/ are spelt the same way but pronounced differently.

**Homophony:** Homophonous words are words where the “graphemic distinctions are neutralized phonemically” (Rogers, 2005, p. 16). For example, in English, the words *one* and *won* are pronounced the same /wʌn/ but spelt differently.

**Interlanguage:** The linguistic system of an adult second language user is called an interlanguage as it has influences from both the first and second languages as well as language universals (Archibald, 1998; Major, 2001; Selinker, 1972).

**Letter:** A letter is a shape that is “recognized as [an instance] of abstract graphic concepts which represent the basic units of an alphabetic writing system” (Coulmas, 1999, p. 291).

**Ligature:** A ligature refers to two graphemes that are fused together and written as one unit. For example, <æ> is a ligature for <ae>, and <w> is a ligature for <uu>. (Coulmas, 2003)

**Literacy:** According to Coulmas (1999), literacy is a “mastery of writing and reading skills” (p. 302).

**Logograph:** A logography is a writing system where words or morphemes are the units of representation such that a written grapheme can represent a word or morpheme (Coulmas, 1999; Cheung & Chen, 2004; DeFrancis, 1990).

**Mapping Principle:** A mapping principle refers to what sound units (i.e., morphemes, syllables, or phonemes) graphemes map onto (e.g., Perfetti, 2003; Wang et al., 2005). For example, alphabetic orthographies like English or Korean map graphemes onto phonemes while logographic orthographies like Chinese map graphemes onto syllabic morphemes (DeFrancis, 1989).

**Markedness:** Markedness refers to the relative commonality and complexity of linguistic elements. Those elements that are simple or common are considered *unmarked* and those that are complex and uncommon are considered *marked*. (Archibald, 1998; Major, 2001)

**Mental Lexicon:** Each speaker of a language stores all the words they know in a mental dictionary (lexicon). The mental lexicon contains many thousands of items. (Cook, 2004)

**Morpheme:** The smallest meaningful unit in a language.

**Morphophonemic orthography:** In morphophonemic orthographies, graphemes (or strings of graphemes) represent morphologically related forms often at the expense of pronunciation consistency. That is, the morpheme has the same visual representation even though the pronunciation may differ (Coutsougera, 2007). For example, the spelling of the words *insane* /*insejn*/ and *insanity* /*insænti*/ indicate that the words are morphologically related, and the spelling does not reflect pronunciation difference between the vowels represented by the grapheme <a>.

**Negative Transfer:** This type of transfer refers to when an L1 feature is transferred into a learner's interlanguage and hinders the learning of the L2 (Archibald, 1998; Major, 2001).

**Nucleus:** The nucleus is the most sonorous part of a syllable and is usually a vowel (Rogers, 2000). For example, in the word /*bʊk*/, the vowel /*ʊ*/ is the nucleus.

**Onset:** The onset is the part of the syllable that precedes the nucleus (Gombert, 1996; Rogers, 2000). For example, in the word /*sniz*/, the consonants /*s*/ and /*n*/ – which come before the nucleus /*i*/ – form the onset /*sn*/.

**Orthographic depth:** Orthographic depth refers to the consistency and predictability of letter-to-sound correspondences in a language (Frost & Katz, 1989; Katz & Frost, 1992; Liberman et al., 1980).

**Orthographic depth hypothesis (ODH):** The ODH states that in shallow orthographies, the word recognition process involves the language's phonology and that, in deep orthographies, readers must process printed words by their morphology through the word's visual-orthographic structure. (Katz & Frost, 1992, p. 71)

**Orthographic neighbourhood:** An orthographic neighbourhood refers to “the range of strings that can be made by changing one letter or character at a time (Ellis et al., 2004, p. 457). Neighbourhoods can be either dense (where many new words can be generated) or sparse (where very few new words can be generated).

**Orthography:** Orthography refers to the rules or principles by which a script is used for a particular language (Cook & Bassetti, 2005; Read, 1983).

**Phoneme:** A phoneme is a contrastive segment in a language (Rogers, 2000). For example, in English, the phoneme /p/ contrasts with the phoneme /b/ as indicated by the meaning difference between the words /pɪt/ and /bɪt/.

**Phoneme awareness:** Phoneme awareness refers to the ability to analyse and mentally manipulate spoken language at the phonemic level (e.g., Cheung, 1999; Goswami, 1999; Read et al., 1986; Yopp, 1988). Phoneme awareness is one of the three sub-levels of phonological awareness. (See also Phonological Awareness.)

**Phoneme blending:** In a blending task, participants are presented with two syllables. They are asked to take the initial phoneme from the first syllable and the vowel from the second syllable and combine these phonemes to form a new syllable (Cheung, 1999).

**Phoneme completion task:** Participants must supply the final phoneme in a single syllable word (Carroll, 2004).

**Phoneme counting task:** Participants must count the number of phoneme ('sounds') in words (e.g., Lehtonen & Treiman, 2007; Treiman & Cassar, 1997).

**Phoneme deletion task:** Participants must remove either the beginning or final phoneme from a single syllable word and produce the word without that removed phoneme (Carroll, 2004; Cheung, 1999).

**Phoneme identity task:** Participants are given a target sound illustrated in an example word; then, they must identify (from 2 words) which word starts (or ends) with the same sound as the target. (e.g., Bowey, 1994; Fletcher-Flinn et al., 2011; Wallach et al., 1977)

**Phoneme isolation task:** Participants identify a specific sound in a give word. For instance, the participants would have to identify /k/ as the first phoneme in the word *cat*. (e.g., Caravolas & Bruck, 1993; Castles et al., 2009; Yopp, 1988)

**Phoneme monitoring task:** Participants must push a button as soon as they here the target. (e.g., Dijkstra et al., 1995; Frauenfelder et al., 1995; Hallé et al., 2000; Morais et al., 1986)

**Phoneme oddity task:** Participants must identify the odd word out based on phoneme difference – either onset, medial, or final phonemes. For instance, participants must identify that *deck* is the odd word out from the following words *fit*, *fan*, *deck* because the other two words begin with the phoneme /f/. (e.g., Bowey, 1994)

**Phoneme reversal task:** Participants must reverse two specific phonemes in a word. For example, participants have to switch the- first and last sounds in the word *pit* to create the word *tip*. (e.g., Alegria et al., 1982; Castles et al., 2003; Yopp, 1988)

**Phoneme segmentation task:** Participants identify the phonemes in a given word. For example, the participants must identify that the word *big* has the phonemes /b/, /ɪ/, and /g/. (e.g., Cossu et al., 1988; Williams, 1980; Yopp, 1988)

**Phonemic orthography:** The only function of graphemes in a phonemic orthography is to represent phonemes (Coutsougera, 2007). The Greek and Spanish orthographies are examples of phonemic orthographies.

**Phonological awareness (PA):** Cheung (1999) defines phonological awareness as “an individual’s ability to analyse spoken language into smaller component sound units and to manipulate them mentally” (p. 2). PA has three levels: the syllable, onsets and rimes, and the phoneme.

**Phonological Recoverability:** Phoneme recoverability “refers to how systematically the graphemic representation can be converted into the phonological representation” (Vokic, 2011, p. 395)

**Pinyin:** Pinyin is a phonemic alphabet that is the standard Romanization system in China. This orthography uses Roman letters to represent Chinese sounds. (Coulmas, 1999; DeFrancis, 1990; Killingly, 1998)

**Positive Transfer:** This type of transfer refers to when an L1 feature is transferred into a learner’s interlanguage and facilitates the learning of the L2 (Archibald, 1998; Major, 2001).

**Regularity:** Regularity refers to “the consistency with which representations correspond to the linguistic units within a writing system” (Read, 1983, p.157).

**Rime (also rhyme):** The rime is the part of the syllable that contains the nucleus and the coda. (Gombert, 1996; Rogers, 2000) For example, in the word /kæt/, the vowel /æ/ and the coda /t/ form the rime /æt/.

**Rime judgement:** Participants must match syllables that share the same rime (Cheung, 1999).

**Script:** A script is “the graphic form of the units of a writing system” (Coulmas, 2003, p. 35)

**Second language (L2):** An L2 is a language other than a speaker’s native language (Cook, 2002; Major, 2001).

**Segment:** A segment is a consonant or vowel in any given language (Rogers, 2000).

**Shallow orthography (transparent):** Shallow orthographies have more regular one-to-one letter-to-sound correspondences. That means, letters have only one sound, and

phonemes have only one representation. Serbo-Croatian and Spanish are examples of languages with shallow orthographies. (Katz & Frost, 1992; Liberman et al., 1980; Rogers, 2005)

**Syllabary:** A syllabary is a writing system where the syllable is the unit of representation such that graphemes represent syllables or moræ (Coulmas, 1999; Chueng & Chen, 2004; Rogers, 2005).

**Syllable:** A syllable is a “phonological unit of organisation” that is “typically larger than a segment and smaller than a word” (Rogers, 2000, p. 314). All syllables contain a nucleus (i.e., a vowel or syllabic consonant) and may also contain an onset and/or coda.

**Transfer:** Transfer refers to “the process whereby a feature or rule from a learner’s first language is carried over to the IL [interlanguage] grammar” (Archibald, 1998, p. 3). Transfer can be either positive or negative.

**Word-to-word matching task:** Participants must identify if the given words share the same phoneme. For example, participants would have to decide whether *pen* and *hit* begin with the same phoneme. (e.g., Cheung & Chen, 2004; Treiman & Zukowski, 1991; Yopp, 1988)

**Writing:** Writing is defined as “the use of graphic marks to represent specific linguistic utterance” where these marks “mak[e] an utterance visible” (Rogers, 2005, p. 2)

**Writing system:** A writing system uses visual or tactile graphemes to represent language. It has a systematic relationship to language and a systematic internal structure and organization (Coulmas, 1999; Rogers, 2005).

## APPENDIX B: Translated versions of “The North Wind and the Sun”

### English Translation

The north wind and the sun were disputing which was stronger, when a traveler came along wrapped in a warm cloak. They agreed that the one who first succeeded in making the traveler take his cloak off should be considered stronger than the other. Then the north wind blew as hard as he could. But the more he blew the more closely did the traveler fold his cloak around him; and at last the north wind gave up the attempt. Then the sun shone out warmly, and immediately the traveler took off his cloak. And so the north wind was obliged to confess that the sun was the stronger of the two.

### Russian Translation

Северный ветер и солнце спорили, кто сильнее. В это время мимо них проходил путник в тёплом плаще. Они решили, что тот будет сильнее, кто первым заставит путника снять плащ. Тогда северный ветер стал дуть изо всех сил. Но чем больше он дул, тем плотнее путник закутывался в плащ. В конце концов, северный ветер прекратил свои усилия. Тогда выглянуло жаркое солнце, и путник сразу снял плащ. И северный ветер вынужден был признать, что солнце сильнее него.

### Mandarin Translation

yǒu yī cì , běi fēng hé tài yáng zhèng zài zhēng lùn shéi bǐ jiào qiáng 。 tā men zhèng hǎo kàn dào yǒu gè lù rén zǒu guò , nà gè rén chuān zhù yī jiàn dòu péng 。 tā men jiù jué dìng , shéi kě yǐ ràng lù rén tuō diào nà jiàn dòu péng , jiù suàn shéi bǐ jiào lì hài 。 yú shì běi fēng jiù pīn mìng dì chuī 。 méi xiǎng dào , tā chuī dé yù lì hài , lù rén jiù yù shì yòng dòu péng bāo jǐn zì jǐ 。 zuì hòu , běi fēng méi bàn fǎ le , zhǐ hǎo fàng qì 。 jiē zhe , tài yáng chū lái wēn nuǎn de zhào yào le yī xià , lù rén jiù lì kè bǎ dòu péng tuō diào le 。 yú shì , běi fēng zhǐ hǎo rèn shū , chéng rèn tài yáng bǐ jiào lì hài 。

**APPENDIX C: Secondary data collect response sheet**

**NATIVE ENGLISH SPEAKER**

- |           |           |           |
|-----------|-----------|-----------|
| 1. _____  | 18. _____ | 35. _____ |
| 2. _____  | 19. _____ | 36. _____ |
| 3. _____  | 20. _____ | 37. _____ |
| 4. _____  | 21. _____ | 38. _____ |
| 5. _____  | 22. _____ | 39. _____ |
| 6. _____  | 23. _____ | 40. _____ |
| 7. _____  | 24. _____ | 41. _____ |
| 8. _____  | 25. _____ | 42. _____ |
| 9. _____  | 26. _____ | 43. _____ |
| 10. _____ | 27. _____ | 44. _____ |
| 11. _____ | 28. _____ | 45. _____ |
| 12. _____ | 29. _____ | 46. _____ |
| 13. _____ | 30. _____ | 47. _____ |
| 14. _____ | 31. _____ | 48. _____ |
| 15. _____ | 32. _____ |           |
| 16. _____ | 33. _____ |           |
| 17. _____ | 34. _____ |           |

## NONNATIVE SPEAKERS OF ENGLISH

1. word \_\_\_\_\_  
1 2 3 4 5 6 7 8 9  
native non-native

2. word \_\_\_\_\_  
1 2 3 4 5 6 7 8 9  
native non-native

3. word \_\_\_\_\_  
1 2 3 4 5 6 7 8 9  
native non-native

4. word \_\_\_\_\_  
1 2 3 4 5 6 7 8 9  
native non-native

5. word \_\_\_\_\_  
1 2 3 4 5 6 7 8 9  
native non-native

6. word \_\_\_\_\_  
1 2 3 4 5 6 7 8 9  
native non-native

7. word \_\_\_\_\_  
1 2 3 4 5 6 7 8 9  
native non-native

8. word \_\_\_\_\_  
1 2 3 4 5 6 7 8 9  
native non-native

9. word \_\_\_\_\_  
1 2 3 4 5 6 7 8 9  
native non-native

10. word \_\_\_\_\_  
1 2 3 4 5 6 7 8 9  
native non-native

11. word \_\_\_\_\_  
1 2 3 4 5 6 7 8 9  
native non-native

12. word \_\_\_\_\_  
1 2 3 4 5 6 7 8 9  
native non-native

13. word \_\_\_\_\_  
1 2 3 4 5 6 7 8 9  
native non-native

14. word \_\_\_\_\_  
1 2 3 4 5 6 7 8 9  
native non-native

15. word \_\_\_\_\_  
1 2 3 4 5 6 7 8 9  
native non-native

16. word \_\_\_\_\_  
1 2 3 4 5 6 7 8 9  
native non-native

17. word \_\_\_\_\_  
1 2 3 4 5 6 7 8 9  
native non-native

18. word \_\_\_\_\_  
1 2 3 4 5 6 7 8 9  
native non-native

19. word \_\_\_\_\_  
1 2 3 4 5 6 7 8 9  
native non-native

20. word \_\_\_\_\_  
1 2 3 4 5 6 7 8 9  
native non-native

21. word \_\_\_\_\_  
1 2 3 4 5 6 7 8 9  
native non-native

22. word \_\_\_\_\_  
1 2 3 4 5 6 7 8 9  
native non-native

23. word \_\_\_\_\_  
1 2 3 4 5 6 7 8 9  
native non-native

24. word \_\_\_\_\_  
1 2 3 4 5 6 7 8 9  
native non-native

25. word \_\_\_\_\_  
1 2 3 4 5 6 7 8 9  
native non-native

26. word \_\_\_\_\_  
1 2 3 4 5 6 7 8 9  
native non-native

27. word \_\_\_\_\_  
1 2 3 4 5 6 7 8 9  
native non-native

28. word \_\_\_\_\_  
1 2 3 4 5 6 7 8 9  
native non-native

29. word \_\_\_\_\_  
1 2 3 4 5 6 7 8 9  
native non-native

30. word \_\_\_\_\_  
1 2 3 4 5 6 7 8 9  
native non-native

31. word \_\_\_\_\_  
1 2 3 4 5 6 7 8 9  
native non-native

32. word \_\_\_\_\_  
1 2 3 4 5 6 7 8 9  
native non-native

33. word \_\_\_\_\_  
1 2 3 4 5 6 7 8 9  
native non-native

34. word \_\_\_\_\_  
1 2 3 4 5 6 7 8 9  
native non-native

35. word \_\_\_\_\_  
1 2 3 4 5 6 7 8 9  
native non-native

36. word \_\_\_\_\_  
1 2 3 4 5 6 7 8 9  
native non-native

37. word \_\_\_\_\_  
1 2 3 4 5 6 7 8 9  
native non-native

38. word \_\_\_\_\_  
1 2 3 4 5 6 7 8 9  
native non-native

39. word \_\_\_\_\_  
1 2 3 4 5 6 7 8 9  
native non-native

40. word \_\_\_\_\_  
1 2 3 4 5 6 7 8 9  
native non-native

41. word \_\_\_\_\_  
1 2 3 4 5 6 7 8 9  
native non-native

42. word \_\_\_\_\_  
1 2 3 4 5 6 7 8 9  
native non-native

43. word \_\_\_\_\_  
1 2 3 4 5 6 7 8 9  
native non-native

44. word \_\_\_\_\_  
1 2 3 4 5 6 7 8 9  
native non-native

45. word \_\_\_\_\_  
1 2 3 4 5 6 7 8 9  
native non-native

46. word \_\_\_\_\_  
1 2 3 4 5 6 7 8 9  
native non-native

47. word \_\_\_\_\_  
1 2 3 4 5 6 7 8 9  
native non-native

48. word \_\_\_\_\_  
1 2 3 4 5 6 7 8 9  
native non-native

49. word \_\_\_\_\_  
1 2 3 4 5 6 7 8 9  
native non-native

50. word \_\_\_\_\_  
1 2 3 4 5 6 7 8 9  
native non-native

51. word \_\_\_\_\_  
1 2 3 4 5 6 7 8 9  
native non-native

52. word \_\_\_\_\_  
1 2 3 4 5 6 7 8 9  
native non-native

**APPENDIX D: Dictation response sheet**

**ENGLISH WORDS**

- |           |           |           |
|-----------|-----------|-----------|
| 1. _____  | 27. _____ | 53. _____ |
| 2. _____  | 28. _____ | 54. _____ |
| 3. _____  | 29. _____ | 55. _____ |
| 4. _____  | 30. _____ | 56. _____ |
| 5. _____  | 31. _____ | 57. _____ |
| 6. _____  | 32. _____ | 58. _____ |
| 7. _____  | 33. _____ | 59. _____ |
| 8. _____  | 34. _____ | 60. _____ |
| 9. _____  | 35. _____ | 61. _____ |
| 10. _____ | 36. _____ | 62. _____ |
| 11. _____ | 37. _____ | 63. _____ |
| 12. _____ | 38. _____ | 64. _____ |
| 13. _____ | 39. _____ | 65. _____ |
| 14. _____ | 40. _____ | 66. _____ |
| 15. _____ | 41. _____ | 67. _____ |
| 16. _____ | 42. _____ | 68. _____ |
| 17. _____ | 43. _____ | 69. _____ |
| 18. _____ | 44. _____ | 70. _____ |
| 19. _____ | 45. _____ | 71. _____ |
| 20. _____ | 46. _____ | 72. _____ |
| 21. _____ | 47. _____ | 73. _____ |
| 22. _____ | 48. _____ | 74. _____ |
| 23. _____ | 49. _____ | 75. _____ |
| 24. _____ | 50. _____ | 76. _____ |
| 25. _____ | 51. _____ |           |
| 26. _____ | 52. _____ |           |

**SECOND LANGUAGE WORDS [RUSSIAN / MANDARIN]**

1. \_\_\_\_\_
2. \_\_\_\_\_
3. \_\_\_\_\_
4. \_\_\_\_\_
5. \_\_\_\_\_
6. \_\_\_\_\_
7. \_\_\_\_\_
8. \_\_\_\_\_
9. \_\_\_\_\_
10. \_\_\_\_\_
11. \_\_\_\_\_
12. \_\_\_\_\_
13. \_\_\_\_\_
14. \_\_\_\_\_
15. \_\_\_\_\_
16. \_\_\_\_\_
17. \_\_\_\_\_
18. \_\_\_\_\_

19. \_\_\_\_\_
20. \_\_\_\_\_
21. \_\_\_\_\_
22. \_\_\_\_\_
23. \_\_\_\_\_
24. \_\_\_\_\_
25. \_\_\_\_\_
26. \_\_\_\_\_
27. \_\_\_\_\_
28. \_\_\_\_\_
29. \_\_\_\_\_
30. \_\_\_\_\_
31. \_\_\_\_\_
32. \_\_\_\_\_
33. \_\_\_\_\_
34. \_\_\_\_\_
35. \_\_\_\_\_
36. \_\_\_\_\_

37. \_\_\_\_\_
38. \_\_\_\_\_
39. \_\_\_\_\_
40. \_\_\_\_\_
41. \_\_\_\_\_
42. \_\_\_\_\_
43. \_\_\_\_\_
44. \_\_\_\_\_
45. \_\_\_\_\_
46. \_\_\_\_\_
47. \_\_\_\_\_
48. \_\_\_\_\_
49. \_\_\_\_\_
50. \_\_\_\_\_
51. \_\_\_\_\_
52. \_\_\_\_\_

## APPENDIX E: Participant Consent Form

### *Participant Consent Form*

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#### **Perceptual Illusions:**

#### **How do Native English speakers hear sounds in English, Russian, and Mandarin words?**

You are being invited to participate in a study that is being conducted by Carolyn Pytlyk, who is a PhD student in the Department of Linguistics. As a doctoral student, Carolyn is required to conduct research as part of the requirements for her PhD. The research is being conducted under the supervision, Dr Sonya Bird. You may contact Dr Bird at [sbird@uvic.ca](mailto:sbird@uvic.ca).

#### **Purpose and Objectives**

This research investigates how individuals hear the sounds that make up words in languages they are more vs. less familiar with. This research aims to identify and understand the difficulties native English speakers encounter when trying to isolate the component sounds of English, Russian, and Mandarin words and to discuss possible reasons for and solutions to such problems and/or difficulties.

#### **Importance of this Research**

Research of this type contributes to the growing body of knowledge on second language (L2) phoneme awareness. Specifically, the research will contribute to our understanding of what factors affect our perception of sounds in language with which are familiar and those we are not familiar.

#### **Participant Selection**

You are being asked to participate in this study because you are either 1) a native English speaker who is learning either Russian or Mandarin as an L2, OR 2) a native English speaker who has not learnt either Russian or Mandarin.

#### **What is involved?**

If you agree to voluntarily participate in this research, and you are a Russian or Mandarin learner, your participation will include a 30 minute identification task where you will count the sounds in English, Russian, and Mandarin words and a 20 minute dictation task where you will write the words that you hear. You will also complete a questionnaire to ascertain your language learning background. If you are not a learner of Mandarin or Russian, your participation will include judging the nativeness of English, Russian, and Mandarin words as well as the background questionnaire.

#### **Inconvenience**

Participation in this study may cause some inconvenience to you as you will have to allot approximately 60 minutes for participation.

#### **Risks**

There are no known or anticipated risks to you by participating in this research.

**Benefits**

The potential benefits of your participation in this research include learning more about how L2 speech perception works which may, in turn, help with your second language learning. If you want a more detailed report about the study, we can send it to you when a report is available.

**Voluntary Participation**

Your participation in this research must be completely voluntary. Any relationship with the researcher (i.e., as a fellow classmate) must not affect your decision to participate. If you would not participate if you did not know the researcher, then you should decline. If you do decide to participate, you may withdraw at any time without any consequences or any explanation. If you do withdraw from the study, your data will not be used for the analysis and will be destroyed.

**Anonymity**

In terms of protecting your anonymity, all data collected will be kept completely anonymous. All information and the data collected will be arranged and stored according to your identification numbers. Any analysis and mentioning of the testing processes will be anonymous; no names or other defining characteristics will be revealed.

**Confidentiality**

The confidentiality of your data will be protected by ensuring that all your data and information is stored in password protected files and/or in a locked research lab.

**Dissemination of Results**

The results of this study may be shared with others in the following ways;

- (1) presentations at scholarly meetings (i.e., conferences),
- (2) a published article, and
- (3) a dissertation.

*(Please check the boxes to which you consent.)*

**Disposal of Data**

I agree to let this data be saved for the purposes of future research by either these or other researchers.

I would like my data to be destroyed after their use for these projects.

**Contacts**

Individuals that may be contacted regarding this research include Dr Sonya Bird (sbird@uvic.ca) and Carolyn Pytlyk (pytlykca@uvic.ca). In addition, you may verify the ethical approval of this study, or raise any concerns you might have, by contacting the Human Research Ethics Office at the University of Victoria (250-472-4545 or ethics@uvic.ca).

Your signature below indicates that you understand the above conditions of participation in this study and that you have had the opportunity to have your questions answered by the researchers.

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*Name of Participant*

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*Signature*

---

*Date*

***A copy of this consent will be left with you, and a copy will be taken by the researchers.***

**APPENDIX F: Background Questionnaire**

**Participant Questionnaire**

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Dear Participant,

Please be advised that this is not a test. This is a questionnaire designed to identify your language background. The information provided by you below will be used in conjunction with your data collected from the study. In order to ensure your anonymity, no names will be elicited. Instead, you will be assigned an identification code. All data will be stored according to these identification numbers. If at any time you decide to withdraw from this study, all the data collected (including the information provided here) will not be used for the analysis and will be destroyed. If you have any questions or concerns, Carolyn Pytlyk (pytlykca@uvic.ca) will be happy to discuss them with you. Thank you for your participation.

**BACKGROUND INFORMATION**

Age \_\_\_\_\_ Gender \_\_\_\_\_

What dialect of English do you speak (ex. Canadian English, British English ...)?

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**LANGUAGE LEARNING INFORMATION**

What is your second language?      RUSSIAN      MANDARIN      OTHER

Have you studied any languages other than English and Russian/ Mandarin?    YES    NO

If so, what language(s)?

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How long?

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Do you consider yourself

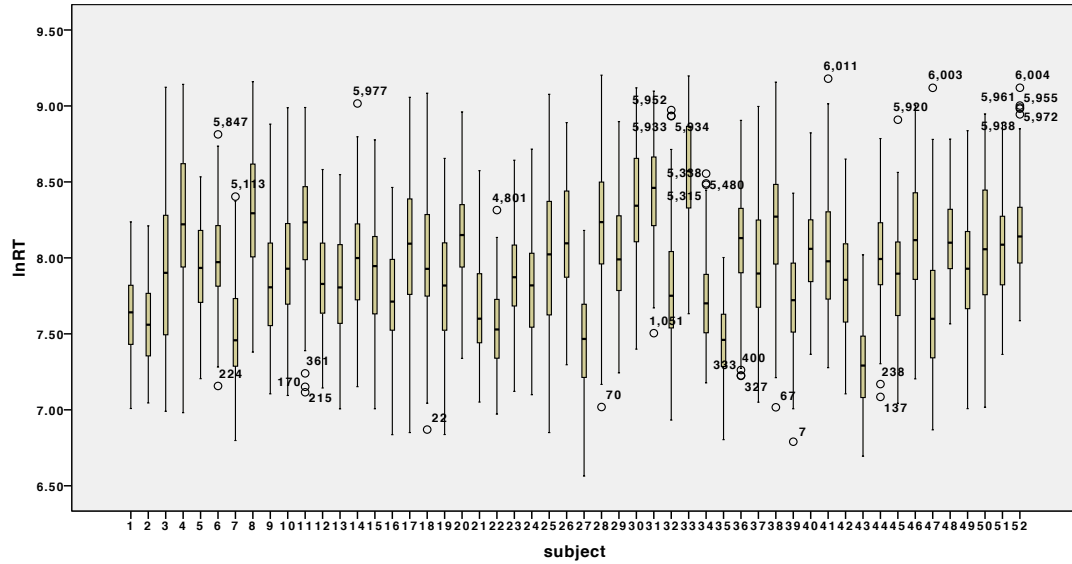
MONOLINGUAL       BILINGUAL       MULTILINGUAL

Do you have any known speech and/or hearing difficulties?      YES      NO

## APPENDIX G: Boxplots identifying RT outliers

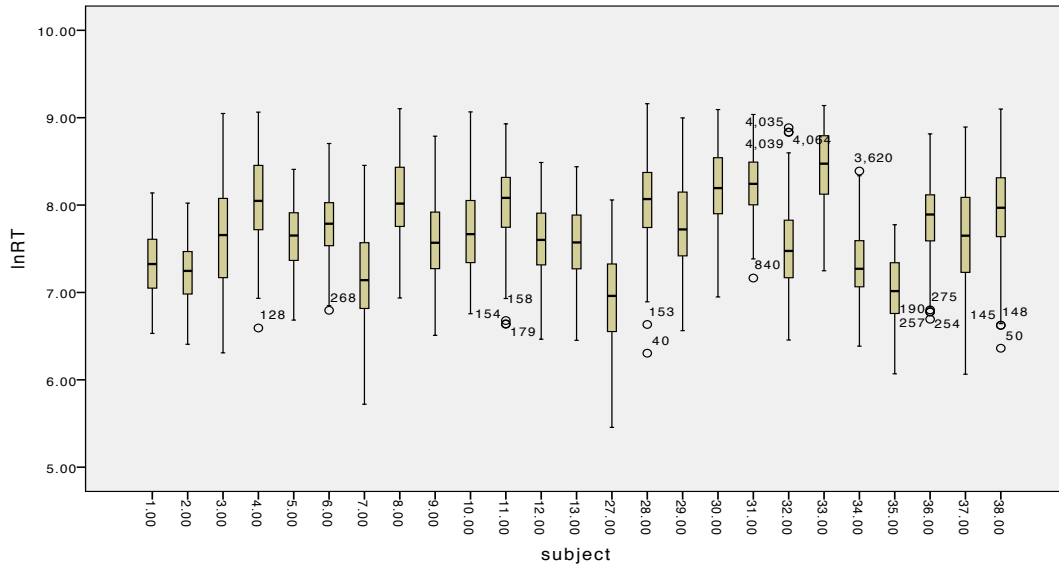
All circles in the following boxplots indicate RT outliers; these outlier values were not used in the analyses of the RT data.

**InRT**



**Figure G.1** Boxplots identifying RT outliers for the *overall* data

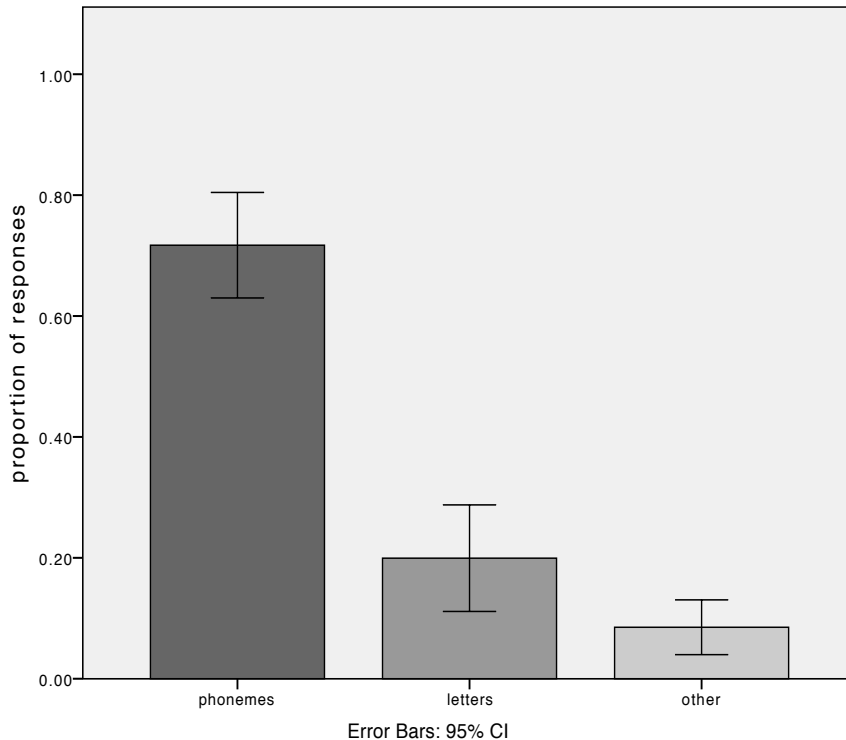
**InRT**



**Figure G.2** Boxplots identifying RT outliers for the *subgroup* data

## APPENDIX H: Response summaries

Response summaries by *phoneme*, *letter*, and *other*



**Figure H.1** Mean proportion of responses for the English mismatched tokens

These data were analysed with a 1-way repeated measures ANOVA with *response type* (phoneme, letter, other) as a within-subjects factor. The main effect for *response type* was significant ( $F(1,68)=53.721$ ,  $p<0.001$ ), indicating that a significant difference between at least two levels of *response type* factor. Subsequent analyses showed a significant difference between phoneme response and letter response ( $F(1,34)=38.546$ ,  $p<0.001$ ), with participants more often providing a response consistent with the number of phonemes in the word than with the number of letters in the word. Similarly, the analyses also showed a significant difference between phoneme response and other response ( $F(1,34)=143.117$ ,  $p<0.001$ ), with participants more often providing a response consistent with the number of phonemes than with a number other than the number of phonemes or letters in the word. Finally, the analyses showed a significant difference between letter response and other response ( $F(1,34)=4.468$ ,  $p<0.05$ ), with participants more often providing a response consistent with the number of letters in a word than with a number other than the number of phonemes or letters in a word.

Word	Transcription	Response					
		1	2	3	4	5	n.r.
tree	/tri/	1	2	<b>49</b>	0	0	0
toot	/tut/	0	2	<b>48</b>	2	0	0
when	/wɛn/	0	3	<b>47</b>	2	0	0
knee	/ni/	1	<b>47</b>	4	0	0	0
soup	/sup/	0	1	<b>47</b>	4	0	0
she *	/ʃi/	2	<b>93</b>	8	0	0	1
pole	/pɒl/	0	2	<b>46</b>	4	0	0
sue	/su/	0	<b>46</b>	6	0	0	0
shot	/ʃɒt/	0	1	<b>46</b>	5	0	0
fish	/fɪʃ/	0	1	<b>46</b>	5	0	0
dome	/dom/	0	3	<b>46</b>	2	1	0
coo	/ku/	3	<b>46</b>	2	1	0	0
rue	/ru/	2	<b>45</b>	5	0	0	0
tea/tee	/ti/	7	<b>45</b>	0	0	0	0
heat	/hit/	1	3	<b>45</b>	3	0	1
who	/hu/	4	<b>44</b>	4	0	0	0
sock	/sɒk/	0	1	<b>44</b>	7	0	0
give	/gɪv/	0	1	<b>44</b>	7	0	0
pea/pee	/pi/	6	<b>44</b>	3	0	0	0
whom	/hum/	1	3	<b>42</b>	6	0	0
stool	/stu:l/	0	0	7	<b>43</b>	2	0
speak	/spi:k/	0	0	6	<b>43</b>	3	0
month	/mʌnθ/	0	0	4	<b>41</b>	7	0
truth	/truθ/	0	0	7	<b>39</b>	5	1
talk	/tɒk/	0	3	<b>35</b>	13	0	1
quick	/kwɪk/	0	0	15	<b>35</b>	2	0
king	/kɪŋ/	1	2	<b>34</b>	14	0	2
long	/lɒŋ/	0	0	<b>32</b>	20	0	0
new	/nu/	0	<b>25</b>	26	1	0	0
six	/sɪks/	1	2	34	<b>17</b>	0	0
tax	/tæks/	0	2	35	<b>15</b>	0	0
box	/bɒks/	0	1	38	<b>13</b>	0	0
high	/haɪ/	1	39	<b>11</b>	1	0	0
my *	/maj/	2	<b>81</b>	<b>21</b>	0	0	0
go	/gow/	1	<b>50</b>	<b>1</b>	0	0	0

\* Both *my* and *she* have twice the number of data (i.e., 104) because there was a counterpart for each target stimuli in each language.

**BOLD:** response = number of phonemes (i.e., correct response)

SHADED: response = number of letters

n.r. = no response

**Table H.1** Response summaries by item of the English mismatched words for the overall data (total = 52)

word	transcription & translation	Response					
		1	2	3	4	5	n.r.
я	/ja/ ( <i>I</i> )	6	7	0	0	0	0
звать	/zvatʲ/ ( <i>to call</i> )	0	0	1	11	1	0
альт	/alʲtʲ/ ( <i>viola</i> )	0	1	12	0	0	0
юг	/jukʲ/ ( <i>south</i> )	0	5	8	0	0	0
жить	/žitʲ/ ( <i>to live</i> )	1	2	11	0	0	0
кровь	/krofʲ/ ( <i>blood</i> )	0	0	1	12	0	0
дождь	/doʒdʲ/ ( <i>rain</i> )	0	0	1	12	0	0
пять	/pʲatʲ/ ( <i>five</i> )	0	0	7	6	0	0
семь	/sʲemʲ/ ( <i>seven</i> )	0	1	11	1	0	0
весь	/vʲecʲ/ ( <i>whole</i> )	0	0	11	2	0	0
здесь	/zdʲesʲ/ ( <i>here</i> )	0	0	0	11	2	0
дать	/datʲ/ ( <i>to give</i> )	0	0	13	0	0	0
шесть	/ʃestʲ/ ( <i>six</i> )	0	0	1	12	0	0
день	/dʲenʲ/ ( <i>day</i> )	0	0	11	2	0	0

**Table H.2** Response summaries by item of the Russian mismatched words for the subgroup data (total = 13)

Word	transcription & translation	Response					
		1	2	3	4	5	n.r.
wàng	/wanʅ/ ( <i>to forget</i> )	0	1	9	2	0	0
yī	/i/ ( <i>one</i> )	7	5	0	0	0	0
shān	/ʃanʅ/ ( <i>mountain</i> )	0	1	11	0	0	0
wǔ	/u/ ( <i>five</i> )	5	5	2	0	0	0
huáng	/xwanʅ/ ( <i>yellow</i> )	0	1	4	4	3	0
shūo	/ʃwɔ/ ( <i>to speak</i> )	1	2	8	1	0	1
yuè	/ye/ ( <i>month</i> )	0	6	6	0	0	0
yòng	/jɔŋʅ/ ( <i>to use</i> )	0	0	10	2	0	0
yīn	/inʅ/ ( <i>reason</i> )	1	3	7	1	0	0
péng	/pʰɛŋʅ/ ( <i>friend</i> )	0	1	9	2	0	0
duì	/twejʅ/ ( <i>correct</i> )	0	3	7	2	0	0
máng	/maŋʅ/ ( <i>busy</i> )	0	1	8	3	0	0
shéi	/ʃejʅ/ ( <i>who</i> )	0	4	7	1	0	0
tīng	/tʰiŋʅ/ ( <i>listen</i> )	1	1	7	3	0	0

**Table H.3** Response summaries by item of the Mandarin mismatched words for the subgroup data (total = 12)