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Investigating The Lexical Support In Non-Native English Speakers Using The Phonemic Restoration Paradigm

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INVESTIGATING THE LEXICAL SUPPORT IN NON-NATIVE ENGLISH SPEAKERS USING THE PHONEMIC RESTORATION PARADIGM

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ABSTRACT

Samuel and Frost (2015) investigated the differences between native and non-native English speakers' lexical influence in speech perception. Using the selective adaptation method, the study showed that lexical support was weaker in less language proficient non-native speakers than native speakers; however, lexical support became stronger in more proficient non-native speakers. The present study investigated the lexical support in speech perception between native and non-native English speakers. Unlike the method used by Samuel and Frost (2015), the present study used the phonemic restoration paradigm. The benefit of using this method is to investigate the difference between native and non-native speakers in perceptually restoring missing phonemes. It was hypothesized that native speakers will show a higher phonemic restoration effect than non-native speakers, as well as greater sensitivity to the phoneme position in a word. In the current study, a group of native speakers and a group of non-native speakers participated in a phonemic restoration task. Both groups were presented with four-syllable stimuli words with one phoneme either replaced with white noise (replacement condition), or white noise added on that phoneme (added condition) in either the third syllable or the forth syllable, followed by an intact version of the same word. Participants rated the degradation of the manipulated word compared to its intact version. Results showed that both native and non-native speakers rated the added versions of the word more similar to the intact version than the replaced version. In addition, both native and non-native speakers rated the manipulated (i.e., added or replaced) versions of the word more similar to the intact version when the manipulated phoneme was in the fourth

syllable than when the manipulated phoneme was in the third syllable. However, non-native speakers rated the replaced versions of manipulated words as similar to the intact versions as the native English speakers.

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INTRODUCTION

Speech perception has a unique position in the study of cognitive psychology in general and psycholinguistics in particular. Many studies were dedicated to understanding this system, and the goal was to understand the mediating processes and representations between the moment speech signals of a spoken word provoke the cochlear of the ear and the moment that word accesses the mental lexicon (Samuel, 1997). One of the important aspects studied in speech perception is the influence of the mental lexicon (or the lexical level) on the phonemic level (or the pre-lexical level) in the perceptual system. Studies showed that the lexical level provides feedback regarding what phoneme is appropriate in a particular position of the speech stream in the pre-lexical level. The lexical influence is stronger when an individual phoneme in a spoken word is masked by noise (Samuel, 1987; 1996; 1997; 2001) or when that phoneme is heard ambiguously (Ganong, 1980; McQueen, Cutler, & Norris, 2006; Norris, McQueen, & Cutler, 2003).

Previous studies on the lexical influence on the pre-lexical level investigated the perceptual processing of speech in native speakers regarding their first language. Little has been done to examine the second language lexical influence on the phonemic perception of that second language. To the author's knowledge, the only study that investigated the lexical influence on second language speech perception is the study of Samuel and Frost (2015). In their study, they compared the lexical support to English phonemic perception between native English speakers, native Hebrew speakers who are highly proficient in English, and native Arabic speakers who are less proficient in

English. For their study, Samuel and Frost used the selective adaptation method. Participants engaged in a pre-posttest, where they identified ambiguous utterances that were between the phonemes /s/ and /sh/ on a continuum. After the pre-test, participants listened to words ending with either /s/ (e.g. bronchitis) or /sh/ (e.g. diminish) sound. However, the end points of these words were replaced with ambiguous utterances that were between the phonemes /s/ and /sh/. Participants responded whether they heard an /s/ or a /sh/ sound at the end of each word. This is called the adaptation phase. Later, they took the post-test. Results showed native English speakers identified fewer ambiguous sounds on the continuum as /s/, when listening to words which originally had an /s/ ending. Native English speakers identified fewer ambiguous sounds on the continuum as /sh/, when listening to words which originally had /sh/ ending.

Native Hebrew speakers performed in a similar way although not as strong as native English speakers. Native Arabic speakers did not show any significant difference between identifying the ambiguous sounds before and after the adaptation phases. The idea of the selective adaptation method is that when participants are highly exposed to one of the two phonemes, they develop an adaptation to that phoneme, thus making it less salient. Participants are less likely to identify the utterance as phonemes to which they developed adaptation. In the adaptation phase, Samuel and Frost (2015) used words in which they replaced their final phonemes with an ambiguous utterance between the /s/ and /sh/ sounds. Their hypothesis was that the lexical level would provide feedback to the pre-lexical level to perceive the utterance as the actual final phoneme of each word (e.g. /s/ for bronchitis and /sh/ for diminishing), and that is what happened with native English speakers. The lesser degree of adaptation found in native Arabic speakers, and to some extent to native Hebrew speakers, was attributed to language proficiency; the more proficient an individual is in a language, the stronger the lexical support will be.

The goal of the present study is to extend the investigation in the difference between native and non-native speakers in lexical support. The difference between this study and Samuel and Frost's study (2015) is that this study will use the enhanced phonemic restoration paradigm developed by Samuel (1996). The purpose of using this method is that this study will investigate the role of the lexical support in restoring a missing phoneme instead of identifying an ambiguous phoneme. In the phonemic restoration paradigm, participants will be presented with stimuli words, with one phoneme either replaced by white noise or white noise added on that phoneme followed by the intact version of that word. Participants will rate the degradation of the manipulated words compared to the intact version of the words. This investigation would contribute to the study of lexical influence on the perception of phonemic information.

Another goal of this study is to investigate the sensitivity of non-native speakers to the second language contextual information (i.e., the phonemic information adjacent to the target phoneme), which increases the lexical support. Previous studies showed that a phoneme position plays an important role in the strength of the phonemic restoration effect. Particularly, the restoration effect is found to be stronger when the target phoneme is in a later position in a word (Samuel, 1981a; 1996). Earlier syllables of a word serve as contextual information for the target phoneme, and the longer this contextual information is, the stronger the phonemic restoration will be (Samuel, 1981a). Therefore, the present study will also manipulate the target phoneme position in the experimental words to test participants' sensitivity to contextual information. This study will manipulate the initial phoneme of the third syllable and the initial phoneme of the fourth syllable in four-syllable words.

Speech Perception

Most of the studies in speech perception agree that there are three levels of processing in speech perception. There is an acoustic feature processing level, in which the features of speech signals, such as the power of the speech, are identified. Then there is the phoneme (or pre-lexical) processing level, in which received speech features at the feature level are represented and identified by their phonological outputs. And finally, there is the lexical processing level, in which words and meanings of words are identified from their phonological elements (McClelland, Mirman, & Holt, 2006). The disagreement, however, is in the direction of speech stream in which the speech information is processed. The two main approaches to speech perception are the autonomous approach and the interactive approach.

One of the leading models in the autonomous approach is the Fuzzy logical model of speech perception (FLMP) developed by Massaro (1989). In this model, the speech stream is processed in the perceptual system in a unidirectional way, starting from the feature level and ending in what is called a lexical decision level. The lexical decision level is where the decisions are made about the identity of the speech information. In this model, when speech information is distorted with irrelevant noise, a metalinguistic judgment would be use to compensate for distorted phonemes. Phonetic identification compensates for the incomplete information by the lexical decision.

In the interactive approach, interaction is assumed between three different levels of speech perception (i.e. speech level, the phoneme level, and word level). The direction of the speech stream goes from the low levels of the perceptual system (a bottom-up process), as well as from the high levels (top-down process). One of the leading models of the interactive approach is the TRACE model developed by McClelland and Elman (1986). The assumption of the interactive activation approach is that as the speech stream goes through the three levels of the perceptual system, each perceptual level provides feedback to the preceding level. The feedback occurred when the proceeding level received incomplete speech information due to noise mixed with speech signals (McClelland & Elman, 1986; McClelland, Mirman, & Holt, 2006). When the pre-lexical level detects sound features from the feature level, this information might be distorted due to environmental factors such as irrelevant noise. This inconvenience would cause problems to the pre-lexical level regarding the identification of the speech signals as phonetic information. In this situation, the lexical level would provide feedback to the pre-lexical level to compensate for the missing phonemes or to retune the ambiguous phonemes as shown in Figure 1. Note that the feedback transfers from the lexical level to the pre-lexical level (McClelland, Mirman, & Holt, 2006).

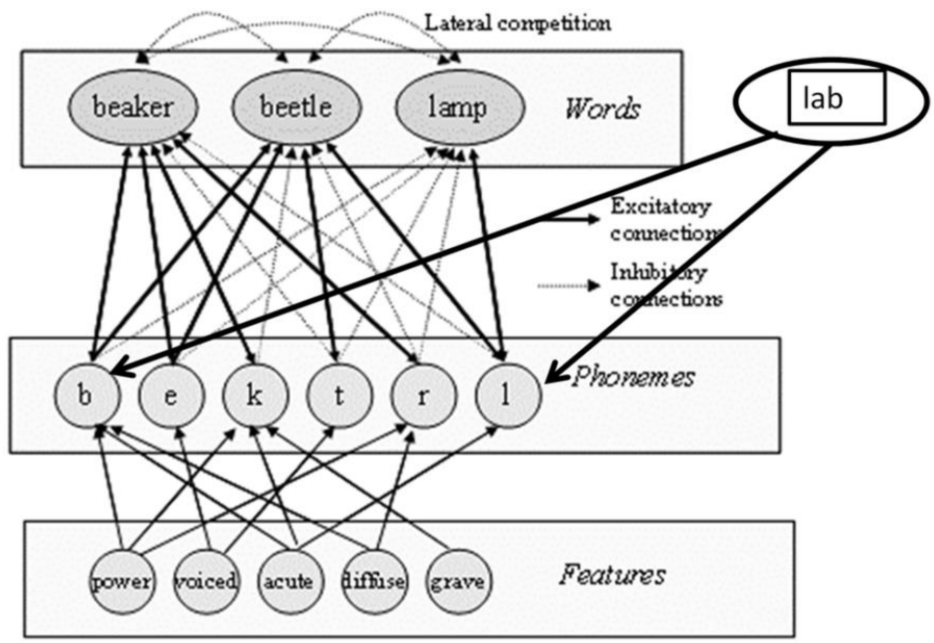

Figure 1. The TRACE model from McClelland & Elman (1986)

An important aspect of the interactive approach is the lexical influence on the pre-lexical. This influence is important to explain the compensation of missing phonemes in a spoken word representation. Even when a spoken word is ambiguous regarding one of its phonetic components, listeners can perceive the spoken word somewhat accurately. The explanation for this is that the mental lexicon provides feedback to the perceptual level (or the pre-lexical level) that would account for completing this phonetic information. The involvement of mental lexicon in this process indicates that language fluency, as well as lexical development, will influence the pre-lexical level.

The influence of the lexical processing level on the pre-lexical processing level is shown in the study of Warren (1970). When the speech phonemes are masked partly or entirely by an extraneous sound, listeners naturally restore the missing phoneme to comprehend the speech sound efficiently. This phenomenon is called the phonemic restoration effect (Warren, 1970; 1971). Samuel (1997) also used the phonemic restoration effect to investigate the lexical influence on the pre-lexical perceptual level in the selective adaptation method. In the study of Samuel (1997) an eight-step phonemic continuum was constructed between consonants /b/ and /d/. The continuum contained ambiguous sounds that are a mixed between /b/ and /d/. Ten words were selected for the adaptation phase. Five of these words had the /b/ sound in the third syllable (e.g., exhibition) and the other five had the /d/ sound also in the third syllable (e.g., armadillo). Noise replaced the /b/ and /d/ sounds in these words. The results showed that even with the /b/ and /d/ sounds being replaced by the noise, the words still produced adaptation effect.

The format of the lexical knowledge is not episodic, which means that the mental lexicon does not store words as a whole with all its details as one episode. Rather, it stores the details of a word in an abstract form. When a word is stored in the mental lexicon, its details- such as the sound features, phonemes, or syllables- can be independently activated when influencing the pre-lexical level. The lexical entry enables the mental lexicon to provide feedback to the pre-lexical level. Also, lexical entry helps retune the phonemic perception of spoken information. For example, when listening to a native language with a different accent that changes the standard phonetic sound in a word, the mental lexicon retunes the perception of that utterance within that word to be perceived as an intact word. Another example is when listening to speech information at a speed rate degrading phonemic sounds in a speech. In this case, the lexicon retunes the phonemic level to accommodate the degraded sounds in speech information.

The contextual components of speech information play a role in this lexical retuning, as shown by Norris, McQueen, and Cutler (2003). Norris et al. selected a set of words for a test. These words are either ending with the fricative /f/ or /s/. Listeners were instructed to make lexical decisions about these words (i.e., report whether they heard a word or not). Half of the listeners heard the /f/ final words with the /f/ replaced by an ambiguous sound between /f/ and /s/, and the /s/ with no changes. The other half heard the /s/ final words with the /s/ replaced by an ambiguous sound between /f/ and /s/, and /f/ final words with no changes. After that, participants were instructed to phonologically categorize 14 ambiguous sounds in a 14-step continuum, in which on one of the endpoints of the continuum was an /f/ and on the other endpoint was an /s/. In between 12 steps on the continuum are ambiguous sounds that are a mix between the /s/ and the /f/ sounds. The result showed that the listeners who heard the /f/ final words, in which an ambiguous sound replaced the /f/ sound, were more likely to categorize the ambiguous sounds on the continuum as /f/. This is because the lexical level retuned the perceptual level to perceive the ambiguous sound in the experimental words as an intact sound that is compatible with phonetic components of those words.

These previous studies provide strong support for the interactive approach of speech perception. Indeed, the mental lexicon does influence the pre-lexical perceptual level when encountering speech information that is phonologically incomplete or degraded by extraneous sounds. However, these studies were conducted with native speakers. It is important to note that language proficiency contributes to the strength of the lexical influence because lexical knowledge constructs the mental lexicon. This would lead to the question of the strength of lexicon influence on the phonemic perceptual representations when encountering speech information in a listeners' second language. Will the lexical influence be less effective when perceiving speech information in a second language? Before going into this question, it is important to understand the lexical development of a second language acquired in adulthood.

Non-Native Speakers' L1 Lexical Development

Before discussing non-native speakers' lexical development, it is important to define non-native speakers. Non-native speakers are those who acquired their second language in their adulthood after their mother tongue is fully established (Lecumberri, Cooke, & Cutler, 2010). It is important here to note that the main difference between native and non-native speakers is the level of development of their mental lexicon. Many studies showed that the advantages of native language proficiency come from acquiring the native language since early childhood. Lenneberg (1967) proposed a hypothesis that there is a critical period in a person's life in which language acquisition is at its highest efficiency. This critical period is during the time before a person reaches puberty. It should be noted that Lenneberg generated his conclusion from indirect evidence such as the difference in recovery time from aphasia between children and adults, and language acquisition progress before and after puberty. Although there have been arguments about the validity of the critical period theory, it was shown that language acquisition abilities decline in a stable way with age (Johnson, 1992; Johnson & Newport, 1989; 1991). This theory shows the advantage of early language acquisition in the development of the mental lexicon of that language; the lexical development depends on the amount of language knowledge such as phonological, morphological, syntactic, and semantic knowledge of a language (Jiang, 2000).

In the case of second language acquisition, it is shown that the time of acquisition plays a significant role in second language proficiency. Johnson and Newport (1989) found that people who arrived in the United States at the age of seven were more native-like in language skills than people who came after puberty. This finding would support the hypothesis that language acquisition at an early age has an advantage over language acquisition after puberty. However, many studies have contradicted the idea that a critical period is crucial to the ability to acquire language skills (Birdsong, 1992; Bongaerts et al., 1995; Harrington, 1995; Ioup et al., 1994; White & Genesee, 1996). For example, White and Genesee (1996) found that there were no differences in grammatical and judgment tasks between non-native speakers of different ages, at which they started second language learning. This would highly suggest that a second language proficiency could be achieved at a higher level regardless of the onset age of acquisition.

With these contradicting studies, it is possible that there is another factor that differentiated between native and non-native speakers regarding language proficiency. One important aspect is the level of exposure to the second language. It is without a question that native speakers of any language have the advantage of being highly exposed to their language compared to non-native speakers of that language (Wolter, 2001). The development of language is considered a gradual development based on the amount of exposure to that language (Namei, 2004; Wolter, 2001).

The effect of exposures on language proficiency is shown in the study conducted by Namei (2004). The study investigated the lexical development of a Persian-Swedish bilingual group and a Persian and Swedish comparison groups using a word association task, a task that requires participants to say the first word that comes into their mind when they hear a stimulus word that they were given. In this test, the type of response reflects the development of the mental lexicon. These responses are divided into three stages: clang responses, syntagmatic responses, and paradigmatic responses. In clang response, the responses are phonologically similar to the stimuli word regardless of any semantic relation (dog-log). In the syntagmatic responses, the response follows a sequential relationship with the stimuli word (dog-bite). In the paradigmatic response, the responses are of the same class (dog-animal) as the stimuli words (Kent & Rosanoff, 1910). Clang responses are more frequent for language beginning learners, whereas the paradigmatic responses are more frequent with advanced language learners. The syntagmatic responses are in between the clang and the paradigmatic responses. Namei (2004) examined the development of the mental lexicon of bilingual Swedish-Persian participants and compared that to those of monolingual either in Persian or Swedish. All Participants ranged from 6 to 12 years of age. They were selected based on their language proficiency level, which is measured by their school level; these levels were divided into grade zero (last year of preschool), 3, 6, 9, 10, and 12. The results showed that all participants in the earlier level (grade zero) were highly associated with clang responses; regardless of on what language the participants were tested. For syntagmatic association, bilingual participants showed in their Persian language that this association was the lowest in grade

6 and at its highest in grade 10 and 12. In their Swedish language, grade 3 was the lowest in syntagmatic responses; however, it is at its highest in grade 10 and 12. Finally, bilingual participants showed less paradigmatic association in grade zero in both their languages but a strong association in grade 3, 10, and 12. Regardless of the intervening responses of the types of associations in the results of Namei's study, one could notice a pattern in which the higher the school level is, the more advanced the accusation response would be, whether this is the first or second language.

This previous study highlights the importance of language exposure in the development of the mental lexicon seeing that the Persian-Swedish bilinguals developed similar proficiency levels in both languages. However, it can be argued that both these languages were established in the same period of the individual life, which is not very far from the critical period theory (Johnson, 1992; Johnson & Newport, 1989; 1991). The investigation on the effect of language exposure on second language proficiency and the similarity between the first and the first language should be conducted after the age of puberty to rule out the assumption of a critical period for language proficiency. This problem was investigated in the study of Soderman (1993). In his study, he compared the word association performance between four groups. The first group consists of participants at the age of 13 and 14 that have been studying English for three years, and the second group consists of participants between the age 17 and 18 and have been studying English for seven years. The third and fourth groups were university students with advanced English proficiency, but one group was more advanced because participants in that group were majoring in English, whereas the other group comprised of participants majoring everything other than English. The result showed no significant differences between the three advanced groups, with most of their responses were between syntagmatic and paradigmatic responses. On the other hand, the three-year English experienced students, while responding with some paradigmatic and syntagmatic responses, they were more likely to respond with clang responses and “other” responses (anomalous or repetitive responses). This study contradicts the study of the critical period, in which the language acquisition skills decline after puberty, seen that the youngest participants in the study of Soderman were between 13 and 14 years old (1993).

The level of language proficiency is highly related to the development of the mental lexicon, whether it is the mental lexicon for the first language or the second language. Studies showed that one of the main factors of language proficiency is the depth of individual word knowledge (DIWK) in the mental lexicon. According to the DIWK model, individual word knowledge is the knowledge and understanding of all the aspects of an individual word and not only the meaning of that word. (Wolter, 2001). Some words in a language are “well-known” regarding what their meaning, how they are pronounced, and how different verb forms are derived from its verb root. Depending on the degree of knowledge, words can be fairly well known words, moderately known words, slightly known words, and some words are unknown to the individual. Wolter (2001) investigated the relationship between the type of word association responses and the strength of word knowledge in the mental lexicon. He found that the word association response, as it gets more complex (i.e., shifts from a syntagmatic to a paradigmatic response) correlates positively with the depth of the knowledge of words used in the word association task. For example, the word "dog" elicits the word "animal" (paradigmatic response) when the word is "well-known," compared to the word "horopter" which will elicit "phoropter" (clang response).

So far, it is evident that there is a relationship between the development of the language's mental lexicon and language proficiency, but could there be a connection between the development of the mental lexicon and speech perception? As explained earlier, the studies of the interactive approach of the perceptual system showed that there is an interaction between the lexical level and the pre-lexical perceptual level. If mental lexicon provides feedback to the pre-lexical level, then the lexical feedback will vary in efficiency based the level of lexical development.

In a similar way, Samuel and Frost (2015) found that the lexical feedback for second language perception varies depending on the degree of proficiency in that second language. One suggestion is that in the case of less proficient non-native speakers, the perception of their second language speech information depends on their first language mediating the second language perception. The perceptual information in less proficient non-native speakers maps into the first language's mental lexicon before being translated to the mental lexicon of the second language (Kroll, Van Hell, Tokowicz, & Green, 2010). Seeing that the perceptual information is mapped to the first language' mental lexicon, the process of providing lexical feedback to the perceptual level would be inefficient because the translation from the first language to the second language is post-perceptual in nature. This mediation of the first language's mental lexicon becomes less active with more experience and proficiency to the second language.

Phonemic Restoration

As explained earlier, the study of Samuel and Frost (2015) investigated the lexical influence on the phonological perception in a second language used the selective adaptation method. However, this study examined the lexical influence only in recognizing an ambiguous phoneme in the speech information. Moreover, it did not account for the importance of the strength of the contextual components of the speech information, (i.e., how the phoneme position would affect the strength of the lexical influence). The selective adaptation cannot control the lexical effect of the phoneme position. The phonemic restoration effect can be a useful method to solve this problem.

The phonemic restoration is the process of perceptually restoring missing phoneme in a spoken word that was heard (Warren, 1970). The effect occurs due to the interaction between the top-down (lexical influence) and the bottom-up (contextual components) processing in the perceptual system. Listeners perceptually restore a part of speech (usually a phoneme) that was replaced by an extraneous sound. Warren (1970) demonstrated in two experiments the effect of replacing a single phoneme in a word with either a cough or a tone. In both experiments, the participant heard the sentence "the state governors met with their respective legislators convening the capital city," with the first /s/ in the word "legislators" replaced with a cough sound in the first experiment and with a tone in the second experiment. Participants were given a typed statement of the sentence and will be instructed to circle the position where a sound of a cough or a tone occurred and whether this sound completely replaced the target position or not. Approximately all of the participants reported that all speech sounds were present.

Moreover, most of the participants mislocalized the replacing noise (a cough or tone) and circled wrong positions of the sound imposed in the word. Warren (1970) attributed this phenomenon to the listener language skills. What is surprising about this phenomenon is that it is so compelling that the listeners could not distinguish between a physically existing phoneme and a perceptually recognized one (Warren & Obousek, 1971). The downfall of the method used by Warren is that it is an indirect measure of the strength of restoration. for example, participants who mislocalized the replacing noise by six letters does not necessarily means that they are better in restoration than participants who mislocalized the replacing noise by three letters (Samuel, 1981). Another limitation is that the method used by Warren only accounts for the miss rate (reporting that the word is intact when a phoneme is missing). The absence of the false alarm rate (i.e., reporting that the word is not intact when there is no missing phoneme) could cause confusion. This confusion is whether the hit rate (reporting that a word with a missing phoneme is not intact) is due to restoration failure or some form of bias toward hit rate response.

To solve this problem, Samuel (1981b) developed a paradigm to measure the strength of the phonemic restoration by adding a new condition to the old method. The added condition was a noise merely superimposing noise on the target phoneme. Using the signal detection theory, the new method contains two versions of a word: one where the noise replaces the target phoneme and the other where the noise is superimposed on that target phoneme. Participants are presented with these two versions in a random order, and they are asked to respond whether the noise is added to the target phoneme or replaced it. A correct response to the two versions of the word indicates greater discrimination between the added and the replaced versions of the word, thus, showing poor restoration of missing phonemes. On the other hand, an incorrect answer to the replaced version, where the phonemic restoration occurs (miss rate), indicates poor discrimination between the added and the replaced versions, which mean restoration occurred. Response to this method uses the signal detection theory, in which responding to the added version as intact is a hit rate and the replaced version as not intact is a correct rejection. Responding to the added version as not intact is a false alarm while responding to the replaced version as intact is a miss. The discriminability between the added and replaced version of the same word is measured by signal-to-noise sensitivity index (d' or the d-prime) as shown in Figure 2. This sensitivity index indicates the overlap between the signal (the phoneme sound) and the signal plus noise, in the sense that the d' measure that equal to zero means that the noise is not distinguishable from the signal sound (see Wolfe et al., 2012).

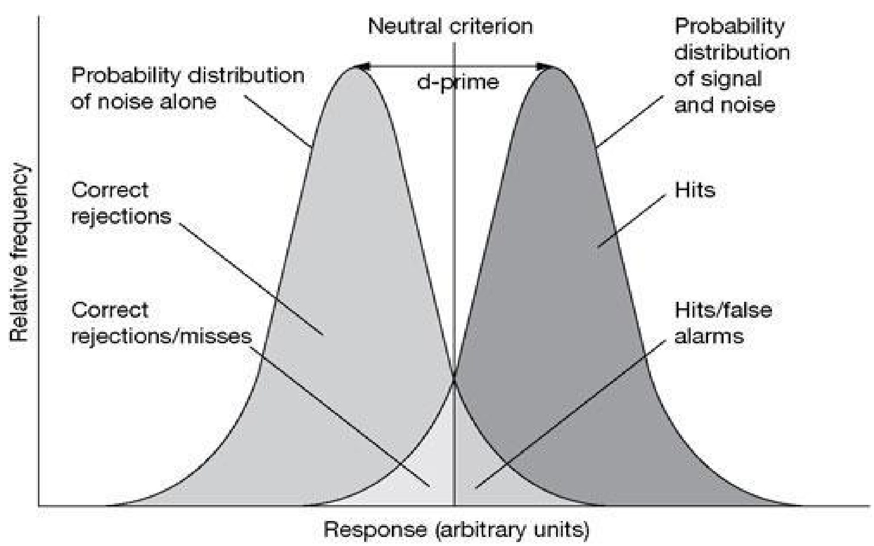

Figure 2. Signal detection theory showing the *d'*

In the phonemic restoration effect, the lexical influence provides feedback about the missing phoneme based on the phonological context that surrounds the missing phoneme. These phonological contexts provide the mental lexicon with confirming information about the encountered spoken word, which helps the lexical level decide what phoneme is appropriate in the missing spot of the word. Thus, the impact of the phonemic restoration effect is influenced by the use of bottom-up and top-down processing. Each process type has a unique contribution to restoring the masked phoneme. In the role of the bottom-up process, certain features of the given spoken word increase the phonemic restoration more than other features (Samuel, 1981b; 1996). One of the bottom features that increase the phonemic restoration is the word length effect. The word length has an effect on the phonemic restoration strength; a masked phoneme in a four-syllable word is more restorable than in a two-syllable word. The word length is attributed to the idea that longer words provide more contextual cues for the mental lexicon to restore the appropriate missing phoneme. Another feature of the contribution of the bottom-up process is the phoneme position, which also contributes to the strength of the phonemic restoration; missing phonemes in the final syllable are more restorable than when they are in the initial syllable. The phoneme position is attributed to the lexical access of the target word. An initial syllable of the word activates several words in the mental lexicon that would be to be the word that is perceived in the perceptual system (Samuel, 1981a). By the time the final syllable with the missing phoneme access the mental lexicon, the number word candidates in the mental lexicon are reduced to one word, which is the appropriate word (Samuel, 1987).

There have been many studies that used the phonemic restoration paradigm (e.g., Mattys, Barden, & Samuel, 2014; Sahin & Miller, 2009; Samuel, 1981b; Trout & Poser, 1990), and have been proven to be a reliable method to study the phonemic restoration effect. However, Samuel (1996) redeveloped the phonemic restoration paradigm. This new paradigm used an eight-point scale of the intactness of the added and replaced version instead of the signal detection analysis. The reason for redeveloping the phonemic restoration paradigm is for the purpose of detecting the smallest lexical influence in restoring the missing phonemes in the phonological representations in the perceptual level. In the old version of the phonemic restoration paradigm, participants are required to respond whether the word is intact of or not. This procedure is prone to post-perceptual bias in which participants respond concerning whether what they heard forms a word or not. The procedure of the new paradigm is as follows: The participants will be informed that they will hear two versions of a word. They should report how degrading the first version is related to the second one on a scale from 1 to 8, with 1 being (most unlikely) and 8 being (most likely). Participants hear a version of the manipulated word (added or replaced) followed by the intact word. This method also provides a direct measure because it uses an eight-point scale test.

Present Study

The present study was conducted to test differences in the lexical influence between native and non-native speakers of the English language in the phonemic restoration task. It is assumed that based on the difference in the development of the mental lexicon between native and non-native speakers that native speakers would perform more poorly in the discrimination task than non-native speakers. This would occur because native speakers have a higher development of the mental lexicon and, therefore, restore more missing phonemes than non-native speakers based on the level of language proficiency of the non-native speakers. In addition, native speakers will show a stronger restoration when the manipulated phoneme is in the final syllable than in the middle syllable. Non-native speakers will show no significant difference in phonemic restoration between the manipulated phonemes in the final syllable and the middle syllable.

Hypotheses

Based on the study of Samuel (1996), rating reports on the added version of a word will be higher than the ratings of replaced version. This is because in the added version the target phoneme is not removed but a white noise is superimposed on that phoneme. Thus, the existence of the target phoneme itself would be a cue or bottom-up confirmation to the perception of a spoken word. It is hypothesized that:

1. Both native and non-native speakers will report that the added version of a word is more intact than a word in the replaced version.

Based on the studies of Samuel (1981a, 1981b, &1996), the target phoneme position is also expected to affect the phonemic restoration. It is predicted that the latter position of the target phoneme will show a greater phoneme restoration effect than the middle position.

This is based on the assumption that the proceeding syllables of a word would provide contextual bottom-up information to the following syllables. Therefore, the latter the replaced phoneme is in a word, the more restorable that phoneme will be.

2. Both native speakers and non-native-speakers will report the replaced version is more intact when the target phoneme is in the beginning of a last syllable than when the target phoneme is in the beginning of a penultimate syllable. (*A penultimate syllable is the syllable before next to the last syllable).

Based on the study of Samuel and Frost (2015), language proficiency has an effect on the lexical influence on the pre-lexical perceptual level of the phonemic representation. Thus, native speakers will perform better than non-native speakers in the phonemic restoration test will. It is hypothesized that:

3. Native speakers will show greater phonemic restoration effects in the phoneme manipulation condition (added vs. replaced phoneme), as well as the placement of manipulated phoneme condition (last vs. penultimate syllable).

Method

Participants

Forty-five participants were recruited for the study. Twenty-four native English speakers, 11 males (M_{age} = 21.18, SD_{age} = 3.52) and 13 females (M_{age} = 23.38, SD_{age} = 9.47), and 21 non-native speakers, 6 male Chinese (M_{age} = 25.17, SD_{age} = 1.94) and 14 female Chinese and 1 female French (M_{age} = 23.53, SD_{age} = 3.18). Participants were recruited from Fort Hays State University.

Native and non-native speakers were given a questionnaire that contains demographic questions. Questions were added to the questioner of the non-native speakers regarding their level of English proficiency, such as how long they were learning English, how long they lived in the United States, and whether they have taken the Test of English as a Foreign Language (TOEFL) or International English Language Testing System (IELTS). Some of the non-native speakers did not take the TOEFL or IELTS exam. However, they provide information, in months, about the time they spent learning English (M = 141.71, SD = 42.02) and the time they spent living in the United States of America in months (M = 15.43 SD = 14.32).

Materials

A total of thirty, four-syllable words were used in this experiment. These words were taken from the Longman Dictionary, 4th edition, and were chosen from the 3000 frequently spoken and written words. These words varied in target phoneme positions (15 words with the target phoneme in the beginning of the third syllable and 15 words with the target phoneme at the beginning of the fourth syllable) and in noise conditions (15 words with noise replacing the target phonemes and 15 words with noise added to the target phonemes). Liquid and nasal phonemes were used as they are a "good medium" range regarding restorability when the replacement sound is white noise, away from ceiling (fricatives) or floor (vowels) effect (Mattys, Barden, & Samuel, 2014).

Procedure

Two versions of each of the original words illustrated in figure 3 were created; the replaced version, in which white noise replaces the target phoneme, as shown in figure 4, and the added version, in which the white is superimposed on the target phoneme, as shown in figure 5. Words were recorded on Adobe Audition; a software used to record and manipulate sounds. Creating white noise was done by using PRAAT (http://www.fon.hum. uva.nl/praat/), a software that is designed to manipulate and analyze phonetic information. Duration and intensity of the target phoneme in each word recording was auditorily located to create the white noise. The white noise was generated with the same duration as the target phoneme for each word and was created using the formula "RandomGauss" in PRRAT. "RandomGauss" formula referred to generating random sound numeric values following a Gaussian distribution. A white noise was generated ($M = 0$, $SD = 0.25$), with the intensity of the white noise matched the intensity of each target phoneme. Three versions of each word was used in this study: a version in which the white noise was replacing the target phoneme, a version in which the white noise was superimposed on the target phoneme, and a version in which no manipulation was done. Note that each white noise generated for each target phoneme will match that target phoneme in duration and sound intensity. In the added condition, the combination of the white noise and the phoneme waveform generated lower intensity. So the intensity of this combination was raised manually to match the intensity of the natural phoneme.

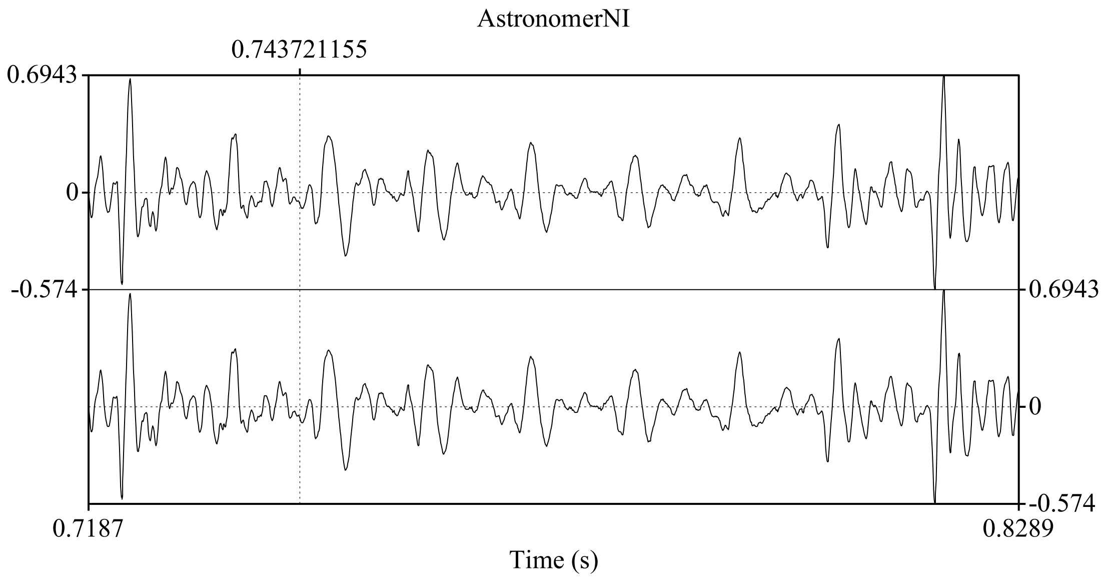

Figure 3. Word Waveform with no Noise.

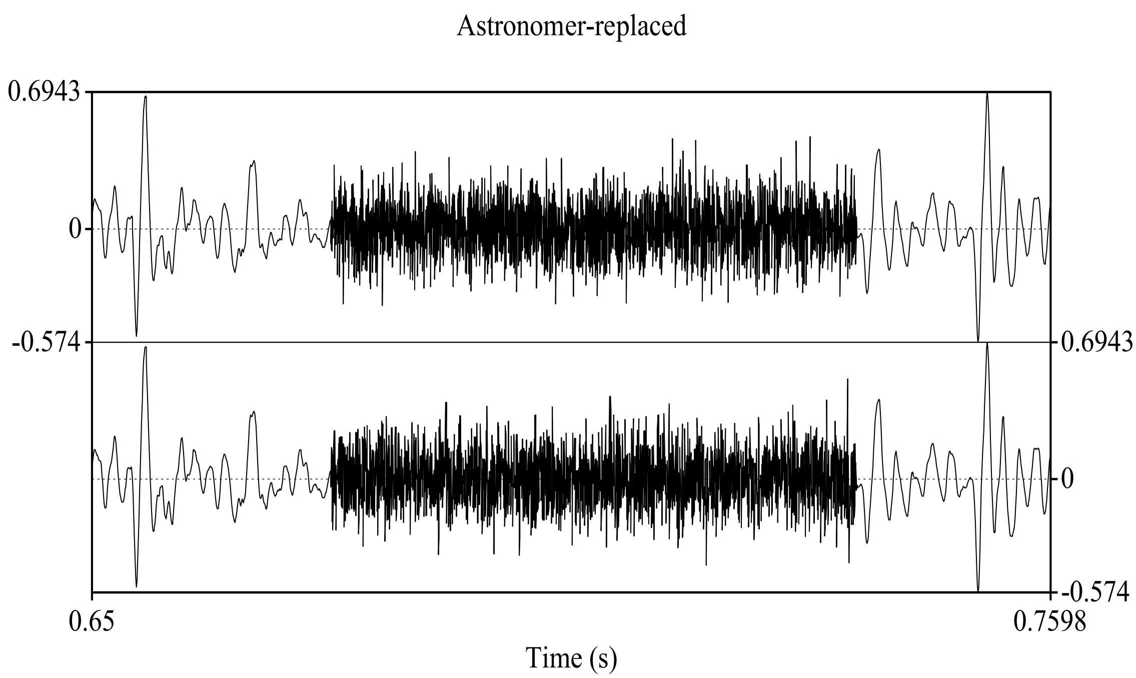

Figure 4. Word Waveform with Replacing Noise

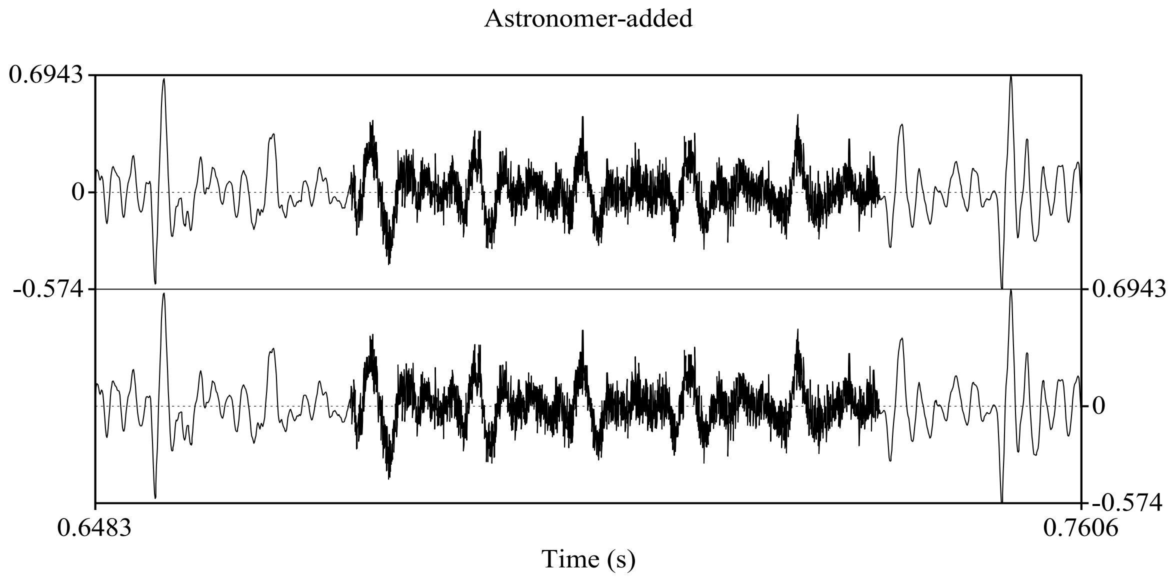

Figure 5. Word Waveform with added Noise

The experiment was conducted in the computer laboratory in the psychology department at Fort Hays State University. The participants were informed that they will hear two versions of a word in a sequence and they will report how degraded the first version is compared to the second version on a scale from 1 to 8 (1 = most unlike, 8 = most like). Participants used headphones to hear the test words. The trial started by hearing the manipulated version of the word (added or replaced). After approximately 750ms, a burst of noise followed by the intact word and followed by another burst of noise. After that, the participant responded on the 8-point scale. There was a pause for about 1s before the start of the next trial.

Results

To test the hypotheses, a 2 (added and replaced) x 2 (native and non-native) x 2 (middle syllable and last syllable) mixed factorial ANOVA was used to analyze the results.

There was a main effect for the phoneme position, $F(1, 43) = 4.43$, $p = .041$, partial $\eta^2 = .09$. Participants rated the manipulated (with either added or replacing noise) and intact versions of the words more similar when the manipulated phoneme (added or replaced) was in the fourth syllable ($M = 7.09$, $SD = 0.14$) compared to when the manipulated phoneme was in the third syllable ($M = 6.88$, $SD = 0.13$).

There was a main effect for noise condition, $F(1, 43) = 26.97$, $p < .001$, partial $\eta^2 = .39$. The similarity between the manipulated and intact versions of words was rated higher when the noise was added ($M= 7.15$, $SD = 0.12$) compared to when the noise replaced the target phoneme ($M= 6.82$, $SD = 0.14$).

There was a main effect for the subject groups, $F(1, 43) = 21.13$, $p < .001$, partial $\eta^2 = .33$. Non-native speakers ($M= 7.56$, $SD = 0.18$) rated the similarity between the manipulated and intact versions of the words more similar than did native speakers ($M = 6.42$, $SD = 0.17$).

No interaction was found between phoneme position and subject groups, $F(1, 43) = 0.10$, $p = .752$, $\eta^2 < .01$. Native and non-native speakers were compared regarding their responses when the target phoneme was in the third syllable and when the target phoneme was in the fourth syllable. Non-native speakers ($M = 7.64$, $SD = 0.20$) rated the similarity between the manipulated and intact versions of the words more similar when the target phoneme was in the fourth syllable than did native speakers ($M = 6.54$, $SD = 0.19$). Non-native speakers ($M = 7.47$, $SD = 0.19$) rated similarity between the manipulated and intact versions of the words more similar when the target phoneme is in the third syllable than did native speakers ($M = 6.30$, $SD = 0.18$).

An interaction was found between noise condition and subject groups, $F(1, 43) = 7.88$, $p = .007$, $\eta^2 = .16$. Non-native speakers ($M = 7.64$, $SD = 0.20$) rated the similarity between the manipulated and intact versions of the words more similar when white noise is added to the target phoneme than did the native speakers ($M = 6.68$, $SD = 0.16$). Non-native speakers ($M = 7.49$, $SD = 0.20$) rated the similarity between the manipulated and intact versions of the words more similar when white noise replaced the target phoneme than did the native speakers ($M = 6.17$, $SD = 0.17$). The interaction was probed for simple effects; the effect of noise condition for non-native speakers was not statistically significant, $F(1, 43) = 3.41$, $p =.072$, $\eta^2 = .08$, but the effect of noise condition for native speakers was statistically significant, $F(1, 43) = 43.81$, $p < .001$, $\eta^2 = 1.02$. The subject groups were driving the interaction between the noise condition and subject groups.

No interaction was found between phoneme position and noise condition, $F(1, 43) = 0.91$, $p = .345$, $\eta^2 = .02$. The similarity ratings between the manipulated and intact versions of words in the third syllable was higher when the noise was added to the target phoneme ($M = 7.07$, $SD = 0.13$) than when the noise replaced the target phoneme ($M = 6.70$, $SD = 0.15$). The similarity between the manipulated and intact version of the word in the fourth syllable was higher when the noise was added to the target phoneme ($M = 7.24$, $SD = 0.13$) than when the noise replaced the target phoneme ($M= 6.95$, $SD = 0.15$).

No interaction was found between phoneme position, noise condition, and subject groups, $F(1, 43) = 0.35$, $p = .557$, $\eta^2 < .01$. Non-native speakers ($M = 7.56$, $SD = 0.19$) rated the similarity between the manipulated and intact versions of the word in the third syllable more similar when the noise is added to the target phoneme than did the native speakers (*M* = 6.59, *SD* = 0.18). Non-native speakers (*M* = 7.39, *SD* = 0.12) rated the similarity between the manipulated and intact versions of the word in the third syllable more similar when the noise replaced the target phoneme than did the native speakers (*M* = 6.02, *SD* = 0.20). Non-native speakers (*M* = 7.72, *SD* = 0.19) rated the similarity between the manipulated and intact versions of the word in the fourth syllable more similar when the noise is added to the target phoneme than did the native speakers (*M* = 6.76, *SD* = 0.17). Non-native speakers (*M* = 7.58, *SD* = 0.22) rated the similarity between the manipulated and intact versions of the word in the fourth syllable more similar when the noise replaced the target phoneme than did the native speakers (*M* = 6.32, *SD* = 0.21).

Table 1

Means and standard deviations for all groups.

Subject Group	Phoneme Position	Noise Condition	Mean	SD
Native group	Third syllable	Added	6.586	.179
		Replaced	6.019	.198
		Both	6.303	.179
	Fourth syllable	Added	6.764	.174
		Replaced	6.319	.205
		Both	6.542	.185
	Both	Added	6.675	.159
		Replaced	6.169	.189
	Total		6.422	.169
Non-Native	Third syllable	Added	7.556	.191
		Replaced	7.390	.211
		Both	7.473	.191
	Fourth syllable	Added	7.717	.186
		Replaced	7.581	.219
		Both	7.649	.198
	Both	Added	7.637	.170
		Replaced	7.486	.202
	Total		7.561	.181

Table 2

Summary of results from ANOVA analysis.

Factor	F	p	η_p^2
Phoneme Position	4.43	.041	.09
Noise Condition	26.97	< .001	.39
Subject Group	21.13	< .001	.33
Phoneme Position * Subject Group	0.10	.752	< .01
Noise Condition * Subject Group	7.88	.007	.16
Phoneme Position * Noise Condition	0.91	.345	.02
Phoneme * Noise * Subject	0.35	.557	< .01

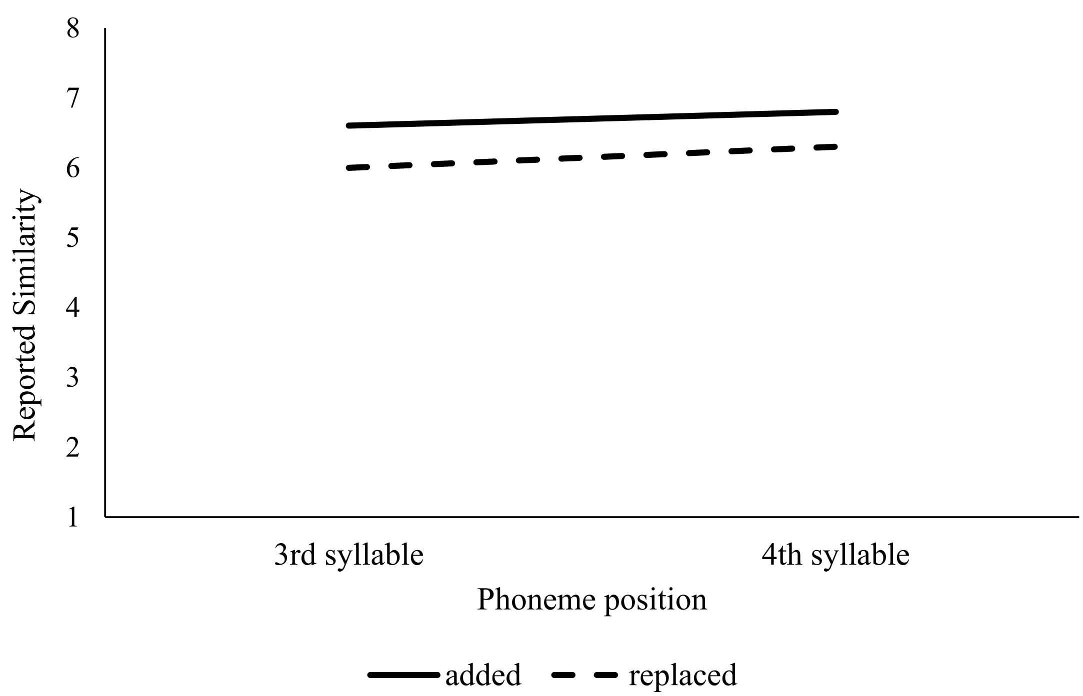

Figure 6. Native speakers' reported similarity when manipulating the third and fourth syllable.

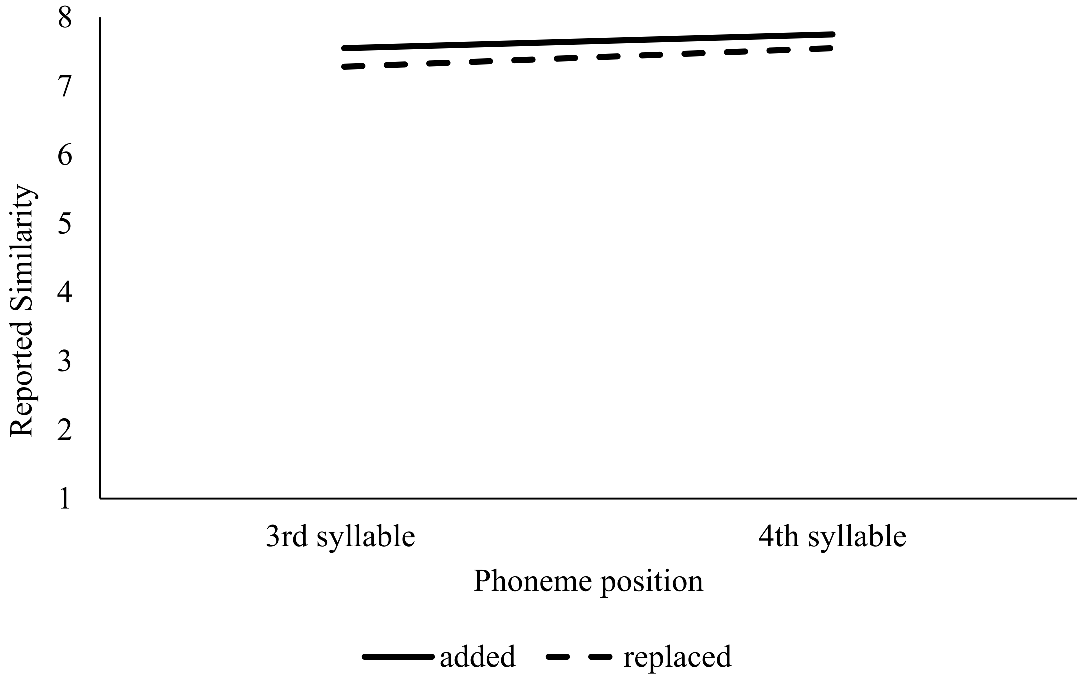

Figure 7. Non-native speakers' reported similarity when manipulating the third and fourth syllable.

Discussion

Results from this study supported the hypothesis that both native and non-native speakers reported that the added condition of the words is more intact than the replaced condition of the words. In addition, both native speakers and non-native speakers reported that the replaced condition is more intact when the target phoneme is at the beginning of the fourth syllable than when the target phoneme is at the beginning of a third syllable. However, Native speakers did not show greater phonemic restoration effects in the phoneme manipulation condition (added vs. replaced phoneme), as well as in the placement of manipulated phoneme condition (fourth vs. third syllable). These results can be explained as follows.

First, participants' ratings on the similarity between the manipulated and intact versions of the words were higher when the white noise was added to the target phoneme than when the white noise was replacing the target phoneme. This result replicated the findings in the previous studies on the phonemic restoration effect (Mattys, Barden, & Samuel, 2014; Samuel, 1996). When white noise is added to the target phoneme, the sound waveform of the target phoneme is still in its place, enabling the individual to hear that phoneme. The sound of that target phoneme itself can be considered as a bottom-up confirmation to the perceptual system (Samuel, 1996) in addition to the adjacent phonemic contextual information within the spoken word. On the other hand, when the white noise entirely replaces the target phoneme, the bottom-up confirmation of the target phoneme disappears. This shows the perceptual system depends only on the adjacent phonemic contextual information within the spoken word. The disappearance of the target phoneme degraded the perception of the spoken word compared to the target phoneme being merely combined with the extraneous noise as shown in the experiment.

Second, participant ratings on the similarity between the manipulated and intact versions of words were higher when the manipulated phoneme was in the beginning of the fourth syllable than when the manipulated phoneme was in the beginning of the third syllable. This finding also replicated the findings in previous studies (Samuel, 1981b; Samuel, 1996). When the manipulated phoneme comes later in the spoken word, the preceding phonemic contextual information in that word works as bottom-up confirming information for the upcoming target phoneme (Samuel, 1981a). When contextual information preceding the target phoneme enters the mental lexicon, the mental lexicon forms candidate words that would fit the description of the entering phonemic contextual information. When more phonemic contextual information enters the mental lexicon, the number of lexically formed candidate words decreases. This is because words that do not fit the description of contextual information will fall from the selection (Samuel, 1987). when the target phoneme comes in the final syllable of a four-syllable word, the phonemic contextual information preceding that target phoneme becomes longer (i.e., three syllables preceding the target phoneme) and have more phonemic contextual information than when the target phoneme comes in the third syllable of a four-syllable word (i.e., two syllables preceding the target phoneme). The more phonemic contextual information preceding the target phoneme is, the stronger the confirmation of the target phoneme will be. This is because the number of candidate words formed in the mental lexicon decreases as more phonemic contextual information enters the mental lexicon until one word formed in the lexicon matches the spoken word, thus, facilitating the restoration of the target phoneme.

Finally, and most surprisingly, the native speakers performed less phonemic restoration than non-native speakers did. The rating of the similarity between the manipulated and intact versions of the words was lower in the native English-speaking group when the target phoneme was replaced by white noise compared with the ratings of non-native speaking group. The result showed that non-native English speakers might have restored the missing phonemes when the target phoneme is replaced by white noise more than native English speakers are. This result was interesting because native English speakers should have developed higher mental lexicon than non-native English speakers, thus, enabling them to perform the phonemic restoration more efficiently than non-native speakers.

One possibility is that the non-native speaking group's English language experience was higher than we expected. Their English experience might have enabled them to perform the phonemic restoration effect because their mental lexicon is in a developed level for this performance. However, that does not explain how the non-native speaking group outperformed the native speaking group. If non-native speakers have a well-developed mental lexicon, it should not be more developed than the native speakers' mental lexicon because native speakers have been exposed to their language at a very early age. Therefore, it would have been possible if the native and non-native speakers performed in a similar way.

Another potential problem with the result can be the level of understanding the requirements to complete this task. As the instructions of the task required, the participants should rate how degraded the manipulated version of a stimulus word is compared to the intact version of the same word on a scale from one to eight. The rating scale was labeled as "most unlike" on the one and "most like" on the eight as it was designed in the study of Samuel (1996) and in the study of Mattys, Barden, and Samuel (2014). The non-native speaking group may have misunderstood the task as rating whether the first word and the second word are the same. However, the description of the experiment given in the consent form was clear in explaining that the rating was based on the similarity between two versions of the same word when one version is reduced in quality by white noise in that version. The experimenter also emphasized the description of the experiment and that the similarity rating should be based on word quality. Thus, this problem can be ruled out as an explanation for our result.

A third possibility is that the participant did not show high sensitivity (or discrimination between phonemes). Most responses of the non-native speakers were the end scores on the scale (either 7 or 8). Non-native speakers might have rated the similarity between the manipulated and intact versions of the words more similarly than native speakers because the non-native participants could not detect the differences between phonemes and felt overwhelmed. This might have led them to respond similarly to all words. On the other hand, results of the native speakers' responses varied across the entire scale, and therefore showed sensitivity/ differences between words tested.

Limitations

One of the limitations of the study is that although the stimuli words were designed to have a version with one phoneme replaced by white noise and another to have the white noise added to the same phoneme, there was no auditory example from the previous studies (Mattys, Barden, & Samuel, 2014; Samuel, 1996). This is important to compare the similarity between generated stimuli in this study and the ones used in previous studies.

Another limitation is that the non-native speaking groups were recruited from different academic levels. Non-native speakers' academic levels varied between the bachelor's level and the masters' level. The English as a Second Language (ESL) program would have been a good place to recruit participant because the level of English proficiency is the same to some degree for each level at the ESL program. Unfortunately, the ESL program did not have enough students in the same academic semester this study was conducted. Had we had the same level of English proficiency among non-native speakers, we might have found different results.

Also, when selecting the words for the experiment, the fifteen words where the target phoneme in the fourth syllable was dominated by the liquid phonemes /l/ and /r/. This result might have affected subjects' responses. Although the liquid and nasal phonemes are a good medium in terms of storability, each phoneme class have its properties in terms the strength of restoration when using a different replacing sound, for example. When using pure tone instead of white noise, liquid phonemes were more restorable than Nasals (Samuel, 1996). If this difference in phoneme class has an effect on the present study, the effect of phoneme position might be attributed to the difference in phonemes class, thus, affecting the results of the present study.

Future Recommendations

It is recommended that the level of English proficiency for non-native speakers be controlled. The non-native speaking group should be measured on their English proficiency and assigned to the group based on that level of proficiency. It is also recommended to design an experiment in which there are different groups of non-native speakers based on their level of English proficiency (i.e., low, medium, and high level of English proficiency) and compare their results to a native speaking group.

Another recommendation is to conduct the study with different non-native English speaking populations. The current study was conducted to investigate the difference between native and non-native English speakers in the phonemic restoration effect, and the non-native population were Chinese students. The purpose of choosing one non-native English speaking population was to control for the influence of the first language. A past study has found a mediation of the first language's mental lexicon between the perceptual and lexical level of the second language in the first stages of the second language proficiency (Kroll, Van Hell, Tokowicz, & Green, 2010), and the more proficient the language learner becomes, the less the first language becomes involved in mediating the perception of the second language. However, the effect of the first language might exceed the mediation of the perception of the second language. Previous studies showed that the first language has an effect on the lexical decision of the second language when two phonemes in the second language are not distinguishable in the first language, which make non-native speakers perceive two words that differ only in those undistinguishable phoneme as homophones (Pallier, Colome, & Sebastian-Galles, 2001). This can be done by assigning non-native speaking groups with each group composed of a different non-native speaking population (e.g., Spanish group, German group, Japanese group etc.) and comparing theme with a native English speaking control group. However. It is important to consider the phonemic system of each language. In the present study, we used two types of phoneme class: liquid and nasal phonemes. Some languages might not have these phonemes. For example, The Japanese language does not have the liquid phonemes /l/ and /r/ (Flege, Bohn, Jang, 1997), which may affect the results of the study. The results may be attributed to the lack of phoneme experience instead of the development of the second language's mental lexicon. It is also important to note the when using different phoneme classes, the noise used as an added or replacing sound should change. For example, when using vowel phonemes, it is better to use pure tone noise (Samuel, 1987; Samuel, 1996).

In conclusion, the study of Samuel and Frost (2015) examined the difference between native and non-native speakers in lexical to the pre-lexical level of speech perception. By using the selective adaptation method, they found that the lexical support is related to language proficiency, in which the higher the language proficiency is, the stronger the lexical support would be. The present study aimed to investigate this assumption by using the phonemic restoration method. The logic of the phonemic restoration method is that the higher the lexical development is, the stronger the phonemic restoration would be. This study was aiming to understand the difference between native and non-native speakers in perceiving spoken words and whether native speakers have the advantage of perceiving spoken words in situations where irrelevant noise is present. In addition, understanding the phonemic restoration effect in a second language perception would provide further insight on whether non-native speakers would have difficulties in perceiving spoken words with the present of irrelevant noise. The results were not consistent with the study of Samuel and Frost (2015) as non-native speakers showed more phonemic restoration effect than did the native speakers.

Although these findings did not support the expected hypotheses of this study, it is considered as further contribution to the literature investigating the lexical influence to the pre-lexical level. In addition, we believe it made a positive contribution to the field of study on second language acquisition.

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Appendix A

Four-Syllable Experimental Words With Liquid and Nasal Phonemes on the Middle and Final Syllables.

Phonemes in the middle syllables (underlined).

1. ALTERNATIVE
2. CALCULATION
3. COMBINATION
4. CORPORATION
5. DECLARATION
6. DECORATION
7. EVOLUTION
8. EXAMINATION
9. EXPLANATION
10. INFORMATION
11. OPERATION
12. POPULATION
13. PREPARATION
14. RECOGNITION
15. REGULATION

Phonemes in the final syllables (underlined).

1. ABSOLUTELY
2. ADVERTISEMENT
3. APPROXIMATE
4. CATEGORY
5. ESTABLISHMENT
6. EVENTUALLY
7. EXTRAORDINARY
8. LITERALLY
9. MILITARY
10. NECESSARY
11. ORDINARY
12. SECRETARY
13. TEMPORARY
14. UNFORTUNATE
15. UNLIKELY

Appendix B

Eight-Point Word Similarity Scale.

From 1 (most unlike) to 8 (most like), to what degree did the previous two words resemble each other?

Most unlike 1 2 3 4 5 6 7 8 Most Like

Note: the same scale was presented in each trial.

Appendix C

Survey.

1. What is your sex? Male Female
2. What is your ethnicity?
3. How old are you? ________
4. What is your major? ___________
5. Are you a native English speaker?

If no, answer the following questions:

6. How long have you been studying English?
7. How long have you been in the U.S.A?
8. Have you taken the TOEFL test?
9. If yes, what was your score?
10. Have you taken the IELTS test?
11. If yes, what was your score?

Appendix D

IRB Approval

FORT HAYS STATE UNIVERSITY

Forward thinking. World ready.

OFFICE OF SCHOLARSHIP AND SPONSORED PROJECTS

DATE:	March 31, 2016
TO:	Mohammed Alsahli
FROM:	Fort Hays State University IRB
STUDY TITLE:	[886869-1] Investigating the Lexical support on the Low-Level of Perception in Non-Native Speakers Using the Phonemic Restoration Paradigm
IRB REFERENCE #:	16-093
SUBMISSION TYPE:	New Project
ACTION:	DETERMINATION OF EXEMPT STATUS
DECISION DATE:	March 31, 2016
REVIEW CATEGORY:	Exemption category #2

Thank you for your submission of New Project materials for this research study. The departmental human subjects research committee and/or the Fort Hays State University IRB/IRB Administrator has determined that this project is EXEMPT FROM IRB REVIEW according to federal regulations.

Please note that any changes to this study may result in a change in exempt status. Any changes must be submitted to the IRB for review prior to implementation. In the event of a change, please follow the Instructions for Revisions at http://www.fhsu.edu/academic/gradschl/irb/.

The IRB administrator should be notified of adverse events or circumstances that meet the definition of unanticipated problems involving risks to subjects. See http://www.hhs.gov/ohrp/policy/AdvEvntGuid.htm.

We will put a copy of this correspondence on file in our office. Exempt studies are not subject to continuing review.

If you have any questions, please contact Leslie Paige at lpaige@fhsu.edu or 785-628-4349. Please include your study title and reference number in all correspondence with this office.