Effects of L1 Spanish and L2 English sublexical and lexical processing on English L2 word reading speed and accuracy, and reading comprehension

by

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Abstract

EFFECTS OF L1 SPANISH AND L2 ENGLISH SUBLEXICAL AND LEXICAL PROCESSING ON ENGLISH L2 WORD READING SPEED AND ACCURACY, AND READING COMPREHENSION

by

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This study explores the word identification processes used by adult bilingual Spanish/English readers of varying proficiencies in both L1 and L2, and how these relate to reading comprehension levels in L1 and L2. It has been proposed in word reading research that lexical processing (accessing the word directly from the lexicon) is more efficient than sublexical processing (assembling the phonology of a word letter by letter). This investigation is concerned with the type of bilingual processing used by readers of varying ability. Three groups of Spanish/English bilingual readers, who differed across both L1 and L2 in their reading comprehension levels, performed a reading and listening task in both Spanish (Experiment 1) and English (Experiment 2). A third monolingual control group performed the task in their L1, English (Experiment 3). The on-line procedure involved presenting words visually and aurally, for participants to make a yes/no choice as to whether the words match. This bimodal task, not previously used in second language research, presented equal difficulty for readers of all proficiency types. The written words appeared in either uniform (lower) case or alternating (aLtErNaTiNg) case, to test reliance on lexical processing during word identification. Overall,

L1 Spanish readers of all proficiency levels used similar strategies for L1 word identification, but the less proficient readers showed this effect when orthographic form was disrupted, i.e., when the stimuli were presented in alternating case. In L2, the less proficient readers tended to rely more on a sublexical strategy, while the high proficiency group used a lexical strategy. Crosslinguistic correlations indicated that readers who showed more disruption (as evidenced by higher reaction times) to alternating case stimuli in L1 Spanish had lower proficiency levels in English, indicating that L1 reading skill influences L2 reading proficiency. These findings combined support dual route models of reading, and have important implications for educational decisions: both sublexical and lexical skills are emergent in L1 and L2, and should be focused on in instructional settings.

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Chapter 1: Introduction

Research in word identification has focused on specifying the information (e.g., phonological or orthographic) that readers use when reading words. Furthermore, different types of information may be used in varying proportions depending on the orthography or the reader's proficiency. Bilingual word identification research has focused for the most part on high-skilled readers; however, there has been little research about bilingual low-skilled readers. This research focuses on the reading skills of the adult low-skilled bilingual reader, with a view towards gaining an understanding of whether they identify words lexically (i.e., through accessing the lexicon directly) or sublexically (e.g., using a letter by letter processing strategy).

Background

The present study investigates the processing strategies that readers use during first language (L1) and second language (L2) word identification, how these strategies affect word reading speed and accuracy, and whether they are related to reading comprehension levels in L1 and L2. In particular, we will be focusing on L1 readers who differ in their L1 reading comprehension levels and, potentially, in their word reading strategies. We are interested in the overarching research question: Are there differences in the processing strategies used by lower versus higher skilled L1 readers when they are reading words in a second language?

This issue is important both from a theoretical as well as an educational perspective. Some fluent bilinguals have overall slower reading speeds than monolinguals (Favreau & Segalowitz 1983), even when their proficiency is equivalent in the language where the differences emerge. This has been linked to a lack of automaticity in word recognition and weak

orthographic processing by bilingual readers (Segalowitz 1986). It has long been recognized that automatic word recognition is a prerequisite for strong comprehension (Adams 1990; Perfetti 1985). As Wren (2006) explains, when cognitive resources are used for decoding during the reading process, then these resources are not available for use in interpreting and understanding the text that is being read, and this slows down comprehension. Since speed and fluency in word reading are linked to strong reading comprehension skills in L1 and L2 readers (Bell & Perfetti 1994; Cunningham, Stanovich & Wilson 1990; Koda & Zehler 2008, 1994; Alderson 2000), it is important to investigate the processes used by L2 readers of English in word identification. Furthermore, an examination of the processes underlying word identification for readers of varying L1 levels will potentially lead to an understanding of how L1 contributes to the sub-skills of the developing L2 reader. Moreover, it is well established that L1 readers at lower reading levels in their native language have many more difficulties in learning to read in a second language than their high level L1 counterparts (August & Shanahan 2006; Collier 1995; Chamot 2002; Cummins 1996). This has become an important educational issue as the number of lower skilled L1 readers is substantial. According to the National Commission on Adult Literacy (2008), 50% of the immigrants who arrive in the United States each year have low L1 literacy rates. Establishing educational policies for these L2 learners needs to start with an understanding of how learners identify words in a second language because identification of words is fundamentally linked to reading comprehension (Perfetti 1985).

Purpose of the Study

This study expands on current knowledge about how second language learners of English identify words, by examining a relatively understudied subgroup of English second language learners: learners who have low reading skills in their native language, Spanish. It has been well-documented that reading skill in L2 is strongly linked to reading skill in L1 (Alderson 1984; Bernhardt & Kamil 1995; Carrell 1991; Cummins 1979; Yamashita 2002), and strong word identification skills have also been linked to efficient reading in both L1 and L2. Although there has been a substantial body of research on children learning to read in a second language, there has been relatively little research on the processing strategies adults utilize during L2 word identification. Furthermore, the research that has been conducted has for the most part been concerned with L2 learners who are highly skilled in L1 reading (Chikamatsu 2006; Wang & Koda 2005; Fender 2003; Brysbaert & Van Wijnendaele 2003; Koda 1998); the issue of lower-skilled L1 readers learning to read a second language has been largely neglected. However, it is clearly an important educational and social issue, as there is a substantial population of low-literacy L1 adolescents and adults who are learning to read English.

The two languages at issue in this study are Spanish and English. Spanish and English are very different in terms of their orthographic transparency (Frost et al. 1987; Ziegler & Goswami 2005), and as such provide an interesting comparison in terms of the types of sublexical components, e.g., the spoken and written units within words that include phonological and orthographic information (Sun-Alperin & Wang 2011), required for word identification as well as the extent to which these skills in L1 and L2 are related. When children are first learning to read L1 Spanish, the orthography is accessed easily through phonemes because each letter corresponds to one phoneme and vice-versa, whereas L1 English children need to access

multiple size units (including phonemes and whole words) almost immediately when learning to read (Ziegler & Goswami 2005). The orthographic transparency of a language determines how children begin to learn to read (Seymour et al. 2003), as well as the ease with which the orthographic code is learned; however, there is much debate about whether or not orthographic transparency influences more experienced readers (Oney, Peter & Katz 1997), who may use word-level units, syllable-based units or orthographic rime (the written part of the syllable consisting of the vowels and following consonants) units when reading, regardless of the transparency of the orthography (Defior et al. 1996; Valle-Arroyo 1996). Furthermore, some research has shown that even fluent L1 readers have inconsistent phonemic awareness (Scarborough et al. 1998), which suggests that phonemic awareness may only be a requirement for the beginner, not fluent reader. Therefore, in the present study, a central focus will be on determining the extent to which readers access smaller or larger units when reading words in L1 and the developing L2.

Much of the research conducted in L2 reading acquisition has used methodological paradigms involving either lexical decision or naming. These are both problematic in that they could create experimental confounds for L2 readers. The lexical decision task generally taps the accuracy and speed with which a reader accesses word knowledge, but an L2 learner whose lexicon is still developing may not have enough experience with words in the new language to know for sure whether a particular string of letters is a word or not. Similarly, naming tasks (in which readers “name the word” that they see) also are difficult for L2 learners because the learner must read the word “aloud,” and accuracy of word reading is one of the variables in such tasks. With the L2 reader, whose phonology is still developing and often not target-like, the examiner cannot determine whether or not a word is being misread, i.e. inaccurately read, or just

mispronounced. In the present study, the methodology for the on-line experiment does not require readers to either read aloud or make lexical decisions. Instead, readers are administered a visual/aural matching task in order to tap into the sub-skills utilized during phonological recoding. Recoding[1] is the process through which visually or orally presented words are assigned a pronunciation within the phonological system, and are then made available for lexical access. This task is a receptive task, so the reader reads the word, recodes and then compares the output with what is heard. Methodologically, this will also be an opportunity to test this type of task with bilingual readers. After an extensive search of the literature, only two other instances of this task being used have been found (Johnson & Cortwright 1969; Frost & Katz 1988), and both involved L1 readers.

Another important objective in using this task is to conduct an on-line investigation of the strategies that low literacy readers use in both L1 and L2. Lexical decision and naming tasks are not useful tools to use with learners who have limited literacy as they would most likely have difficulty reading words aloud or making decisions about words. These two types of task could be daunting for readers who are not skilled in L1, and thus, the tasks would not provide any accurate information as to the skills readers are applying. There has been some research using a similar task with L1 learners of varying literacy levels (Johnson & Cortwright 1976), but this task has not been used with L2 learners.

Prior research has scarcely touched on the processes underlying word identification for adult L2 learners, and especially those with lower L1 literacy (Tarone et al. 2009). Second language acquisition is based on data garnered from one particular segment of the L2 population (high skilled readers), leading to a large gap in SLA theory and real-world application. The

[1] Cunningham et al. (2011) state that *recoding* and *decoding* are identical in meaning.

central motivation for the present study is to conduct an investigation of the processing strategies underlying L1 and L2 word identification using a methodology that will be accessible for low literacy readers. The task will measure word reading speed and accuracy; since speed and fluency of word reading are linked to strong reading comprehension skills in L1 and L2 readers (Bell & Perfetti 1994; Cunningham, Stanovich & Wilson 1990; Koda 1994; Alderson 2000), it becomes imperative to investigate the processes used by L2 readers of English in word identification.

Overview: Organization of Dissertation

Chapter 2 is a review of the literature pertaining to L1 and L2 word identification, models of word reading and low skilled readers. Chapter 3 details the methodology and results for the Spanish for three different groups of Spanish/English bilinguals. Chapter 4 presents the methodology and results for the English data, including bilingual groups and a monolingual control group. Chapter 5 contains a general discussion of the results. Chapter 6 concludes with theoretical and educational implications.

Chapter 2: Word identification Processes in Bilingual Reading

Background

Research in reading has uncovered a strong relationship among phonological awareness, decoding, and word identification in both L1 and L2. These terms are interrelated, so this chapter begins with some definitions. This chapter then focuses on various models of word identification, surveys word identification strategies used by L1 and L2 readers, examines the impact of orthographic depth on word identification, and a discusses the characteristics of L1 and L2 low skilled readers.

Definitions

Phonological awareness is a broad term referring to an awareness of the phonological structure of spoken language. Phonological awareness can encompass any size unit of sound. Three important units subsumed under phonological awareness are 1) the syllable, a unit of sound containing a vowel and the consonants surrounding that vowel, 2) the onset/rime, the onset constituting the first consonant of a syllable, and the rime constituting the vowel and remaining consonants, and 3) the phoneme, the smallest contrastive unit of sound in a specified language. Another important term which is prevalent in reading research is *decoding*. Decoding is synonymous with *phonological recoding*, and it means transforming a visual string into its

phonological components for the purposes of word identification. *Word identification* has been defined in a variety of ways depending on the model being used. In the most general sense, it includes recognizing the orthographic, phonological and semantic information that specify a particular word.

Models of Word Identification

A fundamental aspect of the reading process is word identification. Efficient word identification has been shown to be linked to strong reading comprehension (Gough & Juel 1991**;** Juel, Griffith & Gough 1986; Stanovich 1982; Shanahan 1984.) The idea is that the reader who can quickly associate a string of graphemes with a lexical representation in memory has more resources to devote to understanding the meaning of a text (Wren 2006). Various models have been proposed to explain the process of word identification. One set of models includes phonological activation as an inherent part of visual word identification (Perfetti 2007, 1998; Ziegler & Goswami 2005; Katz & Frost 1992), while a second set of models places orthography as the most important element in visual word identification, with phonology playing a post-lexical role (Rastle 2007; Coltheart et al. 2001). A third set of models is fundamentally different in that it portrays word identification as originating from units within a network (Harm & Seidenberg 2004; Plaut 1997); in this type of model there are only distributed representations, no local ones, and all kinds of information (orthographic and phonological) interact in identification. In this review, the discussion will focus on the first and second model types as these two types postulate local representations and differ in terms of phonological activation.

The extent to which phonological information is activated in the initial identification of the word is not just of theoretical interest; it is also important in terms of understanding the processing strategies used by the reader across a variety of writing systems and orthographies. If phonological activation is an inherent part of word identification, then this suggests that there will be similarities across readers and across writing systems in terms of word identification. However, if phonological activation is not necessary for, but can influence word identification, then this suggests the possibility that word identification strategies will vary quite widely across readers and writing systems. In the following section, the focus will be on the varying models of word identification.

Perfetti: Restricted Interactive Model

Perfetti (2007) defines word identification as "rapid retrieval of a word's phonology and meaning" (p. 358). Word identification is fundamental to successful reading because without efficient word identification, subsequent processes (e.g., word integration and semantic processing) will be less than automatic, causing significant disruption in comprehension. Furthermore, it is a complex process involving the interaction of a number of variables. According to Perfetti (2005), the process of identifying a word entails the successful recovery of three elements: pronunciation (phonetic features and phonological principles), orthographic form (grapheme representations), and meaning (semantic features on lexical items).

Phonological principles are involved in all aspects of word identification. Phonological information is encoded within the word in the mental lexicon and is later used for retrieval of the word (Perfetti 2007). Furthermore, at the core of word identification are the phonological procedures that enable decoding of the word to take place. Decoding and word identification are

strongly connected (Perfetti 1991; 1987), as well as the use of letter knowledge by beginners during early decoding[2].

Perfetti contrasts implicit, or computational, knowledge with explicit, or reflective, knowledge. As he explains, implicit knowledge facilitates the computation of connections between phonemes and graphemes and allows for the pronunciation of strings composed of graphemes, whereas explicit knowledge means having an awareness of those connections. When children are first learning to read, they can use implicit knowledge of phoneme/grapheme connections even if their only knowledge of phonemes is as letter names (e.g., letter 'd' connects to the phoneme /d/). However, as decoding skills become stronger, the child can make use of explicit knowledge to understand and strengthen the relationship between phoneme and grapheme representations.

The beginner reader has what Perfetti calls a functional (orthographic) lexicon, which differs qualitatively and quantitatively from the lexicon of the more experienced reader. (See Figure 1.) Unlike in the lexicon of the experienced reader, world knowledge and expectations interact with word identification in the functional lexicon. This is because word identification early on is variable and imprecise as phoneme and grapheme representations are not yet strongly bonded to each other. This suggests a top down processing system, one which relies on contextual information to assist in word identification. As lexical knowledge grows and orthographic representations become more fully specified and complete, they move to the autonomous lexicon which is impenetrable from world knowledge. Second, the functional

[2] Early development of word identification skills in beginner readers is facilitated through implicit phonemic knowledge. This is true of readers of alphabetic systems as letter knowledge can be used to gain access to phonemes in words. And in studies of adult low skilled readers, it has been shown that most lack phonological, and specifically, phonemic awareness. This impinges on decoding skills and ultimately on word identification. The implication is that beginner readers of all ages need access to phonological information to identify words (Perfetti & Marron 2007).

lexicon relies on decoding rules, which are used less and less as more words are acquired and represented in the lexicon. The letter by letter decoding rules are replaced by more context sensitive rules governing grapheme/phoneme mapping; Decoding rules become more refined as well as better adapted to the specifics of the orthography. For example, an English specific analogical process would develop as stronger lexical representations are formed. A reader who had strong representations for ‘take,’ ‘make,’ and ‘bake’ would be able to use ‘ake’ as an entry into identifying a new word with that rime (the written part of the syllable consisting of the vowels and following consonants). Lexical entries continue to increase as do the potential number of entries based on decoding and analogies. Crucially, the lexical entries are not represented as holistic word forms or patterns; they are instead abstract letter patterns that are bonded to phonemes and are represented in the lexicon as word identities.

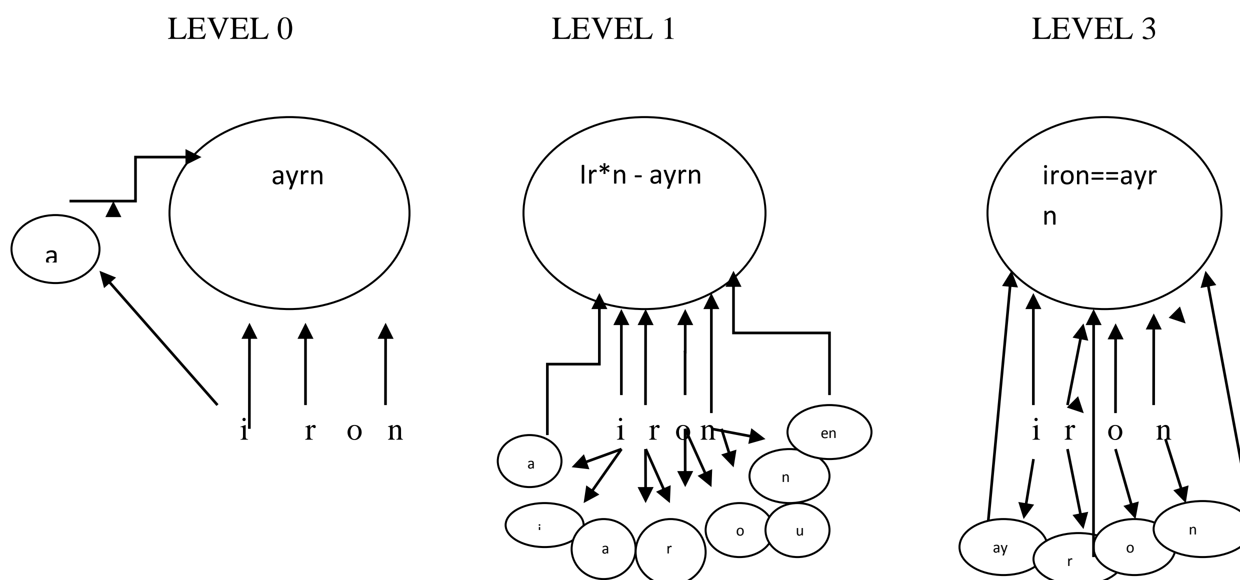

Figure 2.1. Development of redundant phonemic information over three hypothetical levels of reading acquisition. The large circles are word representations; they contain spellings and pronunciations. The small circles are phonemes connected with particular letters. At Level 0, there is only pronunciation, no spellings, so the representation is only phonemic. At Level 1, there is a proliferation of phonemic possibilities as the representation is developing. The * represents non-specific vowel information. Level 3 is a complete, fully specified word representation with the orthographic representation bonded to the phonemic representation. Figure adapted from Perfetti 1992.

Perfetti further states that the quality of lexical representations develops through specificity and redundancy. Representations become more specific as letters move into their correct positions, and they show more redundancy as various phonemic representations attached to a particular word. That is, the word 'speak' could be identified through the abstract letter-phoneme connections, or through identification of a familiar rime sequence, -EAK, which would be identified during a lexical search for a word. This characterization of lexical entries emphasizes the importance of phonological representations as integral to words and their identification (Perfetti 1992; Ehri 1992; Stuart & Coltheart 1988).

After the establishment of the autonomous lexicon, the experienced reader has access to fully specified lexical entries. These entries are graphemes bonded to phonemes, and as such are intrinsically linked to a phonological code as well as an orthographic code. According to Perfetti, lexical access can only occur through the activation of a "phonologically referenced name code." This idea rests on a fundamental property of written language – its basis in spoken language.

Writing systems are designed to encode spoken language, and as such they are phonological in nature. This idea is instantiated in the Universal Phonological Principle (UPP) (Tan & Perfetti 1998), which states that word reading activates phonology at the lowest level of language allowed by the writing system (phoneme, syllable, morpheme, or word). The UPP applies to all writing systems, but it is parameterized according to the phonological specifications of the particular writing system. For instance, word reading in an alphabetic writing system (e.g., Spanish) activates phonology at the phonemic level, while word reading in a logographic system (Chinese) activates phonology at the morpheme or word level.

Evidence for the automatic activation of phonology has been demonstrated in numerous studies. Studies using a backward masked priming technique[3] (Perfetti & Bell 1991; Xu & Perfetti 1999; Berent & Perfetti 1995) have shown that there is an effect of phonological priming which occurs with pseudo-homophone primes in English. For instance, in one priming experiment (Xu & Perfetti 1999), words and primes were presented to participants in order to determine the importance of orthographic and phonological information. Each target word (e.g., *bake*) was paired with three kinds of pseudoword masks: a phonemic mask (e.g., *baik*); a grapheme mask (e.g., bawk); and a control (e.g., crub). During each trial, a target word was presented, followed by a mask (phonemic, grapheme, or control). Immediately following each trial, subjects were told to write down the (target) word they had seen. The results revealed that, on average, participants correctly identified target word/phoneme mask pairs more often than either target/grapheme or target/control pairs. This result suggests "rapid, automatic and obligatory phonological processing during lexical access." (Xu & Perfetti, 1999, p. 26). The same results have been found for other languages. Gronau & Frost (1997) used a backward masked priming task and found evidence of phonological coding during word recognition in Hebrew. Brysbaert (2001) examined the phonological priming effect with Dutch speakers and found that a target word (e.g., 'fijn' 'nice') was recognized more often when a homophonic pseudo-word followed (e.g., 'fein'; 51%) than when a grapheme control prime followed (e.g., 'foun'; 42%).

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[3] In a masked priming technique, the reader sees a mask (####) on the computer screen, followed very briefly (50 ms) by a prime word. The brief presentation of the prime is hypothesized to trigger automatic processing of the word at a subconscious level, which is presumed to have an influence on the processing of the target word. After the prime, the target word is presented, and the reader must then complete a task, such as lexical decision, or writing the target word. The backward masked priming technique is the same except that the target word is presented first, followed by the prime word.

To sum up, the restricted interactive model views word identification as a developmental process, one which begins with impoverished entries and ends with solid entries, based on specific and redundant bonding between orthographic and phonological representations. The process of decoding leads to strengthening bonds between spellings and pronunciation, and over time the reader is able to access the representation as an orthographic-phonological entity.

The Dual Route Cascaded Model

While the Restricted interactive model postulates phonology as inherent to word identification, other theorists do not necessarily agree with this characterization. One of the most studied models is the Dual Route Cascaded model (DRC) of word identification, whose underlying assumption is that orthographic information is the most important source for identifying words, while phonological information is influential in identification but not required (Rastle 2007; Castle et al. 2001). In this model, phonological information is accessed later, post-lexically if readers are reading familiar words. Arguments against inherent phonological activation in visual word identification come from neuropsychological data, which demonstrate that patients with severe phonological or semantic impairments can still identify words (Coltheart 2004; Coltheart et al. 2001). The DRC model stipulates bi-directional connections among the various components that contribute to word identification, but the central focus of the architecture is the activation of orthographic nodes in the orthographic lexicon (Rastle 2007). Figure 2.2 below depicts the model.

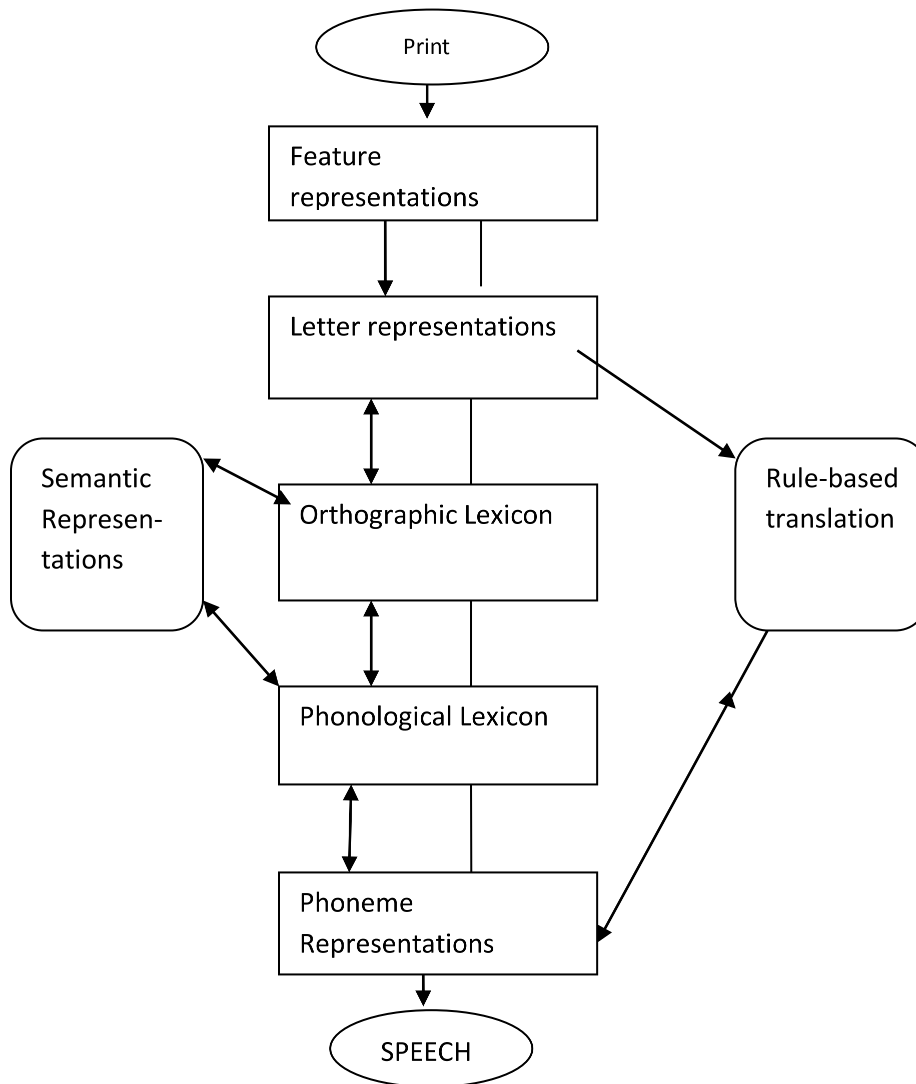

Figure 2.2. The Dual route cascaded model of word recognition. Adapted from Coltheart et al. (2001).

The DRC specifies two different routes for recognizing words: the assembled phonology route (also referred to as sublexical route) (e.g., the matching up of grapheme/phoneme correspondences), which results in phonological recoding of the written stimulus, and the direct route (also referred to as the lexical route) which connects the written stimulus directly to a lexical look-up (lexicon) where phonology is assigned post-lexically. Two parallel routes are postulated in order to explain English regular and irregular word identification. Regular words are those which follow the grapheme/phoneme mapping rules of the language (e.g., *last*); irregular words do not follow grapheme/phoneme rules, and are, therefore, not predictable (e.g., *yacht*). Hence, an alternative route to the sublexical route is necessary for irregular words to be recognized because they need to be recognized as an orthographic whole. According to the dual route model, a non-phonologically mediated route (e.g., a lexical or direct route) is viable, and in fact, necessary, at least for a language such as English which is orthographically opaque. This model of reading assumes that both the lexical and sublexical routes are activated in parallel, and that the lexical route is faster than the sublexical. The lexical route is seen as the normal route for processing familiar words, while the sublexical route handles nonwords and unfamiliar words.

Evidence in favor of two routes for word reading has been found for English. Baron & Strawson (1976) tested regular and irregular words on two groups of L1 English readers (called *Phoenician*[4] and *Chinese*) who used different processing strategies during word reading. The *Phoenician* readers tended to rely on sublexical processing of words, while the *Chinese* relied on

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[4] The Phoenician alphabet is said to be the first widely used alphabetic orthography; thus, Baron & Strawson (1976) labeled strong users of phonological processing *Phoenician*.

lexical processing. They then tested the two groups in a naming task and recorded reading times and error rates. Their prediction was that the *Phoenician* group would show a greater difference between exception (opaque) words and regular (transparent) words than the *Chinese* group because the Phoenician group used sublexical processing and would have difficulty with words that were not consistent. They found the predicted interaction; the Phoenician group had a higher reading time difference between exception and regular words than the Chinese group did. This is consistent with the idea that a reader who relies on sublexical processing will be slower to read words that are opaque.

In a second experiment, Baron & Strawson (1976) used alternating case to determine whether or not different processing strategies were used for regular and exception (irregular) words for L1 English readers. In this particular task, readers were asked to read words that were deformed in terms of font (using alternating case), e.g., 'tAkE'. The hypothesis was that alternating case would disrupt larger unit or whole word processing, but would not be as disruptive to phonemic processing since this occurs grapheme by grapheme. Baron & Strawson found "a greater effect of mixed case on exception than on regular words" (p. 391), and cited this as evidence that readers used a direct access or lexical approach for reading irregular words.

A number of studies have used alternating case methodology as a means of determining whether or not readers are using a sublexical strategy or a lexical/larger unit strategy when reading words (Mayall 2002; Mayall & Humphreys 1996; Miller 2011; Mason 1978). This methodology has been successfully employed in neurophysiological studies which have examined patients with impairment in various parts of the brain (Braet & Humphreys 2006). For example, it was found that alternating case was extremely disruptive in a word naming task measuring speed and accuracy to patients with parietal lobe impairment, and that this type of

impairment typically impeded sublexical processing. The authors suggested that this was due to a disruption in letter feature identification. As a result, other resources need to be brought to bear on word identification, including serial processing (sublexical processing) of letters, and patients with this type of damage have difficulty compensating for the loss of letter features. It is also suggested that these patients have an over-reliance on visual codes, which, when disrupted, causes a problem because they have difficulty with serial or sublexical processing. This suggests that when case is disrupted through mixed case stimuli, the reader must rely on phonological coding; however, if the reader has a deficit in sublexical processing, then that reader will have a greater difficulty recovering because sublexical processing abilities are not strong.

The dual route mechanism allows for two types of word identification strategies: 1) a strategy that accounts for reading frequent and familiar words; 2) a strategy that accounts for reading novel words. The dual route model of reading can be reconciled with Perfetti's account of reading development in that both models acknowledge that sublexical processing is used to a lesser degree as the reader gains proficiency in accessing the orthographic lexicon directly. Where they differ is in the phonological component as Perfetti's view places phonology as primary; phonological activation is inherent to word identification, so word identification cannot occur without activation of the phonological representation. On the other hand, in the Dual route model, words can be identified through their orthography, and then be assigned a phonological representation, so orthographic information is primary.

The Orthographic Depth Hypothesis

As Frost et al. (1987) point out, word identification entails the matching up of a grapheme string with a lexical representation. Furthermore, it is accepted that mediation between these two entities requires the use of at least one of two possible coding systems: (1) a code that makes reference to phonemic structure when examining the grapheme input (i.e. sublexical processing); and (2) a code that is based on an abstract representation of the grapheme unit, which could be a whole word (lexical processing) or a smaller morphological unit (Katz & Frost 1992). The factors determining the type of mediation used are the reader's proficiency, the complexity of the stimuli and the demands of the task (Frost et al. 1987).

Research involving languages other than English also revealed a fourth factor: the transparency of the orthography (e.g., Oney et al. 1997; Defior et al. 1996; Valle-Arroyo 1996; Lukatela & Turvey 1990; Gholamain & Geva 1999). Evidence was found for the use of different coding systems depending on the transparency of the orthography, and this led researchers to posit the Orthographic Depth Hypothesis (ODH) (Katz & Frost 1992; Frost et al. 1987). According to the ODH, this difference in orthographies will also be present in the reader's processing strategies for word identification. The hypothesis is that readers of a transparent orthography will use phonological coding (sublexical processing) for identifying words, while readers of an opaque orthography will use a code that refers to the morphology through the visual-orthographic structure of the word. This would involve accessing the whole word or morphological units of a word and the accompanying phonological representations from a lexical store. In the strong version of the ODH, sublexical processing is the only way to read words in a transparent orthography. The reasoning is that phonemic information is sufficient for identification of words when the mapping between orthography and phonology is isomorphic.

However, as Katz & Frost (1992) point out, this is not a reasonable option as even in transparent orthographies, such as Serbo-Croatian, stress related rules apply that govern pronunciation and cannot be determined through sublexical processing[5]. The information about stress would have to be located in a lexical store, and then be accessed directly from that store. Furthermore, effects of frequency and word superiority effects in lexical decision and naming tasks in transparent orthographies provide evidence for whole word or larger unit access during word identification (Valle-Arroyo 1996; Defior et al. 1996).

The weak version of the hypothesis postulates that the two strategies for reading are complementary, and that the way these strategies blend together in the reading process will depend in large part upon the constraints of the particular orthography (Katz & Frost 1992). It is this version that Katz & Frost present to account for differences between orthographies in processing words.

There are mainly three types of evidence in favor of the ODH in L1 reading. First, it has been shown that young readers of German and Welsh (transparent) are better at reading non-words than their English (opaque) counterparts (Wimmer & Goswami 1994; Lopez & Gonzalez 1999; Rack et al. 1992). This demonstrates that sublexical processing is more dominant in a transparent orthography. Second, there is a difference in error types, with children who read transparent orthographies making pronunciation errors with non-words, and children who read opaque orthographies making word substitution errors with non-words (Wimmer & Hummer 1990; Seymour & Elder 1986). This demonstrates that the former group is using a phoneme by phoneme analysis, whereas the latter group is processing the non-word as a whole and

[5] According to Frost (2005), stress in two syllable words in Serbo-Croatian always falls on the first syllable; however, words with more than two syllables are not predictable in terms of stress assignment; therefore, a lexical store is necessary to account for stress assignment information.

substituting it with a lexical representation that approximates the orthographic structure of the non-word. The third piece of evidence is the strong relationship between word length and reading latency in a transparent language as compared to an opaque language. Ellis & Hooper (2001) demonstrated that word length affected reading times much more often (70%) in Welsh than in English (22%), providing evidence for a left to right assembly of phonological structure in the transparent language and resulting in slower reading times for longer words (Ellis et al. 2004).

On the other hand, there has been evidence that contradicts the strong version of the ODH as well, with various studies demonstrating that sublexical processing is not the only processing strategy used by fluent readers of transparent orthographies (Sanabria et al. 2009; Defior et al.1996; Sartori & Masuto 1982; Valle-Arroyo 1996). In studies of Spanish speaking children, it was found that children of varied reading levels, including dyslexic children, made use of both a lexical and sublexical strategy while reading. This is counter-evidence for the strong version of the ODH, and evidence for the Dual route model, which supports the parallel activation of both processing strategies.

Sanabria et al. (2009) tested Spanish speaking dyslexic children and normal reading level controls in a word and pseudoword reading task. In this experiment, children read aloud words and pseudowords presented on a computer screen. The experimenter recorded accuracy for each trial, and reaction times were recorded as well. It was hypothesized that there would be a switching cost if children switched from a sublexical to a lexical strategy (or the converse), and furthermore, that this would provide evidence for the use of both types of strategy. To test this hypothesis, a 2 x 2 design was used: Stimulus Pair (match, mismatch) x Word Type (word,

pseudoword). Pseudowords are always accessed sublexically; therefore, it lexical processing was used for words, a processing cost should be evident.

Overall results showed that dyslexic children read more slowly than the normal reading controls, and younger children read more slowly than older children. The effect of lexicality was present in both younger and older children as well as dyslexic and normal controls: pseudowords were read more slowly than words. An interesting effect was that dyslexic 3rd graders and 6th graders varied as to their word reading (with 3rd graders reading more slowly), but showed very similar reading times for pseudowords. This indicates that sublexical reading is prevalent across age levels with dyslexics and points towards the inability to integrate phonological information at the letter level as the source of difficulty in word identification.

Moreover, a switching cost was evident (although less so for stronger readers) when the preceding stimulus did not equal the following stimulus. This result, in combination with the finding on lexicality, provides support for a dual strategy analysis of Spanish reading[6]. Both Defior et al. (1996) and Valle-arroyo et al. (1996) also confirm the use of both strategies in Spanish speaking children, and the increase of the lexical strategy as readers become more skilled.

An important question that presents itself in consideration of the data on dyslexic readers as well as beginner readers is: Why is lexical processing faster than sublexical and what facilitates the speed in skilled reading? According to some of the reading models discussed above (the Dual Route Cascaded model, for example), information from multiple levels feeds forward and backward to facilitate word identification. For instance, the orthographic lexicon

[6] It is likely that both strategies are used across orthographies; however, there may be timing differences in terms of the speed at which the phonological route is used. For instance Ziegler et al. (2003) found that French differed from English in the timing of phonological information during word identification.

and the phonological lexicon will send information back and forth as necessary to achieve word identification. This cascaded system is efficient and allows for quick identification. Perfetti's Restricted Activation model postulates a developmental process of strengthening phoneme/grapheme bonds in lexical representations. As lexical representations become more complete, sublexical processing diminishes because it is not needed to such a great extent.

Through examination of low skilled readers and comparison with higher skilled readers, a more complete understanding of sublexical and lexical processing can be acquired. Zeigler et al. (2003) compared English (opaque orthography) and German (transparent orthography) dyslexic children in order to determine the extent of differences in dyslexia for transparent and opaque orthographies. They found that both German and English dyslexics used a predominantly sublexical strategy for word identification. Nonword decoding for both English and German children was much slower than for normal reading controls. In addition, there was a length effect found for dyslexics in both languages that was not present in the normal controls for either language; this suggests that word reading also relied on a sublexical strategy.

Although some skilled German readers have been shown to use small unit analysis when reading, this seems to be qualitatively different from the letter by letter analysis used by German dyslexics, which suggests that the skilled German reader is able to use that small unit (e.g., phonological) information more efficiently in identifying a lexical item. This highlights the importance of the efficient use of phonological information during word identification, and how dyslexia is characterized across languages by a deficit in using phonological information. Interestingly, the English dyslexics in the study showed a strong deficit as well in using larger unit (e.g., rime) information as compared to normal English controls. It has been well documented (Treiman et al. 1995) that English word identification uses larger units due to the

inconsistency of grapheme/phoneme correspondences, and if that information is not able to be used effectively, it could slow down word identification. It appears that sublexical processing in the absence of the efficient use of grapheme/phoneme units and their amalgamation may be the underlying cause of slow word identification.

The Psycholinguistic Grain Size Theory

In a refinement of the ODH, the psycholinguistic grain size theory (PGST) (Ziegler & Goswami 2005) posits that children learning consistent orthographies will rely mainly on grapheme/phoneme correspondences (GPC), while children acquiring less consistent orthographies will have to be flexible and employ many strategies in learning to read. They will need to "…develop strategies at multiple psycholinguistic 'grain sizes', whole word, onset-rime analogy, and grapheme-phoneme recoding." (Goswami 2002, p. 146). As Goswami points out, there is an immediate "mapping problem" (p. 144) for the beginning reader of an alphabetic orthography because the most accessible phonological units are the larger units, e.g., syllables and rimes, whereas the most accessible unit in print is the letter. Languages with very consistent orthographies and less marked phonological systems are the most accessible to readers because in many of the words the phoneme and onset-rime segmentation are identical. Therefore, the reader is able to exploit the phonological knowledge of the larger units and find immediate feedback in the printed letters which represent phonemes. For example, in Spanish, phoneme segmentation is often isomorphic with onset-rime segmentation. For example, in the word 'casa' /k/ /a/ /s/ /a/, /k/ is the first phoneme and the onset of the syllable 'ca', and /a/ is the second phoneme as well as the rime of the syllable 'ca.' This allows the beginner reader of Spanish to have easy access into the orthography. On the other hand, English represents a significant

mapping problem for the beginner reader because of its orthographic inconsistency and complex syllable structure. First, onset-rime segmentation is rarely identical to phoneme segmentation. Furthermore, one letter does not consistently map to one phoneme in English. This means that when learning to read in English, phonological/orthographic processing of different grain sizes (e.g., onset-rime, grapheme/phoneme), as well as some lexical strategies will be required. As Goswami states, “In orthographies like English, children with good onset-rime skills can exploit larger regularities in the spelling system, for example, by using rhyme analogies to help them build up a reading vocabulary (“light – fight,” “beak – weak”).” (p. 145) Proponents of the theory suggest that learning to read a particular orthography requires an awareness of the granularity, or the size of unit that determines the mapping between phonology and orthography in that orthographic system (Figure 3).

Syllable	GRASP
Onset-rime	GR ASP
Nucleus-coda	A SP
Phoneme	G R A S P
Phone	The clusters of articulatory features whose abstract representations are phonemes

Figure 2.3. Schematic description of different psycholinguistic grain sizes (Ziegler & Goswami 2005)

There is some experimental data to support the PGST. Wimmer & Goswami (1994) and Frith et al. (1998) found that children learning to read orthographically transparent orthographies used a sublexical strategy, not a larger unit strategy. In an interesting study conducted by Goswami et al. (2003), German and English children were tested on their native language reading skills. These two languages provide a good comparison as they are similar phonologically and orthographically, but are extremely different in terms of consistency of grapheme/phoneme correspondences. As mentioned above, English is inconsistent (i.e., opaque), while German is completely consistent (i.e., transparent). The hypothesis was that German readers would use a small-size unit (e.g., phoneme/grapheme correspondence) strategy in decoding, while English readers would use a mixed (small and large unit) strategy. In order to test this hypothesis, two types of stimuli were created in both languages:

1) *Large unit non-words*: orthographic neighbors[7] of real words; they were one letter away from a base word (e.g., *dake fake*). Therefore, these non-words could be read through analogy to real words by using the orthographic rime –ake.

2) *Small unit non-words*: NOT orthographic neighbors of the real word (e.g., *daik*). Therefore, these non-words could not be read through analogy, and could only be read through a smaller unit analysis (e.g., d—ai—k)

In this experiment, young readers were asked to aloud a series of lists of non-words. One of the lists was composed of large unit non-words, which had familiar rimes; a second list contained small unit non-words, which had to be decoded grapheme by grapheme. The final list contained mixed stimuli, large unit and small unit non-words. The stimuli were presented in three blocks:

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[7] An orthographic neighbor is defined by Coltheart et al. (1977) as a word that can be created by changing one letter in a stimulus word, e.g., 'fake' 'make' or 'horse' 'house'.

small unit, large unit, and mixed (small/large) unit. The German readers showed no differences in reading across the three blocks; however, the English readers were less accurate and slower in the mixed block, demonstrating a switching cost between the two processing strategies (small and large unit). The researchers argue that this is evidence that English readers use a "flexible strategy" (i.e. using the orthographic rime OR using phoneme/grapheme correspondences for recoding), whereas German readers use a strictly phonemic strategy even when it is possible to use a larger unit strategy. This is exactly what PGST predicts given the transparency of German orthography and opacity of English. One issue not addressed in the study is that these were young children, ages 7-9; therefore, we might not see evidence for a large unit strategy being used in German until readers are older and have more print experience. However, it is clear from this study and research by Treiman (1995) on English speaking children, that the orthographic rime is accessed by English readers.

Although the psycholinguistic grain size theory is based on L1 learning, it has implications for the L2 learner; if phonological recoding is based on a particular size of a unit (e.g., phoneme in Spanish or multiple units in English), then the L2 learner might have to learn to use a different strategy for recoding during L2 reading. For example, Strid & Booth (2007) found that balanced Spanish/English bilinguals processed words differently on-line, with Spanish readers using the syllable as a processing unit, and English readers using a larger (unspecified) unit. It may be that readers employ these larger units to gain quick access to lexical items. Moreover, as stated earlier, it may be that all experienced readers read words using larger units (or lexically) regardless of whether the orthography is transparent or opaque.

Transparent orthographies: Phonological vs. Lexical Reading

The broad issue often explored in the literature concerns predictions of the Dual Route model and the ODH, as well as the question: Do all orthographies lend themselves to both routes?

Spanish orthography is generally transparent; each letter corresponds to one phoneme and vice-versa. This has led to much debate about how Spanish readers read words. On the one hand, the PGST and ODH suggest that readers of transparent orthographies will read sublexically, i.e. matching letters to phonemes. On the other hand, there is much evidence to suggest that experienced readers of all orthographies whether transparent or opaque, read lexically.

Sartori & Masutto (1982) conducted a study with native Italian readers to determine whether or not they were reading primarily lexically or sublexically, and whether or not disruption through alternating case would induce readers to use a sublexical route. Readers saw 4 conditions in this experiment in both uniform and alternating case.

Condition 1: Non-homophone	'Il pino e un sempreverde' *Pine is evergreen*
Condition 2: Homophone	'Storie di amanti' *Stories of lovers*
Condition 3: Pseudo-sentence	'Storie diamanti' *Stories diamonds*
Condition 4: Non-sentence	'Il vino e un sempreverde' *Wine is evergreen*

In this study, readers read the groups of words and were given two tasks to fulfill. The first task required that they respond yes/no as to whether the group of words made sense as written, which encouraged readers to focus on the visual (e.g., lexical) form of the words. The

second task required that they respond yes/no as to whether the group of words made sense as pronounced, which encouraged readers to focus on the phonological (e.g., sublexical) form of the words.

In task one, with the focus on visual processing, it took longer for readers to respond ‘no’ (i.e., the words do not make sense as written) to pseudo-sentences (‘storie diamanti’) than to non-sentences (‘Il vino es un sempreverde’) in both uniform (156 ms) and alternating (143 ms) case. In the uniform condition, the reader was faced with a conflict between lexical and sublexical processing. The pseudo-sentence was phonologically legitimate yet syntactically and semantically incorrect. Therefore, the lexical and phonological routes came up with a mismatch, and there had to be a re-check of the analysis. This resulted in longer response times. In the alternating case condition, the visual component was disrupted, so phonological processing took over. Phonological processing resulted in a legitimate representation for the pseudo-sentences, which then had to be re-checked (with the visual component), thus resulting in longer response times.

In task two, with the focus on phonological processing, the pseudo-sentence (‘storie diamanti’) took longer (190 ms) than the homophone sentence (‘storie di amanti’) in the uniform condition because there was a conflict between lexical and sublexical processing with the pseudo-sentences as in task one. Sublexical processing resulted in a legitimate representation, which did not match with the visual (written) representation. For the homophone sentences, there was no mismatch between the visual and phonological results.

However, in the alternating case condition, the difference between pseudo-sentences and homophone sentences was greatly reduced (43 ms) because lexical processing was disrupted in

the pseudo-sentences and the homophone sentences. The reader had to then wait for sublexical processing in both cases to check for legitimacy of the representation.

This experiment showed that sublexical processing will occur before lexical processing if there is a degraded lexical stimulus, such as alternating case; this demonstrates that a degraded visual stimulus will induce readers to rely more on serial processing. The Dual Route Model claims that both processing strategies are activated, but that the lexical route is faster. The results shown here provided evidence for that fact that both strategies were activated, and furthermore, that sublexical processing 'took over' when lexical processing was disrupted. The researchers also concluded that Italian reading used both lexical and sublexical routes despite the fact that word reading could be accomplished with solely the sublexical route.

In a recent study by Schroeder (2011), native German readers were given a lexical decision task using alternating case as a variable in order to test the hypothesis that low skilled readers do not make use of multiletter (e.g., orthographic) information as efficiently as high skilled readers do. The rationale was that alternating case has been shown to disrupt both lexical processing and sub-lexical processing (Besner & Johnston 1989) because the letter identification process in both routes is impeded by case alternation. However, according to Schroeder, case alternation is particularly damaging to sublexical processing, that is the grouping together of graphemes which represent a cohesive phonological unit (e.g., the letters 'sch' in German correspond to one phoneme /Š/. According to Schroeder, high skilled readers should be better at using multi-letter information during sublexical processing; however, this ability would be impeded by alternating case. Schroeder predicted that high skilled readers would do better with normal case items than low skilled readers because they could make use of multiletter information more quickly and efficiently. Therefore, high skilled readers would read nonwords

more quickly than low skilled readers do. However, alternating case items would disrupt the high skilled readers as they would not be able to process multiletter items efficiently, resulting in a nonword latency similar to low skilled readers. Schroeder tested students between the ages of 13 and 17 on their reading comprehension, word and nonword reading. The reading comprehension task determined the student groups: high and low reading comprehension. They were then administered a lexical decision task using monosyllabic nouns and pronounceable nonwords. Participants saw 100 experimental stimuli in both normal and alternating case conditions, and had to decide whether the string presented was a word.

The results showed that alternating case affected two aspects of word identification: 1) early letter identification was disrupted (affecting both the lexical and sublexical route). Both words and nonwords were affected by alternating case. 2) Sub-lexical processing was particularly disrupted evidenced by a large effect of lexicality (word vs. non-word) in the alternating case condition. Furthermore, low skilled readers showed a substantial lexicality effect as compared to high skilled readers. This indicates that low skilled readers had greater difficulty with the sublexical processing required for reading nonwords.

The central finding was that higher level readers were equally impeded as lower level readers by alternating case in nonwords, and this result contrasted with the high level readers' very strong ability in reading the normal case nonwords. This confirmed the hypothesis that high skilled readers make use of multiletter information in order to facilitate phonological recoding, and that this facilitation was disrupted by case alternation. The fact that high skilled readers showed substantially more disruption with alternating case nonwords suggests that without lexical information to draw from, high readers were unable to recover quickly from the fact that sublexical information was impaired. In the Dual route cascaded model, lexical information can

influence orthographic processing, so word reading has an advantage over nonword reading; it appears that efficient processing of phonological and orthographic information at the sublexical level can be influenced by lexical information. Sublexical and lexical processing work together according to this understanding of the model.

As Schroeder points out, this study provides support for the Psycholinguistic Grain Size Theory as it demonstrates that skilled readers group letters in accordance with what the orthography dictates. The data also provide evidence for the Dual Route Model as readers demonstrated an effect of lexicality (i.e., words were read faster than nonwords). Schroeder notes that German syllable structure is complex, and that this may account for why multi-letter groupings are particularly important in German recoding. Thus, the most efficient grain size for German orthography is larger rather than smaller, and a strong reader of German would be able to use these larger groupings efficiently[8]. On the other hand, it is possible that in a transparent orthography with a less complicated syllable structure there might be fewer multiletter groupings, and a smaller effect of alternating case. For example, Barca et al. (2006) found that low and high skilled Italian readers used multiletter rules to the same extent, and this may be because Italian has relatively few context-sensitive letter rules (e.g., ‘c’ and ‘g’ are pronounced differently depending on the following vowel) as well as a simpler syllable structure. Thus, multi-letter grouping does not involve acquiring complex consonant clusters (e.g., ‘spr’) and position-specific pronunciations to the same degree as it does in German. As a result, children learning to read Italian can rely on grapheme/phoneme processing, that is, a smaller grain size for processing. Therefore, it is not clear to what extent alternating case in non-words would affect multi-letter groupings in a transparent orthography, such as Italian or Spanish.

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[8] This result contrasts with an earlier mentioned result showing that German orthography is more efficiently accessed phonemically.

In a series of studies by Defior and colleagues, native Spanish speaking children were tested on their word reading strategies (Defior et al. 2006; Defior et al. 1996). Defior et al. (1996) gave children of varying reading levels different length words, pseudowords, and nonwords to read aloud. Children from grades first through sixth were tested; there were 20 normal readers and 4 below average readers (reading age was 2 years below chronological age) in each grade level (except first grade, for which there were no diagnostics to distinguish reading levels). The variables included word length (number of syllables), lexical category (stated above), lexical frequency and syllabic structure (CV; VC; CVC; CCV; CVV; CVVC and CCVC). The results revealed that both normal and below average readers showed an effect of length, which is indicative of the use of a sublexical strategy, but at the same time demonstrated a lexical effect, with words read faster than pseudowords and non-words as well as a frequency affect. These two variables indicate the use of a lexical strategy. Overall, error rates were higher for the lower readers, and they never achieved beyond a 70% correct response, whereas the normal readers eventually reach 90% correct. The researchers conclude that developmentally, readers of all levels are behaving in the same way, and furthermore, that both use a phonological as well as lexical route, providing evidence for the Dual Route Model of word reading for both low and high skilled Spanish readers.

In another study of native Spanish-speaking children in different grades, Valle-Arroyo (1996) provides evidence for the transition between beginner and higher level reader Valle-Arroyo tested native Spanish speaking children on their use of phonological and visual processes in word identification. The hypothesis was that even in a transparent orthography, there should be a developmental shift in processing as reading experience grows, from a phonological to a lexical process. Valle-Arroyo proposed that if one uses a predominantly sublexical process, then

it is expected that *regularity* of the words and *word length* will affect reading times and number of errors. However, if one reads using a predominantly lexical process, then *lexicality* and *frequency* would be the factors that influence reading times and number of errors. Lexicality is defined as that property which designates a string of graphemes as a word.

Since Spanish has no irregular words, regularity could not be a variable in Valle-Arroyo's study. Therefore, the prediction was that children who were using a strong sublexical process would show effects of word length, while children using a lexical process would demonstrate effects of lexicality and frequency. As Valle-Arroyo (1996) explains, if a reader is reading visually, then the only relevant variable is word *familiarity*. He states, "If the reader knows the sequence of letters composing the word and its sound, he or she should be able to read it, independent of whether the word is regular or irregular, short or long" (p. 96). Therefore, the variables affecting lexical processing in Spanish are frequency and lexicality as these are relevant to familiarity, and the variable affecting sublexical reading is length as this is relevant to the assembly of grapheme/phoneme correspondences.

Table 2.1. Variables in Valle-arroyo (1996) study. Variables marked are evidence of either visual or phonological processing.

	Word length	**Frequency**	**Lexicality**
Visual process		**X**	**X**
Phonological process	**X**		

In this study, Spanish speaking children read aloud a randomized list of 144 words and nonwords, which varied as to frequency (words) and length (words and nonwords). The dependent variables were number and type of error.

An examination of the error data of the amalgamated word and nonword results found that length had an overall significant effect across all grades. Looking specifically at length and frequency (Table D), an important finding was that the word length by frequency interaction was significant for first and third graders; that is, no effect of length was found with high frequency words, but medium and low frequency words showed a reliable length effect. On the other hand, sixth graders showed no significant interaction between word length and frequency at all in word reading. However, the sixth graders did demonstrate an effect of length with pseudowords. The data show that for less skilled readers long lower frequency words will take longer to read than short lower frequency words; this suggests that these readers used a sublexical strategy because the lexical strategy (used with high frequency words) failed to achieve word identification with lower frequency items. But the high skilled readers showed no effect of length on lower frequency words because they used a predominantly lexical strategy; that is, they have strong lexical representations of low and high frequency items. Overall, these results suggest that beginner (first and third grade) readers of Spanish use a predominantly sublexical strategy when reading words, but that this strategy evolves fairly quickly into a lexical strategy. However, pseudoword reading still requires a sublexical strategy as demonstrated by the length effects for the sixth grade readers.

Table 2.2. *Length x frequency interaction for word reading. Yes = length and frequency interacted. No = length and frequency did not interact*

	High frequency	Medium frequency	Low frequency
1st graders	NO	YES	YES
3rd graders	NO	YES	YES
6th graders	NO	NO	NO

In another developmental study, Acha & Perea (2008) examined how reading level affected lexical decision times for long and short Spanish words and pseudowords. Third-grade (beginner readers) and sixth grade (intermediate readers) children were tested along with college students (proficient readers) in order to track the developmental path that word identification strategies follow. The hypothesis was that as lexical processing became the more dominant strategy and sublexical processing was relied on to a lesser extent, more proficient readers should show a decrease in the difference between short and long words. Results supported this hypothesis, demonstrating a developmental change that occurred over time from a sublexical to a lexical word reading strategy.

Table 2.3. *Difference in milliseconds between long and short items (Acha & Perea 2008)*

	Long words – short words	**Long pseudowords – short pseudowords**
Beginner:	114	77
Intermediate:	80	121
Proficient	13	86

Beginner readers demonstrated a larger difference between long and short words than pseudowords, while intermediate and proficient readers showed a larger difference between long and short pseudowords. In fact, proficient readers demonstrated virtually no difference between long and short words, yet they showed a large difference between long and short pseudowords. This suggests a greater use of the lexical strategy for more experienced learners as lexical entries are more fully specified and available for rapid access. However, pseudowords still require sublexical processing, so length effects are present.

Davies (2007) tested Spanish speaking children to determine whether or not there were qualitative differences among dyslexic readers and two higher reading groups, ability-matched readers (younger than the dyslexic readers), and chronological age – matched readers (same age as dyslexics). The study focused on word frequency, word length and orthographic neighborhood size. Participants read lists of words and the time taken to read each list was recorded. Although the dyslexic and ability-matched readers read more slowly than the age-matched readers, it was found that across all participant groups lexical knowledge was accessed;

this was evident because of neighborhood and frequency effects for all three groups. He concluded that lexical effects are found in young readers as well as readers with learning disabilities, providing support for the idea that transparent orthographies do not rely solely on sublexical processing.

Taken together, these studies indicate that readers of transparent orthographies, from beginners to proficient, use both strategies, with the phonological strategy being more prominent for inexperienced readers and the lexical strategy taking precedence for experienced readers. However, it is evident that the word identification system is complex, and that there are complexities within both the lexical and sublexical processes. The various studies above demonstrate that there exist cooperating strategies which are used to varying degrees across reading levels (Acha & Perea 2008; Davies 2007; Valle-Arroyo 1996; Defior et al. 1996) and that these strategies can be employed in a compensatory manner when visual input is degraded (Schroeder 2010; Sartori & Masutto 1982). It also appears that sublexical information is used in a refined way by high level readers (Schroeder, 2011), and that the reading system is designed so that sub-lexical information specific to the orthography is accessed. Skilled readers can use that information in building up an orthographic representation. Direct lexical access is evident in beginner readers (Davies, 2007) as well as below average readers (Defior et al.); the use of direct lexical access starts early on and continues to strengthen as the reader grows more proficient. This provides support for the Dual Route model as well as Perfetti's model of the autonomous lexicon, and it suggests that transparent and opaque orthographies rely on similar strategies for accessing words. At the same time, there are differences in terms of the degree to which readers rely on these strategies, as well as different units which they may use for achieving direct lexical access. As the Schroeder (2011) study demonstrates, high level reader may have stronger

sublexical skills allowing them to efficiently group letters together and access words more efficiently.

As other researchers have noted (Seymour et al., 2003; Goswami 2002), children learning opaque orthographies must rely strongly on lexical access from early on as there are some words that are not subject to sublexical processing (e.g., *yacht*). In transparent orthographies, children tend to learn the grapheme phoneme correspondences relatively quickly; phonological processing is always an option in this type of orthography. There is some suggestion that English readers use onset-rime units as a way of accessing words (Treiman, 1995). However, it has been shown that Spanish speakers do not access the rime during reading (Jimenez & Venegas, 2004), but rather they tend to rely on the syllable for word access (Strid & Booth, 2007).

In summary, the idea that readers may use different units of access is developed in Psycholinguistic grain size theory, which states that readers of transparent and non-transparent orthographies will use different grain sized units which couple phonological and orthographic information to access lexical items. For the most part, Psycholinguistic grain size theory is a model of developing readers; however, the theory allows for the fact that older or more proficient readers will use the largest grain size, i.e. the word, during reading (Ziegler & Goswami 2006). Underlying Psycholinguistic grain size theory is the idea that word identification must be mediated by phonologically based units (e.g., rime, syllable, etc.) This is in line with Perfetti's claim that phonology is an inherent part of word identification even at the lexical level.

The architecture for reading might include two routes as proposed by Coltheart et al. (2001), but it also plausible and supported well by the empirical evidence presented in this

chapter that the lexical route is mediated by larger grain sizes compatible with the particular orthography and working within the constraints of that orthography. Therefore, direct lexical access may use the syllable as a basic unit in Spanish and the rime or larger unit in English. Table 2.4 below shows phonological units that are potential candidates for accessing words in Spanish and English.

Table 2.4. *Potential phonological units for word identification in Spanish and English*

	Spanish	English
PHONEME	X	X
SYLLABLE	X	
RIME		X

Orthographic depth and L2 reading: L1 to L2 Transfer

If orthographic depth plays a role in word identification as outlined in the Orthographic depth hypothesis and Psycholinguistic grain size hypothesis, then this has implications regarding word identification for L2 readers who may be more reliant on phonological processing in a transparent L1, but who need to adapt to lexical processing in an opaque L2. This raises the question of whether or not there is transfer of L1 processes during L2 reading in languages with different orthographic depths, and the degree to which transfer of L1 processes affects speed and accuracy of L2 word reading.

While the issue of transfer is important, the contribution of L2 knowledge to the word identification process is equally important. As the second language reader becomes more proficient in L2 reading, we expect that L2 word recognition processes will make a larger contribution to word reading than L1 processes; an important question, therefore, is whether or not there is a developmental shift in type of processing (e.g., shifting from sublexical to lexical) as the L2 reader becomes more proficient.

A number of crosslinguistic studies have examined the issue of L2 word identification processes. Koda and colleagues have conducted much research in this area and have demonstrated that there are both transfer and developmental effects on L2 word reading (Wang & Koda 2005; Chikamatsu 2006). In the Wang & Koda (2005) study, both Korean and Chinese students learning L2 English (ESL) were sensitive to English word properties, such as frequency and regularity. Wang & Koda concluded that this demonstrated L2 influence on word identification processes of the L2 learner. At the same, time the Chinese readers were less skilled than the Korean readers at sublexical processing, and Wang & Koda hypothesized that this was due to L1 influence. This is because Chinese is logographic, and therefore, does not make use of phonemic information in word identification. In contrast, Korean is alphabetic and, therefore, relies on phonemic processing. In another study, Chikamatsu (2006) found evidence for a developmental shift in the type of word identification process used by L2 readers of Japanese (L1 English). Lower L2 proficiency readers tended to use phonological processing, but the higher L2 proficiency readers used lexical processing. Chikamatsu attributed this change to a

lessening of the L1 phonological influence and an increasing influence of lexical processing in the logographic L2[9].

Akamatsu (2003) used alternating case to test the effect of first language word identification processes on second language reading. As discussed above, case alternation task is a well-established method of identifying sublexical versus lexical processing of words in L1 word recognition (Baron & Strawson 1976). Akamatsu hypothesized that readers of an alphabetic writing system (Persian), which employs phonological processing, would be less disrupted by case alternation than readers of logographic writing systems (Chinese and Japanese), which rely heavily or exclusively on lexical processing. The results showed that Chinese and Japanese ESL students displayed more disruption during lexical decision with case alternating words than Persian ESL students did. Akamatsu attributed this difference to logographic readers' heavy reliance on visual processing, which is disrupted by alternating case. The Persian readers relied on sublexical processing, which involves more intraword inspection, so case alternation was not as disruptive to that process.

The situation is more complex because in addition to relying on visual processing, logographic readers are also not sensitive to the properties that make up alphabetic orthographies, namely the correspondence between graphemes and phonemes. Therefore, there is a dual process occurring here. They read visually because that is how their L1 orthography functions, and they cannot quickly recover from alternating case because they have weak phonemic processing skills.

[9] Another possibility is that lexical processing increases across the board as L2 readers become more proficient in L2 word identification.

In a lexical decision task (Koda 1988), ESL readers had to make rapid decisions about strings of letters. They saw one set of words, which forced readers to use the sublexical route; for example, readers saw 40 pairs of strings consisting of a pseudohomophone and a nonce word (e.g., rane/tane), and they were asked to choose the word in the pair that sounded like a real English word. The second set of words forced readers to use visual processing; for example, readers were given a real English word and a corresponding pseudoword (e.g., rain/rane) and were told to choose the real English word as quickly as possible. If readers depended solely on sublexical processing, then either of the two words would result in a match; however, if lexical processing were dominant then only the real English word would result in a match. Koda found that readers from opaque orthographies depended more heavily on visual information for word reading than those from transparent orthographies.

In the above studies, there was a strong effect of L1 on L2 word reading. L1 readers of logographic writing systems do not have the same exposure as readers of alphabetic systems do to the alphabetic principle, which stipulates that letters and letter combinations correspond to phonemes. Therefore, if the L2 is alphabetic, L1 logographic readers might tend to use a visually oriented strategy that is influenced less by phonology. The results of the studies suggest that readers of an L1 logographic writing system will not be able to ‘fall back’ on phonological processing when reading an in L2 alphabetic system as easily as L1 alphabetic readers do. The difference between logographic and alphabetic is a difference of a greater magnitude than the difference between two alphabetic orthographies. However, there is debate about the differences among alphabetic orthographies in terms of the use of a phonological or lexical strategy, and this is directly related to the transparency of the orthography.

There have been few studies specifically comparing word identification processes between alphabetic systems, and how these processes may affect second language reading. In one such study conducted by Mumtaz & Humphreys (2001), the focus was on the use of lexical and sublexical strategies in bilingual children. Mumtaz & Humphreys hypothesized that Urdu orthography, which is phonologically transparent, encourages readers to use a strictly sublexical route when reading, but that English, with a deeper orthography, allows for both a sublexical and lexical route. In their study of Urdu-English bilingual and English monolingual children, they found that the bilinguals were better at reading English regular words and non-words, but the monolingual children were stronger readers of irregular words. Their conclusion was that transfer of first language reading skills occurred: the Urdu-speaking children were adept at using phonology during word reading as evidenced by the fact that they could easily access regular English words. However, they were not as skilled as their monolingual counterparts in reading irregular words because these words could not be decoded in a straightforward way and thus required lexical processing. This study provided evidence for transfer of a sublexical processing strategy for word identification.

Other related studies have focused on the size of units (i.e. phoneme, syllable) accessed during word recognition. This issue of 'grain size' of the phonological unit is addressed in a number of studies and is based on the psycholinguistic grain size hypothesis (Ziegler & Goswami 2005). Essentially, the grain size hypothesis is an extension and development of the ODH. The difference between the two is in how phonology is viewed. Grain size theory emphasizes the phonological nature of the units that are accessed, whether the units are small or large. The Universal Phonological Principle, which views phonology as inherent to word

identification, is an important underpinning of PGST as phonological information is integral to the units accessed during reading.

In a study conducted with bilingual/biliterate Hindi/English speaking children, Mishra & Stainthorpe (2007) compared the size of the units used during word reading in the two languages. They found that readers used primarily phonemes or syllables to identify words, and that this depended on which language they acquired literacy in first. The children who learned to read in Hindi first and then in English accessed different units when reading the two languages – the syllable for Hindi and the phoneme for English. In contrast, the children who learned to read in English first and Hindi second accessed the phoneme only when reading in both Hindi and English. In the Hindi-first group, syllable processing during word identification did not transfer from Hindi to English reading – readers used the syllable in Hindi and used the phoneme in the second language of literacy (English) to access words. However, in the English-first group, readers started out using phonemic processing in English and transferred that strategy to Hindi reading.

This study provides some evidence for PGST. Although Hindi relies on syllabic processing, the smaller phonemic unit can apparently be used as well. Therefore, transfer of phonological processing is facilitated from English to Hindi. On the other hand, English orthography is not compatible with syllable processing as a general rules, so this strategy does not transfer from Hindi to English. This demonstrates that word access based on grain sizes is based on the constraints of a particular orthography. This study does not directly address the issue of phonological versus lexical processing; however, it does give us insight into the way in which transfer of processing strategies may operate.

On the other hand, Strid & Booth (2007) conducted an on-line experiment with Spanish-English bilinguals which showed early access during visual word recognition of the syllable in Spanish and a larger unit in English. This study was on-line, so it may have accessed different stages in the identification process from the previous study which was off-line. When bilinguals read Spanish words, the syllable was accessed, but when they read English words, a larger (unidentified, but possibly the *prosodic word*) unit was accessed. This research suggests that Spanish readers access words phonologically with the syllable as the basic unit, and that English orthography encourages the reader to use a larger more visual access route.

The preceding studies highlight the fact that alphabetic orthographies may vary as to which units are accessed during word identification. At the same time, this contrasts with earlier studies of L1 readers (Sanabria 2009, Valle-arroyo 1996,) which show that readers of transparent and opaque orthographies use lexical as well as sublexical strategies. These conflicting results could be reconciled in the following way. The use of a sublexical strategy is useful for identifying new words and pseudowords, but once the reader becomes proficient and has a lexical store of words to draw from, there may be larger units (syllable, rime), perhaps grapheme/phoneme bundles that are used as access points into a word identification. The frequency of these larger units would also factor into the visibility and use in identifying a word.

Low literacy adults

The findings discussed in the preceding section strongly suggest that older children use a predominantly lexical reading strategy, while reserving the sublexical strategy for new words or

non-words; in contrast, younger children tend to rely more heavily on sublexical processing as they do not have secure lexical knowledge of many words. High reading comprehension levels have also been shown to be related to reliance on larger unit reading in children, while low reading comprehension levels have been associated with letter by letter processing (Schroeder 2011). At the same time, it is clear that even beginner and dyslexic readers rely to some degree on lexical processing. L2 studies have demonstrated that L1 word reading strategies influence how readers identify words in L2, but that proficient L2 readers of alphabetic orthographies are able to adapt to the L2 processing strategy (Strid & Booth 2007). L1 logographic readers reading L2 alphabetic orthographies have more difficulty adopting L2 word reading strategies. Although there has not been as much research with low skilled adult readers, there have been some studies pointing to a lack of phonemic awareness, and a reliance on sublexical processing. The studies below discuss the findings on word identification in low literacy adults.

Low literacy: L1

There has been some research, although not extensive, on adults with low literacy in several languages, including English, Turkish, Serbo-Croation and Spanish (Lukatela et al. 1995; Durgunoglu & Oney, 2002; Thompkins & Binder, 2003; Greenberg et al. , 1997; Jimenez et al., 2010). Thompkins & Binder (2003) compared native English speaking adults in basic literacy classes with children who had the same reading levels. The independent variables in the study were age group (adults and children) and reading-level group (more skilled and less skilled). Adult readers were divided into reading groups based on their scores on the Test of Adult Basic Education, version 7 (1994), and children were tested using the Wide Range Achievement Test-3 (1993). Less skilled adult readers read at a mean 2.59 reading grade level (Range: 0 to 3.3.;

SD=.85), and less skilled children read at a mean 2.47 (Range: 0 to 3; SD=.83). The more skilled adults read at a mean 4.98 reading grade level (Range: 4 to 6.9; SD =.93), and children read at a mean of 4.67 (Range: 4 to 7; SD = 1.05). In all, 99 children between the ages of 5 and 8 were tested, and a sub-group of 30 who matched the more and less skilled adult readers was selected for the experiment.

Subjects were administered a series of phonological and orthographic tasks, and the hypothesis was that phonological awareness, orthographic knowledge, short-term memory and context would affect reading level. Because of previous studies (Greenberg et al. 1997), in which adults were shown to use orthographic knowledge as a means of word identification more than reading-level matched children, Thompkins & Binder (2003) investigated the extent to which phonological awareness was still important for adults. Adults have other cognitive resources to draw upon when reading, so there has been some speculation that perhaps phonological information can be bypassed when adults are learning to read. However, this was not the case. Instead, phonemic awareness was found to account for a unique portion of the variance in reading level. Furthermore, when examining reading level and age groups, all three phoneme tasks resulted in a distinction between the more skilled and less skilled readers. This is crucial because it highlights the importance of phonemic knowledge as well as efficient phonological recoding in skilled reading (Perfetti 1985).

Phonological processing, in particular phonemic processing, has also been shown to be crucial for transparent orthographies as well. In a series of studies with Portuguese low literacy adults, Morais et al. (1986) found that these learners had difficulty segmenting speech into units that were smaller than syllables. They had more success segmenting words into syllables and recognizing rhymes, but even with these tasks, they could not perform as well as skilled readers.

Lukatela et al. (1995) tested Turkish adults who did not have any formal schooling in phoneme and syllable counting and deletion tasks in order to gain an understanding of their level of phonological awareness. Groups were divided according to letter knowledge as many of the participants had incomplete learning of the alphabet, and reading achievement was predicted by letter recognition. Results demonstrated that adults who were completely illiterate and could not recognize letters had no ability to distinguish phonemes, while the participants with better letter recognition and reading levels were also better at the phoneme counting and deletion tests. Furthermore, all groups were better at syllable counting than phoneme counting tasks. The results were expected given that phonemic awareness is generally taken to coincide with literacy instruction, whereas syllable and rhyme awareness occurs at the pre-school level. These results support a reading model that focuses on automatic phonological activation as central to word identification. Perfetti's work suggests that decoding skills and the understanding that letters represent phonemes are crucial to the development of lexical representations, which leads to automatic word identification. The researchers concluded that with Turkish, letter knowledge is a strong precursor for the acquisition of phonemic awareness. It is possible that this is also true for other transparent orthographies since letter names are related to phonemes in a direct manner in these types of orthographies.

A recent study of low literacy Spanish readers also provided evidence for the importance of phonological awareness (particularly phonemic) during reading. Jimenez et al. (2010) tested low-literacy adults, reading disabled children and a younger group of children who were matched in reading levels to the other two groups. They tested each of the groups in a series of phonemic tasks (blending, isolation, segmentation, and deletion) and found that the low-literacy adults and reading disabled children scored significantly lower than the younger reading-level matched

children on these tasks. It appears that phonemic awareness is strongly related to reading skill in both children and low literacy adults in opaque and transparent orthographies. It is generally assumed that phonemic awareness is developed as a reader learns to read an alphabetic orthography; awareness of phonemes prior to learning to read is not evident in children. (ref)

Low literacy: L2

The present study is concerned with the relationship between first language (L1) and second language literacy (L2), and more specifically, the similarities and differences in L2 word identification processing skills for readers of varying L1 reading comprehension levels. As will become evident, a more comprehensive theory of second language acquisition (SLA) and, specifically of L2 reading must include knowledge about how low literacy L1 learners learn to read in a second language.

In SLA research, most studies focusing on reading in L2 have focused on highly educated L1 speakers; low-educated and low-literacy L1 speakers have been largely neglected in the field (Craats et al. 2006). Yet it has become clear that low literacy L1 learners are increasingly enrolled in both secondary schools and adult ESL programs. Tarone et al. (2009) cite some startling statistics from 2001 that "among Hispanic students age 15-17 who were newcomers, more than one-third were enrolled below the level that corresponds to their age and were not literate in Spanish (Jamieson, Curry, and Martinez 2001)", while Short and Fitzsimmons (2007) state that there is a "literacy crisis" for English language learners.

There have been numerous studies demonstrating that there is an important connection between literacy skills in L1 and literacy skills in L2. This body of research has lent support to

the interdependence hypothesis (Cummins 1979), which states that literacy and language skills in L1 transfer to L2. At the same time, it has been shown that certain skills and knowledge are not transferred because they are language-specific and must be acquired; therefore, a reader needs to reach a certain threshold in L2 language proficiency to become literate in L2. The fact that learning to read in a second language involves both L1 and L2 is acknowledged by most researchers (Koda & Zehler 2008), and the fact that it involves L1 reading and L2 language proficiency has been framed in the well-known query by Alderson (1984), "Is second language reading a reading problem or a language problem?" What has not been investigated to any real extent is whether there is a relationship between how words are processed by L1 and L2 readers and the extent to which L1 literacy levels influence this relationship.

While alphabetic orthographies differ as to transparency, this does not imply a dependence of one type of word identification strategy by readers of a particular orthography. The evidence points towards a use of both a sublexical strategy as well as lexical strategy (Coltheart et al. 2001; Valle-arroyo 1996; Zeigler et al. 2003; Defior et la. 1996) by transparent and opaque orthographies, with differences evident in the reliance of one over the other as well as in developmental use of one strategy over the other (Seymour et al., 2003). In fact, the two strategies may work in parallel as many models suggest (e.g., the Dual route model), with accommodation to the orthographic structure (Psycholinguistic grain size theory) of the system built into the word identification process.

Summary

In sum, when children are beginning to read, they read more slowly than more experienced readers (Valle-arroyo 1996), and this use of the sublexical strategy is a necessary

step towards understanding the orthography and how it maps graphemes to phonemes. Children then begin to use larger units to access words (Treiman et al. 1995; Zeigler & Goswami 2005), and these units vary depending on the orthography. More opaque orthographies may use larger units (even word units) as smaller units are less reliable in terms of identification. Children who have difficulty reading may rely solely on a sublexical strategy as they have difficulty integrating the phonological information into larger chunks that can be used to access lexical entries (Zeigler 2003; Sanabria et al. 2009). The inability to use phonological information in word identification may be related to deficits in phoneme identification as demonstrated with low skilled adult readers who have difficulty with phoneme deletion and substitution tasks. On the other hand, adult readers may be able to compensate for a lack of phonological skills in word identification by using a larger visual procedure that bypasses phonological amalgamation.

This investigation: Sublexical and lexical processing in L1 and L2

This study will investigate the issue of phonological and lexical processing in Spanish L1 and English L2, and how these are related to L1 and L2 word identification (and specifically, word reading speed and accuracy) and reading comprehension. In particular, we will be focusing on L1 readers who differ in their L1 reading comprehension levels and, potentially, in their relative use of phonological and lexical processing of words. We are interested in the extent to which low and high skilled readers use similar word identification strategies in both their L1 and L2 and the extent to which L1 influences L2 word reading. These issues are important both from a theoretical as well as educational perspective, as they make predictions about future L2 readers. The research questions for our inquiry our presented below. In the next chapter, we will discuss the methodology.

Research Questions:

L1 Spanish effects:

1. To what extent do L1 Spanish readers of varying reading levels rely on lexical versus sublexical processing in Spanish word identification?

Prediction 1: Higher level L1 Spanish readers will rely more on lexical processing than lower level L1 Spanish readers.

2. To what extent are L1 speed and accuracy in word reading related to reading comprehension levels in L1?

Prediction 2: An increase in L1 word reading speed and accuracy will be associated with an increase in L1 reading comprehension level.

L2 English effects:

1. To what extent do L1 Spanish readers rely on lexical versus sublexical processing in L2 English word identification?

Prediction 3: L1 Spanish readers with high English reading levels will rely more on lexical processing than those with low English reading levels.

2. To what extent are L2 speed and accuracy in word reading related to reading comprehension levels in L2?

   Prediction 4: Speed and accuracy in L2 word reading will be related to reading comprehension levels in L2.

Crosslinguistic effects:

3. Is there a crosslinguistic relationship between L1 and L2, such that L1 word reading speed and accuracy will be correlated with L2 word reading speed and accuracy?

   Prediction 5 : Word reading speed and accuracy in L1 will be associated with word reading speed and accuracy in L2.

4. Is there a crosslinguistic relationship between L1 and L2, such that L1 reading comprehension levels will correlate with L2 word reading speed and accuracy?

   Prediction 6: L1 reading comprehension level will be positively associated with L2 word reading speed and accuracy

Chapter 3: Processing Spanish

This study investigates word identification strategies used by adult native Spanish speakers in both their L1 (Spanish) and L2 (English). In the previous chapter, it was proposed that word identification strategies are related to reading comprehension skills in both Spanish and English. In particular, we expect that reading strategies in Spanish will have an effect on reading strategies in English.

In order to test this prediction, this chapter reports the findings from a study using adult speakers of Spanish who were learners of English as a second language. The participants for the study were recruited from various college campuses as well as adult education programs in New York City. Three sub-groups of participants differed from each other based on their proficiency in English (High/Low) and Spanish (High/Mid/Low), as measured by proficiency tests. A fourth group of participants were monolingual speakers of English.

Experiment 1: Bilinguals in Spanish

Participants completed an on-line word matching task probing word identification strategies separately in each language. The task was designed to minimize second language effects that could be problematic in naming and lexical decision tasks. Most reading research with second language learners involves either naming or making lexical decisions. These tasks

are typically used to elicit on-line measures of reading speed and accuracy in the second language. However, there are potential difficulties in using these tasks with second language readers, especially low-skilled readers. A lexical decision task requires readers to distinguish lexical items from pseudowords. With higher-level bilinguals, this may be a reasonable means of assessing word knowledge, but lower-level readers will undoubtedly have a more difficult time distinguishing real words from pseudowords as they do not have strong lexical representations. A naming task has a built-in confound: when a word is named incorrectly, it is not clear whether the reader is misreading the word (e.g., mispronouncing the word), or whether the reader truly does not know the word (e.g., because of incomplete lexical information or a lexical gap). The task used here was designed to prevent interference from extraneous factors, such as pronunciation errors or incomplete word knowledge. In the word matching task, participants saw a word presented visually (e.g., *break*) and immediately heard a word that either matched or did not match the word presented visually. At that point, the participant made a decision as to whether the two words matched. The other very important reason for using a matching task was because we were interested in examining the strategies used for recoding, i.e., translating written letters into abstract phonological codes used for lexical access. Identifying a match between a visual and an auditory presentation could signal that phonological recoding has taken place.

The design of the English experiment included two variables: alternating case (i.e., letters in a word alternate between small and large case) and word type (i.e., monosyllabic words of varying syllabic structures). Both alternating case and word type were selected as variables in order to investigate the grain size accessed during word reading. Alternating case was chosen as a variable that would help to distinguish between reading lexically and sub-lexically. Previous

research has shown that when readers read lexically, alternating case will lead to a higher processing cost than when readers use a sublexical strategy (Akamatsu 2003; Baron & Strawson 1976). Word type was chosen as a variable to test different strategies that low-skilled and high-skilled readers might use when reading transparent, consistent and opaque words in English, as well as to determine whether or not a developmental change occurs as readers become more proficient. It was predicted that if readers did not use a lexical strategy, then consistent and opaque words would show a higher processing cost than transparent words. Furthermore, it was expected that more proficient L2 readers would be better at reading consistent and opaque words than less proficient L2 readers. The Spanish experiment included two variables: alternating case (like in English) and word length. Since there exist few instances of opacity in Spanish orthography, length was used as a variable for distinguishing between lexical and sub-lexical processing.

The following chapters present the findings from two experiments performed with the same bilingual participants: Chapter 3: Experiment 1 in Spanish, Chapter4: Experiment 2 in English, and Experiment 3 with monolingual English speakers. The chapters close with a summary of the findings.

Method

Participants

Participants were all native Spanish speakers studying English at the time they were tested. All participants were between the ages of 18 and 58. We report data from a total of 36

participants[10], 12 in each of three Spanish-English proficiency profiles: participants with high proficiency in both Spanish and English (High-High Group), participants with high proficiency in Spanish and low proficiency in English (Mid-Low Group), and participants with low proficiency in both Spanish and English (Low-Low). Participants were recruited from colleges and adult ESL programs in the New York City area, and were paid $25 each for their participation.

The participants in this study were recruited from three different types of settings: 27 were a group of adults attending classes at community ESL programs in order to improve their English language skills. 6 were college students taking ESL classes at the time of testing in addition to their core classes, and 3 were college students who had finished their ESL coursework and were taking core classes only; of these 9, 6 were in the High-High group, and 3 were in the Mid-Low group.

Participants were administered a background questionnaire, which asked about schooling, number of years living in the United States, and other variables related to their language history. The questionnaire, as administered in Spanish, is available in Appendix 1. Responses to this questionnaire help describe the participants' language history with more detail. A summary of key language history information is provided in Table 3.1, and the raw responses provided by the participants are provided in Appendix 2. Participants had been living in the United States for as little as 1 year to 22 years (mean, 7.4; SD, 5.4). Ages ranged from 18 to 58 (mean=33.8; SD= 11.9); there were 24 females (66%). Formal education in the native language varied from 0 to 12 years, and formal education in the second language also varied from 0 to 12 years. In all, 2 of

[10] A total of 12 additional participants were tested but excluded from this report: 5 had incomplete data, 2 had error rates of 50% or higher on the Spanish on-line task, 4 had error rates at 10% or more, which were very higher relative to their proficiency levels, 1 had higher reading comprehension in English than in Spanish.

the participants noted in the questionnaire that their education in their native country had been interrupted for over four years and later resumed[11].

Table 3.1. Participant background characteristics: mean age, length of residence in the United States, years of formal education in L1 and L2, and reading comprehension score in L1 and L2. (Standard deviations appear in parentheses.)

	Age	**Length of Residence in U.S.**	**Years of Formal Education**		**Reading Comprehension Score**	
			L1	**L2**	**L1**	**L2**
High-High	26.7 (8.7)	8.2 (5.1)	8.2 (4.2)	3.6 (4.2)	10.8 (0.6)	8.5 (2.4)
Mid-Low	35.8 (11.2)	7.3 (5.8)	10.9 (1.2)	0.1 (0.3)	8.8 (1.6)	2.5 (0.7)
Low-Low	39.0 (12.5)	6.7 (5.6)	8.4 (3.0)	0.1 (0.3)	4.3 (1.1)	2.4 (0.8)

Proficiency in L1 and L2 was measured using the Reading Comprehension section of the Spanish Academic Language and Literacy Diagnostic (ALLD) (Pearson, New York) and the English version of the same diagnostic. This diagnostic is an assessment of reading comprehension skills from grades 1 through 11, and it can be used with students of any age or grade. Currently, the diagnostic is used in 200 New York City schools to identify students with interrupted formal education. Interrupted formal education results in below-grade reading levels, generally two grades below or more. The reading comprehension section contains eight reading leveled reading passages (including one practice passage, which was not scored), with a total of 38 multiple choice questions[12]. The questions probed various higher-order skills related

[11] Participants were asked whether or not they had ever left school in their native country and then returned, and if so for how many years.
[12] The number of questions for each passage varied from 3 to 6 questions.

to reading, from text comprehension, to drawing conclusions, to inferencing. Reading levels were tabulated and accessed through an Internet-based evaluation system.

This diagnostic was chosen because it was originally designed to be used with readers of varied skill levels, and the participants in this study varied widely in both Spanish and English reading comprehension. After the scores were tabulated, three groups were created based on the distribution of reading comprehension scores in both languages (see Figure 3.1). For Spanish, participants reading at the sixth grade level and higher were designated to be in the "High" reading comprehension category. For English, "High" readers were those reading at the fifth grade level or higher. It seemed reasonable to expect that the cutoff for the high group would be slightly lower in the second language than the native language. Unless readers are balanced bilinguals and biliterate, reading comprehension levels will be lower in the second language as compared with the native language.

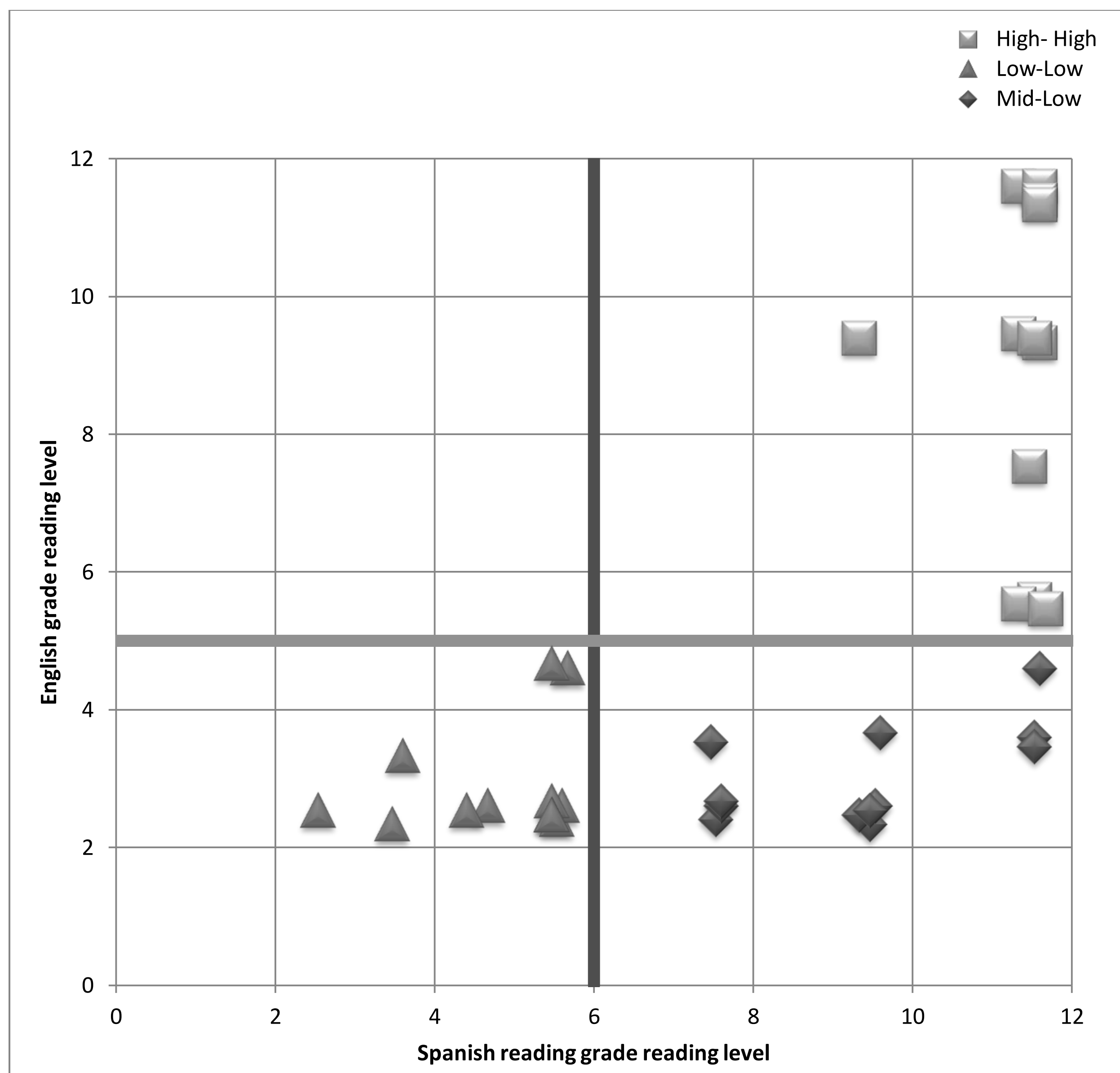

Figure 3.1. Scatterplot of Spanish (*x*-axis) and English (y-axis) reading comprehension scores for the 12 participants in each of the groups, High-High , Low-Low, and Mid-Low. The solid lines indicate the thresholds between high- and low-proficiency groups for Spanish (a score of 6) and English (a score of 5)

Spanish reading comprehension levels ranged from grade 2 to grade 11, as did English reading comprehension levels. Table 3.1 shows means and standard deviations across groups. Spanish reading comprehension levels differ significantly across all three groups, [HH]vs[ML]

$t(22)=4.11$ $p< 0.0005$, [HH]vs[LL] $t(22)=18.96$ $p< 0.0001$ [ML]vs[LL] $t(22)=8.33$ $p< 0.0001$. English reading comprehension levels differed significantly between the High-High group and both the Mid-Low and Low-low groups, but not between the Mid-Low and Low-Low group, [HH]vs[ML] $t(22)=8.24$ $p< 0.0001$, [HH]vs[LL] $t(22)=8.24$ $p< 0.0001$, [ML]vs[LL] $t(22)=0.28$ $p< 0.7841$.

Materials

Materials for the task were adapted from Acha and Perea (2008). There were 64 experimental words varying in length from six to nine letters (32 short, 32 long); these are all provided in Appendix 3. Words were grouped according to length. The mean number of characters for the short words was 6.5 (SD = 0.09; range 6-7 characters (e.g., *cerezo*, *estufa*, *tiburón*)); the mean number of characters for the long words was 8.5 (SD = 0.12; range 8-9 characters (e.g., *semáforo*, *ensalada*, *felicitar*)).

Mean word frequency was based on a Spanish database (Davis & Perea, 2005), with the frequency of short words equaling 18 per one million, and long words equaling 19 per one million. All the targets were considered familiar to beginner readers as they were present in the word frequency count for first-grade children (Corral, Goikoetxea & Laseka, 2004)[13]. The mean number of orthographic neighbors was 1.2 for short and 1.7 for long words. There were an additional 64 fillers, 32 of which were long, mean 8.5, SD = 0.09; range 8-9, 32 short, mean 6.5,

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[13] As the words were taken from an experiment conducted in Spain, the word list was reviewed by a Mexican Spanish speaker in order to eliminate any words that were not used in Latin American Spanish.

SD = 0.09, range 6-7. These were included to distract from the experimental materials in the matching task.

The 64 experimental items were all matching pairs in the task; that is, the written and audio stimuli corresponded to the same word (e.g., babero-babero). The 64 additional items were mismatching pairs (e.g., babero – cerezo).

Furthermore, each item also appeared in alternating case form. Alternating case is a technique used for investigating the use of a lexical versus sublexical strategy in word reading. The case of the word is distorted (aLtErNaTiNg cAsE) in order to break up lexical units, thereby forcing the reader to use a different processing mode.

The items were pseudo-randomized using DMDX software. In addition, there were 24 practice items and 64 fillers of varying lengths.

Procedure

Participants were given a background questionnaire in Spanish to complete. Participants were tested in small groups (3-8) at a time, each seated at a computer station, wearing headphones for the auditory presentation and using the keyboard to interface with the display.

The experiment was conducted using the DMASTR software (DMDX) developed at Monash University and at the University of Arizona by K.I. Forster and J.C. Forster. The items were presented in bimodal fashion: first visually, then auditorily. For each trial, a word appeared centered on the computer screen for 350 ms, and was immediately followed by auditory presentation of another word. Participants were asked to press a ‘yes’ button if the two words

matched, and a ‘no’ button if they did not match. After the visual and auditory presentation, participants had 3 seconds to respond; otherwise, the words ‘no response’ appeared on the screen and no time was recorded. Participants controlled the appearance of items by pressing the space bar. After each trial, participants were given feedback on the computer screen as to whether their answer was correct or incorrect, as well as reaction times. Reaction times were measured from the onset of the spoken stimulus. Items were pseudo-randomized.

Instructions were given in Spanish as well as English, and participants had the opportunity to practice with 24 practice items and to ask questions about the procedure before starting the experiment. This part of the session lasted approximately 45 minutes.

After they finished the matching task, participants were administered the reading comprehension component of the Academic Language and Literacy Diagnostic in Spanish. Participants were given 50 minutes to complete the diagnostic. The entire session took approximately 2 hours to complete.

Analysis

Raw reaction time data were analyzed for outliers; upper and lower cutoffs for RTs were established at 500 ms and 2800 ms, and reaction times more than 2.0 standard deviation units away from the mean of a subject were trimmed. Analyses of variance (ANOVAs) reported below were performed over summary reaction time and error data by participants and items, in a design that included the variables of Group (High-High, Mid-Low, Low-Low), Case (uniform,

alternating), Length (short, long), Word Type (CVC, CVCC, CVCe, CVVC, CVCeOP, CVVCOP). Correlations were run on participants based on summary reaction time and error rate data.

Results

In this experiment, variables affecting units of word identification were investigated in L1 Spanish. The first hypothesis was that higher skilled readers would rely on lexical processing more than lower skilled readers. This question was addressed empirically by examining mean reaction time and error data for effects of length and alternating case across the three reading comprehension groups. The second hypothesis was that L1 word reading speed and accuracy would be related to L1 reading comprehension levels. This question was investigated through correlational data. An effect of alternating case was evident across all three groups, but no effect of length. There was no correlation found between RT data and reading levels, but there was a significant correlation between error data and reading levels. The results are summarized in Figure 3.2 below.

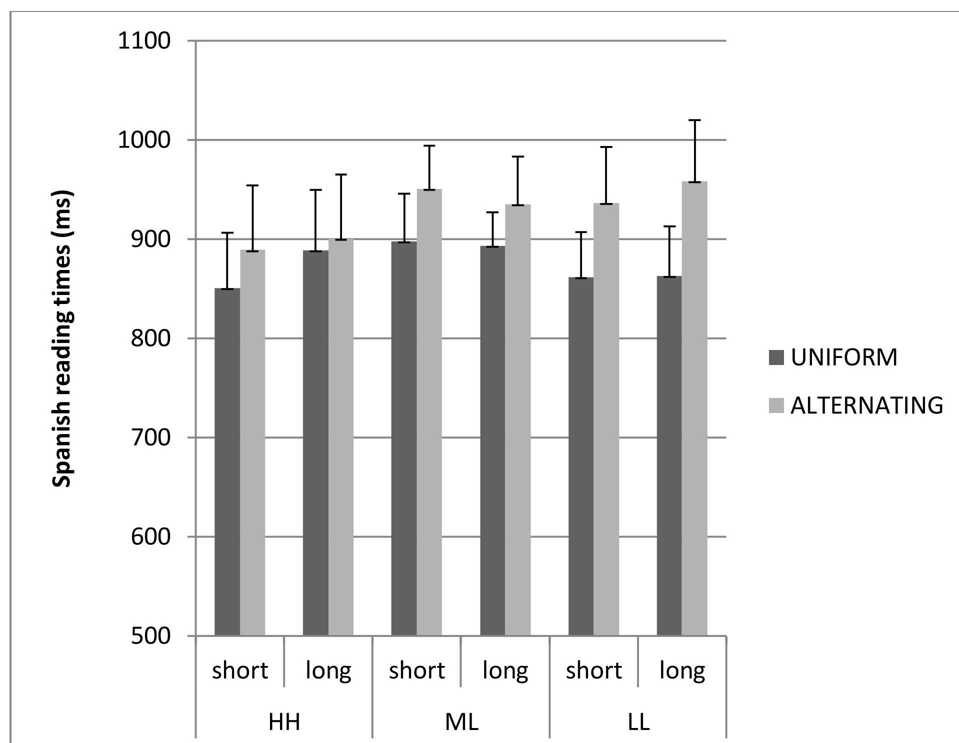

Figure 3.2. RTs for High-High, Mid-Low and Low-Low groups reading in Spanish, as a function of length (Short, Long) and case (Uniform, Alternating)

As Figure 3.2 clearly shows, materials presented with alternating case (928 ms) had a processing cost compared to materials with uniform case (877 ms). This was confirmed in the analyses, which revealed a main effect of Case, $F_1(1,33) = 27.90$ $p<0.001$; $F_2,(1,81) = 39.10$ $p<0.001$. The cost incurred by alternating case was evident in all three groups, indicating that the disruption of orthographic groups in words affected word reading. However, this processing cost varied by group, as indicated by the Group x Case interaction which was marginally significant across participants and significant across items, $F_1(2,33) = 3.08$ $p<0.06$; $F_2(2,81) = 4.47$ $p<0.05$. The disruption was greatest in the Low-Low group (85 ms, $F_1(1,23)=27.80$ $p<0.001$; $F_2(1,55)=27.20$ $p<0.001$), followed by the Mid-Low group (48 ms, $F_1(1,23)=10.10$

p<0.005; $F_2(1,55)=16.50$ p<0.001), and smallest in the High-High group (25ms, $F_1(1,23)=6.23$ p<0.05); $F_2(1,53)=3.75$ p<0.06. A correlation between L1 reading level and the processing cost of alternating case (as evidenced in the overall difference between alternating and uniform case for participants) found that as L1 reading level increased the processing cost of case decreased, $r = -0.44$ $p < 0.01$ (Figure 3.3)

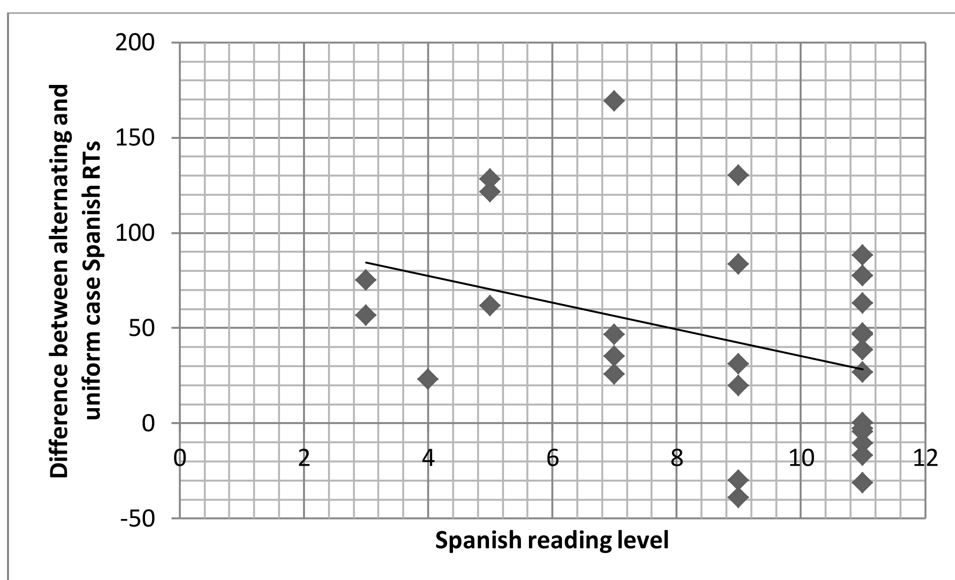

Figure 3.3. Correlation between Spanish reading level and the overall difference between alternating and uniform case for Spanish RTs

Length was included as a factor in the design to investigate whether readers were using a sublexical procedure: evidence of the use of a sublexical procedure has been offered in previous studies reporting effects of length (longer reading times for long words). In the reaction time data, the mean difference between long and short words overall was 25 (ms). The main effect of Length was not significant ($F_1(1,33)=1.60$ p.0.10; $F_2(1,81)=1.84$ p>0.10) and did not interact with Group (Group x Length: $F_1(2,33)=2.14$ p>0.10; $F_2(2,81)=1.20$ p>0.10), Case (Case x

Length: $F_1(1,33)=0.23$ p>0.10; $F_2(1,81)=.50$ p<0.10), or in the three-way interaction (Group x Case x Length: $F_1(2,33)=1.47$ p>0.10; $F_2(2,81)=0.41$ p>0.10). This suggests that all three groups relied on a lexical, rather than sublexical reading procedure for the materials.

With a grand mean reaction time of 905 ms, the Low-Low readers were not significantly slower overall in word reading than the two other groups (grand mean for Mid-Low group: 919 grand mean for High-High group: 882); main effect of Group $F_1(2,33)=0.13$ p>0.10; $F_2(2,81) = 2.61$ p<0.08. As can be seen in Figure 3.3, there was a non-significant correlation between L1 reading comprehension scores and reading times, $r = -0.14$; $p > .10$. This was unexpected as low skilled readers generally have longer reaction times for lexical decision and naming tasks than high skilled. The fact that reaction times did not differ significantly may be a function of the fact that these items were highly familiar.

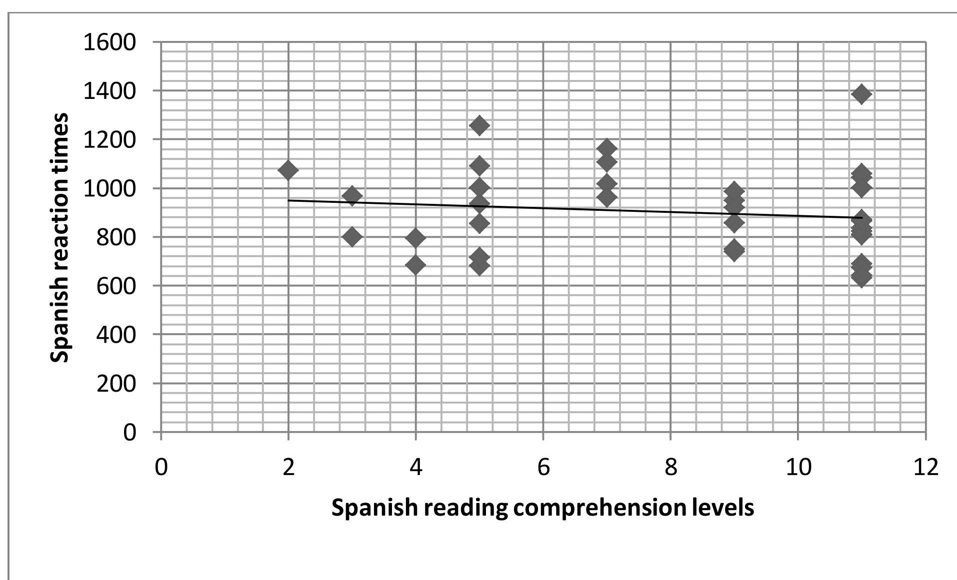

Figure 3.4. Correlation between Spanish reading comprehension levels and reaction times

The lack of a correlation between reading level and reaction times indicates that reading levels did not interact with reading times of these high frequency stimuli. In contrast, as shown in Figure 3.5, there was a strong correlation between greater reading level and lower error rates, $r = -0.49$; $p < .005$, which suggests the possibility of a speed/accuracy trade-off with the lower level readers.

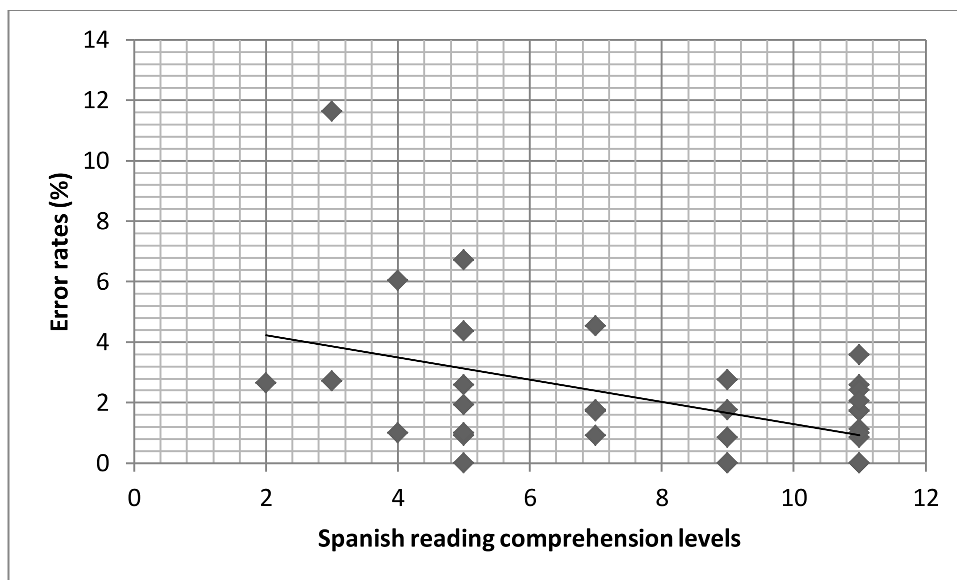

Figure 3.5. Correlation between Spanish reading comprehension levels and error rates

An ANOVA on the error data showed a main effect of Group $F_1(2,33) = 3.84$ $p<0.05$; $F_2(2,81) = 9.85$ $p<0.001$. The Low-Low group had the largest percentage of errors, 3.5%; the Mid-Low group had a 1.4% error rate, and the High-High group had a 1.1% error rate. A main

effect of length across participants was also found $F_1(1,33) = 4.89$ $p<0.05$, as well as a marginal effect across items $F_2(1,81) = 3.14$ $p<0.08$, with short items producing more errors. No other main effects or interactions were significant (all p's>0.10).

The error data revealed a possible outlier, with an error rate at 11.7%. A correlation was conducted after removing the data point, and the correlation was found to be significant $p < 0.05$.

Summary

In summary, the Spanish data from Experiment 1 reveal a strong effect of case, which increases in processing cost as reading levels decrease. This may be a function of strong reliance on orthographic information and an inability to compensate when orthographic information is not available. Furthermore, there was no effect of length found, which suggests that readers were using a lexical strategy overall. Finally, reaction times were not significantly different across the three proficiency groups although error rates did differ between the high skilled and low skilled readers, with low skilled readers making more errors overall. In sum, the three groups behaved similarly in terms of reaction times as well as regarding the length variable. However, they showed a difference in terms of the effect of alternating case and error rates. The prediction was that more proficient readers would rely on lexical processing, while less proficient readers would rely on sublexical processing. It was found that readers of all levels relied on lexical processing. Furthermore, it was predicted that higher reading comprehension levels would be correlated with faster reaction times and more accuracy; it was found that reading comprehension was correlated with error rates, but not with reaction times.

Chapter 4: Processing English

In Experiment 1, evidence was provided that demonstrated lexical processing during word identification for all three groups of Spanish readers. Differences among the groups were more apparent when lexical reading was disrupted due to alternating case, where it was found that the low proficiency readers had more difficulty than the high proficiency readers in overcoming the disruption from alternating case. In Experiment 2, variables affecting word identification units in L2 English are investigated using an on-line task. The first hypothesis is that higher level L2 readers rely more on lexical processing than lower level readers. This hypothesis is investigated empirically through analysis of reaction times and error rates on transparent, consistent and opaque conditions as well as the uniform and alternating conditions. The second hypothesis is that L2 English reading levels are associated with L2 word reading speed and accuracy, and this is tested with a correlation analysis. Chapter 4 includes English data from the bilingual participants, an analysis of the crosslinguistic data resulting from Experiment 1 and Experiment 2, and the results of English monolingual readers.

Experiment 2: Bilinguals in English

Method

Participants

The participants from Experiment 1 were the same for Experiment 2. They were divided into 3 groups: High-High, Mid-Low, and Low-Low; Table 3.1 details key information regarding participants' reading comprehension in L1 and L2, age, years of formal education and length of residence.

Materials

The experiment used a 3 x 2 x 6 design: Group (high-high, mid-low, low-low); Case (uniform, alternating); Word Type (CVC, CVCC, CVCe, CVVC, CVCeOp, CVVCOP). The Case variable was the same as in the Spanish experiment; it was included to test for lexical processing and the extent of reliance on orthographic information. The Word Type variable was included to test for sublexical versus lexical processing.

The experimental items were comprised of 12 items across 6 word types, totaling 72 items. Each of the experimental items appeared twice, once in uniform case and once in alternating case. There were also 24 fillers, in two versions, uniform and alternating case. In addition, there was an equivalent set of filler words, similar in form to the 72 experimental items. The response to the experimental items was always 'yes', since the visually and the auditorily presented words always matched. Fillers always contained a mismatch between the visually and

the auditorily presented word, such that the correct response was systematically ‘no’. Fillers also appeared in uniform and alternating case.

Stimuli lists were created for each of the following syllable type conditions: CVC (e.g., *sad*, *run*, *pass*, *bag*, *jam*, *map*), CVCC(e.g., *hand*, *hold*, *card*, *went*, *belt*, *sort*), CVCe (e.g., *side*, *made*, *fine*, *bite*, *late*, *name*), CVVC (e.g., *road*, *mail*, *bean*, *coat*, *paid*, *team*), CVCeOP (e.g., *give*, *love*, *done*, *lose*, *were*, *move*), CVVCOp (e.g., *bear*, *does*, *head*, *said*, *great*, *break*). The mean frequency (f) per million for each word type (based on the SUBTLEXUS word frequencies database, Brysbaert 2002) was: CVC, f: 85; CVCC, f: 188; CVCe, f: 280; CVVC, f: 159; CVCeOP, f: 1456; CVVCOp, f: 330. Materials for the task were all monosyllabic, 3-5 letter words. Monosyllabic words were used based on previous research (Baron & Strawson 1976; Akamatsu 2004), which demonstrated that readers may read regular monosyllabic words letter by letter, and exceptional monosyllabic words lexically (whole word). Three categories of words were selected: 1) opaque: words that cannot be decoded by using normal grapheme-phoneme correspondences; they are exceptional in their pronunciation; 2) consistent: words made up of specific orthographic rimes (e.g., ‘-ITE’ as in ‘bite’), which are pronounced in a consistent manner; 3) transparent: Words which are easily decoded because they follow the normal grapheme/phoneme mapping rules of English. Each of the words was then selected based on codas. Of the 12 words in each category, 6 words were chosen whose codas were legal in Spanish, and 6 whose codas were not. In Spanish, only 5 phonemes are permitted in coda position, /D/, /R/, /l/, /n/, /s/ (Núñez-Cedeño and Morales-Front 1999). Therefore, in each of the word sets, 6 words ended in one of the permissible phonemes, and 6 did not. This coda distribution was included in the study in order to look for potential native language effects during

word identification. Each of the items appeared in alternating case as well as uniform case. The first letter of each word was always in lower case (e.g., sAd; dOeS).

Procedure

The procedure was the same as Experiment 1, except participants saw and heard words in English rather than Spanish and were administered the Reading Comprehension section of the Academic Language and Literacy Diagnostic in English rather than Spanish. The diagnostic consisted of eight reading passages with a total of thirty-eight multiple choice questions, and participants were given 50 minutes to complete the diagnostic.

Analysis

The experimental design included three factors: Group (High-High, Mid-Low, Low-Low), Case (uniform, alternating), and Word Type (CVC, CVCC, CVCe, CVVC, CVCeOP, CVVCOP). Mean reaction times and error rates by participants and items were subjected to analyses of variance, in which Case and Word Type were treated within participants, and Case was treated within items. The same analyses were performed with the English data as with the Spanish data.

Results

In this experiment, word identification in L2 English was investigated to determine the processing mode (lexical or sublexical) used by L1 Spanish readers of varying levels. The first hypothesis was that higher level L2 readers would rely on a lexical strategy, while lower level readers would rely on a sublexical strategy. The second hypothesis was that high reading comprehension levels would be correlated with faster reaction times and fewer errors. The results for the English data are summarized in Figure 4.1 below.

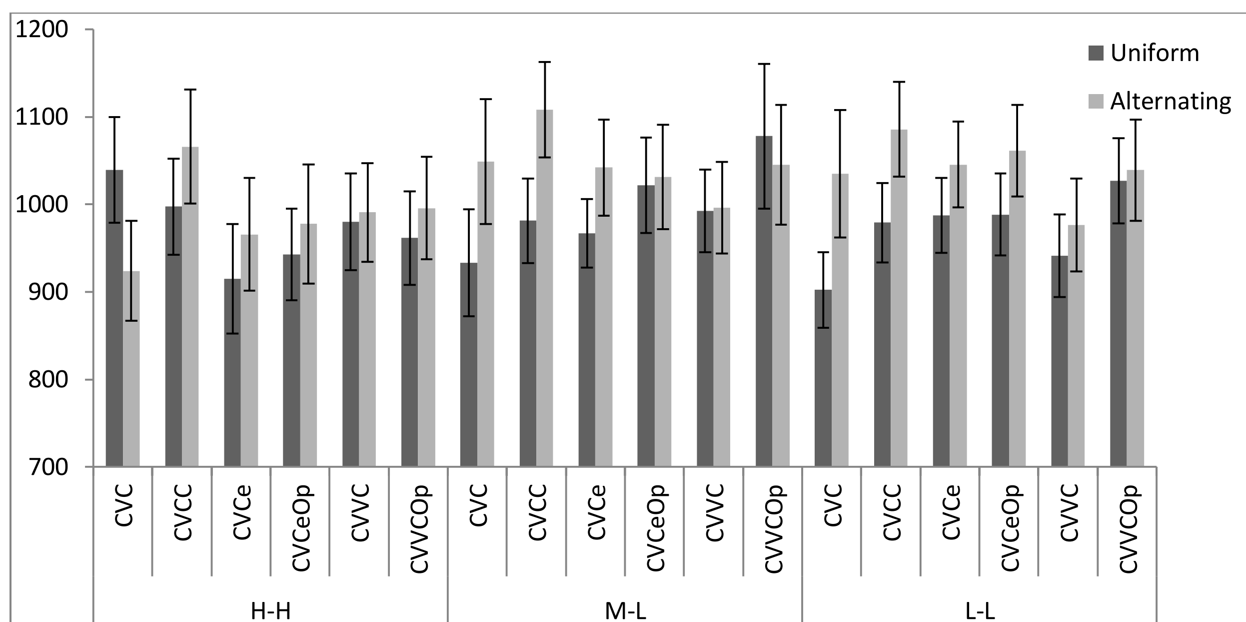

Figure 4.1. English reading times (in ms) for High-High, Mid-Low, Low-Low groups, as a function of Case (uniform, alternating) and Word Type (CVC, consonant-vowel-consonant; CVCC, consonant-vowel-consonant-consonant; CVCe, consonant-vowel-consonant-silent e; CVCeOp, consonant-vowel-consonant-silent e, opaque word; CVVC, consonant-vowel-vowel-consonant; CVVCOp, consonant-vowel-vowel-consonant, opaque word)

As with the Spanish results, alternating case resulted in a processing cost (main effect of Case was significant, $F_1(1,33) = 14.5$ $p<0.001$; $F_2(1,198) = 30.5$ $p<0.001$), which varied across

groups. Group x Case was not significant by participants but was significant by items, $F_1(2,33)=1.93$ p>0.10; $F_2(2,33) = 4.30$ p<0.05. The three-way interaction Group x Word Type x Case was significant, $F_1(10,165)=2.16$ p<0.05; $F_2(10,165) = 2.94$ p<0.005. In subanalyses, the Low-Low group demonstrated a significant effect of Case, with alternating case materials read 69 ms more slowly than uniform case materials, $F_1(1,11) = 12.5$ p<0.005; $F_2(1,11) = 21.4$ p<0.001. The Mid-Low group showed a marginally significant effect for participants and a significant effect for items, with alternating case materials read 49 ms more slowly than uniform case materials, $F_1(1,11) = 3.87$ p<0.07; $F_2(1,11) = 16.3$ p<0.005. For the High-High group, Case was not significant, with alternating case materials read 12 ms more slowly than uniform case materials, $F_1(1,11)=0.97$ p>0.10; $F_2(1,11)=.78$ p>0.10. Alternating case placed a greater processing cost on the Low-Low group relative to the other two groups, indicating their greater reliance on orthographic information. A correlation between L2 reading comprehension level and the cost of alternating case (as evidenced in the overall difference between alternating and uniform case L2 RTs) for each participant was calculated and found to be marginally significant, $r = -0.32$ $p < 0.10$. (See Figure 4.2).

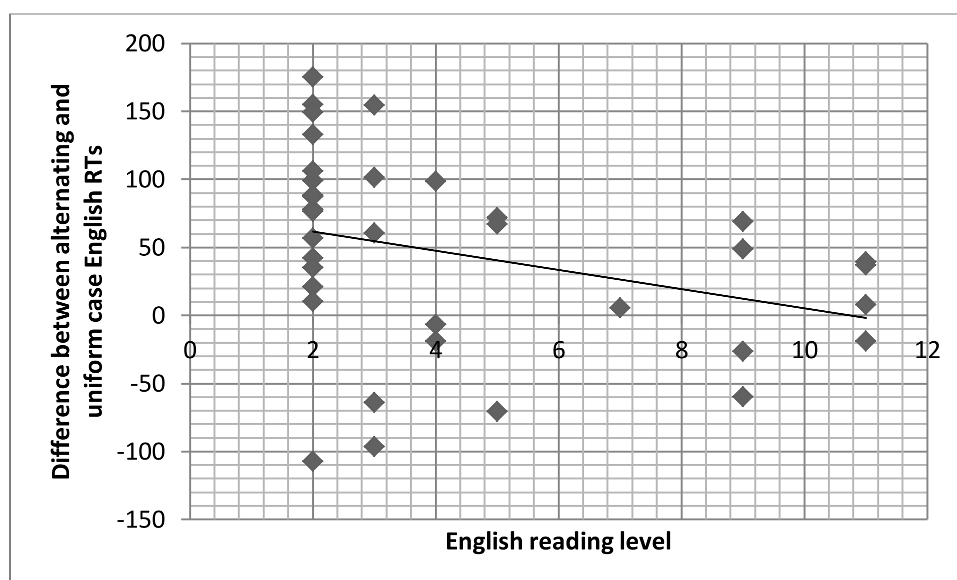

Figure 4.2. Correlation between English reading level and the overall difference between alternating and uniform case English RTs

The main effect of Word Type was significant, $F_1(5,165) = 3.11$ $p<0.05$; $F_2(5,198) = 3.89$ $p<0.005$, with a marginal interaction for Word Type x Case across participants but significant across items, $F_1(5,165) = 2.13$ $p<0.06$; $F_2(5,198) = 3.12$ $p<0.01$. Group x Word Type was not significant.

Subanalyses of the Word Type and Case interactions pointed towards differences in processing between transparent and opaque word types. Uniform data were examined separately because it was thought that this could provide evidence as to which processing mode readers normally used. The Low-Low group and the Mid-Low group incurred a processing cost (Low-Low group: 105 ms. on average; Mid-Low group: 117 ms. on average) for the two opaque word type conditions (CVCeOp and CVVCOp) relative to the transparent condition (CVC). The Low-Low group had a marginal difference between CVC and CVCeOp of 85 ms, [cvc_uniform]vs[cvceop_uniform] $t_1(11)=2.16$ $p< 0.06$; $t_2(22)=2.14$ $p<0.06$, and a significant difference between CVC and CVVCOp of 124 ms, [cvc_uniform]vs[cvvcop_uniform] $t_1(11)=2.72$ $p< 0.05$; $t_2(22)=3.27$ $p<0.05$. The Mid-Low group showed a significant difference between CVC and both opaque word types (CVCeOp: 89 ms; CVVCOp: 145), [cvc_uni]vs[cvceop_uni] $t_1(11)=2.41$ $p< 0.05$; $t_2(22)=2.41$ $p<0.05$; [cvc_uni]vs[cvvcop_uni] $t_1(11)=3.22$ $p< 0.01$; $t_2(22)=3.22$ $p<0.05$. The differences found in the Low-Low and Mid-Low groups between the transparent and opaque conditions are indicators of an increased cost for

opaque stimuli, which suggests difficulty with lexical processing[14]. This is consistent with reported research demonstrating a cost for opaque words compared to transparent words.

Conversely, the High-High group showed an unexpected rise in reaction times for the uniform CVC condition (Mean reaction time: (1039 ms) in contrast to all other uniform word types (CVCC, 997 ms; CVCe, 915 ms; CVVC, 980 ms; CVCeOp, 943 ms; CVVCOp, 962 ms). The CVC Word Type was significantly slower than its alternating counterpart, as seen in the pairwise comparison, [cvc_uniform]vs[cvc_alternating] $t_1(11)=2.21$ $p< 0.05$, $t_2(22)=4.00$ $p< 0.005$. The alternating condition appeared to facilitate the CVC reaction times, which may account for the lack of an effect of Case with the High-High group.

Reaction time results also pointed towards an overall processing cost for the Mid-Low and Low-Low readers as compared with the High-High readers for the consistent words (CVCe and CVVC) and the opaque words (CVCeOP and CVVCOp) in uniform case. The consistent and opaque words required English-specific knowledge of rimes (e.g., -ITE in ‘bite’; -AME in ‘game) and specific words (‘sure’; ‘were’). This difference in processing of word types was not unexpected for lower level readers and shows difficulty in using larger grain sizes in L2 English. Figure 4.3 below shows the reaction times for transparent, consistent and opaque word types for each group.

[14] Both the opaque conditions have higher frequency counts than the CVC condition (CVCeOP: Mean 1456 per million; CVVCOp: Mean 330 per million; CVC: Mean 85 per million). Therefore, the fact that the opaque conditions took much longer to read despite the higher frequencies lends support to the idea that readers have difficulty with lexical processing.

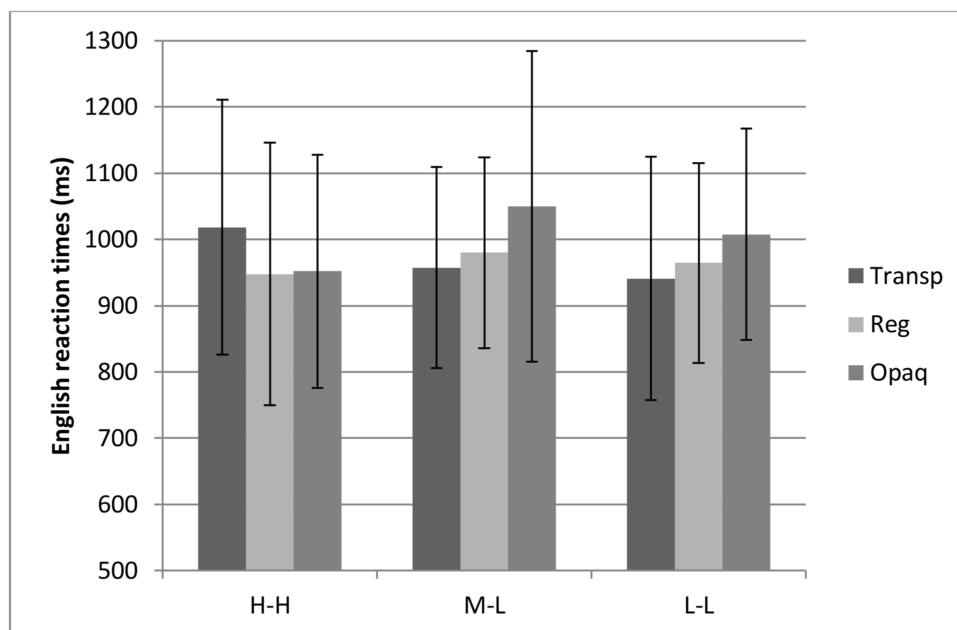

Figure 4.3. Reaction times across groups for transparent, regular and opaque words

The main effect of Group was not significant across participants but was significant across items, $F_1(2,33)=.19$ $p>0.10$; $F_2(2,33) = 6.17$ $p<0.01$. Average reading times for each group in milliseconds were: High-High group mean (ms): 980; Mid-Low group mean:1020; Low-Low group mean: 1006. A correlational analysis of reading comprehension level and reaction time revealed a non-significant/marginal trend between increasing reading levels and decreasing reaction times, $r = -0.29$; $p < 0.10$ (Figure 4.4). This trend was in contrast to the non-significant correlation between Spanish reading comprehension and reaction times, indicating that in this study, these two aspects were marginally linked in the second language.

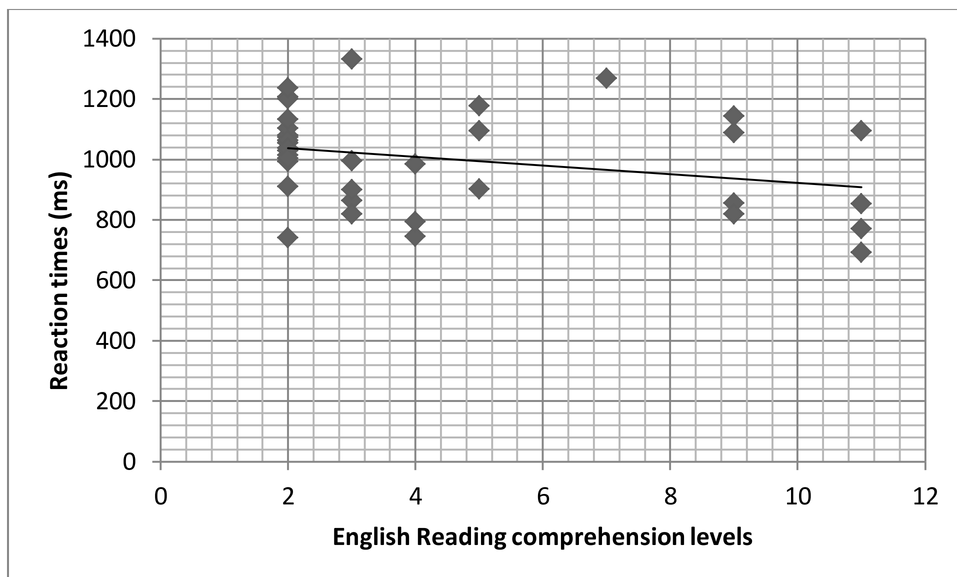

Figure 4.4. Correlation between English reading comprehension levels and reaction times

The error data revealed a main effect of Group, F_1 (2,33) = 16.0 $p < 0.001$, with the Low-Low group producing the highest number of errors. The main effect of Word Type was significant, F_1 (5,165) = 6.05 $p < 0.001$ and the interaction of Word Type x Group was also significant, F_1 (10, 165) = 2.27 $p < 0.05$. The main effect of Case was marginally significant, F_1 (1,33) = 3.34 $p < 0.08$ as was the three way interaction of Group x Word Type x Case, $p < 0.07$. No other interactions were significant.

Item analyses were done separately for each of the groups. For the High-High group, Word Type was not significant, $p > 0.10$, but Case was significant, F_2 (1,11) = 7.36 $p < 0.05$. The interaction between Word Type and Case was significant across items and participants for the High-High group, F_1 (5,55) = 3.13 $p<0.05$; F_2 (5,55) = 3.76 $p < 0.01$. The interaction between Word Type and Case was most likely due to the difference in error rates between the CVCeOP condition, with alternating case showing many more errors than uniform case (5%), t_1

(11) = 1.47 $p > 0.10$; $t_2(11)=3.18$ $p < 0.005$, and the CVVCOp condition, with alternating case showing significantly more errors (7%), $t_1(11)=2.82$ $p < 0.05$; $t_2(11)=2.99$ $p < 0.05$. This suggests that the opaque word types (CVCeOP and CVVCOP) were read lexically as demonstrated by the significantly higher reaction times in the alternating case condition; readers had difficulty compensating for the disruption as opaque words, by definition, are read lexically.

For the Mid-Low group, the main effect of Word Type was significant across items and participants, $F_1(5,55) = 2.68$ $p<0.05$; $F_2(5,55) = 2.54$ $p<0.05$. The main effect of Case was not significant by participants ($p > 0.10$) and marginally significant by items, $F_2(1,11) = 4.61$ $p<0.10$. The interaction Word Type x Case was significant across participants and items, $F_1(5.55) = 2.73$ $p < 0.05$; $F_2(5.55) = 4.12$ $p < 0.005$, most likely due to the difference between the uniform and alternating CVCC conditions, with the alternating condition showing more errors. This indicates that the CVCC words were read lexically in the uniform condition, resulting in higher reaction times in the alternating condition.

The main effect of Word Type was significant across participants and marginal across items for the Low-Low group, $F_1(5,55) = 4.39$ $p < 0.005$; $F_2(5,55) = 2.22$ $p<0.10$. There were no other significant effects (all p's > 0.10).

The Low-Low group displayed many more errors than the other two groups, and this was evident in the correlation between English reading comprehension and English error rates, $r = -0.58$; $p < 0.001$ (Figure 4.5).

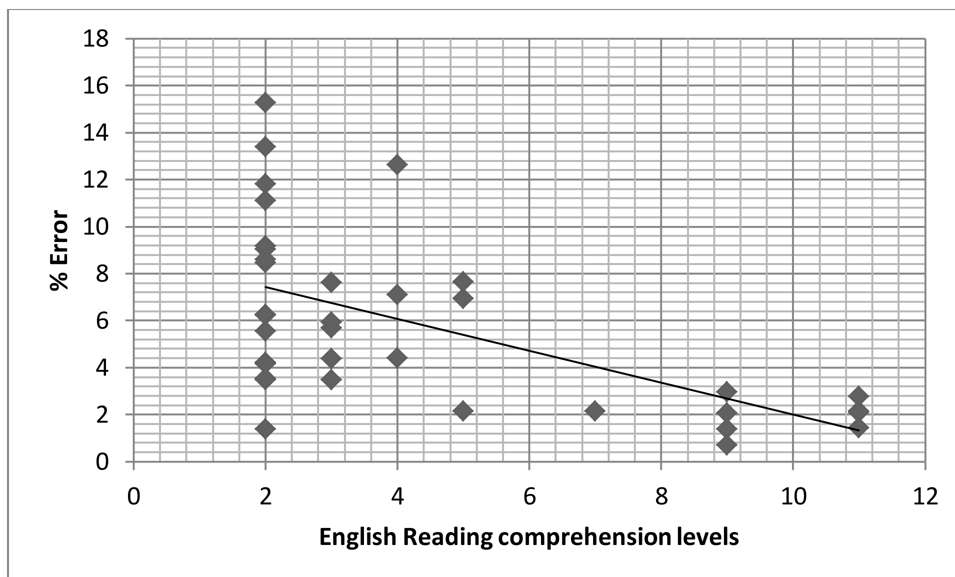

Figure 4.5. Correlation between English reading comprehension levels and error rates

Crosslinguistic effects

Across Experiment 1 and Experiment 2, it was predicted that there would be a correlation between L1 Spanish and L2 word reading speed and accuracy. A second prediction was that there would be evidence of a relationship between L1 reading level and L2 word reading skills. To test these predictions, reaction time and error data were analyzed, and correlations were conducted with L1 and L2 reading data.

As expected, there was a strong correlation between Spanish and English reaction times across subjects, $r = .63$; $p > 0.001$ (Figure 4.6); however, error rates were not correlated $r = 0.215$; $p > 0.10$ (Figure 4.7). Mean reaction times tended to be consistent across individuals, but error rates were probably more influenced by individual knowledge of particular words.

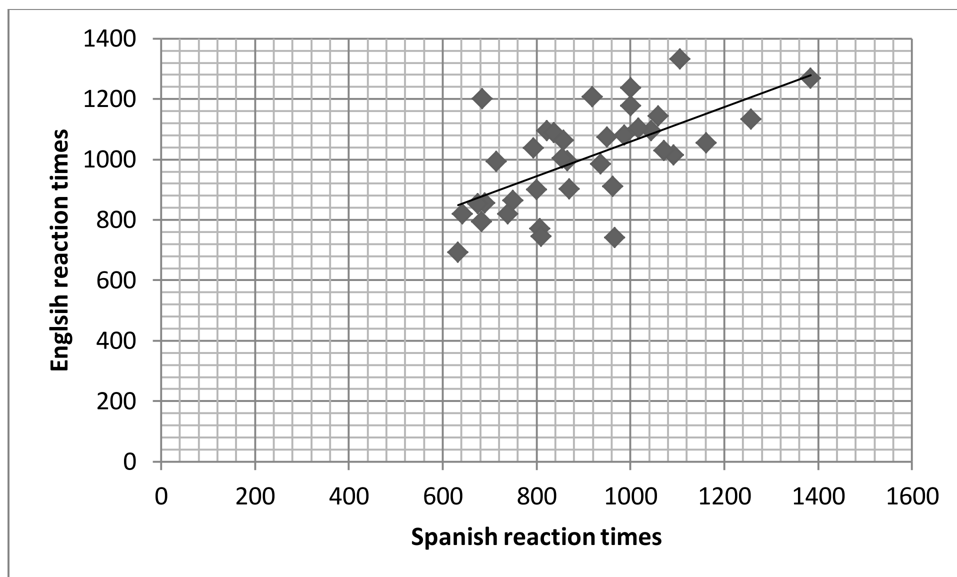

Figure 4.6. Correlation between mean Spanish and English reaction times

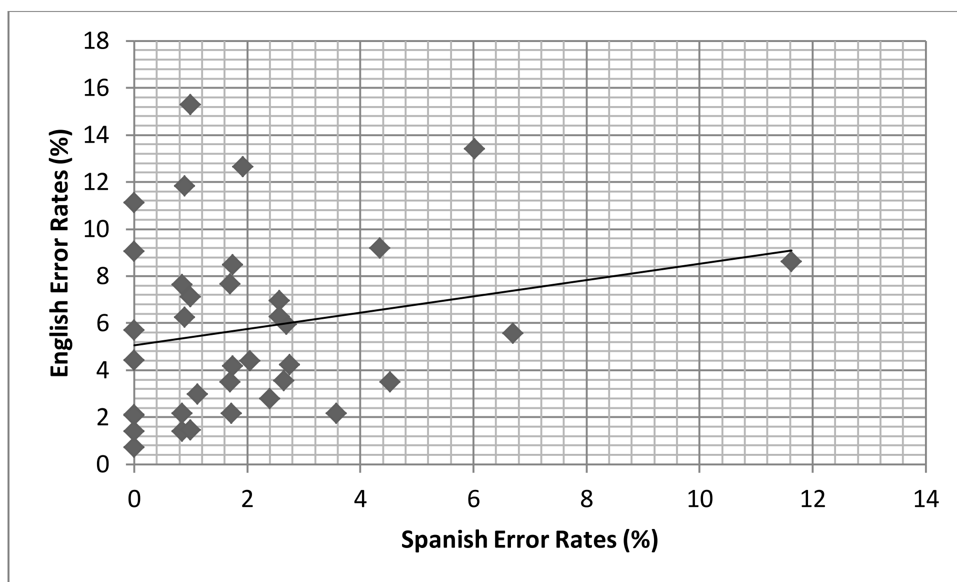

Figure 4.7. Correlation between mean Spanish and English error rates

There was evidence for influence of L1 reading level on L2 word reading. Despite the fact that the Mid-Low and Low-Low group had similar English reading levels (2.4 and 2.5 respectively), L2 error rates were significantly lower for the Mid-Low group when compared with the Low-Low group, suggesting that L1 reading level is related to L2 word identification, [ML]vs[LL] $t_1(286) = 3.76$ $p < 0.001$.

Further evidence of L1 influence on L2 reading was provided through an analysis of the alternating case data. As L1 reading proficiency increased, there was a decrease in the effect of alternating case on L2 reaction times (as evidenced by a decrease in the difference between alternating case RTs and uniform RTs). To further examine this effect, 2 correlations were run, which addressed the relationship between the L1 Spanish and L2 English. Each correlation examined the overall difference between alternating and uniform case for each participant and each participant's reading level:

1) L2 reading level and difference between alternating and uniform condition for L1 RTs
2) L1 reading level and difference between alternating and uniform condition for L2 RTs

The prediction was that L1 reading comprehension level would be related to L2 word reading. This prediction was tested directly with correlation number (2). Figure 4.8 below shows the correlation, which was marginally significant, $r = -0.29$ $p < 0.10$.

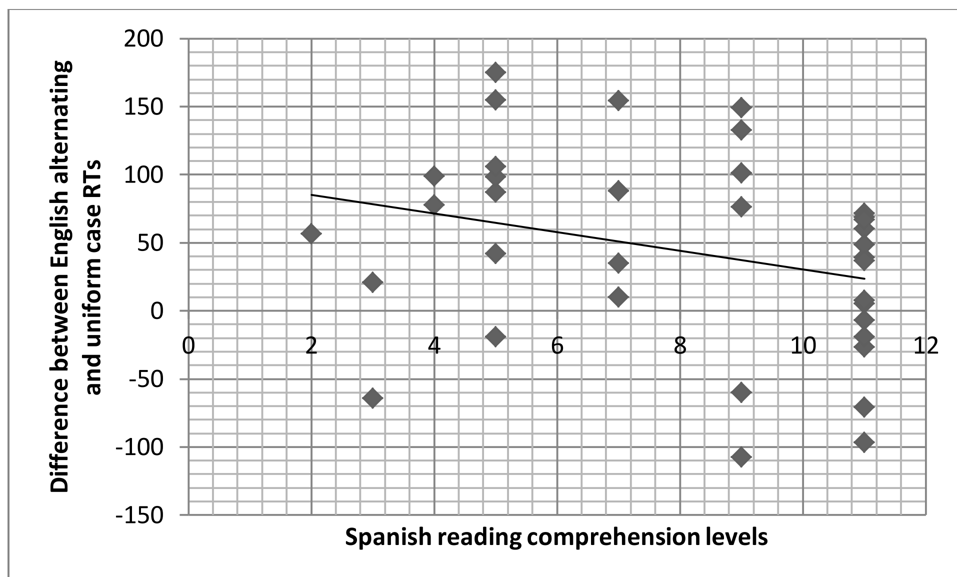

Figure 4.8. Correlation between Spanish reading comprehension levels and the overall difference between alternating and uniform case English RTs

Correlation number (1), which addressed the L1 difference between alternating and uniform RTs and L2 reading levels was found to be significant, $r = -0.36$ $p < 0.05$, indicating a relationship between L1 reading skills and L2 reading comprehension (Figure 4.9)

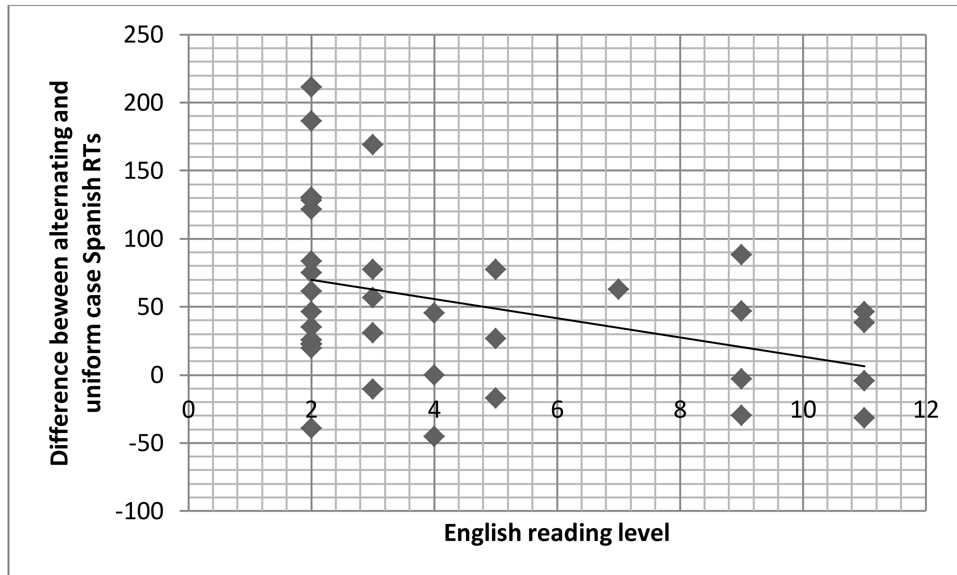

Figure 4.9. Correlation between English reading level and the overall difference between alternating and uniform case Spanish RT

The crosslinguistic comparisons reveal differences between the Mid-Low and Low-Low groups, which indicate that higher L1 proficiency was related to fewer errors in L2 word identification. Furthermore, it was found that an increase in L2 reading comprehension levels was related to a decrease in processing cost of alternating case, indicating a relationship between L1 and L2 reading skills.

Summary: Bilinguals processing English

To summarize, in a similar trend to the Spanish results, the English data showed an effect of case which decreased as reading levels increased. However, unlike with the Spanish data, the High-High group had no effect of case. This may be related to differences between the materials for the two experiments. Effect of word type was more complex across the groups. With the uniform case words, the Low-Low and Mid-Low groups showed a tendency towards higher reading times for the opaque condition as compared with the transparent CVC condition. This was in contrast to the High-High group, which displayed the converse, high CVC reaction times compared to the opaque conditions. Unlike the Spanish data, the correlation between higher English reading levels and lower reactions times were marginally related. Error data revealed that errors increased for each group as reading levels decreased.

Experiment 3: English monolinguals

Experiment 3 tested fluent native readers of English on the English stimuli used in Experiment 2. This created a balance in the participant design as the High-High Spanish group was comprised of fluent native readers of Spanish. Furthermore, the inclusion of the English monolingual group functioned as a control group for the bilingual readers in Experiment 2.

This group was predicted to act in a similar manner to the High-High bilingual group except that their reading times would be faster.

Participants

Participants were 12 monolingual English speakers. They ranged in age from 21 – 55, with a mean age of 33. (SD = 13.72). All 12 participants scored at the 11th grade level on the Academic Language and Literacy Diagnostic.

Materials, Procedure, & Analysis

The materials and procedure used were the same as those used in Experiment 2. The same protocol was followed in analyzing the data, using correlations and Analyses of Variance with a design including Case and Word Type as factors.

Results

Figure 4.10 below shows the reaction time data for the English control group.

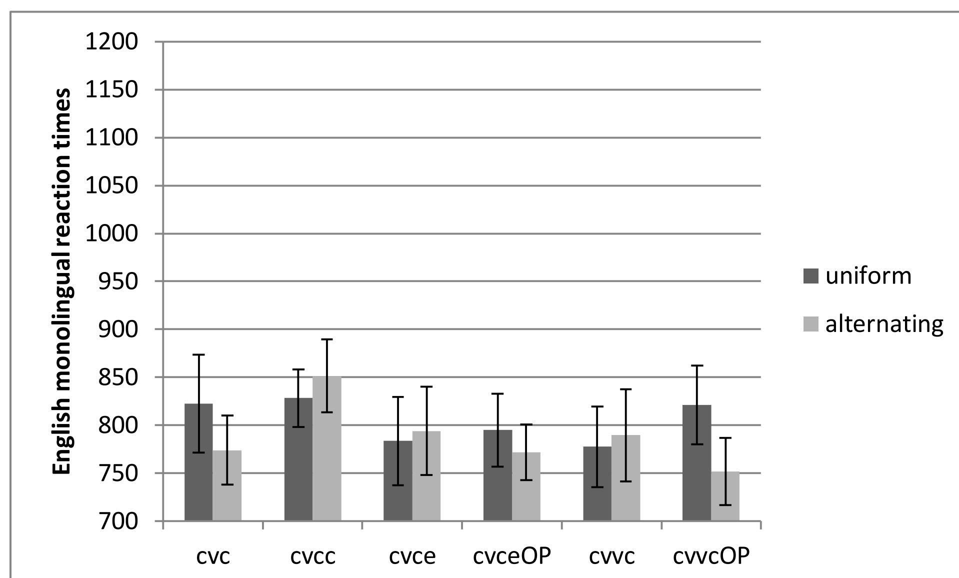

Figure 4.10. Reaction times for English monolinguals across Case (uniform, alternating) and Word Type (CVC, CVCC, CVCe, CVCeOp, CVVC, CVVCOp)

An ANOVA conducted on the data revealed that the main effect of Case was marginal across participants and not significant across items, $F_1(1,11) = 3.64$ $p<0.08$; $F_2(1,11) = 2.95$ $p>0.10$., with a significant interaction of Case x Word Type, $F_1(5,55) = 2.92$ $p<0.05$; $F_2(5,55) = 2.54$ $p< 0.05$. This interaction may have been driven by the CVVCOp and CVC alternating case data points (similar to the CVC alternating case data with the High-High group), which suggested a facilitating effect of Case in terms of reaction times. Subanalyses revealed no effect of alternating case on CVC (CVC uniform, 823 ms; CVC alternating, 774 ms) across participants and a significant effect across items, $t_1(11) = 1.55$ $p >0.10$; $t_2(11) = 2.23$ $p <0.05$. A significant effect of alternating case was found on CVVCOp (CVVCOp uniform, 821 ms; CVVCOp alternating, 752 ms), $t_1(11) = 3.51$ $p <0.005$; $t_2(11) = 3.39$ $p <0.01$, indicating a robust facilitating effect of alternating case on reaction times to CVVCOp. The main effect of Word Type was

found to be significant across participants but not items, $F_1(5,55) = 3.49$ $p<0.01$; $F_2(5,55) = 1.95$ $p>0.10$. Overall means for the three word type groups were 826 ms for transparent, 781ms for consistent and 808 ms for opaque.

The error data revealed no effects or interactions across participants or items, all p's >0.10.

Summary

In summary, Case did not have a significant effect on the English monolingual data, except marginally across participants as a facilitating effect. There was an interaction between Case and Word Type, which appears to be largely related to the decrease in reaction times for the alternating condition of the CVVCOp word type compared to the uniform condition. Crucially, the monolingual results were similar to the High-High bilingual English results, in that alternating case had no effect, or possibly a facilitative effect with particular word types. The High-High bilingual group and the monolingual group patterned similarly with respect to alternating case as did the Mid-Low and Low-Low groups; this indicates a developmental trend as the bilingual reader approximates L2 processing strategies. One major difference between the monolingual and bilingual groups was that the monolingual readers had much faster reaction times than any of the three groups in English. This was expected as it has been shown that some bilinguals (including those proficient in L2) read more slowly in the second language than native readers do (Favreau & Segalowitz 1983).

Chapter 5: General Discussion

The results of Experiments 1 and 2 provide evidence for variation in word identification skills across reading proficiency levels and language. In addition, they lend support to the proposition that L1 reading proficiency is related to L2 reading skill. The results from Experiment 3 show that the High-High group behaved in a similar manner to the monolingual group, thus providing evidence for a developmental shift towards L2 processing strategies with the higher readers. In this chapter, results of Experiments 1, 2 and 3 will be discussed in light of prior research in this area.

Experiment 1: Bilinguals reading Spanish

In Experiment 1, the central finding was that alternating case affected each of the proficiency groups, but to a different extent. The most proficient readers were the least affected by alternating case, the least proficient readers were the most affected, and the medium proficiency readers were in the middle range. The data suggest that higher reading level was related to how quickly readers can recover from a stimulus degraded by alternating case. Alternating case has been hypothesized to impair lexical or multiletter (unit larger than a letter, smaller than a word) processing (Baron & Strawson 1976; Besner & McCann 1987; Mayall 2002; Schroeder 2011) because case alternation breaks up common letter combinations found in the orthography. When readers are overly reliant on orthographic processing as in the case of logographic (e.g., Chinese) readers, who use visual processing (Akamatsu 2003) and are less skilled at phonological processing, then these readers will have fewer compensatory strategies (e.g., phonological skills) to make up for the disruption of orthographic information in the case of a degraded stimulus. In a similar manner, lower level alphabetic readers may be more

adversely affected by alternating case because they are overly reliant on orthography and unable to use compensatory processes in the way that high level readers can. This may be because due to the fact that low literacy readers have a deficit in phonological skills.

These results confirm previous research showing that reading alternating case increases reading times in tasks for most readers, such as lexical decision (Besner & McCann 1987; Mayall & Humphreys 1996; Schroeder 2011), naming (Baron & Strawson 1976; Mayall & Humphreys 1996), and semantic judgments (Sartori & Masuto 1982). The task in this study had not been previously used with alternating case, so the finding of an effect confirms prior research. These findings are also in accordance with prior research showing that lower level readers are more disrupted by alternating case than higher level readers in word reading (Martens & de Jong, 2006; Mason 1978; Schroeder 2011).

The effect of case across groups in L1 Spanish also has implications regarding orthographic transparency across languages and its relation to sublexical processing. It has often been assumed that languages such as Italian and Spanish, which are orthographically transparent and have fewer complex syllable structures will not be as susceptible to alternating case (Schroeder 2011). The reasoning is that when orthographic units are impaired because of case alternation, readers can recover quickly with minimal cost because phoneme/grapheme correspondences are predominantly isomorphic in transparent orthographies (Frost & Katz 1988). The results of this study provide counter-evidence to this proposal as Spanish readers of all levels were affected by alternating case. One possible explanation for these results is that the first syllable in Spanish has been shown to be primary in accessing words (Strid & Booth 2007), and alternating case breaks up the first syllable unit, thus resulting in an increase in reaction time. It is plausible, as outlined by Taft, Alvarez & Carreiras (2007), that better Spanish readers are

extra sensitive to syllabic structure, and are thus able to access it even when the orthographic structure does not facilitate it.

Reading groups did not differ significantly in reading times, and this was unexpected as prior research has shown that low level readers have slower word reading times than higher level readers (Mason 1978; Perfetti 1985; Adams 1990; Juel 1988; Goswami & Bryant 1990). Research with dyslexic Spanish children has demonstrated that they read more slowly than their normal reading counterparts (Sanabria et al. 2009). Most research has been conducted with low-skilled children, not low-skilled adults, so it is very possible that these adults were able to use other resources (e.g., visual, cognitive) to assist in identifying words (Greenberg et al. 1997), and that these resources enabled them to read as quickly as higher level readers (at least for high frequency words).

Another prediction was that length would affect low level readers more than high level readers. This prediction turned out to be incorrect; length did not have an effect at all. These results are in line with Valle-arroyo's (1996) study showing that length effects in words disappear by grade 6, and they indicate that adult readers (even low skilled) can bypass effects of length if they are reading high frequency words.

Overall, there were no significant RT differences between the higher and lower L1 Spanish groups, suggesting that word identification processes might have been following a similar path. But all groups were affected by case although differing in the degree of the effect. One explanation might be that the three groups were using a predominantly lexical strategy. However, in the alternating case conditions, when the initial syllable was impaired (e.g., bAbErO), a forced strategy of serial processing took over. The initial syllable in Spanish words

is a crucial unit in visual access of Spanish (Strid & Booth 2007; Álvarez et al. 2000) . This initial disruption of the first syllable of the alternating case words affected all groups, but affected the less skilled group the most, possibly because they have more difficulty integrating lower level phonological information when the orthographic stimulus is disrupted.

Schroeder (2011) has suggested that in languages with complex syllable structures (e.g., German), there might be more of a tendency to access multiletter (e.g., orthographic) groups in word identification, and furthermore, that when alternating case disrupts these groups, it leads to higher reading times. According to Schroeder, it is not clear whether this account works for languages with simpler syllable structures, such as Italian and Spanish, which do not have large numbers of consonant that cohere together in clusters. However, it seems plausible that breaking up orthographic groups in less syllabically complex languages would also lead to impairment of visual word identification. Strid & Booth (2007) demonstrated that Spanish bilinguals access the syllable, and that if they are first primed with a letters that cross a syllable boundary (e.g., VC) where the V is in a separate syllable from the C, then this impairs their syllable access. So multiletter groups may involve syllables for Spanish, and if these are broken apart through case alternation, it may lead to difficulty for lower level readers.

The strong form of the Orthographic depth hypothesis, which suggests that transparent orthographies rely more strongly on sublexical processing strategies, was not confirmed. The general Dual route cascaded model of reading, which assumes that high frequency words are read lexically is a better fit for the Spanish data. At the same time, within the Dual route model, there is room for either a weaker form of the ODH or the Psycholinguistic grain size theory, both of which propose that word reading is tailored to the orthography. If it is true that the Spanish readers in this study showed effects of alternating case because of a disturbance in the initial

syllable, then this would support the idea that grain size (e.g., syllable) is important in word identification.

The lack of length effect in this study is in line with Valle-arroyo (1996), showing no effect of length as Spanish readers increase in proficiency. It is probable that the adult readers in our study had high enough reading levels to read high frequency words lexically without resorting to a sublexical strategy. This result also supports the proposal that readers of transparent orthographies do not use a sublexical strategy as a first resort for high frequency words (Defior et al. 1996). All 3 groups of readers used a lexical strategy; it is possible that inclusion of low frequency items might have forced the lower readers to use a sublexical strategy (Mayall 2002). Regarding alternating case, the syllable has been demonstrated to be an important unit of access for retrieving lexical items in Spanish, and if the orthographic syllable unit is disrupted, then this has consequences for all readers. Therefore, it is plausible that the impairment in the initial syllable of Spanish words was particularly disturbing to readers, resulting in an effect of alternating case for all readers, but particularly the lower level readers.

Experiment 2: English results

Unlike the Spanish results, there was marginal significance found between English reading levels and reading times, with higher reading levels associated with lower reading times. This suggests that the higher level readers found it easier to perform the word matching task in the study, perhaps due to stronger word knowledge. Furthermore, the two lower groups (in particular the Low-Low group) had a significantly higher number of errors than the High-High group, demonstrating weak lexical knowledge of English words. When readers have weak

lexical knowledge, then sublexical strategies are implemented to aid in word identification. In this study, the lower level groups more reliant than the High-High group on a sublexical strategy.

An interesting result showed that the two lower groups were similar in terms of reaction times to the transparent uniform CVC condition and the two opaque conditions: uniform CVCeOp and uniform CVVCOp. The Low-Low and Mid-Low groups read the CVC condition substantially faster than the two opaque conditions. This demonstrates that these readers did not have strong knowledge of opaque word types, and could not access them easily from the lexicon. Despite the fact that these words were opaque and could not be easily decoded in the same way that regular words can be, sublexical strategies were relied upon to assist in word identification, and this resulted in longer RTs (Baron & Strawson 1976; Sartori & Masutto 1982; Suárez & Meara 1989).

In contrast, with regard to the CVC condition, the High-High group had a pattern that was more consistent with the English monolingual group. For both groups, the uniform CVC had high RTs as compared with its alternating counterpart. In the case of the High-High group, this difference was significant, and for the monolinguals it was significant only across items. Furthermore, neither group showed a main effect of alternating case. In fact, alternating case had a marginal facilitating effect across participants for the monolingual group. It is possible that the high RTs in the CVC condition were related to neighborhood frequency effects, which have been shown to be inhibitory in English word reading (Carreiras, Perea & Grainger, 1997; Grainger, O'Regan, Jacobs & Segui, 1989). The CVCs used in the experiment have potentially numerous neighbors, many of which may be more frequent and thereby likely to be activated during word identification.

Another possibility is that the upper case letters in the alternating case words were salient to the reader, so they helped to facilitate word identification. Grainger (2012) has proposed a multiple routes model, which has a coarse-grained word identification route that functions alongside the sublexical route. His proposal is that salient letter pairs are used in reading to aid in word identification. Both the monolingual and High-High readers would have had sufficient lexical and orthographic knowledge of English to take advantage of the coarse-grained route.

Case alternation was included as a variable to investigate how readers would handle reading transparent, consistent and opaque words in English when orthographic information was disrupted. Overall, the case results were similar in trend to the Spanish case results, but interestingly, English alternating case tended to result in less disruption across each group as compared with the Spanish. Across the three groups, the Low-Low group showed the most disruption, the Mid-Low group less disruption, and the High-High group had no effect of alternating case. These results are not consistent with a cross-language account that proposes stronger effect of alternating case on opaque, syllabically complex orthographies (Schroeder 2010; Frost & Katz 1989). One explanation is that the English stimuli were highly frequent, and it has been shown that highly frequent words are amenable to fast and efficient lexical feedback from the lexical mechanism, which can transfer information about word units that can aid in word identification (Mayall 2002; Mayall & Humphreys 1996). This may have favored the High-High group in particular since their reading levels were sufficiently strong enough in English to have knowledge of the high frequency stimuli.

Case alternation affected the Mid-Low and Low-Low groups more strongly than it did the High-High group, which is an indication that the lower L2 groups had more difficulty integrating sublexical information when orthographic information was disrupted. The High-

High group, on the other hand, showed no effect of case alternation; thus, they were efficient at integrating letter components despite the alternating case. But the lower groups possibly did not have the kind of strong lexical knowledge of English words, and thus, had difficulty using feedback. Therefore, the default strategy was the sublexical (letter by letter) strategy.

Crosslinguistic effects

Experiments 1 and 2 revealed some interesting crosslinguistic effects. The most important effect was that higher L1 reading levels were associated with fewer errors even when L2 reading levels were equivalent. Comparing the Mid-Low and Low-Low groups, it was found that the Mid-Low group were more accurate in identifying words than the Low-Low group; since their English reading level means were comparable, an important source of the difference would be the L1 reading level. Another possibility is that the difference results from the fact that the Mid-Low group had on average 2 more years of formal education in Spanish than the Low-Low group. More likely, reading level and years in school are related factors that influence each other. These results are consistent with other studies showing that L1 reading skill is an extremely important predictor in the development of L2 reading skill (Koda & Zehler 2008; Bernhardt & Kamil 1995; Cummins 1979).

Further evidence of crosslinguistic influence was demonstrated with the significant correlation between an increase in L2 English reading comprehension and a lessening in the difference between alternating and uniform case RTs in L1 Spanish. If, as proposed, the rise in reaction times to alternating case is due to an inability to use compensatory sublexical information efficiently, then this correlation demonstrates that L1 reading skills can directly impact L2 reading level. A strong L1 reader, who can access compensatory information

efficiently when orthographic information is disrupted through alternating case, will have more success with L2 reading comprehension.

The ability to encode lexical information and use it efficiently is most likely derived from a common ability, which can then extend across language. The general design of a lexical system is probably similar across alphabetic orthographies, but its implementation will vary depending on the specifics of the orthography and phonology. Therefore, if the foundation for this ability is already present in the L1 reader, then it will be much easier to implement a similar system in the second language.

Overall, the results from Experiment 2 confirm that low level readers in a second language were more affected by case alternation than high level readers (Miller 2011; Mason 1978), and that this was most likely caused by a difficulty in integrating sublexical information as well as a lack of sufficient lexical knowledge to compensate for the disrupted stimulus. Furthermore, lower level readers in a second language will tend to rely on sublexical strategies even in a relatively opaque orthography when lexical strategies fail to access a word, while higher level readers will use a lexical strategy, especially with high frequency words. The study also found a relationship between L1 reading level and L2 reading skills, which is consistent with previous research.

Chapter 6: Conclusion

This study focused on how readers of varying L1 Spanish levels identified words in L1 as well as L2 English. Differences as well as similarities in processing were found across the three proficiency groups, High-High, Mid-Low and Low-Low. In L1 Spanish, all three groups used lexical processing; however, they reacted differently when stimuli were disrupted by alternating case, with the lower groups less able to recover from that disruption. In L2 English, it was found that the high level readers used lexical processing, but the low level readers used a mixed strategy of lexical and sublexical processing.

One main finding of this study was that L1 Spanish low-skilled readers were able to access high frequency Spanish words lexically, similarly to their high-skilled counterparts. A difference between the low and high skilled readers was revealed when orthographic units were disrupted. Although the low-skilled readers took more time than the high skilled readers to integrate sublexical and lexical information, this did not affect their overall reading times. Adult low skilled readers of Spanish (average grade level 4) have sufficient lexical and sublexical skills to identify frequent words efficiently.

A second finding was that low L2 English proficiency readers had slightly higher reading times than high L2 English proficiency readers, and substantially more errors, indicating weak lexical knowledge. Furthermore, low-skilled readers showed a rise in reading times for opaque words in English as compared to transparent words, revealing a reliance on sublexical processing to aid in identifying these words. The higher L2 readers tended to pattern with the monolingual controls in their responses to the CVC word type as well as in a lack of effect of alternating case.

A third finding was that there was crosslinguistic facilitation of word identification skills from L1 Spanish to L2 English. The Mid-Low group had significantly fewer errors in retrieving English words than the Low-Low group despite the fact that these two groups had comparable English reading levels. Moreover, a correlation was found between an increase in L2 English reading level and a decrease in the difference between alternating and uniform case RTs in L1 Spanish, demonstrating influence of L1 reading skills on L2 reading comprehension.

These findings provide support for dual route models of reading. Readers can make use of lexical and sublexical strategies and do so in both transparent and opaque orthographies. The fact that low-skilled adult readers use both strategies in word identification has implications for educational decisions. Emphasis on both sublexical (e.g., phonological and syllabic awareness) as well as lexical skills in L1 and L2 (e.g., morphological knowledge) should be primary for adults with low literacy skills.

There were also methodological findings. The bimodal task had not been used in second language research, and it proved to be useful, especially for low-level readers, who found the task less daunting than a task that might have required them to make lexical decisions or pronounce words. This type of presentation could be used with other tasks, such as hearing a word and making a choice from a set of visually presented stimuli.

There were several limitations to this study. Because the stimuli for the English and Spanish experiments were so dissimilar, it was difficult to make cross-comparisons regarding the variables. Comparable materials would have enabled for there to be a more cohesive design. Furthermore, a larger sample size would have given more support for the results. Finally, adding a task using pseudowords would have rounded out the design and provided more information

about sublexical processes. Pseudowords must be read sublexically, so it would be informative regarding readers' skills in doing letter by letter processing.

Future research should include more studies with adult low-skilled readers, both on-line and off-line to determine the specific type of sublexical skills they possess, as well as longitudinal research to test training of adult readers in various lexical and sub-lexical skills to determine how these can impact reading in a second language. Low-skilled L1 readers are a growing population in secondary schools and community colleges; therefore, it becomes imperative to investigate the skills and strategies they possess in L1 literacy in order to help them to acquire L2 literacy.

Appendices

Appendix 1. Background questionnaire in English and Spanish

Questionnaire

Male ___ Female ___

Age ____

Country of origin____________________

Home language______________________

Other languages______________________

1. How many years did you attend school in your native country?

0 years____ 1-4 years_____ 5-9 years______ 10+_______

2. What was the last grade you attended in your native country? How old were you?

3. In your native country, did you leave school for any amount of time and then return later to finish? If so, how much time?

4. Have you attended elementary school or high school in the U.S.? If so, for how many years?

5. How long have you lived in the United States?

1-2 years______ 3-5 years______ 6+ years_______

6. Which language do you feel more comfortable using, English or Spanish?

Cuestionario

Masculino___ Femenino____

Edad_____

País de origin____________________

Idioma ______________________

Otros idiomas______________________

1. ¿Cuántos años has asistido a la escuela en tu país de origen?

   1-4 años ___________ 5-9 años______ 10 + años_______

2. ¿Cuál fue el último grado en el que participaste en tu país de origen? ¿Qué edad tenías?

3. ¿Dejaste de ir a la escuela por un tiempo y después regresaste a terminarla? ¿Por cuánto tiempo?

4. ¿Has asistido a la escuela primaria o secundaria en los EE.UU.? Si es así, ¿por cuántos años?

5. ¿Cuánto tiempo has vivido en los Estados Unidos?

   1-2 años_____ 3-5 años______ 6 + años_______

6. ¿En qué idioma te sientes más cómodo, inglés o español?

Appendix 2. Background information for participants (Participant identifier, Gender, Age, Length of residence, Formal education L1 (years), Formal education L2 (years), Spanish reading level, English reading level, Proficiency group)

Participant Identifier	Gender	Age	Length of Residence	Formal education L1	Formal education L2	Spanish reading comprehension level	English reading comprehension level	Proficien group
1	F	34	6	12	0	11	9	H-H
2	F	19	8	5	7	11	11	H-H
3	F	19	9	5	7	9	9	H-H
4	F	18	4	8	4	11	5	H-H
5	F	26	5	11	0	11	9	H-H
6	F	40	16	14	0	11	7	H-H
7	F	39	4	12	0	11	9	H-H
8	F	29	6	8	0	11	5	H-H
9	F	37	4	12	0	11	5	H-H
10	M	20	20	0	12	11	11	H-H
11	F	20	10	4	8	11	11	H-H
12	F	19	6	7	5	11	11	H-H
1	F	19	1	10	1	5	4	L-L
2	M	29	2	4	0	5	2	L-L
3	F	32	16	4	0	2	2	L-L
4	F	51	6	11	0	5	4	L-L
5	M	20	2	10	0	4	2	L-L
6	M	40	14	10	0	5	2	L-L
7	M	55	12	9	0	3	3	L-L
8	M	39	1	12	0	5	2	L-L
9	F	39	11	3	0	3	2	L-L
10	M	41	3	8	0	4	2	L-L

Participant Identifier	Gender	Age	Length of Residence	Formal education L1	Formal education L2	Spanish reading comprehension level	English reading comprehension level	Proficien group
11	F	45	2	10	0	5	2	L-L
12	F	58	10	10	0	5	2	L-L
1	M	18	6	12	1	11	4	M-L
2	F	49	6	12	0	9	2	M-L
3	M	49	9	12	0	9	2	M-L
4	M	25	3	12	0	9	2	M-L
5	F	47	15	9	0	9	3	M-L
6	F	29	6	10	0	7	2	M-L
7	F	34	6	9	0	11	3	M-L
8	F	32	5	11	0	11	3	M-L
9	F	36	5	12	0	7	2	M-L
10	M	20	2	10	0	7	2	M-L
11	F	45	2	10	0	9	2	M-L
12	M	45	22	12	0	7	3	M-L

Appendix 3: Spanish stimuli, short/long, uniform/alternating

Short uniform	Long uniform	Short alternating	Long alternating
babero	camarote	bAbErO	cAmArOtE
cerezo	favorito	cErEzO	fAvOrItE
minero	caracola	mInErO	cArAcOl
peluca	cualidades	pElUcA	cUaLiDaDeS
pecera	limonada	pEcErA	lImOnAdA
salero	zapatero	sAlErO	zApAtErO
Ultima*	marinero	uLtImA*	mArInErO
mimoso	cariñoso	mImOsO	cArIñOsO
nevado	cocinero	nEvAdA	cOcInErO
palabra	Semaforo*	pAlAbRa	sEmAfOrO*
peludo	camiseta	pElUdO	cAmIsEtA
joyero	escopeta	jOyErO	eScOpEtA
estufa	ensalada	eStUfA	eNsAlAdA
gotera	gasolina	gOtErA	gAsOlInA
abejas	amapolas	aBeJaS	aMaPoLaS
tirita	Mecanico*	tIrItA	mEcAnIcO*
ranitas	navidades	rAnItAs	nAvIdAdEs
vieron	maravilla	vIeRoN	mArAvIlLa
canicas	pesadilla	cAnIcAs	pEsAdIlLa
pelear	felicitar	pElEaR	fElIcItAr
Tobogan*	golosinas	tObOgAn*	gOlOsInAs
azafata	Corazones**	aZaFaTa	cOrAzOnEs**
Tiburon*	Mamiferos*	tIbUrOn*	mAmIfErOs*
regalar	mariposas	rEgAlaR	mArIpOsAs
dibujar	vegetales	dIbUjAr	vEgEtAlEs
deberes	contento	dEbErEs	cOnTeNtO
educado	trabajando	eDuCaDo	tRaBaJaNdO
ovejita	zapatilla	oVeJiTa	zApAtIlLa
agotada	vagabundo	aGoTaDa	vAgAbUnDo
ocupado	chocolate	oCuPaDo	cHoCoLaTe
abanico	jardinero	aBaNiCo	jArDiNeRo
Leñador	pasajeros	lEÑaDoR	pAsAjErOs

*Due to an error in omission of accent marks, these stimuli were not included in the analysis (*ultima, tobogan, tiburon, semaforo, mecanico, mamiferos*).

** Due to an error, the stimulus *corazones* was omitted from analysis.

Appendix 4. English stimuli, normal and alternating case

sad	hand	side	road	come	bear
mad	land	ride	load	give	dead
run	hold	made	jail	have	does
sun	cold	trade	mail	love	head
pass	hard	fine	mean	done	said
mass	card	mine	bean	were	great
bag	went	white	coat	lose	break
tag	sent	bite	boat	gone	bread
sam	belt	late	paid	some	swear
jam	felt	hate	maid	shoe	steak
cap	sort	name	team	sure	sweat
map	short	game	beam	move	wear

sAd	hAnD	sIdE	rOaD	cOmE	bEaR
mAd	lAnD	rIdE	lOaD	gIvE	dEaD
rUn	hOlD	mAdE	jAiL	hAvE	dOeS
sUn	cOlD	tRaDe	mAiL	lOvE	hEaD
pAsS	hArD	fInE	mEaN	dOnE	sAiD
mAsS	cArD	mInE	bEaN	wErE	gReAt
bAg	wEnT	wHiTe	cOaT	lOsE	bReAk
tAg	sEnT	bItE	bOaT	gOnE	bReAd
sAm	bElT	lAtE	pAiD	sOmE	sWeAr
jAm	fElT	HAtE	mAiD	sHoE	sTeAk
cAp	sOrT	nAmE	tEaM	sUrE	sWeAt
mAp	sHoRt	gAmE	bEaM	mOvE	wEaR

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