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Sensitivity to Consonantal Context in Reading English Vowels: The Case of Arabic Learners

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SENSITIVITY TO CONSONANTAL CONTEXT IN READING ENGLISH VOWELS: THE CASE OF ARABIC LEARNERS

by

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ABSTRACT

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Both experimental and anecdotal evidence document the difficulty Arabic learners of English demonstrate when learning to read and write in English. The complex phoneme-grapheme mapping rules for English may explain this difficulty in part, but the question remains why Arabic learners in particular have difficulty decoding English.

This dissertation attempts to pinpoint what specific sub-word-level processes may contribute to this observed difficulty Arabic learners of English commonly experience. Vowel processing is an appropriate place to begin given the inconsistency of the grapheme-phoneme mappings for English vowels. The statistical patterns of the English language itself for the relationship between the onset and vowel or vowel and coda greatly enhance the likelihood of a particular vowel pronunciation, reducing the inconsistency for vowel grapheme-phoneme mappings. When reading, native English speakers use the context (preceding and following consonants) in which a vowel occurs to narrow the range of possible pronunciations, and are thus said to demonstrate sensitivity to consonantal context. For this dissertation, sensitivity to consonantal context in reading English vowels was tested for three groups (Arabic speakers, native English speakers, and speakers from other language backgrounds) using an experiment based on a prior study of native speakers.

Results indicate that non-native speakers of English show less sensitivity to consonantal context than native speakers of English, especially in the greater use of

the critical vowel pronunciation in control contexts. Furthermore, Arabic speakers show even less sensitivity to consonantal context than both the native English speakers and speakers from other language backgrounds, especially for vowel-to-coda associations. In fact, the results for the Arabic speakers for three of six vowel-to-coda test cases run counter to the expected outcome, resulting in what might be called anti-sensitivity to consonantal context. The small number of participants in the Arabic group limits the ability to draw a strong conclusion, but that the results for the Arabic group run opposite the expected outcome for some test items warrants future study.

TABLE OF CONTENTS

LIST OF TABLES

CHAPTER 1: INTRODUCTION

Vowels in English Orthography

Acquiring English orthography is a difficult task for non-native speakers of English, especially for Arabic speakers (Hayes-Harb, 2006; Randall & Meara, 1988; Ryan & Meara, 1991). Indeed, the complex phoneme-grapheme mapping rules for English vowels (see Cook, 2004; Emerson, 1997; Rollings, 2004; Venezky, 1999) make it even difficult for native English-speaking readers to assign the correct phonemic value to the vowel letters as they learn to read.

The purpose of this dissertation is to pinpoint what specific sub-word-level processes may contribute to this observed difficulty Arabic learners of English commonly experience. Vowel processing is an appropriate place to begin given the inconsistency of the grapheme-phoneme mappings for English vowels. If we can better establish at what point the English writing system gives the most difficulty, we can begin to help learners better acquire an understanding of the system and improve their reading proficiency.

Background to the Study

The English language's system of many letters representing one sound and many sounds represented by one letter, along with its irregular grapheme-to-phoneme mappings, have led many to criticize the English spelling system as chaotic. However, the system is not as chaotic as some would have us believe. George Bernard Shaw's famous lament, for instance, that the word "fish" might as well be spelled "ghoti" (/f/ as in *rou<u>gh</u>*, /ɪ/ as in *w<u>o</u>men*, /ʃ/ as in *na<u>ti</u>on*), ignores English *graphotactics*. Similar to *phonotactics*, the system of constraints upon what are legal sound combinations in a given language, graphotactics is the system of constraints upon what are legal letter combinations in various positions (initial, medial, final) in the syllable of a word. In Shaw's example of "ghoti," the phoneme /f/ is never spelled "gh" word initially, the /ɪ/ in women is irregular, and /ʃ/ is never spelled "ti" word finally.

Indeed, the relative consistency of the English spelling system has been demonstrated in recent studies by cognitive reading psychologists (Kessler & Treiman, 2003). In a statistical study of English monosyllabic words, Kessler and Treiman (2001) showed that when consonant information before and after a vowel is taken into consideration, the consistency of a vowel is much greater than when the onset, vowel, and coda are considered separately. Building on this knowledge, in nonword pronunciation studies, Kessler and Treiman (2003) showed that adults are sensitive to this increased vowel consistency when consonantal context is considered. That is, the vowel pronunciation a native English speaking reader assigns to vowel letters when pronouncing nonwords that follow English spelling conventions is influenced by the consonants surrounding the vowel.

In another nonword pronunciation study, Treiman, Kessler, Zevin, Bick, and Davis (2006) showed that sensitivity to consonantal context correlates with reading proficiency for native speaking children. The effect of consonantal context on vowel pronunciation strengthened up to fifth grade reading level, at which point the effect is similar to adult levels.

Statement of Purpose

The goal of this dissertation is to fill the gap in the current literature regarding the cross-linguistic use of consonantal context in decoding English words. The case of Arabic learners of English is an appropriate case to consider because as a group, Arabic learners have more difficulty decoding English at the level of graphemes than learners from other language backgrounds (Hayes-Harb, 2006). This could be due in part to the different L1 reading/decoding strategies, the structural differences between the Arabic and English writing systems, and the differences in the organization of the mental lexicon in Arabic and English.

Significance of the Study

In order to inform the design of teaching methodologies meant to assist Arabic learners in the acquisition of English reading, researchers must address basic questions about how Arabic readers process English. We must also establish that Arabic readers process English differently than L2 readers of English from other native language backgrounds with regard to sensitivity to consonantal context in decoding English vowels. The proposed research will be of interest to second language acquisition theorists, reading theorists, second language writing system theorists, and ESL teaching specialists.

Research Questions and Hypotheses

The relative strength of the bond between vowel and coda in the English writing system itself and the demonstrated sensitivity native speakers have to consonantal context when reading and spelling English vowels has been well-documented. Sensitivity to consonantal context also correlates with reading and spelling proficiency for native speakers.

Crosslinguistic studies of writing systems suggest that those whose native language writing system employs a shallow orthography (one with clear and consistent phoneme-grapheme mappings) may experience decoding difficulties when learning a deep L2 orthography (one with opaque and inconsistent phoneme-grapheme mappings) because it requires greater reliance on the orthographic route than the phonological route. Furthermore, learning a deep orthography requires word recognition of units larger than individual graphemes for successful decoding.

However, these differences in shallow vs. deep and small unit vs. large unit processing do not fully explain the difficulties Arabic speakers encounter when reading English. The unique characteristics of the Arabic writing system, specifically its exclusion of short vowel information in written text, coupled with the documented difficulty L1 Arabic speakers have reading English invite investigation. Perhaps the information encoded by the units themselves (Arabic triconsonantal semantic root vs. English onset-vowel and vowel-coda phonographic units) is a critical factor. This dissertation will address the following questions.

- Do non-native English speakers demonstrate a degree of sensitivity to context when decoding English vowels that differs from L1 English speakers? For example, do they show more or less sensitivity to onset-vowel or vowel-coda associations than native speakers?

- Do Arabic speakers demonstrate a degree of sensitivity to consonantal context when reading English vowels that differs from L2 English speakers from other native language backgrounds?
- Does sensitivity to consonantal context in decoding English vowels correlate with English reading proficiency for non-native speakers of English?

Given that L1 reading strategies and psycholinguistic processes are persistent (that is, readers may not change from their L1 reading strategies to strategies that may be more effective in the L2), the first hypothesis is that L2 readers are not sensitive to consonantal context in the same way that native speakers are. The second hypothesis is that Arabic readers perform significantly differently than their L2 counterparts. The third hypothesis is that reading proficiency in English does correlate with sensitivity to consonantal context given the results reported above for native speakers. Lack of sensitivity to consonantal context when decoding English vowels may explain in part the difficulty Arabic learners encounter when dealing with the English writing system.

Methodology

In order to test our hypotheses, we have conducted a study of sensitivity to consonantal context based on a previous study with native speakers (Treiman, Kessler, & Bick, 2003). Prior studies of sensitivity to consonantal context come from the field of reading psychology. To date, such studies have not been extended to non-native speakers of English, and the present research expands current knowledge by extending the study to a new population. The current research also helps bridge the gap among different disciplines (reading psychology, English as a Second Language, cross-linguistic writing systems).

Because the study was extended to a non-native speaking population, an auditory discrimination task was added to the silent pronunciation task as well as a questionnaire and a Likert confidence rating. In addition, another prior study showed that sensitivity to consonantal context correlates with reading proficiency for native speakers (Treiman et al., 2006). Our purpose in using the reading portion of the WRAT-3(as done in the prior study) was to see if this holds true for non-native speakers as well.

Overview of the Dissertation

This dissertation is organized into five chapters. Chapter 1 states the background, significance, purpose, research questions, and methodology of the study. Chapter 2 reviews the literature in the fields relating to the research questions, namely vowel consistency in English orthography, sensitivity to consonantal context and its relation to reading proficiency, cross-linguistic writing system research, models reading, the Arabic writing system, and the documented difficulties Arabic learners demonstrate when learning to read English. Chapter 3 discusses the research methods used in this study. Chapter 4 analyzes the data from the questionnaire, auditory discrimination task, silent pronunciation task, and Likert rating. Finally, Chapter 5 concludes by summarizing the results, and by presenting pedagogical implications, limitations of this research, and recommendations for further study.

CHAPTER 2: LITERATURE REVIEW

This dissertation encompasses several fields that do not always share contact. In order to explore the issues this dissertation hopes to address, we need to look at previous research in several areas. The first area we discuss is vowels in the English writing system. This area has been researched extensively in the field of reading psychology, where the notions of sound-spelling contingency and sensitivity to consonantal context were introduced. Next we include a general discussion of hypotheses important to cross-linguistic studies of writing systems, specifically the orthographic depth hypothesis and the grain-size hypothesis, as well as a general review of major theories of reading. We end the literature review with a description of the Arabic writing system and the elements that may contribute to the documented difficulties Arabic learners demonstrate when decoding English.

Vowel Consistency in the English Writing System

Vowels are the most troublesome aspect of the English writing system (Cook, 2004; Emerson, 1997; Rollings, 2004; Treiman, Mullennix, Bijeljac-Babic, & Richmond-Welty, 1995; Venezky, 1999). There are only five letters in the English alphabet (six including the letter *y*), but up to fifteen different vowel phonemes in English, depending on the variety being described. A single vowel letter may represent various vowel sounds, and a single vowel sound may be represented by a number of vowel letters or combination of letters. One way the English writing system deals with the paucity of vowel letters to represent its many vowel sounds is to employ combinations of vowel letters. However, there remains a great deal of inconsistency in the system. For example, the sound /i/, may be represented by 12 different spellings: *ea* as in *leaf*, *ee* as in *beef*, *ie* as in *thief*, *e* as in *me*, *eCe* as in *eke*, *iQUE* as in *clique*, *ey* as in *key*, *i* as in *ski*, *ei* as in *Keith*, *ay* as in *quay, eo* as in *people,* and *oe* as in *foetal,* in the British spelling (Barry & Seymour, 1988).

In much past research, words have been classified as either *regular* (defined by predictable sound-spelling correspondences) or *irregular* (defined by exclusion). Although this distinction is still commonly used, it does not capture the complexity of English orthography. Barry and Seymour's (1988) landmark article classifies words according to what they described as sound-spelling contingency. Based on the fact that sounds in English can be spelled a number of ways, Barry and Seymour considered the frequency with which a particular spelling occurs for a particular sound. The spelling for a particular sound thus has a given *contingency* or *probability*. For example, according to their research, for the three most common spellings for the sound /i/, *ea* as in *leaf* occurs in 39.5% of English words, *ee* as in *beef* occurs in 38.6% of English words, and *ie* as in *thief* occurs in only 6.7% of English words**.** The regular/irregular distinction is not lost, but the "regular" spelling of /i/ is ambiguous, since both *ea* and *ee* spellings occur with a similar frequency.

Sensitivity to Consonantal Context

An even finer distinction in sound-spelling correspondences in English is made with the notion of *consonantal context*. Kessler and Treiman (2001) documented that the consonants before and after the vowel may influence the pronunciation of that vowel in statistically regular ways. For example, the vowel letter *o* is normally pronounced by Americans as /a/ as in *mop*, but when followed by the consonant cluster –*ld* or –*lt*, the pronunciation changes to /o/ as in *bold* or *bolt.*

These pronunciations influenced by consonantal context may also be ambiguous, with one pronunciation statistically more frequent than another. For example, the letter *i* followed by the consonant cluster –*nd* may be pronounced either /I/ or /ai/, as in *wind* (action or noun).

When native speakers read English, they use consonantal context both before and after the vowel within the same syllable to disambiguate a target vowel (Treiman et al., 2003; Treiman et al., 2006; Treiman et al., 1995). For example, the following consonant helps the reader decide if the digraph *ea* is to be pronounced /ɛ/ or /i/; it is more likely to be pronounced as /i/ before *p* (as in *cheap*) than before *d* (as in *head*). Readers also use consonant information before the vowel to disambiguate the vowel. For example, the letter *a* is usually pronounced /æ/ as in *ash* or *bash*, but it is pronounced /a/ after the letter *w* or *u* as in *wash* or *squash*. This pattern is historically motivated (Venezky, 1999).

Syllable structure also plays an important role in English grapheme-phoneme mapping rules. The minimal unit of a syllable is the nucleus (usually a vowel). Consonants preceding the nucleus are referred to as the onset. Consonants following the nucleus are referred to as the coda. The vowel-coda unit is referred to as the rime.

According to Kessler and Treiman's (2001) survey of English monosyllables (3,117 words), the vowel-coda unit (the rime) has more statistically significant associations than vowel-onset associations. An association is when the pronunciation of the vowel is systematically associated with a preceding or following consonant. In order to arrive at this conclusion, they developed a measure of conditional consistency. Such a consistency is calculated on one part of the word (onset, vowel, or coda) when another part of the word has a particular value. The consistency of a letter string is 1 if it is always pronounced the same way in that position. Otherwise, consistency is valued between 0 and 1. For example, for the onset letter *c*, the consistency was calculated as .884, the weighted average of the proportions in which *c* is pronounced as /k/ (.938) and /s/ (.062).

Kessler and Treiman (2001) found 34 statistically significant vowel-coda associations for reading and 36 such associations for spelling. On the other hand, only four strong onset-vowel associations were found. They conclude, therefore, that orthographic rime information is more helpful than onset information in determining a vowel's pronunciation and spelling. However, they suggest that the advantage for orthographic rime information is due to the English writing system itself, not because of a psycholinguistic processing advantage for rime information. The associations between vowel and coda are more prevalent in English than the associations between vowel and onset (Treiman et al., 2003). Moreover, as mentioned above, the consonants preceding and following the vowel are only useful in disambiguating the vowel when they belong to the same syllable.

Other languages may present an advantage for units other than the orthographic rime. For example, a study of body-coda units in Korean concluded that the body-coda boundary (e.g., ca-t) is more salient than in onset-rime boundary (e.g., c-at) for Korean children, and furthermore, this body-coda awareness is a predictor of word decoding and spelling in Korean (Kim, 2007). We will return to this issue in the discussion of unit-size.

In a spelling study, Treiman et al. (2002) demonstrated that simply because a consonant letter is adjacent to a vowel letter does not mean that a reader/speller uses that consonant to assign a phonemic/graphic value to vowel letters; the letters must belong to the same syllable. Disyllabic words were used as stimuli in which the syllable boundary placed a consonant following the vowel in a separate syllable. For example, in English, /i/ tends to be spelled *ee* before /d/ and /p/. Based on their hypothesis, the authors expected no more *ee* spellings for /ʃɹi'dok/ than for /ʃɹi'gok/. Indeed, their syllable hypothesis was confirmed in this spelling task specifically designed to answer the question whether consonants must belong to the same syllable to obtain the consonantal context effect.

Eye movement data show that readers use the information visually outside of the direct fixation of the eye (*parafoveal* information) to begin to encode vowel phonemes and that the consonant following the vowel influences the activation of vowel phonemes during silent reading (Ashby, Treiman, Kessler, & Rayner, 2006). This is evidence that consonantal context effects occur in silent reading as well as in pronunciation tasks.

Several studies have investigated the role of consonantal context in native English-speaking children and adults. Experiments in both reading and spelling with both children and adults have consistently shown that native speakers are sensitive to consonantal context when reading and spelling vowels (Treiman & Kessler, 2006; Treiman et al., 2002; Treiman, Kessler, & Bick, 2003; Treiman et al., 2006). In these studies, participants are asked to read a written nonword or spell an auditorily presented nonword as if it were an English word. Literate humans (as opposed to computational models) show sensitivity to consonantal context, but not to the same degree as is reflected in the writing system itself (see Kessler & Treiman, 2001, for the statistical analyses of vowel-onset and vowel-coda associations in English monosyllables).

In experiments comparing the performance of human readers and computational models to the statistics of English, human readers show contextual effects, but not to the extent that might be expected given the statistics of the words they have been exposed to (Treiman et al., 2002). For example, the vowel letter *a* followed by the consonants *ld* is pronounced /ɔ/ in 100% of real English monosyllabic words, but it was only pronounced /ɔ/ in nonwords 55% of the time by native speakers. In other cases as well, native speakers show contextual effects in nonword experiments to a lesser extent than they exist in real English words.

In a study examining how readers (children and adults) learn and generalize new pronunciations for vowel graphemes, Bernstein and Treiman (2004) found that participants were more likely to use the taught pronunciation when the target item and training item shared a consonant and vowel than when they only shared the vowel. For example, participants were taught that the vowel grapheme *uo* (as in the English word *buoy*) was pronounced /u/, as in the training item *zuop*. Participants were more likely to use the /u/ pronunciation when the testing item shared a consonant, as in *zuot* or *fuop*, than when the testing item only shared a vowel with the training item, as in *ruok*. The authors conclude that even children take advantage of the context in which a vowel grapheme occurs as a way of dealing with the variety of grapheme-to-phoneme relationships present in the English writing system. They also find their results consistent with Ehri's (1994, 1995) consolidation model of literacy development, in which context-sensitive spelling-to-sound relationships, or *consolidations*, are learned on the basis of experience with words with recurring patterns. They do not, however, find support for rime advantage in this study. Testing words that shared onset-vowel units were just as helpful as testing words that shared vowel-coda units.

Sensitivity to Consonantal Context and Reading Proficiency

Another important consideration is that these contextual effects correlate with children's acquisition of English reading proficiency. In a study of English-speaking children, Treiman et al. (2006) found that first graders (age 6) were influenced by a vowel's context, refuting the idea proposed by some reading development theorists that children first use context-free associations between phonemes and graphemes before using more complex contextually conditioned associations. These vowel-consonant associations (onset and rime) strengthen up to fifth grade reading level (in their study ages 8-9) at which point they are close to adult levels. Their data also show that sensitivity to coda-to-vowel associations emerged at the same time as sensitivity to onset-to-vowel associations.

Children's acquisition of spelling proficiency shows similar results. Treiman and Kessler (2006) found that children who are better spellers take more advantage of consonantal context, and use of preceding context (onset) tended to emerge three years earlier than use of following context (coda). Use of consonantal context peaks at spelling grade level 6-8, showing that context effects appear earlier for reading than for spelling in English. Similar to the spelling study for adults (Treiman, Kessler, &

Bick, 2002), participants were asked to spell an auditorily presented nonword. Two cases of onset-to-vowel associations and six cases of coda-to-vowel associations were tested.

Cross-linguistic Studies on Writing Systems

The commonalities in L2 word recognition processes across languages are word-frequency effects (high frequency words are processed more quickly and accurately than low frequency words) and word-regularity effects (quicker and more accurate processing of words that follow regular spelling to sound rules).

The Orthographic Depth Hypothesis. What cross-linguistic studies of writing systems have highlighted are that word recognition processes may demonstrate language specific differences. The challenge is to frame the observed differences within theoretical models. Most cross-linguistic studies on writing systems have used the Orthographic Depth Hypothesis (ODH), developed by Katz and Frost (1992) as their theoretical basis. The ODH posits that consistency of sound/symbol mappings determines word-recognition processes. Writing systems with consistent sound/symbol mappings (e.g., Spanish) are referred to as *shallow* or *transparent*. Writing systems with inconsistent sound/symbol mappings (e.g., English) are referred to as *deep* or *opaque*. This terminology was originally coined to describe alphabetic writing systems, but the terms shallow and deep have also been used to describe non-alphabetic writing systems such as the logographic Chinese writing system (deep because the relationship between sound and grapheme is not obvious, although there are hints of phonetic representation in most characters) and syllabic Japanese katakana and hiragana (shallow because the relationship between sound and grapheme is consistent). The ODH predicts that readers of shallow writing systems rely more on the phonological route, and readers of deep writing systems rely more on the visual or orthographic route.

Direction of Opacity. Another factor to consider is the direction of opacity (Frost, 2005): sound to spelling vs. spelling to sound. Some alphabetic writing systems, such as Spanish, have consistent mappings in both directions. Other alphabetic writing systems, such as French and pointed or voweled Hebrew, are consistent from spelling to sound, but inconsistent from sound to spelling. That is, it is easier to read than to spell in such a writing system. In Arabic, pointed or voweled text may be considered consistent in both directions, but unpointed Arabic text underspecifies vowel information making it inconsistent from spelling to sound for reading and more consistent from sound to spelling.

English is inconsistent in both directions; that is, there may be multiple ways to pronounce a word from spelling to sound (consider the verb *read* as base form or simple past) and multiple ways to spell a word from sound to spelling (consider homophones such as *blew* and *blue*).

Decoding Strategies. The decoding strategies for English require not only a grasp of the alphabetic principle (that sounds map onto graphemes), but also sensitivity to consonantal context: to onset-vowel and vowel-coda associations. Previous cross-linguistic studies have shown that L1 processing strategies are persistent even when the L2 may demand different strategies for optimal performance (Koda, 1988, 1996). Koda (1988) states that the word recognition process for shallow orthographies, such as Spanish and Arabic, can be described as linear-mode processing in which the phonological code is accessed prior to meaning. In contrast, the word recognition process for deep orthographies, such as for Chinese and Japanese logograms (called characters and kanji, respectively), can be described as parallel-mode processing, in which access to phonology and meaning occur simultaneously. English lies in the middle of the two extremes and can be described as morphophonemic. Having properties of both shallow and deep orthographies, efficient reading of English uses a dual-coding system in which both strategies (linear-mode and parallel-mode processing) can be employed. In a homophone reading task, parallel-mode readers were found to be significantly more sensitive to anomalies in the visual presentation (Koda, 1988).

Unit-size. In addition to orthographic depth, some researchers are also interested in the size of the units (*grain-size*) that are processed. In a crosslinguistic nonword reading study of children, Goswami, Zielger, Dalton, and Schneider (2003) suggest that English readers (who are learning a deep orthography) switch back and forth between small-unit and large-unit processing, in contrast to German readers (who are learning a shallow orthography), for whom small-unit processing is efficient. Furthermore, they state that, “the need to develop both small-unit and large-unit strategies in parallel may be specific to inconsistent orthographies like English, where small grain sizes are highly inconsistent” (p. 236).

An extension of the Orthographic Depth Hypothesis, the grain-size hypothesis posits that the orthographic consistency of a language determines not only the relative contribution of the lexical and phonological routes, but also the preferred grain size of units that are used during reading (Ziegler, Perry, Jacobs, & Braun, 2001). The more inconsistent an orthography is, the larger the unit-sizes used in reading are.

Another crosslinguistic nonword reading study of children found significant facilitation for shared rimes in English with reduced effects for French (Goswami, Gombert, De Barrera, 1998). We will return to the issue of unit size in the discussion of reading models.

Interdependence Hypothesis vs. Script-Dependence Hypothesis. There are two major competing theories that address the issues of reading in two or more different languages: the interdependence hypothesis and the script-dependent hypothesis. The interdependence hypothesis postulates that similar difficulties will arise in reading two different languages due to a central processing deficit. The script-dependent hypothesis posits that grapheme-phoneme irregularities in a language such as English will result in greater difficulties for an L2 speaker learning to read in English.

Abu-Rabia and Siegel (2003) tested the reading skills of trilingual Arabic-Hebrew-English speaking children. In support of the interdependence hypothesis, they found significant correlations between phonological abilities, syntactic awareness, and working memory across the three languages. However, they also found evidence that orthographic skills may be language dependent. Notably, they found that English spelling errors were closely related to reading errors, and that "[t]hese types of errors result from lack of mastery of the vowels and letter-sound confusions among the readers" (p. 628). Again, the representation of vowels in the orthographic system is important.

Models of Reading

Dual-route Theories. The major theories for reading are *dual-route* and *connectionist* theories. Dual-route theories (see Coltheart, 2005) posit two separate but parallel routes to the access of semantic information in the mental lexicon: the *phonological* or *nonlexical route* and the *visual* or *lexical route*. The phonological route decodes graphemes into phonemes by means of grapheme-phoneme correspondence rules (GPC rules). Nonword reading requires this route. The visual route directly accesses the mental lexicon via the orthographic whole. Irregular word reading requires the orthographic route. For example, the irregular word *yacht* cannot be decoded using typical grapheme-phoneme correspondence rules used in the phonological route. The most cited computational instantiation of the dual-route model is that developed by Seidenberg and McClelland (1989).

The dual-route theory is supported by cases of brain damage that imply an impairment of one of the two routes. In cases of surface dyslexia, a patient is able to read nonwords and regular words aloud, but irregular words suffer; this implies selective impairment of the lexical route. On the other hand, in cases of phonological dyslexia, patients display good reading of real words, but poor reading of nonwords; this implies selective impairment of the phonological route. These reading disorders as a result of brain injury are called acquired dyslexias. Children who show similar reading difficulties as they are learning to read are said to have developmental dyslexia.

Skilled word recognition in English supposes a heavier reliance upon the phonological route in the early stages of reading development and greater reliance upon the visual route with advancement. For comprehension, there is also heavier reliance on textual context to determine a word’s meaning in earlier stages of learning to read English and lesser reliance on textual context as word recognition skills improve with orthographic knowledge. This is in marked contrast to Arabic, where skilled readers show a greater reliance on textual context to assign meaning to a word (Abu-Rabia, 1997).

Connectionist Theories. The second major theory of reading is the *connectionist model*, sometimes called the *single-route* theory. This model is inspired by actual biological models of the neural networks of the human brain (see Plaut, 2005). The major computational instantiations of this model are those done by Plaut (2005). In these models, "cognitive processes take the form of cooperative and competitive interactions among large numbers of simple neuron-like processing units compete and cooperate to yield any given output. Interactions between units are controlled by weighted connections. Units are organized into groups or layers. For example, one group might encode a word's written form, another group might encode its spoken form, and yet another might encode the word's meaning. One benefit of this type of model is that it actually models the learning process.

The proposed research may be interpreted in terms of either model and is not meant to support one or the other. Its main goal is to shed light on L2 word recognition processes.

The Unit-size Debate. We cannot leave our brief discussion of reading models without touching on an important debate that has raged in the field of reading development in recent years, and that it the unit-size debate. As early as 1970, Wylie and Durrell (1970) showed that first-graders could more easily identify a vowel when it was paired with a coda (they called the vowel-coda unit a *phonogram*) than when it was alone. For example, when given written choices of *ack, ick, ock, eck, uck,* the first graders more quickly and accurately identified /ɪck/ as a unit than /ɪ/ alone. They suggested that the vowel-coda unit was the unit of recognition rather than the vowel.

Since then, many researchers have suggested that the rime is a psychologically real unit (Goswami, 1988; Treiman et al., 1995). Bernstein and Treiman (2004) tested the hypothesis that rime units were more easily learned than onset-vowel units, but found that both onsets and codas equally influenced participants' memory of a newly learned novel vowel pronunciation. It appears that rime-advantage is an effect resulting from the statistical properties of English orthography itself (there are significantly more vowel-coda associations than onset-vowel associations).

Unit Boundaries. Given the preference in Korean for body-coda units (e.g. ca-t) over onset-rime units (c-at) (Kim, 2007), we might even question whether the grain-size hypothesis goes far enough; how the syllable itself is structured (body-coda vs. onset-rime) in the mind of the reader may be an important issue worthy of investigation, although it is beyond the scope of this dissertation.

Computational Models. Treiman et al. (2003) compared the influence of consonantal context on the pronunciation of vowels in the performance of human readers versus ten different computational models. None of the models replicated the performance of humans, and the authors suggested ways that the various models need to be modified to account for the influence of consonantal context. The model that performed most closely to humans is that of Norris (1994). In this model, the pronunciation generated considers spelling-sound mappings of a single unit (onset, vowel, coda), the unit in the context of adjacent units, and whole words. For example, for the pronunciation of the vowel in *book*, the model would consider the pronunciation of *oo* in all words with *-oo-*, *boo-*, *-ook*, and *book*.

The Arabic Writing System

The Arabic writing system is an alphabetic writing system that consists of 28 basic letters. Arabic orthography differs from English orthography in several ways (see Palmer, El-Ashry, Leclere, & Chang, 2007, for a table of a Contrastive Analysis of English and Arabic), including letter forms, orthographic depth, reading direction, homophones vs. homographs, morphology, vowels, and in the important issue of diglossia.

Letter forms. Letter forms in English only have two forms: capital and lower case. Cursive script is a variation of block lettering in English. Letter forms in English do not change according to placement in a word, with the exception of capital letters that may be used word initially. In contrast, Arabic is a cursive script, and its letters change form depending on their position in a word (initial, medial, final). In addition, there is a stand-alone form for Arabic letters, so there are up to four forms for each letter (not all letters connect). For more on the forms of Arabic letters and how they connect, see Awde & Samano (1986).

Orthographic Depth. With respect to orthographic depth, Arabic may be considered shallow in its vowelized (or pointed) form. The three long vowels, alif /a/, waw /u/, and ya /i/, are always represented in Arabic script, but short vowel information, realized as diacritical marks, appear only in certain kinds of texts: children's texts, the Koran, and poetry. In its unvowelized (or unpointed) form, which is the norm for everyday texts for adult readers, Arabic orthography is considered deep, like English.

Writing Direction. The writing direction for Arabic is right-to-left, whereas English is written left-to-right. It is beyond the scope of this dissertation to investigate the influence of writing direction; however, prior investigation has already shown that left-to-right reading direction creates a perceptual bias for lateral leftward motion (Morikawa & McBeath, 1992). This leftward lateral motion bias is not due to hand preference or cerebral hemispheric differences.

Homography. English contains many heterographic homophones (words that have the same pronunciation, but different spelling and meaning, such as *meat* and *meet*). Arabic, on the other hand, contains many heterophonic homographs (words that have the same spelling, but different pronunciation and meaning). This high degree of homography in Arabic (Abu-Rabia, 2002) is one reason why skilled Arabic readers rely so heavily on context; in contrast, skilled English readers rely on rapid decoding of individual words. In fact, many theories of reading often emphasize the importance of skilled word recognition. This emphasis may be a biased one based on the reading processes that are favored in English. Abu-Rabia (1997) argues that we may need to reassess universal theories of reading in light of differences that are unaccounted for when these theories are applied to languages other than English, specifically Arabic.

Morphology. Morphology is another area where the Arabic and English orthographies differ. English morphology consists of a system of free and bound morphemes, but as a system it is simpler than Arabic (e.g., English does not use infixes). Arabic is often described as consonantal, rather than alphabetic, because its morphology is based on a triconsonantal root with affixes (prefixes, suffixes, and infixes) used to derive hundreds of variations on the root. Modifications to the root may indicate tense, number, gender, person, and meaning. Many of these modifications are realized through short vowel patterns that are a part of the affix system.

Abu-Rabia and Awwad (2004) studied the function with lexical access of roots and word patterns in Arabic. They assumed that roots are lexical entries that might facilitate lexical access to a large group words that derive from them (see the example for K-T-B in Table 1) and that word patterns are not lexical entries. Their conclusion was surprising: "roots and word patterns have no essential role in word organization in the mental lexicon" (p.321). They suggest instead that familiar words in Arabic are recognized as whole words with "no need for segmentation or knowledge of morphology of those words" (p.334).

We now turn to the primary investigative area for this dissertation.

Vowels. Unlike English, vowels in the Arabic writing system are highly consistent in letter-to-sound mapping (Bauer, 1996). However, in most Arabic texts for adult readers, short vowels are not shown. Short vowels only appear in pointed text for beginners, or in the Koran, or in some cases when pointing is necessary to disambiguate words when semantic context is not sufficient. The reader must supply the short vowel information to read an Arabic text.

Short vowels in Arabic for the most part represent grammatical information such as part of speech, person, number, case, tense and voice (Hayes-Harb, 2006). The Arabic lexicon is organized by tri-consonantal roots that cover a semantic field. This writing system leads to many homographs that are disambiguated by semantic and syntactic context. For example, words with the tri-consonantal root D-R-S have a meaning relationship connected to the idea of *study*. The short vowel pattern A-A-A yields the basic root verb, *to study*, that would be the entry in an Arabic dictionary. Notice that the organization of an Arabic dictionary is not alphabetical in the sense that an English dictionary is in alphabetical order. An Arabic dictionary is arranged in order of consonantal roots. Words created from patterns of short vowels and affixes that alter the root appear together in the same entry of an Arabic dictionary. For example, with the prefix *ma* and the first vowel after D omitted, we have the word *madrasa*, which is a place where D-R-S occurs, namely a school. *Madrasa* appears under the entry D-R-S in an Arabic dictionary. Table 1 gives examples of Arabic words based on the root K-T-B, which means *write*. The root is in bold.

Table 1

Triconsonantal root K-T-B in Arabic

Arabic words derived from K-T-B root	Definition
ka**t**a**b**a	to write
ka**t**ta**b**a	to make someone write
ta**k**aa**t**a**b**a	to write to each other
ista**kt**a**b**a	to dictate
ki**t**aa**b**	book
ma**kt**a**b**	office
ma**kt**a**b**a	library/bookstore
kaa**t**i**b**	clerk
mi**kt**aa**b**	typewriter
mu**k**aa**t**a**b**a	correspondence
mu**k**aa**t**i**b**	correspondent, reporter
mu**kt**a**t**i**b**	subscriber
ku**t**u**b**ii	bookseller
ku**t**ayyi**b**	booklet

Source: Awde, N. & Samano, P. (1986). *The Arabic Alphabet: How to Read & Write It*. New York: Kensington Publishing Corp.

The consonantal root supplies the basic semantic meaning, and short vowel and prefix/infix patterns supply morphological information that further specify the meaning of a word. As mentioned above, short vowel information is usually not included in writing; the reader uses syntactic and semantic context to access the word. Because of the great number of homographs in Arabic, recognition of isolated words is not possible to the degree that it is in English. Abu-Rabia (1997) goes so far as to suggest that word naming as a testing method is not suitable for Arabic due to its homographic nature. Sentence context is crucial for skilled reading in Arabic (Abu-Rabia, 2002). It would appear that the affix-context for the consonants is important in Arabic as opposed to the consonantal context for vowels that is crucial for word identification and reading in English.

Diglossia. We cannot leave the discussion of the differences between Arabic and English orthography without mentioning a crucial difference between the Arabic and English languages. Although English has a variety of spoken dialects, standard written English is not very different from standard spoken English. The situation in the Arabic speaking countries, however, is one of *diglossia*. Diglossia is the situation in which many spoken dialects coexist with a standard written literary language. This literary language is not spoken at home, and is first encountered with formal education. In some ways, when Arab-speaking children learn Literary Arabic, it is akin to learning a second language (Abu-Rabia, 1999).

Documented Difficulties Arabic-speaking Learners Have Reading English

The difficulties Arabic-speaking learners have when they are learning to read English have been documented with both observational and experimental evidence. The end goal is to understand the source of these difficulties so that better teaching methods can be found to better teach English. The following is a review of the relevant literature.

Experimental Evidence. ***Visual and orthographic processing*****.** Brown and Haynes (1985) assessed a battery of eight English reading skills comparing Arabic, Japanese, and Spanish speakers. They tested reading proficiency, visual discrimination of Roman letters, visual discrimination of shapes, translation from spelling to sound, vocabulary knowledge, grammar knowledge, listening comprehension, and progress measures. Among these skills, the Arabic group had the worst performance in visual processing tasks (with the Japanese group performing the best). Overall, the authors conclude that there may be very important differences in groups from different language backgrounds as they learn to read in English.

Word recognition vs. word integration. A cross-linguistic analysis of ESL word-level reading processes of native Arabic and Japanese speakers showed that Arab speakers have more difficulty with pre-lexical word recognition processes in English, whereas native Japanese speakers have more difficulty integrating words into phrase/clause structures for comprehension (Fender, 2003). Both Arabic and Japanese use a non-Roman alphabetic script (although Japanese uses a combination of three scripts, one logographic and two alphabetic). First language word recognition skills in Arabic rely on phonological processing skills (Abu-Rabia, 1997), whereas skilled English word recognition relies more on quick processing of orthographic information. Fender suggests that the irregular phoneme-grapheme mappings in English, especially for vowels, may cause Arabic ESL learners to develop literacy skills in English that “exhibit less efficient and perhaps even less accurate word recognition skills than other ESL populations” (p. 294). In contrast, the similarities in phrase and clause structure in Arabic and English appear to have a facilitating effect for Arabic speakers in terms of word integration skills.

Reliance on consonant information over vowel information. Ryan and Meara (1991), using a missing vowel and matching task, showed that Arabic speaking ESL learners rely more heavily on consonant information than vowel information when compared to both native English speakers and other L2 learners. The Arabic speakers were also slower than the other two groups in performing the tasks. The authors conclude that their data provide “very strong support for the view that Arabic speakers have great difficulty in processing English words” (p. 538).

In a follow-up study, Hayes-Harb (2006) conducted a letter detection task in which native English speakers, Arabic speakers, and other non-native speakers were asked to circle all instances of a target letter (the consonant t or the vowel o) in four passages they were to also read for comprehension. The Arabic speakers exhibited a higher rate of vowel detection errors relative to consonants compared to both native English speakers and ESL learners from other language backgrounds. Post-test interviews with the Arabic participants reveal that some were aware of their differential treatment of vowels and consonants.

Visual search function. An early study by Green and Meara (1987) hypothesized that different scripts would produce different effects in visual search since visual search is sensitive to the nature of the symbols being processed. Indeed, the authors found that the visual search function for Roman letters is M-shaped for English and Spanish speakers (who use a Roman alphabet), but is U-shaped for Arabic and Chinese speakers. The search function is U-shaped for native English speakers for shapes, not for letters. The authors conclude that even when speakers of a language that uses a non-Roman alphabet learn to read English, they do not search the strings of letters in the same way as native English speakers.

In a similar study, Randall and Meara (1998) showed that Arabic speakers react to Roman letters in the same way as they react to Arabic letters, with a U-shaped search function. However, the visual search function is M-shaped for native English speakers when looking at an array of Roman letters, and U-shaped for shapes.

The authors suggest that the differences in search function may be due to differences in reading direction, differences between Roman and Arabic characters, and differences in the English and Arabic writing systems. They conclude that “[i]f Arabs continue to rely on inefficient strategies, as these experiments indicate, they will always be faced with some difficulties on the level of word processing which native speakers of English do not experience” (p. 144).

Observational Evidence. Observational evidence, as well as advice on how to remedy the problem, has often come from the classroom. Some observed difficulties Arabic learners demonstrate with decoding English include mispronunciation of words, slow reading speed, and spelling errors.

Mispronunciation. Ryan and Meara (1991) give some examples of errors made by Arabic speakers who were asked to simply read some words displayed on a computer screen. The errors were collected and published by Alsulaimani (1990); a few examples appear in Table 2.

Table 2.

Word reading errors made by Arabic speakers

Target	**Realisation**
biscuit	basket
circuit	cricket
bowl	ball
castle	custard
hair	higher
splendid	spill
trout	throat
subtle	stable
president	presented
reflection	perfection

Source: Reprinted in Ryan, A., & Meara, P. The case of the invisible English vowels: Arabic speakers reading English words. *Reading in a Foreign Language, 7.2*, 532.

These examples of mispronunciations are indicative of the pre-lexical errors documented in the experimental evidence discussed above.

Reading speed. The slow reading speed of Arabic speakers learning English is notable (Shboul, 1981). Again, this may be attributed to the difficulty in pre-lexical access documented above. Specifically, the complexity of the English orthographic system hinders the reading speed of a reader whose L1 reading strategy is a phonological one.

Spelling. Spelling is the flip side of reading (Ehri, 1997), and there is no lack of observational evidence of spelling errors among Arabic ESL learners. It should be no surprise that of the possible categories for documenting such spelling errors, difficulties spelling the English vowels is a great source of error (Haggan, 1991; Thompson-Panos, 1983). Haggan (1991) attributes the spelling errors to mispronunciation and lack of awareness of spelling rules and patterns even in fourth-year students, and recommends a return to explicit teaching of spelling rules in ESL teaching. A more recent case study of an Arabic-speaking child in an American school as recommends explicit instruction of English spelling patterns as a way to help the student more successfully learn English (Palmer et al., 2007).

CHAPTER 3: METHODOLOGY

The Prior Model Studies

The current study is based on a prior study of consonantal context conducted with native speakers of English (Trieman, Kessler, & Bick, 2003). In Experiment 1, the authors investigated whether college students' pronunciation of medial vowels in monosyllabic nonwords is affected by consonantal context. They selected two cases of onset-vowel conditioning and six cases of vowel-coda conditioning to study. The conditions for each case are described here.

Case 1 for the onset-vowel associations involves the vowel letter *a* before consonants other than *r* or velars in closed syllables. In their analysis of monosyllabic, monomorphemic American English words, Kessler and Treiman (2001) found that the critical vowel pronunciation for this case, /a/, occurs 81% of the time when *a* is preceded by *u* or *w* (the experimental context). However, the critical pronunciation occurs only 1% of the time when the vowel letter *a* is preceded by consonants other than *u* or *w* (the control context). When the vowel letter is preceded by consonants other than *u* or *w*, the vowel is usually pronounced /æ/, the typical pronunciation. Compare the pronunciations of *sash* vs. *squash* and *mash* vs. *wash*.

Case 2 for the onset-vowel associations involves the vowel letters *ar*. The critical vowel pronunciation, /ɔ/, occurs in 100% of monosyllabic, monomorphemic American English words (Kessler & Treiman, 2001) when *a* is preceded by *u* or *w* (the experimental context). The critical pronunciation occurs 0% of the time when preceded by consonants other than *u* or *w* (the control context), in which case /æ/ is the typical pronunciation. Compare the pronunciations of *car* vs. *war*.

Case 1 for vowel-to-coda associations involves the vowel letter *a* followed by *nge*. The critical vowel pronunciation, /e/, occurs in 100% of monosyllabic American English words (Kessler & Treiman, 2001) when followed by *nge,* and 0% when followed by *nce*. The typical pronunciation is /æ/. Compare the pronunciations of *range* vs. *dance*.

Case 2 for vowel-to-coda associations involves the vowel letter *a* followed by *ld* or *lt*. The critical vowel pronunciation, /ɔ/, occurs in 100% of monosyllabic American English words (Kessler & Treiman, 2001) when followed by *ld* or *lt,* and 0% when followed by *nd* or *nt*. The typical pronunciation is /æ/. Compare the pronunciations of *bald* vs. *band* and *salt* vs. *pant*.

Case 3 for vowel-to-coda associations involves the vowel letters *ea* followed by *d*. The critical vowel pronunciation, /ɛ/, occurs in 69% of monosyllabic American English words (Kessler & Treiman, 2001) when followed by *d*, and 0% when followed by the letters *b, l, m, n,* or *p*. The typical vowel pronunciation is /i/. Compare the pronunciations of *dead* vs. *deal*. Notice that the critical pronunciation, /ɛ/, does not occur 100% in the experimental context; the typical pronunciation /i/ also occurs in a significant percentage of American English words when followed by the letter d. Compare the alternate pronunciations of *lead* (verb and noun) and *read* (present and past tense).

Case 4 for vowel-to-coda associations involves the vowel letter *i* followed by *nd* or *ld*. The critical vowel pronunciation, /ai/, occurs in 89% of monosyllabic American English words (Kessler & Treiman, 2001) when followed by *nd* or *ld*, and 6% when followed by the letters *nt* or *lt*. The typical pronunciation is /ɪ/. Compare the pronunciations of *mind* vs. *mint* and *wild* vs. *wilt* (but also *pint* for an example of a critical pronunciation in the control context).

Case 5 for vowel-to-coda associations involves the vowel letter *o* followed by *ld* or *lt*. The critical vowel pronunciation, /o/, occurs in 100% of monosyllabic American English words (Kessler & Treiman, 2001) when followed by *ld* or *lt*, and 0% when followed by *nd* or *nt*. The typical pronunciation is /a/. Compare the pronunciations of *bold* vs. *bond* and *colt* vs. *font*.

The final case for vowel-to-coda associations, Case 6, involves the vowel letters *oo* followed by *k*. The critical vowel pronunciation, /ʊ/, occurs in 94% of monosyllabic American English words (Kessler & Treiman, 2001) when followed by *k*, and 0% when followed by *m*, *n*, or *p*. The typical pronunciation is /u/. Compare the pronunciations of *loon* vs. *look* (but also *spook* for an example of the typical vowel pronunciation in the experimental context).

For Experiment 1, the authors constructed 10 pairs of experimental and control nonwords for each case (2 onset-vowel cases and 6 vowel-coda cases) with 20 fillers. For example, for Case 1 for onset-vowel associations (the vowel letter *a* preceded by *u* or *w*), a sample experimental nonword is *squant*, and a sample control nonword is *spant*.

Twenty-five participants were tested individually. They were asked to pronounce the nonwords as if they were everyday English words, and the responses were taped-recorded. A phonetically trained person who was unaware of the hypotheses of the experiment scored the pronunciations.

The pronunciations were coded as containing the critical pronunciation of the vowel (the pronunciation that would be expected for the experimental stimuli), the typical pronunciation of the vowel (the pronunciation that would be expected for the control stimuli), or some other pronunciation. Less than 3% of responses contained a response having a pronunciation of the vowel that was neither the critical nor the typical vowel pronunciation. In all cases, participants produced more critical pronunciations of the target vowel for the experimental stimuli than for the control stimuli. The difference was statistically significant in all cases both by subjects and items.

In Experiment 2, the study replicated for this dissertation, the authors asked whether the same results would emerge when the participants are tested in groups using a silent pronunciation task and when scoring their own responses. The stimuli for Experiment 2 were the same as for Experiment 1, but the participants were asked to silently pronounce a nonword and then choose whether their pronunciation was more similar to one of two given real English words that the examiner read aloud (the participants did not see the real word choices). For example, when presented with the nonword *squant*, the participants were asked whether they pronounced the nonword more similarly to *font* or to *rant.* The critical pronunciation here is /a/, conditioned by the preceding letter *u*. Participants were also given the option of responding that their pronunciation was similar to neither of the given real English words.

The results followed the same general patterns of Experiment 1, although the group testing with self-scoring proved less reliable. Part of that loss of reliability had to do with the “neither” choice option and whether the real word options shared a CV or VC segment with the nonword presented, suggesting that participants found it more difficult to make judgments involving a single vowel than judgments involving more than one phoneme. This result echoes the conclusion of Wylie and Durrell (1970) which showed that first-graders could more easily identify a vowel when it was paired with a coda than when it was alone. Despite these issues, Experiment 2 yielded the same pattern of results as Experiment 1, and group testing with self-scoring was deemed by the original authors to produce credible data.

Data Collection: Fall 2008

For the present study, we modified the original study. First, the data from the participants were sorted into three groups: native English speakers, Arabic speakers, and speakers of other language backgrounds. We also added an auditory discrimination task to rule out pronunciation judgments being made without the necessary grasp of the sound-symbol correspondences for the vowels in question. We also included a participant questionnaire and a Likert confidence rating for the silent pronunciation task. The reading portion of the WRAT-3 was administered individually to collect data that would correlate sensitivity to consonantal context with reading proficiency. The consent script appears in Appendix A.

The study had to be conducted twice because there were problems with the first set of data that was collected in the fall of 2009 for the silent pronunciation task. Adjustments to the silent pronunciation task were made to correct for the problems, and the study was re-conducted in the spring of 2010.

Questionnaire. We created the participant Questionnaire to collect relevant data about our participants. The questionnaire asked participants' gender, age, and native language. It also asked whether participants have any speech, language, hearing, or neurological disorders (so that data from these participants could be excluded), and whether they are taking any medications that may affect their motor skills. We also asked what other languages they know and how well they know them (they circled basic, conversational, or fluent knowledge for up to three languages). If English was not their first language, we asked where and how long they had studied English. The final question asked what they thought was being tested in the Silent Pronunciation Task. The questionnaire appears in Appendix B.

Likert Confidence Rating. Participants were asked to rate their confidence in their responses to the Silent Pronunciation Task using a 6-point Likert-like scale with 1 being least confident, and 6 being most confident. Answers 1-2 are recorded as not confident, answers 5-6 are recorded as confident, and the middle numbers 3-4 are recorded as neutral.

WRAT-3. The Blue Reading Word List of the WRAT-3 was administered individually to collect data that could be used to correlate sensitivity to consonantal context with reading proficiency. Forty-two words appear on the Blue Reading Word List. The test administrator asks the participant to read the words aloud as the administrator points to each word, allowing 10 seconds for the participant to respond. The words increase in difficulty as the test progresses. According to the Administration Manual, the WRAT-3 Reading Word List is meant to be a measure of word decoding that eliminates the "the contaminating effects of comprehension" (Wilkinson, 1993, p. 10). The test is discontinued after 10 consecutive incorrect responses. One point is given for each correctly pronounced word. The raw score correlates with educational level (K-12 grade, and post high school) and age to indicate the instructional level of the participant.

Auditory Discrimination Task. Since we expanded the participant pool for the Silent Pronunciation Task to non-native speakers of English, it was important to establish that the participants could distinguish the vowel phonemes in question and had them in their phonological inventory. We constructed an auditory discrimination task based on minimal pairs of the target vowels in the Silent Pronunciation Task.

Participants were given an auditory discrimination task to ensure that the vowel contrasts that were tested in the silent pronunciation task are part of their L2 [English] phonological systems. There are eight vowel contrasts in the silent pronunciation task stimuli: a/æ, or/ar, e/æ, ɔ/æ, ɛ/ɪ, ai/ɪ, o/a, and ʊ/u.

If the auditory discrimination task confirms that these vowel contrasts are in the participants' L2 phonological systems, we can rule out the possibility that choices are made with a lack of discrimination ability. Thus we can be more confident that participants' choices on the forced-choice task reflect their sensitivity to consonantal context.

Participants heard a recording by a male native southern speaker of English. They were told that they would hear a pair of words, and that they should circle the word "same" or "different" for each pair according to whether they thought they heard the same or different English words.

The stimuli for the auditory discrimination task were minimal pairs (two for each vowel contrast) for the vowel contrasts of interest. The stimuli appear in Table 3.

Table 3

Stimuli for the auditory discrimination task

Vowel contrast	**Minimal pair 1**	**Minimal pair 2**
a/æ	hot/hat	mop/map
or/ar	tore/tar	bore/bar
e/æ	cape/cap	fate/fat
ɔ/æ	bought/bat	sought/sat
ɛ/i	head/heed	check/cheek
ai/ɪ	pile/pill	light/lit
o/a	hope/hop	cone/con
ʊ/u	look/Luke	soot/suit

A recording was made of a native-speaker of English saying the minimal pairs two times each. The resulting set of stimuli contained two tokens for each word. The reason for having two different tokens for each word is so that participants don't listen for the exact same auditory stimulus to give a 'same' response. Having two tokens forces them to make the judgment on the basis of more abstract phonological information. The sound files were then arranged in random order and burned on a CD for use in the task. Participants had to score 90% correct (i.e., they could miss up to 3 questions) to "pass" the task.

The results for the auditory discrimination task in fall 2008 indicate that the participants did indeed have the vowel phonemes in question in their phonological inventories. Of the 67 non-native speakers tested in fall 2008, 60 participated in the auditory discrimination task. Of those 60, 52 passed (86%), and 8 did not pass (14%). Seven non-native speakers did not participate (were in native-speaking English class in which the task was not administered, or arrived late to class and missed the task). The auditory discrimination task was not administered to native speakers of English, since we assume that they have all the phonemes of English in their phonological inventory. The few non-native speakers of English in the “native-speaker classes” that were tested did not participate in the task.

Because of the success of the auditory discrimination task in the fall 2008 collection of data, no changes were made to the task in the spring of 2009, and native English speakers were also tested so that non-native speakers in those classes would be tested. Of the 108 participants in spring 2009, 4 did not participate in the auditory discrimination task (were late to class). Of the remaining 104 participants (including native English speakers), 96 passed (92% pass rate). All of the 8 participants who failed the auditory discrimination task were non-native speakers. Excluding native-speakers of English, the pass rate for non-native speakers for the auditory discrimination task was 90%. So again, we can be confident that any difficulties in the silent pronunciation task are not due to gaps in the participants’ L2 phonological inventories.

Nonword Silent Pronunciation Task, Fall 2008. ***Stimuli*****.** Following Experiment 2 in Trieman et al. (2003), we used 10 pairs of experimental and control nonwords for each of the 8 cases (although onset-to-vowel Case 1 had only 9 pairs due to an error found in the Trieman et al.’s original study). The nonwords testing onset-to-vowel associations were alike in the coda and differed only in the initial portion. The nonword testing vowel-to-coda associations were alike in the onset and vowel portions and differed only in the final portion. Both the pronunciations with the critical vowel and the typical vowel were phonologically legal in English. All of the nonwords were orthographically legal in English. For each pair of experimental and control nonwords, two real English words were selected, one with the critical vowel pronunciation and the other with the typical vowel pronunciation. In the onset-to-vowel cases, the real-word choices and the nonwords shared a coda. So the listener's task was to choose the real word that sounded more similar to (rhymed with) their silent pronunciation of the nonword displayed. For most of the vowel-to-coda cases, the real-word choices shared the nonword's onset. It was not always possible, however, to find real-word pairs that shared that nonword's onset. For most pairs, the vowel grapheme in the real word with the typical pronunciation was the same as the one in the nonword, but different from the vowel grapheme in the real word with the critical pronunciation. Therefore, any tendency to choose a real word that is orthographically similar to the nonword would lead to a low rate of critical vowel choices.

Additionally, there were 20 filler nonwords, each with two real-word choices. The experimental items, control items, and fillers were randomly intermixed with the constraint that no more than two consecutive items involved the same case to produce a prepared sequence of stimuli for presentation. There were also four practice items using real words instead of nonwords.

Procedure. The participants were tested in groups during their regularly scheduled class periods. They were told they would see a series of nonwords projected on a screen at the front of the classroom (a power point presentation of stimuli). The participants were told to pretend that the nonwords presented were English words and to pronounce each word silently to themselves as if it were an English word. Then the experimenter read aloud the two real word choices in a previously determined random order. Participants were told to circle A on the answer sheet if their pronunciation sounded more like the first word they heard, to circle B if their pronunciation sounded more like the second word they heard, or circle "neither" on their answer sheet if their pronunciation didn't sound like either of the real-word choices that they heard. For the practice items, the examiner explained which response was correct. No feedback was given during the rest of the experiment. There was a rest break halfway through the silent pronunciation task. The task took about 30 minutes to complete.

Participants. Students at a southeastern community college were tested during their regular class periods and offered extra credit for participation. Ninety-nine students were tested in eight classes: 5 sections of Developmental Reading (3 ESL sections), 2 sections of Developmental Writing, and 1 section of English Composition.

Fifteen of the participants were Arabic speakers (11 Egyptian Arabic, 3 Iraqi, 1 Jordanian). Thirty-two of the participants were native English speakers. Fifty-two of the participants were from other language backgrounds (Amharic-10, Bengali-1, Chinese-1, Dari-1, Dinka-1, Farsi-7, Hindi-3, Ikwerre-1, Indonesian-1, Khmer-1, Krio-1, Kurdish-6, Laos-1, Laotian-1, Nepali-1, Portuguese-2, Pushto-1, Russian-1, Somali-4, Spanish-2, Tigrigna-1, Vietnamese-4).

Preliminary Results. There were not enough participants who passed the filler filter to conduct an analysis of the onset-vowel and vowel-coda associations. Of the 15 Arabic speakers, only one passed the filler filter (6.6%), and that speaker also self-identified his native language as both Arabic and Kurdish. None of the Egyptian

Arabic speakers passed the filler filter. Of the 32 native English speakers, only 4 passed the filler filter (12.5%). Of the 52 speakers from other language backgrounds, only 5 passed the filler filter (9.6%). The problem appeared to be the "neither" response option. So we decided to eliminate the "neither" choice option and to re-conduct the study as a true forced-choice task.

When consulted about the issue with the neither choice option, the lead author of the original study, Rebecca Treiman, concurred that the task could be reconstructed as a true forced-choice task since less than 3% of responses in Experiment 1 in Treiman et al. (2003) contained a vowel pronunciation that was neither the critical nor the typical vowel pronunciation, and only 6% in Experiment 2, which is still low (personal communication, 03/16/09). She also suggested that the filler choices share more than one phoneme with the nonword stimuli, since this accounted for some participants' relatively poor performance on filler items that only shared a single phoneme (the vowel) in the original study.

Data Collection: Spring 2009

Questionnaire. There were no changes made to the questionnaire.

Likert confidence rating. There were no changes made to the Likert confidence rating.

WRAT-3. There were no changes made to the WRAT-3.

Auditory Discrimination Task. Because of the success of the auditory discrimination task in the fall 2008 collection of data, no changes were made to the task in the spring of 2009, and native English speakers were also tested so that non-native speakers in those classes would be tested.

Nonword Silent Pronunciation Task, Spring 2009: second attempt at the task. ***Stimuli.*** The stimuli for the nonword silent pronunciation task conducted in spring 2009 were the same except for the changes made to the fillers. We made changes to some of the filler choices, since the authors in Treiman et al (2003) reported that their data suggest that participants found it harder to make judgments when the choices involved only a shared vowel, and not a vowel and another shared phoneme. They concluded that the nature of the choices for the filler items seemed to contribute to participants' poor performance on these items. In addition, when consulted, Rebecca Treiman suggested that the fillers be changed so that they shared more than one phoneme with the real word choices (personal communication, 03/16/09). Therefore, we changed some of the filler choices to share more than one phoneme with the correct response. There were a couple of errors found with the stimuli after the study was conducted. One experimental stimulus for Case 1 for consonant-vowel associations was repeated (*shange*), making the count of stimulus items for this group 11 instead of 10. At the same time, one experimental stimulus for Case 1 for onset-to-vowel associations was inadvertently omitted (*wabs*), making the count of stimulus items for this group 8 instead of 9.

The nonword, real-word, filler, and practice stimuli are in Appendix B.

Procedure. The participants were tested in seven groups during their regularly scheduled class periods as described above. The change from the previous data collection was that the task was a true-forced choice task. Students had to circle A or B on their answer sheet to indicate whether their silent pronunciation of the nonword stimulus sounded more like the first (A) or second (B) of two real English words they heard spoken aloud by the researcher.

Participants. Students at the same southeastern community college were tested during their regular class periods and offered extra credit for participation. One hundred eight students were tested in seven classes: 5 sections of Developmental Writing (all ESL sections), and 2 sections of English Composition.

Twenty of the participants were Arabic speakers (15 Egyptian Arabic, 2 Sudanese Arabic, 1 Afghani Arabic, 1 Jordanian Arabic, 1 Saudi Arabic). Twenty-five of the participants were native English speakers. Sixty-three of the participants were from other language backgrounds (Amharic-11, Bisaya-1, Chinese-1, Farsi-6, French-3, Ghana language-1, Gujarati-2, Hindi-1, Igbo-1, Ikwere-1, Korean-1, Kurdish-12, Lao-1, Madengo-1, Oromo-1, Somali-6, Spanish-4, Tagalog-1, Tigrina-1, Urdu-1, Vietnamese-4, Yoruba-2).

Results. The results for the data collected in spring 2009 will be discussed in the following chapter on data analysis.

CHAPTER 4: DATA ANALYSIS AND DISCUSSION

The following data analysis is for the data collected in the spring of 2009. The data collected in the fall of 2008 is not included here due to the problems with the data from the silent pronunciation task.

Questionnaire

We divided the questionnaire information according to the three groups under consideration: Arabic (20), English (25), and Other Language Background (63). We further subdivided the information according to who passed or failed the filler filter on the silent pronunciation task. The average number of years of English study for all non-native speakers who passed the filler filter was 9.6 years and 9.3 years for those who failed the filler filter; so it does not appear that length of study was a contributing factor on the performance of the silent pronunciation task.

Arabic group (20 total participants). For the Arabic group, 12 were male and 8 were female. Nine participants were age 18-19, 7 were age 20-24, 3 were age 25-34, and 1 was age 35-44. Fifteen were speakers of Egyptian Arabic, and 5 were speakers of Arabic from other countries: Jordan (1), Saudi Arabia (2), and Sudan (2). Knowledge of other languages included Chinese (1), French (2), and Spanish (2). The average number of years of English study reported for all 20 Arabic participants was 9.8 (5.5 abroad; 4.3 in US). Of those who passed the filler filter, the average number of years of English study was 10.1 (6.8 abroad; 3.3 in US), and 9.6 (4.9 abroad; 4.7 in US) for those who failed the filler filter.

Native English group (25 total participants). For the native English-speaking group, 8 were male and 17 female. There were 6 participants age 18-19, 9 age 20-24, 5 age 25-34, 2 age 35-44, and 3 age 45-54. Knowledge of other languages reported included Spanish (7) and Igbo (1); no knowledge of a foreign language was reported for those who failed the filler filter (6).

Other Language Background group (63 total participants). For the speakers from other language backgrounds, 21 were male and 42 female. There were 7 participants age 18-19, 29 age 20-24, 22 age 25-34, 7 age 35-44, and 1 age 45-54. Native languages reported were Amharic (20), Bisaya (1), Chinese (1), Farsi (8), French (4), Ghana language (1), Gujarati (3), Hindi (1), Igbo (2), Ikwere (1), Korean (1), Kurdish (18), Lao (1), Madengo (2), Oromo (1), Somali (8), Spanish (7), Tagalog (1), Tigrina (2), Urdu (1), Vietnamese (4), Yoruba (3).

Participants reported knowledge of languages other than the native language: Amharic (2), Arabic (11), Farsi (1), French (3), German (2), Hindi (1), Kaffana (1), Malaysian language (1), Oromifa (1), Russian (1), Spanish (4), Swahili (3), Tagalog (1), Tigrigna (2), Turkish (1).

The average number of years of English study was 9.4 (5.8 abroad; 3.9 in US) for those who passed the filler filter, and 9.1 (6.2 abroad; 2.9 in US) for those who failed the filler filter. Again, length of English study does not seem to have an impact on performance on the silent pronunciation task.

Likert Confidence Rating

The Likert confidence rating was added to the silent pronunciation task to see if the participants' self-assessment of their performance on the silent pronunciation task matched their actual performance. The scale runs from 1-6, and 1-3 was counted as a low confidence rating, and 4-6 was counted as a high confidence rating. Of the 109 participants, 49 failed the filler filter, indicating that they did not have the skills necessary to perform well on the task, and 59 participants passed the filler filter. Of those who failed the filler filter, 82% gave themselves a high confidence rating (in contrast with their actual performance). Of those who passed the filler filter, 75% gave themselves a high confidence rating (a lower percentage than those who failed the filler filter). Given these results, it would appear that the Likert confidence rating does not add any reliable data to this study.

WRAT-3

One of our research questions was whether sensitivity to consonantal context correlated with reading proficiency. Treiman et al. (2006) had shown that sensitivity to consonantal context correlates with reading proficiency for native English speaking children using the WRAT-3 as the measure of reading proficiency. We had hoped to use the WRAT-3 as well as a measure of reading proficiency, but ran into several difficulties. One is that we were unable to collect the WRAT-3 data for all of the participants who participated in the Silent Pronunciation Task, since the WRAT-3 must be collected individually, and the Silent Pronunciation Task was administered in classroom groups. Some participants were pulled out of class to be tested for the WRAT-3, but there were problems with distractions in the testing environment.

We only have 21 complete WRAT-3 tests: 9 for those who failed the filler filter on the silent pronunciation task, and 12 for those who passed the filler filter. Of the 9 who failed the filler filter, the WRAT-3 reading levels were 5th grade (1), 6th grade (1), 7th grade (1), high school level (5), and post-high school level (1). Of the 12 who passed the filler filter, the WRAT-3 reading levels were 8th grade (1), high school level (5), and post-high school level (6). Recall that the WRAT-3 was not administered to any native English-speaking participants. While it is suggestive that the WRAT-3 reading levels in general are lower for those who failed the filler filter on the silent pronunciation task, we do not have enough data to draw any conclusions.

Auditory Discrimination Task

Of the 108 participants in spring 2009, 4 did not participate in the auditory discrimination task (were late to class). Of the remaining 104 participants (including native English speakers), 96 passed (92% pass rate). All of the 8 participants who failed the auditory discrimination task were non-native speakers. Excluding native-speakers of English, the pass rate for non-native speakers for the auditory discrimination task was 90%. Those who failed the auditory discrimination task were excluded from later analyses, so we can be confident that any difficulties in the silent pronunciation task are not due to gaps in the participants' L2 phonological inventories.

One interesting result is that of those who failed the auditory discrimination task (which was largely successful), most were from native speakers of Amharic (a major language of Ethiopia).

Silent Pronunciation Task, Spring 2009

The Filler Filter. With the change to a forced-choice task, 59 of the 108 total participants passed the filler filter (55%). Recall that the filler filter was included in the original study to ensure that native speakers understood and were paying attention to the task (72% of the participants in Experiment 2 of the original study passed the filler filter). Of the 20 Arabic speakers, 6 (5 Egyptian, 1 Saudi) passed the filler filter

(30%). Of the 25 native English speakers, 19 passed the filler filter (76%). Of the 63 speakers from other language backgrounds, 34 passed the filler filter (54%). However, 4 of those had to be excluded from the analysis of onset-vowel and vowel-coda associations because they did not pass the auditory discrimination task.

The filler filter was included in the original study to ensure that native speakers understood and were paying attention to the task. Of the participants in Experiment 2 of the original study, 72% passed the filler filter. With the change to a forced-choice task, 55% of the total participants passed the filler filter. But when we break that number down, we see that 76% of the native English speakers in the present study passed the filler filter (better pass rate than the original study), 54% of the non-native speakers from other language backgrounds passed the filler filter, and only 30% of the Arabic speakers passed the filler filter. We attribute the higher pass rate for native English speakers in relation to the original study to the changes made to the filler choices themselves, so that the filler choices and filler nonwords shared more than one phoneme, and yet four percentage points is not a marked difference.

Given these results, the question arises as to why a smaller percentage of the Arabic speakers passed the filler filter than the non-native speakers from other language backgrounds. Perhaps the Arabic speakers have a level of orthographic knowledge below which sensitivity to consonantal context might come into play.

An example of a filler item is the auditory pair *ripe/rip* for the nonword *bripe* that is displayed. For a native English speaker, the VCe pattern will yield a “long i” sound, /i/ that has nothing to do with sensitivity to consonantal context (although it does have to do with recognizing the common VCe spelling pattern). Five of the 20 fillers use the VCe spelling pattern to yield a “long” vowel sound (*bripe, fope, sprake, troke, vake*). Similarly, the other fillers should produce a clear “long” (*reet*) or “short” (*blut, feg, glitch, yud, borf, spleck, shig, snet, delp, zung, lish, thruff*) vowel sound or diphthong (*poin, roich*) according to the orthographic rules of English. These orthographic rules of English are acquired by native speakers in clear developmental stages (Bear et al., 2007; Ehri, 1997).

The five major spelling stages are emergent, letter name-alphabetic, within-word pattern, syllables and affixes, and derivational relations. In the emergent stage, learners acquire the letter shapes and begin to learn the alphabet. In the letter name-alphabetic stage, the features that are acquired are the initial and final consonants, short vowels, and digraphs and blends. The within-word pattern stage features are the long-vowel patterns and other vowel patterns. The syllables and affixes stage includes syllable junctures (consonant doubling rule), easy prefixes and suffixes (*-ing, -ed*), harder prefixes and suffixes, and unaccented final syllables *(-ure, -ate, -ent, -ize*). The derivational relations stage includes reduced and altered vowels, bases, roots, and derivatives.

According to Bear et al. (2004), about one quarter of adult native English speakers are stuck in the third stage of orthographic development: the middle within-word pattern stage. This is the stage where the long vowel patterns are acquired, and this is the stage most relevant to our current investigation of consonantal context.

It is beyond the scope of this dissertation to delve deeply into the historical origins of why English vowel patterns are so problematic, but we need to mention the Great Vowel Shift, and the fact that the relationship between “long” and “short” vowels in English currently has no phonetic relation. At one time, the relation between long and short vowels had a phonetic relation, as the vowel systems of the continental European languages still have. The Great Vowel Shift (c. 1450-1750) broke that relationship, but the English spelling system preserves the history of that relationship.

When native English-speaking children learn English, their “mistakes” reveal their desire to reinstate that phonetic relationship between long and short vowels, and they must learn that although long vowels may use the same vowel letters as the short vowels (as in the VCe pattern), the sounds are not related. The pairing of sound to symbol for long and short vowels is complex in English. We attribute the poor performance by the Arabic speakers on the filler filter to a lack of knowledge of phoneme-grapheme correspondence rules in English rather than to inattentiveness to the task.

Onset-vowel Associations. *Native English speakers.*Table 4 presents the results for onset-to-vowel associations from the original study conducted by Treiman, Kessler, and Bick (2003). The mean proportion of critical vowel pronunciations was greater for experimental nonwords than for control nonwords for both Case 1 and Case 2. At an alpha level of < 0.05, the results for both Cases 1 and 2 were statistically significant both by subjects and by items. The statistically significant P values are in bold.

Table 4

Onset-vowel associations in Treiman, Kessler, & Bick (2003) (n = 32)

	Case 1: *a*	Case 2: *ar*
Mean (*SD*) proportion of critical vowel pronunciations, experimental nonwords	0.55 (0.22)	0.15 (0.19)
Mean (*SD*) proportion of critical vowel pronunciations, control nonwords	0.03 (0.06)	0.03 (0.05)
P value for difference, one-tailed t-test by subjects	**< 0.001**	**0.002**
P value for difference, one-tailed t-test by items	**< 0.001**	**< 0.001**

Source: Treiman, R., Kessler, B., & Bick, S. (2003) Influence of consonantal context on the pronunciation of vowels: A comparison of human readers and computational models. *Cognition, 88*, p. 59

Table 5 presents the onset-to-vowel associations for native English speakers for the data collected in spring 2009. Similar to the data from Treiman, Kessler, and Bick (2003), the mean proportion of critical vowel pronunciations is greater for experimental nonwords than for control nonwords for both Case 1 and Case 2. The results for Case 1 and Case 2 are statistically significant both by subjects and by items. Comparing the data from the original study to our own data for native English speakers, we have a more robust finding for Case 2 for mean proportion of critical vowel pronunciations for experimental nonwords than in the original study. Overall we are more confident of our results for non-native speakers that follow given the comparison of our results for native speakers with those of Treiman et al. (2003).

Table 5

Onset-vowel associations for native English speakers (n = 19; df = 36)

	Case 1: *a*	Case 2: *ar*
Mean (*SD*) proportion of critical vowel pronunciations, experimental nonwords	0.48 (0.23)	0.36 (0.23)
Mean (*SD*) proportion of critical vowel pronunciations, control nonwords	0.15 (0.14)	0.12 (0.13)
P value for difference, one-tailed t-test by subjects	**<0.001**	**<0.001**
P value for difference, one-tailed t-test by items	**0.0016**	**<0.001**

Speakers from Other Language Backgrounds. Table 6 contains the onset-to-vowel associations for speakers from other language backgrounds. Similar to the native speaker data, the mean proportion of critical vowel pronunciations is greater for experimental nonwords than for control nonwords for both Case 1 and Case 2, although the results are not as robust for the non-native speakers (excluding Arabic speakers) as they are for the native English speakers. The results for Case 1 and Case 2 are statistically significant both by subjects and by items. These results indicate that non-native speakers are sensitive to consonantal context when reading English vowels.

Table 6

Onset-vowel associations for non-native speakers (n = 30; df = 58)

	Case 1: *a*	Case 2: *ar*
Mean (*SD*) proportion of critical vowel pronunciations, experimental nonwords	0.45 (0.19)	0.27 (0.18)
Mean (*SD*) proportion of critical vowel pronunciations, control nonwords	0.26 (0.19)	0.15 (0.13)
P value for difference, one-tailed t-test by subjects	**<0.001**	**0.0021**
P value for difference, one-tailed t-test by items	**<0.001**	**<0.001**

Arabic speakers. Table 7 presents the data for Arabic speakers (5 Egyptian and 1 Saudi). The mean proportion of critical vowel pronunciations is greater for experimental nonwords than for control nonwords for both Case 1 and Case 2, although not as much as for native English speakers. The results for Case 1 are statistically significant, but the results for Case 2 are not statistically significant either by subjects or by items, likely due to the small sample size. These results suggest that Arabic speakers do show sensitivity to consonantal context for onset-to-vowel associations, although the fact that the mean proportion of critical vowel pronunciations for both experimental and control nonwords are almost equal in Case 2 do lead to some doubt of that conclusion.

Table 7

Onset-vowel associations for Arabic speakers (n = 6; df = 10)

	Case 1: *a*	Case 2: *ar*
Mean (*SD*) proportion of critical vowel pronunciations, experimental nonwords	0.44 (0.17)	0.18 (0.13)
Mean (*SD*) proportion of critical vowel pronunciations, control nonwords	0.24 (0.13)	0.17 (0.16)
P value for difference, one-tailed t-test by subjects	**0.0257**	0.4252
P value for difference, one-tailed t-test by items	**0.0355**	0.4524

We also ran the statistics to include only speakers of Egyptian Arabic (n = 5). It is possible that we can only draw conclusions about speakers of a particular dialect of Arabic instead of drawing conclusions that can be made of Arabic speakers in general. Table 8 presents the results for onset-to-vowel associations for speakers of Egyptian Arabic only. However, there is little difference in the results once the data for the Saudi speaker is removed, although we lose statistical significance for Case 1 in the high *P* value for the by subjects analysis.

Table 8

Onset-vowel associations for Egyptian Arabic speakers (n = 5; df = 8)

	Case 1: *a*	Case 2: *ar*
Mean (*SD*) proportion of critical vowel pronunciations, experimental nonwords	0.4 (0.16)	0.18 (0.15)
Mean (*SD*) proportion of critical vowel pronunciations, control nonwords	0.2 (0.09)	0.14 (0.17)
P value for difference, one-tailed t-test by subjects	0.261	0.3499
P value for difference, one-tailed t-test by items	**0.0113**	0.2676

Although we are limited by the small size of the sample, these results indicate that Egyptian Arabic speakers do show some sensitivity to consonantal context for onset-to-vowel associations.

Vowel-Coda Associations. Tables 9-13 present the results for vowel-coda associations for all groups. For vowel-to-coda associations, participants in Treiman et al. (2003) produced more critical pronunciations of the target vowel for the experimental stimuli than for the control stimuli for all 6 cases tested, and the difference was statistically significant by both subjects and items. The authors concluded that adults' pronunciations of vowels in nonwords are affected by both the onset and the coda; that is, they show sensitivity to consonantal context.

In our data for vowel-to-coda associations, native English speakers demonstrate sensitivity to consonantal context similar to Treiman et al. (2003) that is statistically significant both by subjects and by items for cases 1, 2, 4, and 5 (Tables 9-10). The cases in our native speaker data that require comment are cases 3 and 6.

Recall that for Case 3 (the vowel letters *ea* followed by the consonant *d* for the experimental context, and followed by *b*, *l*, *m*, *n*, or *p* in the control context), the critical pronunciation /ɛ/ occurs in 69% of monosyllabic American English words (Kessler & Treiman, 2001), and the typical pronunciation /i/ may also occur in the experimental context. It appears that our participants are not as sensitive to consonantal context for this case as the participants in the original study, however, given that the typical pronunciation may occur in the experimental context for real English words, the lack of statistical significance for this case is not surprising.

For Case 6 (the vowel letters *oo* followed by the consonant *k* in the experimental context, and followed by *m*, *n*, or *p*), the typical pronunciation of the vowel is possible in the experimental context in real English words (cf. *spook* and *kook*). Although the results for native English speaking participants in Case 6 did not reach statistical significance, the results were stronger than in Case 3, along the lines of the stronger vowel-coda association for *oo* followed by *k* (Case 6) than for *ea* followed by *d* (Case 3).

For both Case 3 and Case 6, the mean proportion of critical vowel pronunciations for experimental nonwords was greater than the mean proportion of critical vowel pronunciations for control nonwords, even though the results did not achieve statistical significance. The native English speakers in this study did show sensitivity to consonantal context for all 8 cases (2 onset-to-vowel and 6 vowel-to-coda cases), reaching statistical significance for 6 cases (both onset-to-vowel cases, and 4 vowel-to-coda cases).

Although the mean proportion of critical vowel pronunciations for experimental nonwords is not as high as it is for native English speakers, the results for speakers from other language backgrounds (Table 11) follow a trend toward sensitivity to consonantal context, although statistical significance was reached only for Cases 2, 5, and 6. It is interesting that statistical significance was achieved for non-native speakers in Case 6 when it did not for Case 6 for native English speakers, although this could be due to the possibility that native English speakers are more likely to be familiar with real English words such as *spook* that contain the typical pronunciation in the experimental context. For all six vowel-to-coda cases, the mean proportion of critical vowel pronunciations for experimental nonwords was greater than the mean proportion of critical vowel pronunciations for control nonwords.

The anomaly again is the Arabic group (Tables 12-13), for which there is no statistically significant difference between the experimental and control conditions. In fact, the mean proportion of critical vowel pronunciations for experimental nonwords for Egyptian Arabic speakers is less than the mean proportion of critical vowel pronunciations for control nonwords for vowel-to-coda associations in Cases 1- 3. These results indicate that the Arabic speakers do not show sensitivity to consonantal context for vowel-to-coda associations, and actually demonstrate what might be called an anti-sensitivity to consonantal context for certain vowel-coda associations, since their results run opposite what might be expected given the statistical present associations in the English language itself.

Table 13 shows the results for the Egyptian Arabic speakers only. There is little difference from the results for the Arabic speakers. The fact that Arabic speakers show some sensitivity to consonantal context for onset-to-vowel associations, but not for vowel-to-coda associations may be due to the special prominence of the rime in English that is lacking in Arabic.

Table 9

Vowel-coda associations in Treiman, Kessler, & Bick (2003) (n = 32)

	Case 1: a	Case 2: a	Case 3: ea	Case 4: i	Case 5: o	Case 6: oo
Mean (*SD*) proportion of critical vowel pronunciations, experimental nonwords	0.57 (0.24)	0.80 (0.23)	0.25 (0.28)	0.48 (0.30)	0.87 (0.16)	0.38 (0.32)
Mean (*SD*) proportion of critical vowel pronunciations, control nonwords	0.17 (0.20)	0.16 (0.19)	0.09 (0.13)	0.07 (0.16)	0.11 (0.13)	0.05 (0.10)
P value for difference, one-tailed t-test by subjects	**< 0.001**	**< 0.001**	**0.002**	**< 0.001**	**< 0.001**	**< 0.001**
P value for difference, one-tailed t-test by items	**< 0.001**	**< 0.001**	**0.001**	**< 0.001**	**< 0.001**	**< 0.001**

Source: Treiman, R., Kessler, B., & Bick, S. (2003) Influence of consonantal context on the pronunciation of vowels: A comparison of human readers and computational models. *Cognition, 88*, p. 60

Table 10

Vowel-coda associations for native English speakers (n = 19; df = 36)

	Case 1: a	Case 2: a	Case 3: ea	Case 4: i	Case 5: o	Case 6: oo
Mean (*SD*) proportion of critical vowel pronunciations, experimental nonwords	0.61 (0.18)	0.75 (0.17)	0.21 (0.15)	0.61 (0.21)	0.69 (0.19)	0.16 (0.16)
Mean (*SD*) proportion of critical vowel pronunciations, control nonwords	0.43 (0.24)	0.45 (0.25)	0.20 (0.15)	0.37 (0.20)	0.33 (0.17)	0.11 (0.10)
P value for difference, one-tailed t-test by subjects	**0.0056**	< **0.001**	0.4543	< **0.001**	< **0.001**	0.0909
P value for difference, one-tailed t-test by items	**0.0056**	< **0.001**	0.4082	**0.0019**	< **0.001**	0.0982

Table 11

Vowel-coda associations for non-native speakers (n = 30; df = 58)

	Case 1: a	Case 2: a	Case 3: ea	Case 4: i	Case 5: o	Case 6: oo
Mean (*SD*) proportion of critical vowel pronunciations, experimental nonwords	0.49 (0.22)	0.57 (0.26)	0.25 (0.22)	0.59 (0.24)	0.60 (0.20)	0.26 (0.23)
Mean (*SD*) proportion of critical vowel pronunciations, control nonwords	0.44 (0.22)	0.44 (0.22)	0.23 (0.16)	0.49 (0.24)	0.40 (0.18)	0.16 (0.14)
P value for difference, one-tailed t-test by subjects	0.2026	**0.0277**	0.3220	0.0627	< **0.001**	**0.0208**
P value for difference, one-tailed t-test by items	0.2522	**<0.001**	0.3707	**0.0043**	**0.0017**	**<0.001**

Table 12

Vowel-coda associations for Arabic speakers (n = 6; df = 10)

	Case 1: a	Case 2: a	Case 3: ea	Case 4: i	Case 5: o	Case 6: oo
Mean (*SD*) proportion of critical vowel pronunciations, experimental nonwords	0.37 (0.12)	0.33 (0.19)	0.28 (0.25)	0.52 (0.33)	0.55 (0.14)	0.25 (0.19)
Mean (*SD*) proportion of critical vowel pronunciations, control nonwords	0.35 (0.14)	0.45 (0.22)	0.33 (0.25)	0.43 (0.23)	0.48 (0.16)	0.18 (0.10)
P value for difference, one-tailed t-test by subjects	0.4142	*	*	0.3133	0.2290	0.2316
P value for difference, one-tailed t-test by items	*	*	*	0.3352	0.3311	0.3830

**P* value not calculated; descriptive statistics were opposite the hypothesized pattern, and we can read these as not significant for the pattern predicted.

Table 13

Vowel-coda associations for Egyptian Arabic speakers (n = 5; df = 8)

	Case 1: a	Case 2: a	Case 3: ea	Case 4: i	Case 5: o	Case 6: oo
Mean (*SD*) proportion of critical vowel pronunciations, experimental nonwords	0.34 (0.11)	0.32 (0.20)	0.28 (0.28)	0.52 (0.37)	0.58 (0.13)	0.18 (0.08)
Mean (*SD*) proportion of critical vowel pronunciations, control nonwords	0.36 (0.15)	0.40 (0.20)	0.36 (0.27)	0.40 (0.24)	0.50 (0.17)	0.18 (0.11)
P value for difference, one-tailed t-test by subjects	*	*	*	0.2824	0.2175	0.5000
P value for difference, one-tailed t-test by items	*	*	*	0.1806	0.2658	0.3151

* *P* value not calculated; descriptive statistics were opposite the hypothesized pattern, and we can read these as not significant for the pattern predicted.

For vowel-to-coda associations, participants in Treiman et al. (2003) produced more critical pronunciations of the target vowel for the experimental stimuli than for the control stimuli for all 6 cases tested, and the difference was statistically significant by both subjects and items. The authors concluded that adults' pronunciations of vowels in nonwords are affected by both the onset and the coda; that is, they show sensitivity to consonantal context.

In our data for vowel-to-coda associations, native English speakers demonstrate sensitivity to consonantal context similar to Treiman et al.(2003) that is statistically significant both by subjects and by items for cases 2, 4, and 5 (Table 2). The p value for Case 1 for native speakers neared statistical significance (0.0056 by both subjects and items). The cases in out native speaker data that require comment are cases 3 and 6.

Recall that for Case 3 (the vowel letters *ea* followed by the consonant *d* for the experimental context, and followed by *b, l, m, n,* or *p* in the control context), the critical pronunciation /ɛ/ occurs in 69% of monosyllabic American English words (Kessler & Treiman, 2001), and the typical pronunciation /i/ may also occur in the experimental context. It appears that our participants are not as sensitive to consonantal context for this case as the participants in the original study, however, given that the typical pronunciation may occur in the experimental context for real English words, the lack of statistical significance for this case is not surprising.

For Case 6 (the vowel letters *oo* followed by the consonant *k* in the experimental context, and followed by *m*, *n*, or *p*), the typical pronunciation of the vowel is possible in the experimental context in real English words (cf. *spook* and *kook*). Although the results for native English speaking participants in this case did not reach statistical significance, the results were stronger than in Case 3, along the lines of the stronger vowel-coda association for *oo* followed by *k* (Case 6) than for *ea* followed by *d* (Case 3).

For both Case 3 and Case 6, the mean proportion of critical vowel pronunciations for experimental nonwords was greater than the mean proportion of critical vowel pronunciations for control nonwords, even though the results did not achieve statistical significance. The native English speakers in this study did show sensitivity to consonantal context for all 8 cases (2 onset-to-vowel and 6 vowel-to-coda cases), reaching statistical significance for 5 cases (both onset-to-vowel cases, and 3 vowel-to-coda cases).

Although the mean proportion of critical vowel pronunciations for experimental nonwords is not as high as it is for native English speakers, the results for speakers from other language backgrounds follow a trend toward sensitivity to consonantal context, although statistical significance was reached only for Case 5 by items. For all six vowel-to-coda cases, the mean proportion of critical vowel pronunciations for experimental nonwords was greater than the mean proportion of critical vowel pronunciations for control nonwords.

The anomaly again is the Arabic group, for which there is no statistically significant difference between the experimental and control conditions. In fact, the mean proportion of critical vowel pronunciations for experimental nonwords for Egyptian Arabic speakers is less than the mean proportion of critical vowel pronunciations for control nonwords for vowel-to-coda associations in Cases 1, 2, and

3. These results indicate that the Arabic speakers do not show sensitivity to consonantal context for vowel-to-coda associations, and actually demonstrate what might be called an anti-sensitivity to consonantal context, since their results run opposite what might be expected given the statistical present associations in the English language itself.

Research Questions Revisited

Let us review our research questions against the data we have collected. Our first research question asks whether non-native English speakers demonstrate a degree of sensitivity to context when decoding English vowels that differs from L1 English speakers—whether they show more or less sensitivity to onset-vowel or vowel-coda associations than native speakers.

Figure 1 compares the results for native English speakers against those for non-native English speakers for onset-vowel associations in the experimental and control contexts. Remember that we would expect the critical pronunciation to be greater for the critical pronunciation in the experimental context than in the control context.

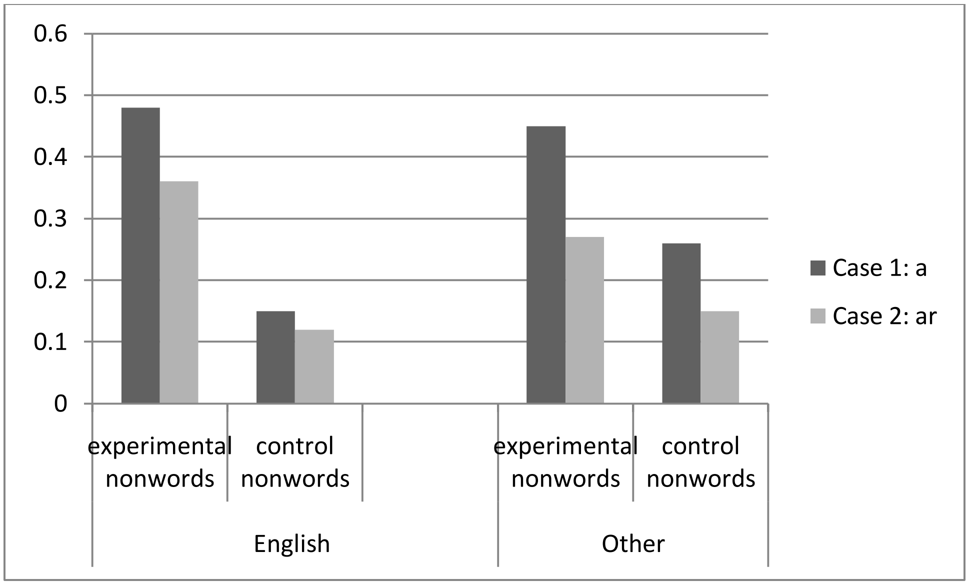

Figure 1. Onset-vowel associations for native English and Other

We can graphically see that for onset-vowel associations, although non-native speakers approach native English speakers in mean proportion of critical pronunciations for experimental nonwords, they have a tendency to use the critical pronunciation more in the control context than native English speakers.

Figure 2 compares the results for native English speakers against those for non-native English speakers for vowel-coda associations in the experimental and control contexts.

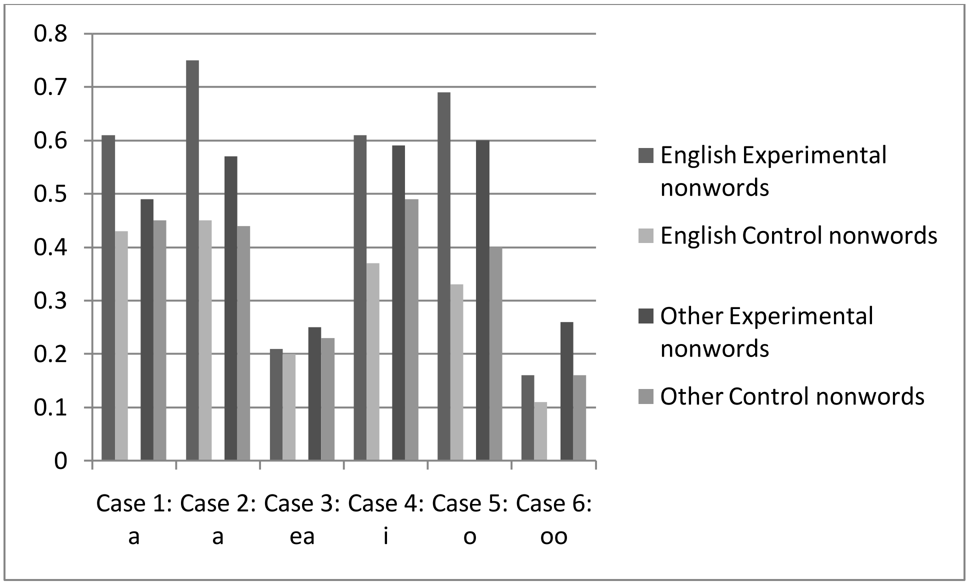

Figure 2. Vowel-coda associations for native English and Other

We can graphically see that for Cases 1, 2, 4, and 5, native speakers show more sensitivity to consonantal context than non-native speakers. Interestingly, in Cases 3 and 6, the mean proportion of critical pronunciations in the experimental context for non-native speakers was greater than for native English speakers. Cases 3 and 6 are however, cases in which the critical pronunciation may occur in experimental contexts in real English words. For Case 3(*ea*), about a third of English words to have the typical pronunciation /ɛ/ and about two-thirds have the critical pronunciation /i/ before the consonant *d*, so there are a large number of English words in which the typical pronunciation might occur in the experimental context. And for Case 6, it is also possible for the typical pronunciation /u/ to occur in the experimental context before the consonant *k* in real English words (cf. *spook* vs. *look*). There is an overall tendency for non-native speakers of English to use the critical pronunciation more frequently in control contexts than native English speakers, and we can conclude that non-native speakers do not show the same degree of sensitivity to consonantal context that native English speakers do. This may be due to the lack of vocabulary non-native speakers generally have in comparison with native English speakers; that is, non-native speakers have not been exposed to a sufficient number of English words to acquire the same degree of sensitivity to consonantal context. We do see, however, that non-native speakers' choices for vowels are influenced by both onset and coda.

Our second research question is whether Arabic speakers demonstrate a degree of sensitivity to consonantal context when reading English vowels that differs from L2 English speakers from other native language backgrounds. We have narrowed Arabic speakers to Egyptian Arabic speakers.

Figure 3 compares the results for Egyptian Arabic speakers against those for non-native English speakers for onset-vowel associations in the experimental and control contexts. Remember that we would expect the critical pronunciation to be greater for the critical pronunciation in the experimental context than in the control context.

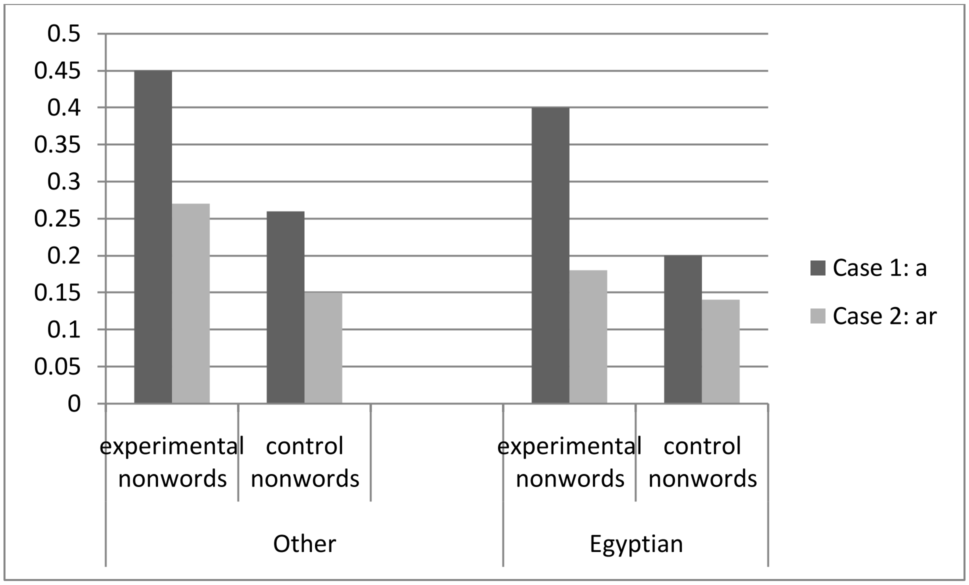

Figure 3. Onset-vowel associations for Egyptian and Other

We see that the mean proportion of critical pronunciations for Egyptian Arabic speakers is less than for speakers from other language backgrounds, although the Egyptian Arabic speakers did not provide the critical pronunciation in control contexts as much as the speakers from other language backgrounds. There is not a great difference between the two groups for onset-vowel associations.

Figure 4 compares the results for Egyptian Arabic speakers against those for non-native English speakers for vowel-coda associations in the experimental and control contexts.

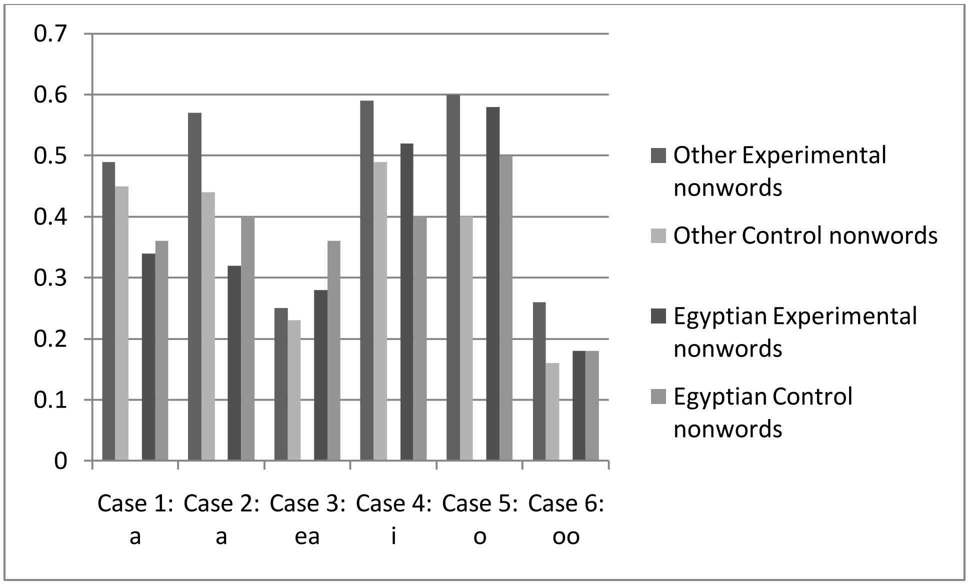

Figure 4. Vowel-coda associations for Egyptian and Other

Figure 4 shows that for Cases 1-3, the mean proportion of critical pronunciations in the control context for Egyptian Arabic speakers actually exceeds the mean proportion of critical pronunciations in the experimental context. This result indicates that indeed Egyptian Arabic speakers show sensitivity to consonantal context that markedly differs from that of speakers from other language backgrounds. Cases 4-6 show the mean proportion of critical vowel pronunciations in the experimental context is smaller for the Egyptian Arabic speakers than for speakers of other language backgrounds, but not to a great extent. We can conclude that Egyptian Arabic speakers do demonstrate sensitivity to consonantal context in reading English vowels that differs from speakers from other language backgrounds for vowel-coda associations.

Our last question is whether sensitivity to consonantal context in decoding English vowels correlates with English reading proficiency for non-native speakers of

English. We were unable to draw a conclusion at this time regarding the relationship between sensitivity to consonantal context and reading proficiency due to a lack of data.

CHAPTER 5: CONCLUSION

Summary of Findings

This dissertation has explored sensitivity to consonantal context by extending prior research to new populations: Arabic speakers and other non-native speakers of English. Our data suggest that in general native English speakers show more sensitivity to consonantal context than non-native speakers of English, and that Arabic speakers in particular show a lack of sensitivity to consonantal context not only compared to native English speakers, but also compared to non-native speakers from other language backgrounds.

Results for native English speakers and L2 speakers (excluding Arabic). Comparing onset-vowel associations for native-English speakers and speakers from other language backgrounds (Figure 1), we see that speakers from other language backgrounds follow the same trend as native English speakers, but that the mean proportion of critical pronunciations is slightly less for L2 speakers than for native English speakers in the experimental context, and is greater in the control context for L2 speakers. This shows that speakers from other language backgrounds show sensitivity to consonantal context, but not to the same degree as native English speakers.

Comparing vowel-coda associations for native English speakers and speakers from other language backgrounds (Figure 2), we see that for Cases 1, 2, 4, and 5, the mean proportion of critical pronunciations is slightly less for L2 speakers than for native English speakers in the experimental context, and is greater in the control context for L2 speakers. However, for Cases 3 and 6, the mean proportion of critical pronunciations is greater for L2 speakers in the experimental context than it is for native English speakers, while it is greater in the control context as well. What is important to look at is the divergence between the mean proportion of critical pronunciations in the experimental vs. the control contexts, and with this in mind we see that speakers from other language backgrounds do not show the same degree of sensitivity to consonantal context as native English speakers do.

Results for L2 speakers and Egyptian Arabic speakers. Comparing onset-vowel associations for non-native English speakers (excluding Arabic) and Egyptian Arabic speakers (Figure 3), we see that speakers from other language backgrounds follow the same trend as non-native English speakers, but that the mean proportion of critical pronunciations is slightly less for Egyptian Arabic speakers than for non-native English speakers in both the experimental and control contexts. This suggests that Egyptian Arabic speakers show sensitivity to consonantal context for onset-vowel associations, but not to the same degree as non-native English speakers.

Comparing vowel-coda associations for non-native English speakers (excluding Arabic) and Egyptian Arabic speakers (Figure 4), we see that for Cases 1-3, the mean proportion of critical pronunciations for L2 speakers in the experimental context is greater than in the control context, but for Egyptian Arabic speakers, the results are reversed, and the mean proportion of critical pronunciations in the experimental context is less than it is for the control context. For Cases 4-6, the mean proportion of critical pronunciations is greater for L2 speakers in the experimental context than it is for Egyptian Arabic speakers. The mean proportion of critical pronunciations in the control context for Case 4 is greater for non-native speakers than for Egyptian Arabic speakers, and for Cases 4-6, it's greater for Egyptian Arabic speakers than for non-native speakers. Looking at is the difference between the mean proportion of critical pronunciations in the experimental vs. the control contexts, we see that Egyptian Arabic speakers do not show the same degree of sensitivity to consonantal context as non-native speakers do. The results for Cases 1-3 are particularly striking, in that the Egyptian Arabic speakers are not following the hypothesized pattern despite their success on the filler filter, which would indicate that they understood and paid attention to the task.

Results for sensitivity to consonantal context and reading proficiency. We were unable to draw a conclusion at this time regarding the relationship between sensitivity to consonantal context and reading proficiency due to a lack of WRAT-3 data.

Teaching Implications

Our research findings suggest certain teaching implications. Sensitivity to consonantal context adds yet another layer of complexity to the orthographic system of English which might best be taught explicitly, but at the appropriate stage of development.

For example, a popular ESL text for teaching reading and writing, *Weaving It Together*, *3rd edition* attempts to teach the consonant doubling pattern with its lesson on comparative and superlative adjectives (e.g., big, bigger, biggest) in its beginner level text (pp. 43-44). When we look at the stages of spelling development, we see that consonant doubling falls into the fourth stage of spelling development (the derivational affixes stage), and is inappropriate to the beginning stage of literacy development (Bear et al., 2007). Fortunately, supplemental materials exist that can be used to teach the vowel patterns of English beginning with the short-vowel stage and moving to the long-vowel patterns (mid within word stage).

These vowel patterns are addressed in instructional materials developed by Bear et al. (2004, 2007 for ELL) and Ganske (2001) for native English speaking children. For example, in Invernizzi, Templeton, and Bear (2004), the patterns with the letters *o* and *i* followed by *–ld*, which yield a long /o/, appear as specifically taught VCC patterns contrasted with VCC patterns in which the vowel sound is short (cf. *fist/find, pond/post*). Similarly, the /u/-/ʊ/ contrast when *oo* is followed by *–k* is taught as an "other ambiguous vowel sound," and the change in vowel sound when the vowel letter *a* is preceded by *w* is also included in the word pattern sorts for within-word patterns (Invernizzi et al., 2004).

Given that Egyptian Arabic speakers show a lack of sensitivity to consonantal context in addition to their observed difficulty with the filler filter portion of the silent pronunciation task, the next question becomes how to teach sensitivity to consonantal context. It is beyond the scope of this dissertation to test the validity of teaching methods we will suggest here, but teaching sensitivity to consonantal context may prove a fertile area for future research. Word Study as described above has proven an effective method for teaching English orthographic patterns to native English speaking children (Bear et al., 2004; Ganske, 2001), ELL children (Bear et al., 2007; Sterbinsky, 2007), and adults (Massengill, 2006). Research using these teaching methods with non-native speaking adults is in its infancy.

Limitations of the Study

Limitations of this dissertation include the small sample size of the Arabic speaker group (which was discussed above), and the lack of WRAT-3 data that would have allowed us to address whether sensitivity to consonantal context correlates with reading for non-native speakers as it has been shown to do for native speakers (Treiman, et al, 2006).

Given the problems presented by the filler filter, we recommend that participants in future studies be tested individually, reading the nonwords aloud and having their pronunciations transcribed as in Experiment 1 of Treiman, Kessler, and Bick (2003). This would eliminate the problem of so much data having to be discarded and would likely yield statistically significant results.

Recommendations for Future Research

This dissertation has expanded the research on consonantal context to non-native speakers of English, particularly to Arabic speakers. Because of the small sample size for Arabic speakers, replications of this study following the methodology of Experiment 1 in Treiman et al. (2003) would be welcome and confirm the present findings.

The present study investigates sensitivity to consonantal context in the reading of English vowels. We would like to see the research extended to address issues of spelling for non-native speakers as well. Although not exactly the same, reading and spelling are complementary processes (Ehri, 1997). Future studies could be modeled on studies of consonantal context and spelling that have already been conducted with native English speaking populations (Treiman et al., 2002).

Another area of interest may be the salience of different sub-word units and their boundaries. In this study, we looked at readers' sensitivity to consonantal context, which is predicated on the reader's ability to chunk or divide the word into onset-rime (VC) and body-coda units (CV). The preference in English for onset-rime information appears to be due to the orthographic properties of the language itself and is language specific. As mentioned above, in Korean, the body-coda boundary (ca-t) is more salient than the onset-rime boundary (c-at) (Kim, 2007). It is possible that even more than grain-size (single phoneme/grapheme, syllable, whole word), the salience of the boundaries within the word are important factors in the reading process. The preference for certain sub-word units may persist from first language preference and be a source of positive or negative transfer for the non-native speaker learning to read English (Figueredo, 2006). It could further pinpoint the problems Arabic speakers learning to read English demonstrate if we could determine what sub-word boundaries are preferred in Arabic, and whether this native-language preference might interfere with the preference for onset-rime information that is characteristic of English.

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Appendix A

Consent Script

Hello, I am Elizabeth Stein, a doctoral student at The University of Memphis, Department of English. I am conducting this research to collect data for my doctoral dissertation.

Thank you for agreeing to participate in my research project. The research results will help me better understand sub-word level reading processes used to read English.

Today you will be participating in a one-on-one reading proficiency assessment (WRAT-3, a standard reading assessment tool), an auditory discrimination task (for non-native speakers only), a silent pronunciation task, and a self-rating of your answers to the silent pronunciation task. The total estimated time for all of these tasks is 30-45 minutes.

Your participation is voluntary. If you do not wish to participate, you may stop at any time. Responses will be confidential, and your name will not appear in the final dissertation. Taking part in this experiment is your agreement to participate.

If you would like a copy of this letter for your records, please let me know, and I will e-mail it to you. If you have any questions regarding this research, contact Dr. Charles Hall at charleshall@rocketmail.com. Dr. Hall is my dissertation advisor at The University of Memphis, Department of English.

If you have any questions regarding your rights as a research participant, please contact the Office for Protection of Human Subjects at The University of Memphis, Administration 315, Memphis, TN 38152, or call (901) 678-5071. This office oversees the review of the research to protect your rights and is not involved with this study.

Thank you again for your help.

Elizabeth Stein

elizabeth.stein@nscc.edu

Appendix B

Participant Questionnaire

ID ________________

Date: ____________________________

1. Gender: (circle one) Female Male

2. Age: (circle one) 18-19 20-24 25-34 35-44 45-54 55-64 65-74

3. Do you have any speech, language, hearing, or neurological disorders? Yes No

If yes, please describe on the back of this page.

4. Are you taking any medications that may affect your motor skills? Yes No

If yes, please describe on the back of this page.

5. What language do you speak with your parents?

____

6. What language do you consider to be your native language?

____

7. What other language/s do you know and how well do you know it/them?

Language 1: ________________ (circle one) Basic Conversational Fluent

Language 2: ________________ (circle one) Basic Conversational Fluent

Language 3: ________________ (circle one) Basic Conversational Fluent

If you speak additional languages, please provide information about them on the back of this page.

8. If English is not your first language, where and how long have you studied English?

Elementary School in the U.S. ________ (years) /other country _________ (years)

Middle School in the U.S. ________ (years) /other country _________ (years)

High School in the U.S. ________ (years) /other country _________ (years)

College in the U.S. ________ (years) /other country _________ (years)

Other school in the U.S. ________ (years) /other country _________ (years)

9. What do you think was being tested?

Appendix C

Stimuli for Silent Pronunciation Task

Items testing onset-to-vowel associations

Case 1, Experimental: *squant, quab, wabs* (inadvertently omitted), *twamp, wadge, squamp, quatch, quap, guat*
Case 1, Control: *spant, clab, trabs, glamp, tadge, namp, flatch, blap, trat*
Real-word choices: *font/rant, sob/dab, cobs/cabs, pomp/camp, lodge/badge, pomp/camp, botch/batch, fop/sap, hot/hat*

Case 2, Experimental: *warge, wark, warse, warx, quarb, quarge, quarm, quarn, swarb, swark*
Case 2, Control: *carge, tark, sharse, garx, darb, garge, narm, starn, tarb, vark*
Real-word choices: *forge/large, pork/park, horse/parse, corks/parks, orb/barb, forge/large, storm/farm, horn/barn, orb/barb, pork/park*

Items testing vowel-to-coda associations

Case 1, Experimental: *blange, brange, crange, drange, shange* (included twice), *quange, sange, spange, slange, snange*
Case 1, Control: *blance, brance, crance, drance, shance, quance, sance, spance, slance, snance*
Real-word choices: *blade/black, brave/brat, crave/cram, drape/drab, shape/shack, quake/quack, sane/sand, space/spam, slate/slam, snake/snap*

Case 2, Experimental: *yald, dald, frald, fralt, talt, nald, pralt, shald, tald*
Case 2, Control: *yand, dant, frand, frant, tant, nand, nant, prant, shand, tand*
Real-word choices: *yawn/yap, dawn/dab, fraud/frat, fraud/frat, taut/tab, gnaw/nap, gnaw/nap, prawn/practice, shawl/shack, taut/tab*

Case 3, Experimental: *clead, chead, swead, glead, pread, quead, splead, squead, stread, yead*
Case 3, Control: *cleam, cheal, swean, gleap, preal, queam, spleab, squean, streal, yeab*
Real-word choices: *clench/cleat, check/cheat, swell/sweet, glen/glee, press/preen, quell/queen, splendid/spleen, squelch/squeeze, stress/street, yes/yield*

Case 4, Experimental: *ild, brild, chind, crind, drind, smind, shrind, slind, snild, swild*
Case 4, Control: *ilt, brilt, chint, crint, drint, smint, shrint, slint, snilt, swilt*
Real-word choices: *aisle/id, bright/brick, chide/chip, crime/crib, drive/drip, glide/glib, shrine/shrill, slight/slip, snide/snip, swipe/swim*

Case 5, Experimental: *brold, chold, crold, golt, jold, nolt, polt, prold, rolt, solt*
Case 5, Control: *brond, chond, crond, gont, jond, nont, pont, prond, ront, sont*

Real-word choices: *broke/bronze, choke/chop, crone/crop, ghost/god, joke/john, node/nod, poke/pod, probe/prod, robe/rob, soak/sock*

Case 6, Experimental: blook*, grook, clook, drook, glook, prook, pook, plook, slook, trook*
Case 6, Control: *bloon, groon, cloom, droon, gloon, proom, poom, ploon, sloom, troon*
Real-word choices: *pull/bloom, pull/grew, pull/clue, pull/drew, pull/gloom, pull/moon, pull/pool, pull/plume, pull/slew, pull/true*

Fillers
blut (mutt/moot), bripe (ripe/rip), feg (leg/ledge), gletch (etch/each), yud (mud/mood), borf (born/burn), fope (soap/soapy), poin (coin/con), spleck* (peck/peek), reet (meet/met), shig (pig*/peg*), sprake* (lake/lack), snet* (pet/pit), delp* (desk/disk), troke (joke*/truck*), vake* (sake/sack), zung (lung/lunge), lish* (lick/leak), thruff (rough*/red*), roich* (Roy/rah)*
*changed from fillers and choices used in Treiman, Kessler, & Bick (2003)

Practice items
cat (bat/but), dog (front/frog), snake (rate/rut), shook (book/beak)