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ACOUSTIC CUES FOR ENGLISH LEXICAL STRESS PERCEPTION BY MANDARIN NATIVE SPEAKERS: A CRITICAL REVIEW

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Previous studies have suggested that Mandarin and English speakers use different phonetic cues in speech perception. In particular, there are many differences between English and Mandarin in terms of lexical stress patterns. Different tones are used to change lexical meanings in Mandarin, whereas such phenomena do not exist in English, which indicates potential inter-language interferences in the perception of English lexical stress by Mandarin English-as-an-Additional-Language (EAL) learners. The current paper discusses Mandarin EAL learners' perception of English lexical stress by critically reviewing previous studies. In general, findings have suggested that Mandarin EAL learners use various phonetic cues in English lexical stress perception, though which phonetic cues are primarily used is still under debate. The paper further identifies several variables that may account for the contrastive findings in previous studies and discusses their potential implications for EAL pedagogy development.

INTRODUCTION

Although the perception of English lexical stress by Mandarin EAL learners have been investigated in experimental settings (Archibald, 1997; Lai & Sereno, 2007; Ou 2004; Wang, 2008), previous studies have shown conflicting findings of the acoustic cues used by Mandarin EAL learners for English lexical stress perception. Although many studies have examined different teaching models in improving students' listening accuracy (Lai 2008; Abe, 2010), most of them have used English native speakers' judgment as the primary criterion to assess participants' improvement, which lacks accurate acoustic measurements.

Exploring the perception process of English lexical stress by EAL learners has significant theoretical and pedagogical implications. Theoretically, studying the acquisition process of lexical stress can reveal how the L2 acquisition process is constrained by interlanguage grammar. As suggested by Flege's (1995) Speech Learning Model (SLM), the mature L1 phonological system plays an active in the process of L2 phonological acquisition: similar sounds in the L1 and L2 may interfere with each other and create difficulties for learners. However, models like the SLM focus mainly on the segmental level of L2 phonological acquisition. Suprasegmental features such as lexical stress are not sufficiently specified. For example, although several studies have documented the phonological difficulties met by Mandarin EAL learners regarding Mandarin-English phonological interactions (Yao, 2008; Wang, 2008; Huang & Radant; 2009), it is only in recent years that EAL lexical perception has attracted increasing attention from L2 phonetics researchers (Lai & Sereno, 2007; Wang, 2008; Yu & Andruski, 2010; Zhang, 2008).

Pedagogically, the acquisition of English lexical stress is very important in EAL instruction since it is closely associated with learners' listening comprehension accuracy. Misperception of stressed syllables in English may lead to inaccurate comprehension, thereby resulting in ineffective communication (Liu, 2007). However, relevant discussions of lexical stress are rarely found in EAL instruction texts and little effort has been made to transfer relevant experimental findings to language classrooms (e.g. Doughty & Long, 2003; Levis, 1999; Lightbown & Spada, 1999; Nuan, 1999).

This paper contributes to these issues by critically reviewing recent studies on the perception of English lexical stress by Mandarin EAL speakers. The review has three major purposes. First, it explores factors that contribute to the marginal status of phonological accuracy studies in applied linguistics, aiming at identifying current gaps on English lexical stress acquisition between classroom-based and experimental studies. Second, it reviews experimental studies on these issues and evaluates their findings, especially on the acoustic cues used by Mandarin EAL speakers for English lexical stress perception. Third, it discusses the potential of transferring experimental findings to real language teaching contexts.

The paper first reviews research on lexical stress perception from an applied linguistics perspective, then compares Mandarin and English lexical stress systems, then examines recent empirical explorations on English lexical stress perception by Mandarin native speakers, followed by the concluding sections.

The Marginalized Status of Phonological Accuracy Studies in Applied Linguistics

English lexical stress acquisition has been somewhat marginalized in previous language pedagogy studies despite its significant roles in EAL listening comprehension and pronunciation (Derwing & Munro, 2005). This phenomenon may partially be attributed to the prevalence of Communicative Language Teaching (CLT) in current EAL education (Doughty & Long, 2003; Lightbown & Spada, 1999; Nuan, 1999). One key factor of CLT was its emphasis of language content rather than form. As a result, lexical stress, along with other elements of language structure, was deemphasized in early CLT frameworks.

Lexical stress is an understudied topic in applied linguistics in general, and the learning of lexical stress for Mandarin learners has not been sufficiently studied. In the following sections, I will focus on experimental studies on English lexical stress perception by Mandarin native speakers and review issues concerning the status of acoustic cues in Mandarin-English phonological interference.

Mandarin and the Lexical Stress Systems of English

Lexical stress can be defined as "the syllable prominence in a word" (Ou, 2004, p. 1541). Generally, the stress systems of natural languages can be presented as the taxonomy in Figure 1, in which languages are categorized as stress, pitch accent, or tone languages (Altmann & Vogel, 2002; Archibald, 1997). "Pitch accent" refers to the use of pitch to mark syllabic prominence whereas "tone" refers to the use of pitch in language to distinguish lexical or grammatical

meanings. It has been argued that all stress languages belong to accentual languages and tone languages are all non-accentual languages. Based on this taxonomy, the primary difference between English and Mandarin in lexical stress is that English is an accentual language with movable stress assignment while Mandarin uses tone lexically to differentiate word meanings.

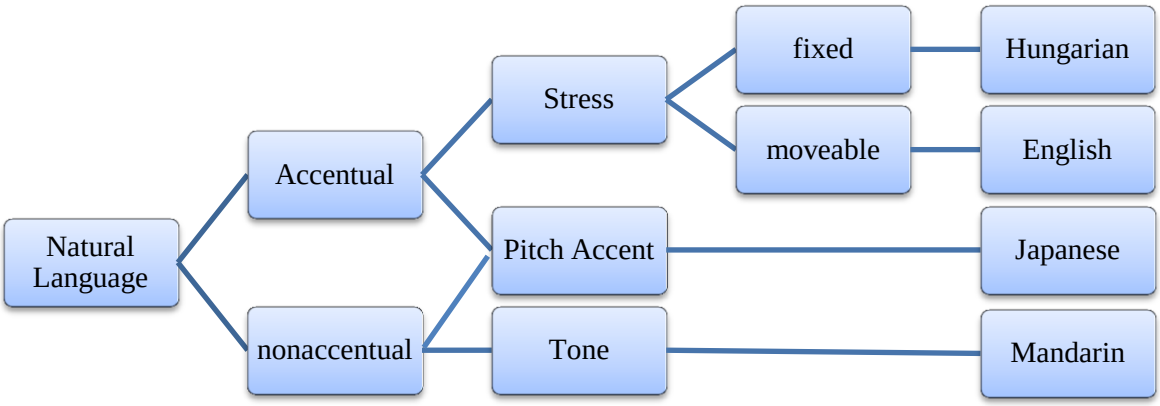

Figure 1. A taxonomy of stress systems in natural languages (adapted from Archibald, 1997)

The acoustic cues for English lexical stress have been extensively studied by researchers (e.g. Fry, 1955; 1958; Lehiste, 1970). Generally, four acoustic cues have been identified for English lexical stress: fundamental frequency (F0), duration, intensity and formant structure (Wang, 2008). Fundamental frequency (F0) is defined as the lowest frequency of a periodic waveform; duration is the time interval; intensity refers to the power of sound; and formant structure is the acoustic resonance of sounds (Hirst, 2006). In English lexical stress perception, the four cues are not weighted equally. Series of studies have shown that the F0 is the most influential factor, followed by duration and intensity. For instance, in the seminal study of Fry (1958), F0 has a consistent effect on duration manipulated word "subject." The research participants tended to judge the lexical stress as occurring word initially when F0 was higher in the first syllable. Fry (1955) also showed that when judging the stress of synthesized words with various duration and intensity manipulations, native speakers' performance was influenced by both duration and intensity cues. Lehiste (1970), reviewing Fry's studies, argued that the F0 was a very strong cue for lexical stress identification while the function of duration and intensity was secondary. A fourth acoustic cue, formant structure has also been discussed in recent studies. For example, it has been suggested that English native speakers have different preferences for the stress patterns in nouns and verbs based on formant structure (Lai & Sereno, 2007; Yu, 2008; 2010).

There are three theories regarding the Mandarin lexical stress system: the non-stress theory, final stress theory, and left-headed theory (Lin, 2001). The non-stress theory says that in Mandarin there is no lexical stress since tones are used lexically. The final stress theory argues that in

typical disyllabic Mandarin phrases[1], stress is word final, as indicated by the longer duration of the second syllable (Chao, 1968). The third theory is the left-headed theory which proposes that Mandarin has initial stress. This theory is supported by the longer onset time and wider pitch of the first syllable (Duanmmu, 2000) as well as other evidence such as the distribution of the neutral tone in Mandarin (Lin, 2001). Lin (2001), however, made three arguments against the final-stress theory: first, in disyllabic Mandarin phrases, the first syllables does not exhibit tone reduction; second, the lengthening of the final syllables may be attributed to a domain-final effect, and third, the lengthening of the final syllables are not observed in polysyllabic sentences (Wang & Wang, 1993). For the present study, I will adapt the left-headed theory.

Despite the various theories on Mandarin lexical stress system, previous research on Mandarin tones has shown that Mandarin native speakers use acoustic cues (F0, duration, and intensity) in Mandarin tone perception and production (e.g. Howie, 1976; Lin, 1988; Moore & Jongman, 1997; Tseng, 1990), which resembles English lexical stress identification. F0 is regarded as the primary acoustic cues for Mandarin tones. For instance, Howie (1976) used synthetic speech with manipulation on the F0 contour in three identification tests and found that participants achieved the best performance when the pitch patterns are maintained. Similar results were reported in Lin (1988), in which the highest discrimination rate in synthesized speech tests (tests using artificially created human speech) was provided by F0. By comparison, the other two acoustic cues (duration & intensity) are believed to have limited influence on Mandarin tone identification. In Lin's (1988) discrimination test, the influence of different duration of the four tones was estimated to contribute to only 3% of the results. Fu & Zeng (2000) suggested that the intensity contour in Mandarin tones is highly correlated with the F0 contour, which makes it the secondary significant factor in Mandarin tone perception.

In sum, acoustic cues (F0, duration, and intensity) are utilized differently in Mandarin and English. These are used for lexical stress identification in English while in Mandarin they are used lexically to differentiate word meanings. Thus, it is expected that for Mandarin EAL learners, their perception of English lexical stress will be influenced by their L1 experience with these acoustic cues. One possibility is that Mandarin EAL learners will transfer their acoustic use in Mandarin into English and thereby memorizing the English stress lexically (Archibald, 1997). Alternatively, they may acquire the use of acoustic cues in English and show similar lexical stress identification pattern as English native speakers.

Previous Studies on English Lexical Stress Perception by Mandarin EAL Speakers

The perception of English lexical stress has been studied among EAL learners with multiple L1 backgrounds, such as Spanish (Archibald, 1993; Guion, Harada, & Clark, 2004), Korean (Guion, 2005), and Mandarin (Archibald, 1997). In general, these studies have confirmed the influence of

[1] Many Chinese linguists (e.g. Chao, 1968) argue that the essential word unit in Chinese is disyllabic; such as the phase "Chi-Fan" that is the composition of "Chi" (eat) and "Fan" (rice). For the consistency of discussion, in the following paper, the "lexical stress" of Chinese refers to the stress patterns in typical disyllabic Chinese phrases.

L1 lexical stress systems on EAL learners' perception of English lexical stress. For instance, Archibald (1993) investigated the acquisition of English metrical parameters by adult Spanish speakers and found that the extrametricality markings[2] in Spanish are transferred in to the participants' L2 English. Similarly, in Guion (2005), both early and late Korean-English bilinguals demonstrated non-native like knowledge of the distributional patterns of stress placement across the lexical classes of noun and verb in English.

One seminal early work on L2 lexical stress acquisition is Dresher and Kaye (1990), which adopted the Principles and Parameters framework by Chomsky and proposed that there were eight parameters on language's phonological system (Table 1). According to this model, different languages employ different values on these parameters, which generate various lexical stress systems. Thus for a L2 learner, acquisition of L2 lexical stress patterns means adjusting the L1 parameters to the L2 settings.

Table 1

Parameters of Phonological Stress System

P1	The word-tree is strong on the [left/right].
P2	Feet are [binary/unbounded].
P3	Feet are built from the [left/right].
P4	Feet are strong on the [left/right].
P5	Feet are quantity-sensitive [yes/no].
P6	Feet are quantity-sensitive to the [rime/nucleus].
P7	A strong branch of a foot must itself branch [yes/no].
P8	There is an extrametrical syllable [yes/no].
P8A	It is extrametrical on the [left/right].

Adopted from Dresher and Kaye (1990)

Following Dresher & Kaye (1990), Archibald (1997) applied this model to investigate the English lexical stress perception and production by Mandarin native speakers in a longitudinal study. He found that in both perception and production tests, the Mandarin subjects showed no acquisition of English stress assignment principles, which indicated that the Mandarin subjects tended to treat English lexical stress as a phenomenon that requires mechanical memorization. Archibald further argued that this could be explained by the different linguistic processing of pitch in Mandarin and English. The fact that pitch is phonemic in Mandarin may transfer to the Mandarin EAL learners' perception of English. This is in accord with studies of lexical stress in other language interactions, such as French speakers who learn Spanish as an L2. In a series of studies of Spanish stress perception by French speakers, Dupoux et al showed that native speakers of French exhibited stress 'deafness.' They had difficulties distinguishing stress contrasts in Spanish, which can be partially attribute to the fact that stress in French is

[2] Extrametricality refers to the phenomena that in certain languages, the rightmost syllable of words can be 'ignored' when metrical structure is constructed (Hulst, 2006).

non-contrastive while it is contrastive in Spanish (Dupoux, Pallier, Sebastián, & Mehler, 1997; Dupoux, Peperkamp, & Sebastián-Gallés, 2001; Dupoux, Sebastián-Gallés, Navarrete, & Peperkamp, 2008).

By comparison, studies under different frameworks have shown conflicting results against the strong argument of Archibald (1997). These studies have demonstrated that at least to some extent, Mandarin EAL learners are able to use acoustic cues in English lexical stress perception. For instance, Ou (2004) conducted perception test of trisyllabic English pseudo-words with 20 postgraduate Mandarin students and found that eight showed sensitivity to extrametricality of different grammatical categories and syllable weight, which indicates some sort of metrical computation of English stress. This result was further tested in Ou (2010) with Taiwanese EAL learners and the results supported the hypothesis that Mandarin EAL learners may be able to improve their phonological awareness of the differences between lexical tone and lexical stress according to their developmental stages.

Furthermore, several recent experimental studies have explicitly investigated the use of acoustic cues by Mandarin EAL learners in English lexical perception and their results generally confirmed Mandarin EAL learners' ability to use acoustic cues in English lexical perception. Wang (2008) used pseudo-words with manipulation in F0, duration, and intensity to test Mandarin EAL learners and English native speakers. Results indicated that, similar to English native speakers, the Mandarin EAL learners showed systematic variation in concordance with the manipulation of acoustic cues. Other evidence is provided by Yu and Andruski (2010), in which real words and hums were also tested along with pseudo-words. The results demonstrated that Mandarin speakers had different response patterns to trochaic and iambic stress in the three types of stimuli, which indicated their sensitivity to stress structure in English.

Other studies have disagreed on the weight of different acoustic cues in Mandarin EAL learners' perception of English lexical stress. In Wang (2008), the Mandarin EAL participants had significantly lower reliance scores in duration and intensity, but higher for F0, which indicated there was a transfer of reliance of F0 in Mandarin tone identification to English lexical stress perception. In other words, the results supported the hypothesis that Mandarin EAL learners can actively redeploy their knowledge of acoustic cues in English stress perception. This result is also supported by Lai (2008), in which advanced Mandarin EAL listeners are found to focus more on maximum F0. In contrast, in Zhang (2007), both Mandarin EAL learners' perception and production of English stress were tested and Mandarin EAL learners used F0 and intensity to a lesser extent while vowel quality was weighted greater than other acoustic cues. Finally, formant structure was also found to influence Mandarin EAL learners' preference of stress perception. In a series of studies, EAL learners identified English pseudo-words with iambic stress patterns significantly more quickly than those with trochaic patterns, which supports the transfer of Mandarin word-final stress to EAL phonological perception (Yu, 2008; Yu & Andruski, 2010; Yu & Sereno, 2007).

The recent experimental studies have provided a complicated picture regarding the acoustic cues used by Mandarin EAL learners in English lexical stress perception. Although all the major

acoustic cues (i.e., F0, duration, intensity, vowel quality, and formant structure) contributed to the perception of English stress, which acoustic cue played the primary role is still under debate.

There are several possible reasons for the varied results. First, the experimental subjects' proficiency of English may have influenced their performance in the perception tests. Although all the studies used advanced Mandarin EAL learners as participants, their exposure to English varied from study to study. In Wang (2008), the participants were college students majoring in English at a Mandarin university; thus their exposure to English was limited to classroom instruction. By comparison, Zhang (2007) and Yu and Andruski (2010) used Mandarin speakers studying in US universities. Their residence in an ESL context may have improved their awareness of English lexical stress. As shown in the comparative analysis in Lai (2008), beginning Mandarin EAL learners tended to rely on duration to identify English lexical stress, which was not found for the advanced EAL group. Ou (2010) also provided evidence to support the claim that phonological training can improve Mandarin EAL learners' phonological awareness. Second, the use of pseudo-words may be a factor since using real words may introduce semantic processing. In Archibald (1997), the test tokens were real words such as "aroma", and "cinema", and one possible interpretation of his results might be that the participants' familiarity with some of the tokens made them process the tokens phonemically. In more recent studies (e.g., Ou, 2010; Wang, 2008), pseudo-words were used as the stimuli. Yu and Andruski (2010) showed that participants' performance did not vary significant between pseudo and real words, which suggested that the use of pseudo-words does not comprise experiment subjects' performance and thus may be regarded as a more reliable measurement than using real word stimuli. Finally, various interpretation of the Mandarin lexical stress system may also lead to conflict experimental findings. As reviewed in the previous section, there are three contrastive theories of the Mandarin lexical stress system. If we adapt the non-stress theory, then results indicating no transfer between Mandarin and English stress are predicted. By contrast, if the existence of lexical stress is assumed in Mandarin, then we would expect some degree of transfer since Mandarin EAL learners are not "stress deaf" under this basis. In the reviewed studies, Archibald (1997) was based on the non-stress theory while Ou (2004) and Wang (2008) adapted the left-headed one. In the series studies by Yu, the final stress theory is used. Such distinctive starting points may affect the follow-up data interpretation. To sum up, the participants' proficiency of English, the stimulus type and the assumptions about Mandarin lexical stress system may also have led to conflicting findings in previous studies. Thus in future studies, these factors should be thoroughly considered in advance.

Many empirical questions regarding Mandarin speakers' perception of English lexical stress are still unsolved. For instance, although experimental studies have shown Mandarin speakers are able to use acoustic cues in processing English lexical stress, the process used is still unclear. One possible situation may be that the Mandarin speakers redeploy their knowledge of acoustic cues in L2 lexical stress; but it is also possible that they are treating stress in English lexicons like tones. Finally, the developmental stages of Mandarin EAL speakers' lexical stress system have not been described.

PEDAGOGICAL IMPLICATIONS AND CONCLUSION

Although pedagogical implications are not the focus of the reviewed studies, their findings provide valuable empirical evidence for EAL's listening comprehension instruction. First of all, all the studies address the importance of raising Mandarin EAL learners' awareness of suprasegmental features in English. Furthermore, the use of pseudo-words in perception tests may also be modified for language assessment. To avoid the familiarity effect, less common words should be used when testing EAL learners' perception of English stress in classroom settings.

In sum, previous studies on Mandarin EAL learners' perception of English lexical stress suggested complicated patterns of acoustic cue-use during identification. Overall, most previous studies suggested that Mandarin EAL learners were able to actively use acoustic cues in processing English lexical stress. However, the studies contradict each other in the weight of different acoustic cues, which indicates a need for careful control of participants' English proficiency, appropriate construction of stimuli, and careful selection of Mandarin lexical stress theory.

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