

PERCEPTION OF ENGLISH LEXICAL STRESS WITH A MARKED PITCH ACCENT BY NATIVE SPEAKERS OF MANDARIN*

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ABSTRACT

Three perceptual experiments were conducted to investigate the perception of English lexical stress with a marked nuclear pitch accent by native speakers of Taiwan Mandarin at the phonological and phonetic levels of processing. The stimuli were English disyllabic word pairs differing only in the position of the stress and in the morphosyntactic categories (e.g., *PERmit* (n.) vs. *perMIT* (v.)), presented for identification or discrimination. The general finding is that Mandarin-speaking learners of English performed in a native-like manner in the unmarked pitch accent context but not in the marked one. Further examination of their performance in the latter context revealed that while experienced learners failed to match the stress patterns with their morphosyntactic categories in the identification task, they could categorize them in the ABX task, which suggests that they were not phonologically deaf to stress. In contrast, inexperienced learners could not do the same, presumably deaf to stress at the phonological level. Yet, their sensitivity to both within- and across-category stress differences in the AX task indicates that they did not experience stress deafness at the phonetic level.

Key words: English prosody, stress deafness, interaction between stress and intonation patterns

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1. INTRODUCTION

It is well-documented that the phonetic categories of one's first-language (L1) have persistent effects on speech perception. The L1 phonological system, which is developed as early as the first year after birth (Werker and Tees 1984), may come to hinder or assist the discrimination of sounds that are non-native to the listener. Observations of this phenomenon have been reported in many second language (L2) studies. For example, it is a challenge for speakers of Japanese to distinguish between the English /r/-/l/, as the two sounds do not contrast with each other phonologically in Japanese (e.g., Goto 1971; Miyawaki et al. 1975). Spanish listeners experience difficulty in discrimination of the English /i/ and /ɪ/ due to the lack of such a contrast in Spanish (e.g., Flege, Bohn, and Jang, 1997; Morrison 2002), whereas German listeners have less difficulty with this vowel distinction because a similar contrast between /i/-/ɪ/ is found in German (e.g., Bohn and Flege 1990; Flege et al. 1997). These examples illustrate how perception is crucially affected negatively or positively by the established native phonetic categories.

Languages differ not only in segmental contrasts but also in the phonological use of suprasegmental features, such as duration, pitch, and intensity, to provide contrast in the meaning of words, phrases, or utterances. Parallel to the findings from segmental studies, the perception of non-native prosodic contrasts is also found to be impeded or assisted by L1. Take the cross-linguistic use of pitch as an example. Some languages do not generally contrast lexical items using the variations of pitch height and pitch contour. Consequently, speakers of such languages show considerable problems in discriminating or interpreting Mandarin lexical tones (Gandour 1978; Wang, Sereno, and Jongman 2006). The problems are found, for instance, in French speakers, who are reported to perceive the synthesized tonal continua of Mandarin Chinese in a less categorical way than Mandarin natives do, presumably because pitch variations are not implemented in French to differentiate word meanings (Hallé, Chang, and Best 2004). The inaccurate interpretation of tones is also observed in native speakers of American English, who tend to misinterpret Mandarin lexical tones (which are used to distinguish word meanings) as English intonation patterns (which are used to attach

syntactic or pragmatic meanings to utterance) (Chen 1997; Juffs 1990). These two examples demonstrate the interference of L1 prosodic contrasts with the perception of L2 prosodic contrasts.

Nevertheless, speakers of tone languages are shown to be able to perceive words or non-words that contrast in the position of stress (e.g., *PERmit* vs. *perMIT*) just as well as speakers of stress languages like English do (Lin, Wang, Idsardi, and Xu 2014; Lukyanchenko, Idsardi, and Jiang 2010). The former's success can be attributed to the fact that stress has multiple phonetic correlates—pitch, duration, intensity, vowel quality, and spectral tilt—among which pitch also serves as a crucial cue to lexical tone. In other words, the shared phonetic cue somehow aids L1 lexical tone language speakers in their perception of lexical stress, despite the typological differences between their L1 and stress languages.

However, it should be noted that the non-native perception of lexical stress reviewed above is primarily investigated when the test words are carried in the unmarked pitch accent context, where the stressed syllable is relatively more prominent than the unstressed syllable in terms of all phonetic correlates—higher pitch, longer duration, and greater intensity. Not much work has been done on how stress is perceived by non-native speakers in the marked pitch accent context (e.g., when stress is not primarily realized in a higher pitch), and there are several reasons to investigate this issue in, for example, English. First, stress is an abstract metrical notion, which dictates the relative prominence relationship between two prosodic constituents (e.g., syllables) (Hayes 1981, 1995; Liberman 1975), but the phonetic realization of the stressed syllable varies with the pitch accent pattern it takes (Beckman and Pierrehumbert, 1986; Ladd 1996). Specifically, in English, a stressed syllable may be associated with either a high or a low pitch. The association of the stressed syllable with a low nuclear pitch accent is exemplified by two of the five common pitch accent patterns in English, as illustrated by Ladefoged (2006). This suggests that the low pitch realization of stressed syllables in English is not uncommon. Therefore, there is a need to investigate the perception of English lexical stress in the marked pitch accent context.

Second, the investigation of the perception of stress in the marked pitch accent pattern might contribute to our understanding of specific problems in relation to L2 English pronunciation as well. For instance, in language teaching and learning, the technique of recast, in which the instructor reformulates a student's utterance by replacing a spotted wrong pronunciation with the correct one (Lyster and Ranta 1997), is sometimes used to help rectify learners' pronunciation errors. Some studies have indicated that the method is effective in helping the acquisition of the English /r/-/l/ contrasts by L1 Japanese learners (Saito 2014). When recast is adopted in the correction of students' error in the placement of stress, stress factors such as an instructor's ability to pronounce the stress in different pitch accent contexts and students' ability to perceive the stress in these contexts would determine whether recast works. An anecdotal datum collected from the author's classroom is given below, where the stressed syllable of the word in question, *important*, is capitalized, and its pitch movement is indicated by impressionistic lines above it.

(1) Teacher: What does VIP stand for?

Student: Very IMpotant person.
[ˈɪmpətənt]

Teacher: You mean very imPORtant person?
[ɪmˈpɔːtənt]

Student: Very IMportant person.
[ˈɪmpɔːtənt]

It is obvious that the student exhibited misplacement of stress in the word *important*, accompanied by the dropping of the post-vocalic /r/, as well. The teacher attempted to recast the errors by uttering the right stress placement in the rising pitch accent pattern, with a more marked pitch accent (a low tone) on the stressed syllable. The recast worked in the case of the omitted post-vocalic /r/, but it was not successful for the

misplacement of the stress because the student might not have been able to capture the instructor's corrected form.

In summary, this paper intends to investigate the perception of English lexical stress in the marked pitch accent context. The following section presents a review of the literature on the perception of stress by non-native speakers, based on which the questions of the current study are generated. Then, the method, the results, and the discussion are presented. Finally, the conclusion ends the paper.

2. LITERATURE REVIEW

The present study is motivated by the observation that there is interplay between word stress and pitch accent patterns. According to Beckman (1986), English typologically belongs to a family of languages in which prominent syllables are marked with lexical stress. Stress, which has a number of phonetic correlates including duration, spectral tilt, and segmental quality, interacts with pitch accent patterns in the formation of the pitch contour of the utterance. Specifically, the stressed syllable is to be associated with the nuclear pitch accent, which may be followed by other pitch accents that indicate phrasal or utterance boundaries. The pitch accents are underlying representations for pitch height that can be categorically labeled as high or low tone, and the surface realization of a certain pitch pattern is assumed to be an interpolation of these underlying target tones (Beckman and Pierrehumbert 1986; Beckman, Hirschberg, and Shattuck-Hufnagel 2005). The examples in (2), presented with underlying tones and impressionistic lines that indicate surface pitch movement, show surface pitch patterns that may occur upon the stressed syllable of a word. In the pitch accent pattern that syntactically denotes “declarative” or “affirmative”, the stressed syllable is realized with a high nuclear pitch accent (or a high word tone; H*), which may be optionally followed by a low phrasal pitch accent (or a low phrasal tone; L-) and a low boundary tone (or a low tone indicating the end of the utterance; L%), as shown in Example (2a). In the pitch accent pattern that denotes interrogation, the stressed syllable bears a low nuclear pitch accent (or a low word tone;



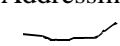
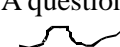

L*), optionally followed by a high phrasal pitch accent (or a high phrasal tone; H-) and a high boundary tone (or a high tone indication the end of the utterance; H%).¹ Among the five common pitch accent patterns in English, as shown in (2) on next page, cited from Ladefoged (2006:126), two have a low nuclear pitch accent (i.e., (2b) and (2c)). In other words, the stressed syllable may coincide with a high pitch, but that is not always the case. Although these examples illustrate that high pitch is not a consistently reliable phonetic cue to stress, it is of considerable interest to investigate whether speakers of a lexical tone language (e.g., Mandarin), who exploit pitch in making lexical distinctions, will be “deaf” to stress when the pitch accent context is relatively marked (e.g., when the stress is applied in the context of a low nuclear pitch accent; L%).

The inability of non-native speakers’ to perceive stress contrasts is known as “stress deafness,” a term originally coined to refer to French speakers’ failure to discriminate non-word pairs that differ only in the position of stress (Dupoux, Pallier, Sebastián, and Mehler 1997). Using an ABX task, Dupoux and her colleagues found that French speakers were unable to ascribe a stimulus X (e.g., *bópelo*) to another stimulus of the same stress pattern, which would be either stimulus A or B (e.g., *bópelo* or *bopélo*). However, after the manipulation of the level of the difficulty of the tasks, French speakers were found to be able to distinguish between the stress minimal pairs in the same-different AX task (e.g., responding whether a heard X (e.g., *bópelo*) is the same as or different from the previously presented A stimulus (e.g., *bopélo*)). Compatible findings have been further confirmed by the series of studies they have conducted (Dupoux, Sebastián-Gallés, Narrete, and Peperkamp 2008; Peperkamp, Dupoux, and Sebastián-Gallés 1999; Peperkamp and Dupoux 2002). These studies suggest that the stress deafness of French speakers occurs only at the phonological level but not at the phonetic level. The inability of French speakers to phonologically

¹ Exceptions have been found in a few varieties of English dialects. For instance, in the Brighton area of the United Kingdom, the pitch accent that indicates interrogation is a falling intonation. However, this should not influence our study because the non-native speakers in this study have acquired major dialects of English (e.g., General American English or Received Pronunciation).

categorize stress is attributed to the lack of phonological representation of lexical stress in French.

(2) Common English pitch accent patterns (cited from Ladefoged (2006:126))

- a. A simple statement in response to *What is her name?*

 A mé li a
 | | |
 H*L- L%
 underlying pitch accent pattern
- b. A yes/no question, equivalent to *Did you say Amelia?*

 A mé li a
 | | |
 L* H-H%
 underlying pitch accent pattern
- c. Addressing Amelia, indicating that it is her turn to speak

 A mé li a
 | | |
 L*L-H%
 underlying pitch accent pattern
- d. A question indicating surprise

 A mé li a
 | | |
 L+H*L-H%
 underlying pitch accent pattern
- e. A strong reaction, reprimanding Amelia

 A mé li a
 | | |
 L+H* L- L%
 underlying pitch accent pattern

Unlike French, Mandarin is a tone language in which pitch height and pitch contour shapes serve as the most important cues in distinguishing the tones and thus word meanings (Chao 1968; Cheng 1973). This might assist native Mandarin speakers' perception of English stress in some cases. For example, when the stressed syllable is phonetically realized in a high pitch, L1 Mandarin speakers are able to perceive English stress contrasts (Lin et al. 2014; Lukyanchenko et al. 2010). Nevertheless, when the stressed syllable is associated with a low pitch, the way in which it is perceived by L1 Mandarin speakers is less well investigated. This lack of investigation is notable, since Mandarin speakers are found to experience a rather different type of deafness, as reported in Ou (2010). The study involved two groups of L1-Mandarin learners of English: One included learners who had learned English for more than ten years and the other included learners who had learned the language for less than three years. In a two-forced choice identification task, the participants were generally able to correctly perceive English non-word stress minimal pairs (e.g., *FERcept* vs. *ferCEPT*) when the stressed syllable was phonetically realized in higher pitch along with longer duration and slightly greater intensity, but were unable to do so when the higher pitch was replaced by a low nuclear pitch accent (L*). In addition, when lexical items were embedded in the marked rising pitch accent pattern, the more experienced learners tended to respond randomly, but the less experienced group showed a bias toward items with iambic stress. These findings suggest that Mandarin speakers experienced a type of stress deafness that arises from the marked pitch accent context.

The issue of stress deafness from the perspective of types of pitch accents, however, is not fully explored in Ou (2010). This is due to the fact that the experiment in the study uses an identification task, in which only a single sound stimulus was presented in each trial, and then a categorization response was required. To perform the task, the non-native speakers had to resort to internal phonological categories stored in the long-term memory. Such a task is argued to be very demanding in the testing of the formation of L2 phonetic categories (Strange and Shafer 2008). A more appropriate approach to investigating the formation of sound categories in a non-native language is suggested

to be an ABX discrimination task, which can accompany an AX discrimination task that assesses non-native listeners' phonetic sensitivity to non-native phones when the phonetic mode of processing is likely to be adopted. Thus, there is a need to re-examine the perception of English lexical stress by L1 Mandarin speakers using different experimental paradigms.

Table 1. The stress deafness constructed based on modes of processing, types of pitch accents and evidence found in previous studies

Context Mode of processing	Unmarked falling (where the stressed syllable is associated with a high pitch accent)	Marked rising (where the stressed syllable is associated with a low pitch accent)
Phonetic mode	Found in L1 French speakers. (Dupoux et al. 1997; Dupoux et al. 2008; Peperkamp et al. 1999; Peperkamp and Dupoux 2002)	Not studied in L1 French speakers yet
	Not studied in L1 Mandarin speakers yet.	Not studied in L1 Mandarin speakers yet
Phonological mode	Found in L1 French speakers. (Dupoux et al. 1997; Dupoux et al. 2008; Peperkamp et al. 1999; Peperkamp and Dupoux 2002)	Not studied in L1 French speakers yet
	Not found and not fully explored in L1 Mandarin speakers (Lukyanchenko et al. 2010; Lin et al. 2014; Ou 2010)	Found but not fully explored in L1 Mandarin speakers (e.g., Ou 2010)

In summary, previous studies have reported cases of stress deafness experienced by native speakers of Mandarin Chinese and French, which are summarized in Table 1 on the previous page. This line of research points to two factors in stress perception: (i) the pitch accent context in which test items are embedded and (ii) the mode of processing that the perceptual experiments require. With these factors in mind, this study aims to investigate L1 Mandarin speakers' perception of English lexical stress in two pitch accent patterns (i.e., unmarked and marked) and by using two tasks (i.e., ABX and AX) that tap into different types of knowledge (i.e., phonological and phonetic). The questions to be pursued are shaded in grey in Table 1.

3. METHOD

3.1 Materials

The stress minimal pairs used in this study were five pairs of disyllabic nouns and verbs with primary stress on the first (i.e., trochaic) or the second (i.e., iambic) syllables: *PERmit* (n.) vs. *perMIT* (v.), *SURvey* (n.) vs. *surVEY* (v.), *IMPact* (n.) vs. *imPACT* (v.), *REsearch* (n.) vs. *reSERACH* (v.), and *IMport* (n.) vs. *imPORT* (v.), where the stressed syllables are spelled in capital letters.² All of these words met the criteria established to ensure that they occurred frequently in language use and thus our non-native participants could be presumed to be familiar with them: That is, they each occurred at least one million times in the CELEX database (Baayen, Piepenbrock, and van Rijn 1993) and appeared in the 7000 wordlist for Taiwan High School Students published by the Ministry of Education in Taiwan. Token stimuli of the words were recorded by a trained phonetician, a female native English speaker with a North American accent, by using a Sony Hi-MD recorder. Each of the words was read three times in two carrier sentences: One was an affirmative statement (i.e., *I said _____*.) to elicit the

² Pairs differing not only in the position of stress but also in the quality of the vowels (e.g., *REcord* vs. *reCORD*) were not included as our main interest was to investigate how suprasegmental features affect the perception of stress.

pronunciations of the word in an unmarked pitch accent context, H*L-L%, and the other was a yes/no question (i.e., *Did you say _____?*) to elicit the pronunciations of the word in a marked pitch accent context, L*H-H%. The recoded items were digitized at 44 kHz (16 bits) and then truncated to the target word at the end of the sentence. This produced three tokens for each word in each of the pitch accent contexts. Three other native speakers of English then checked the tokens of all of the word pairs; two tokens that were judged unambiguously as either nouns or verbs were selected for use.

The vowels of the selected tokens were then measured acoustically and the results are summarized as follows. In the unmarked pitch accent context, the vowels of the stressed syllables were on average 49 milliseconds (ms) longer in duration, 115 Hz higher in pitch, and 6 dB higher in amplitude than those of the unstressed syllables. Figure 1 shows the phonetic characteristics of a sample word pair.

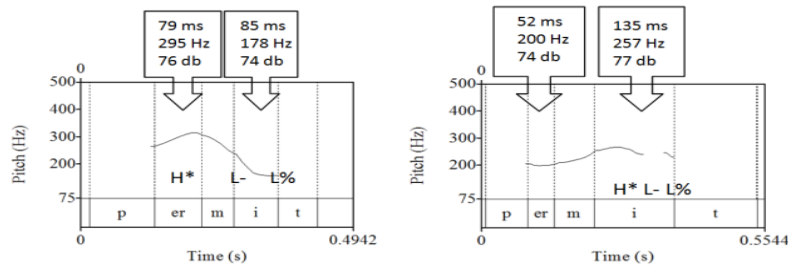


Figure 1. Phonetic characteristics of *PERmit* (left) and *perMIT* (right) in the unmarked pitch accent pattern

In the marked pitch accent context, the stressed syllables were not significantly higher in pitch than the unstressed syllables. The pitch difference of the two stressed patterns lies in the second syllable (i.e., a lower mean pitch when stressed and a higher mean pitch when unstressed (172 Hz vs. 254 Hz on average)). As for duration, the vowels of the stressed syllables were on average 35 ms longer than those of the unstressed syllables. Finally, the intensity was slightly greater in the second syllable in both stress patterns. It seems that the duration and the pitch contour shape of the second syllable are possible cues to the stress

syllable in the marked pitch accent pattern. Figure 2 shows the phonetic information of the word pair, *PERmit* and *perMIT*, in such a pattern.

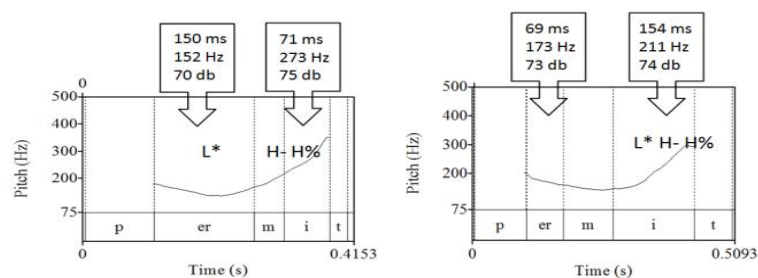


Figure 2. Phonetic characteristics of *PERmit* (left) and *perMIT* (right) in the marked pitch accent pattern

3.2 Participants

Twenty native speakers of English and 40 Taiwanese learners of English were recruited. The native speakers participated as the control group (NE hereafter), and the Taiwanese learners were divided evenly into two groups according to their learning experiences. Twenty of the learners were eight males and 12 females from a university in Southern Taiwan with an average age of 24.5. They had learned English as a foreign language for more ten years; the mean of the duration of their learning, in years, was 11.2 with a standard deviation (SD) of 2.8. They were designated as the experienced Taiwanese group (TwH hereafter). The other 20 participants were nine males and 11 females from a junior high school in Southern Taiwan with an average age of 14.5. They had learned English for less than three years; the mean of the duration of their learning, in years, was 2.4 with an SD of 0.8. They were designated as the inexperienced Taiwanese group (TwL hereafter). None of the participants reported any hearing impairment or speech problems.

3.3 Experiment Design

The experiments of the current study consisted of three tasks that attempted to elicit responses to stress features in the unmarked and

marked pitch accent contexts based on different modes of processing. The first one was an ABX discrimination task, which examined how participants categorized a heard X into two presented stress patterns (trochaic vs. iambic) in two pitch accent contexts (unmarked falling vs. marked rising). In this task, three stimuli A, B, and X were presented one after another once, and the participants were required to classify X as either A or B. Stimuli A and B were always tokens of two words with different stress positions (e.g., A = *PERmit* and B = *perMIT*), whereas X could be another token of the same word as either A or B. The stimulus triplet had an interstimulus interval (ISI) of 1,000 ms, presented in the ABX or BAX order. In addition, because the words were carried in statements or interrogative sentences, all three stimuli were either marked or unmarked in terms of pitch accent patterns. This resulted in 40 trials (10 words x two orders x two intonations), which were divided into two blocks: One contained stimuli in the unmarked falling pitch accent, and the other contained those in the marked rising pitch accent. The order of the trials was random within each block. This task would reveal whether or not participants had the phonetic categories of the two stress patterns and whether or not the phonological mode was likely to be adopted.

The second task was an identification task that required decisions about lexical class. It served as the follow-up to the first ABX task to further examine whether participants who showed sensitivity in the ABX task knew the linguistic functions represented by the two stress patterns (i.e., trochees denoting nouns and iambs denoting verbs). In each trial, there was only one stimulus (e.g., *PERmit*), and it was to be judged by participants as either a noun or a verb. The stimuli also came in the two pitch accent contexts, and therefore, there were 20 trials (10 words x two intonations), all presented randomly.

The final task was the same as the first one with regard to ISI, number of trials, and organization of the blocks, the difference being that it used the AX discrimination design that aimed to test speakers' sensitivity to stress at the phonetic level. Two stimuli, A and X, were presented each time; they were sometimes two tokens of the same word and sometimes tokens of two words with different stress patterns. There were a total of 40 trials (10 words x two AX patterns ("AX-same" or

“AX-different”) x two intonations), and, as in the first task, they were divided into two blocks: One for stimuli delivered with a falling intonation and the other for those delivered with a rising intonation. The trials in each block were also presented in a random order. This task aimed to test participants’ sensitivity to stress differences at the phonetic level.

3.4 Procedure

Participants were seated in front of a response box in a sound-proof chamber and wore headphones. They were informed that there were three listening tasks with 5-minute breaks in between. Instructions about how they were to respond to the auditory stimuli in a trial were then given at the outset of each of the tasks, and the described procedure was repeated until they had completed all of the trials. The instructions were as follows. In the first task, they were asked to determine if the third word which they heard was equivalent to the first or the second one by pressing the associated button on the response box. They were instructed to press button “1” if they regarded the third and the first words as the same word and button “2” if they regarded the third and the second words as the same word. In the second task, they judged whether the spoken word was a noun or verb by pressing button “N” for noun and button “V” for verb after they had decided on its lexical class. In the third task, they determined whether the two stimuli were the same word or two different words by pressing button “S” for “same” and button “D” for “different.”

For tasks composed of two blocks, participants were randomly assigned to complete one of the blocks first, and there was also a pause that allowed them to take a short break before moving on to the other block. In addition, the Taiwanese learners of English were asked to fill out a bio-data questionnaire about their L1 backgrounds and English learning experiences at the end of all the experiments. Participants were each paid two hundred NT dollars (approximately 3.6 US dollars) for their participation.

4. RESULTS

4.1 General Results

The participant's response was either correct or incorrect, coded as 1 or 0, respectively. The percentages of correct responses to stimuli presented in different contexts were calculated for the NE, TwH, and TwL groups. In the ABX task, a correct response was counted when they pressed the button associated with the same word as X. Table 2 shows their mean accuracy rates under different conditions, which are sorted by stress pattern, pitch accent context, and identity of the X stimulus.

Table 2. Mean accuracy rates with SDs in parentheses of the ABX discrimination task in the two pitch pattern contexts (%)

In the unmarked pitch context (i.e., falling intonation):

	Trochaic stress pattern		Iambic stress pattern	
	X= A	X= B	X= A	X= B
NE	93 (9.8)	95 (10.0)	92 (10.1)	89 (10.2)
TwH	91 (12.1)	92 (12.0)	90 (10.3)	90 (12.1)
TwL	91 (12.1)	87 (11.7)	88 (13.6)	89 (12.1)

In the marked pitch context (i.e., rising intonation):

	Trochaic stress pattern		Iambic stress pattern	
	X= A	X= B	X= A	X= B
NE	93 (9.8)	90 (12.1)	88 (12.0)	90 (10.2)
TwH	80 (15.9)	78 (17.0)	82 (12.8)	80 (18.4)
TwL	72 (13.6)	67 (18.7)	72 (12.0)	71 (17.7)

NE: native speakers of English

TwH: experienced learners

TwL: inexperienced learners

In the identification task, a response was correct if participants correctly identified a word with trochaic stress as a noun or a word with iambic stress as a verb. The mean accuracy rates are presented in Table 3. The third task required a categorical discrimination of the A and X stimuli. Thus, participants responded correctly when they selected “same” for two different tokens of the same word and “different” for two

tokens of two words forming a stress minimal pair. Their mean accuracy rates, sorted by pitch accent context, stress pattern, and word identity of X with respect to A, are summarized in Table 4.

Table 3. Mean accuracy rates with SD in parentheses of the identification task in the two pitch pattern contexts (%)

	Unmarked pitch accent context		Marked pitch accent context	
	Noun	Verb	Noun	Verb
NE	95 (8.9)	94 (9.4)	93 (11.7)	93 (9.8)
TwH	96 (8.2)	92 (12.0)	68 (22.8)	66 (17.3)
TwL	96 (8.2)	93 (9.8)	60 (14.5)	84 (13.9)

NE: native speakers of English

TwH: experienced learners

TwL: inexperienced learners

Table 4. Mean accuracy rates with SDs in parentheses of the AX discrimination task in the two pitch pattern contexts (%)

In the unmarked pitch context:

	Trochaic stress pattern		Iambic stress pattern	
	AX-same	AX-different	AX-same	AX-different
NE	94 (9.4)	96 (8.2)	95 (8.9)	94 (9.4)
TwH	92 (12.0)	95 (8.9)	88 (13.6)	92 (12.0)
TwL	88 (10.1)	89 (12.1)	87 (11.7)	90 (12.1)

In the marked pitch context:

	Trochaic stress pattern		Iambic stress pattern	
	AX-same	AX-different	AX-same	AX-different
NE	88 (12.0)	93 (9.8)	90 (16.5)	90 (10.3)
TwH	82 (17.0)	92 (13.6)	80 (18.3)	86 (14.7)
TwL	65 (17.0)	83 (24.5)	65 (17.0)	86 (13.1)

AX-same: when the stimuli A and X are tokens of the same stress pattern

AX-different: when the stimuli A and X are tokens of different stress patterns

NE: native speakers of English

TwH: experienced learners

TwL: inexperienced learners

4.2 Analysis

The participants' responses in all three tasks were subjected to a binominal logistic mixed-effects analysis. Implemented with the lme4 package in R (R Development Core Team 2011), a set of models, which included full models and models that included varying interactions between main effects, was constructed and fitted to the data (i.e., the subjects' responses, coded as 1 for a correct response or 0 for an incorrect response). They were compared using ANOVA, and one model with the best goodness-of-fit to the data was selected for each of the tasks. As fixed-effects, the one for the ABX discrimination task contained L1 (NE, TwH, and TwL, with NE being the baseline level), Context (which was unmarked falling (-0.5) vs. marked rising (0.5)), Stress (which was trochaic (-0.5) vs. iambic (0.5)), and the interaction between L1 and Context. For random effects, it contained by-subject random slopes for Context and Stress and by-subject and by-item random intercepts. The model run on the data of the identification task was the same as the previous one, except that it also contained the interactions between L1 and Stress and between Context and Stress as fixed-effects. The model for the AX discrimination task contained L1, Context, and Pattern, which was the condition in which AX were different tokens of the same word (-0.5) vs. the condition in which AX were tokens of the different words (0.5), as fixed-effects. For random effects, it contained by-subject random slopes for Context and Pattern and by-subject and by-item random intercepts.

4.3 Results of Analysis

4.3.1 ABX discrimination task

The analysis revealed significant main effects for both the NE vs. TwH contrast ($\beta = -0.52$, $SE(\beta) = 0.17$, $z = -3.12$, $p < .01$) and the NE vs. TwL contrast ($\beta = -0.89$, $SE(\beta) = 0.16$, $z = -5.57$, $p < .001$). In addition, the interaction between the NE vs. TwL contrast and Context was significant ($\beta = 0.95$, $SE(\beta) = 0.32$, $z = 2.97$, $p < .01$), and that between the NE vs. TwH contrast and Context was marginally significant ($\beta =$

0.65, $SE(\beta) = 0.33$, $z = 1.95$, $p < 0.1$). These results indicated that there was a significant difference between native and non-native groups, and it could be primarily attributed to the effects of the contexts. That is, both of the learner groups significantly differed from the control group when they ascribed a heard sound stimulus X into trochaic or iambic stress patterns, particularly in the marked pitch accent context (see Table 2). However, despite being not native-like, the performance of the experienced learners in the marked pitch accent context was nonetheless better than that of the inexperienced learners (i.e., 80.0% vs. 71.5%), suggesting that the experienced learners were sensitive to stress at the phonological level.

4.3.2 Identification task

Significant main effects were obtained for the NE vs. TwH ($\beta = -0.96$, $SE(\beta) = 0.27$, $z = -3.56$, $p < .001$) and the NE vs. TwL ($\beta = -0.82$, $SE(\beta) = 0.27$, $z = -2.99$, $p < .01$) contrasts as well as for the interactions between the NE vs. TwH contrast and Context ($\beta = 1.86$, $SE(\beta) = 0.55$, $z = 3.40$, $p < .001$), between the NE vs. TwL contrast and Context ($\beta = 1.55$, $SE(\beta) = 0.55$, $z = 2.80$, $p < .01$), and between Context and Stress ($\beta = 0.97$, $SE(\beta) = 0.44$, $z = 2.23$, $p < .05$). These results indicated that the native English speakers and the Taiwanese learners differed in the way that they identified stress in the two pitch accent contexts. Specifically, the native group correctly identified stress in both contexts, whereas the learner groups correctly identified stress only in the unmarked falling context and not in the marked rising one. These findings showed that in the marked pitch accent context, the experienced learners, who were supposed to be sensitive to stress at the phonological level in the previous task, exhibited a deficiency in the morphosyntactic information in their phonological categories of stress patterns. Their categories might simply lack such information, resulting in their failure to identify the lexical class with which a particular stress pattern was associated. In addition, a comparison of the performance of the learner groups revealed another curious finding that was rather inconsistent with the previous results: It was not the experienced learner group but the inexperienced group who were more similar to the native English speakers in terms of

performance (see Table 3). The result might be attributed to a bias on the part of the inexperienced learners, which will be discussed in more detail in the next section.

4.3.3 AX discrimination task

Significant main effects were obtained for the NE vs. TwH ($\beta = -0.51$, $SE(\beta) = 0.18$, $z = -2.90$, $p < .01$) and the NE vs. TwL ($\beta = -1.06$, $SE(\beta) = 0.17$, $z = -6.45$, $p < .001$) contrasts, Context ($\beta = 0.80$, $SE(\beta) = 0.13$, $z = 6.10$, $p < .001$), and Pattern (Same vs. Different pairing) ($\beta = -0.57$, $SE(\beta) = 0.13$, $z = -4.43$, $p < .001$). The main effects of L1 and Context showed that the three groups of participants generally performed better in one of the pitch accent contexts: that is, the unmarked falling. In addition, for all three groups, the between-category discrimination of stress could be easier to carry out than the within-category discrimination of stress. This phenomenon was evident from the statistical significance of Pattern.

4.4 Correlation Analysis of Stress Sensitivity in the ABX and the AX Tasks

The mixed-effects analysis showed which groups differed and which predictors contributed to significant effects; however, it was also desirable to know whether participants' sensitivity to stress in a particular pitch accent context remained consistent throughout the tasks that required different modes of processing. Because the study investigated stress perception in the phonological vs. phonetic mode, the levels of the participants' sensitivity to stress in the ABX and the AX tasks were compared. To allow for comparison across the tasks, the responses of each participant in each of the tasks were recalculated into a score for level of sensitivity using d-prime (d') of the Signal Detection Theory. For two-alternative forced choice responses, d' scores were calculated using this formula: $(z[\text{hits}] - z[\text{false alarms}]) / \sqrt{2}$, where "hits" are defined as correct responses to stimuli with the trochaic stress pattern (i.e., the correct categorization of a stimulus word X when X is in the trochaic stress pattern in the ABX task and "Same" responses when paired words are both in the trochaic stress pattern in the AX task) and

“false alarms” as incorrect responses to finally-stressed target stimuli (i.e., the incorrect categorization of a stimulus word X when X is in the iambic stress pattern in the ABX task and “Same” responses when X is in the iambic stress pattern and the paired stimulus is in the trochaic stress pattern in the AX task). Hit rates as high as 1.00 and false alarm rates as low as 0.00 were re-coded, respectively, as 0.99 and 0.01. The obtained d' scores for the three groups are shown in Figures 3 and 4.

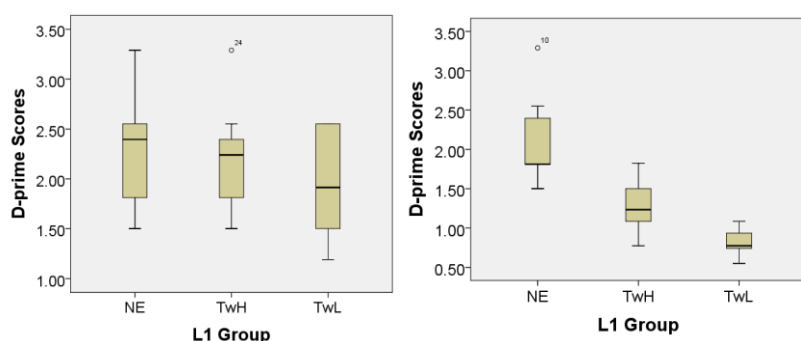


Figure 3. Boxplots of d' -prime scores of NE, TwH, and TwL groups in the unmarked pitch accent context (left) and in the marked pitch accent context (right) of the ABX task

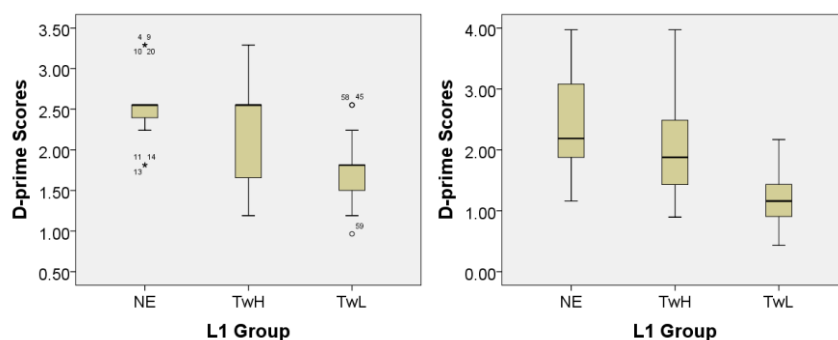


Figure 4. Boxplots of d' -prime scores of NE, TwH, and TwL groups in the unmarked pitch accent context (left) and in the marked pitch accent context (right) of the AX task

If sensitivity to stress at the phonological level developed in parallel with that at the phonetic level, participants' performance on the ABX task would be predictable by their performance on the AX task, or vice versa. That is, it could be expected that there would be a positive correlation between their d' scores in the two tasks. A correlation analysis was conducted to examine this relationship. The results indicated that when the three groups' d' scores in the unmarked pitch accent context were combined in the analysis, no significant correlation between the scores in the ABX task and those in the AX task was obtained ($r = .084$, $p > .10$) (see Figure 5 below), nor was there any significant within-group correlation for the NE ($r = .128$, $p > .10$, two-tailed), TwH ($r = .023$, $p > .10$, two-tailed), and TwL ($r = -.360$, $p > .10$) groups. The correlation was not observed; this was presumably because the non-native learners had reached native-like sensitivity when perceiving stress in the unmarked pitch accent context.

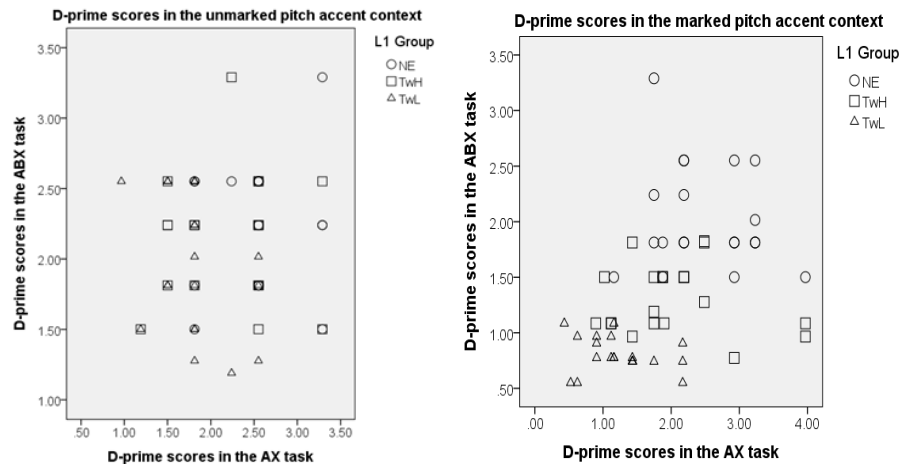


Figure 5. Scatterplots of the d' -prime scores of the ABX task vs. the AX task in the unmarked pitch accent context (left) and in the marked pitch accent context (right), where circles represent English native speakers, squares represent experienced Taiwanese learners, and triangles represent inexperienced learners

The expected relationship, however, was found when the analysis was performed on the d' scores in the marked pitch accent context. With non-significant within-group correlations found for the English native speakers ($r = -.145$, $p > .10$, two-tailed), the experienced Taiwanese group ($r = -.135$, $p > .10$, two-tailed), and the inexperienced Taiwanese group ($r = -.235$, $p > .10$, two-tailed), the results indicated that there was a positive, significant correlation between the d' scores of the three groups in the ABX and the AX tasks when all of their scores were combined to search for an overall relationship ($r = .471$, $p < .01$, two-tailed). In this case, although no tendency was found in any of the groups, the level of sensitivity to stress in one task was predictable by that in the other task if all of the groups of participants were considered. The predictability could be attributed to the poorer performance of the learner groups, especially that of the inexperienced group.

Although the analysis above seems to provide evidence for the lack of the inexperienced learners' sensitivity to stress in the marked pitch accent context at the two levels, the results did not constitute sufficient grounds to deny their ability to discern stress phonetically. A closer examination of their performance in the rising intonation context in the AX task revealed that the significant correlation could be partially attributed to an excessive number of "Different" responses to AX-Same pairs (i.e., two tokens of the same stress pattern) (see Table 4). These responses, which were not counted as "hits," apparently did not lead to an increase in d' scores. However, the tendency to respond "Different" could not be regarded as evidence for the failure of the inexperienced learners to make comparative judgments based on available phonetic cues; instead, it was interpreted to mean that they showed sensitivity to both across- and within-category differences in stress. That is, the learners were more sensitive than expected. Their comparatively lower d' scores in the AX task were a result of the inadequacy of the current definition of sensitivity, in which "Different" responses to AX-Same pairs were not defined as "hits" even when the learners attended to within-category differences. More discussion on this point will be presented in the next section.

5. DISCUSSION

The findings of the experiments are summarized as follows. First, in the ABX task, in which the phonological mode is the most likely to be adopted by the participants, both learner groups performed in a native-like manner in perceiving trochaic and iambic stress patterns that were embedded in the unmarked pitch accent context, where the stressed syllable was associated with a high tone (H*). In contrast, they had difficulties in distinguishing between the two stress patterns under the marked pitch accent context, where the stressed syllable was associated with a low tone (L*), to differing degrees. Specifically, the experienced learners were able to categorize the two stress patterns (with accuracy rates above 80%) but did not achieve native-like accuracy (as the significant effect of the factor L1 suggests). In contrast, the inexperienced learners were unable to categorize the stress patterns in the marked pitch accent pattern. Whereas their native-like performance in the unmarked pitch accent context seems to suggest that a certain phonological representation of “stress” ought to be available, their poorer performance in the marked pitch accent context is interpreted to mean that the phonological representation should be different from that of native speakers.

Also shown are the results of the identification task, which aimed at testing the participants’ knowledge of the linguistic functions denoted by the two stress patterns (i.e., the trochaic pattern tends to denote a noun, whereas the iambic pattern tends to denote a verb). In the unmarked pitch accent context, both learner groups performed in a native-like manner when indicating that the trochaic stress pattern refers to a noun and the iambic stress pattern refers to a verb. It seems that they also know the linguistic functions represented by the two stress patterns. In addition, because only the experienced learners showed perception of the categories of the two stress patterns in the marked pitch accent context in the previous ABX task, their performance in this task has attracted our special attention. These learners were unable to associate the stress patterns with their corresponding morphosyntactic categories in the marked pitch accent. The outcome seems to suggest that the newly established phonetic categories of stress have not yet been associated

with their morphosyntactic functions. Moreover, a surprising finding from the identification task is that the inexperienced learners outperformed the experienced learners in identifying words in the marked context.

Finally, the finding from the AX discrimination task that attracts our interest is that insofar as the marked pitch accent context is concerned, the inexperienced learners responded less accurately to stimuli of the same stress pattern than those of different stress patterns. Although they exhibited stress deafness in the ABX task, the finding reveals that they were sensitive to not only cross-category but also within-category differences in stress.

Several points for discussion arise from the above findings. The first one concerns why both of the learner groups performed in a native-like way in their perception of English lexical stress under the unmarked pitch accent context, but their perception was impaired to some extent in the marked pitch accent context. A plausible explanation is that the phonological representation of our L2 learners is different from that of native speakers. Native speakers' phonological representation of English stress may include at least the cues of duration and pitch, among which pitch is left unspecified and awaits to be determined by the pitch accent it takes. Given that pitch varies with different pitch accents, a listener has to rely on other cues in the perception of stress, as well.³ However, our learners' phonological representation of stress is supposed to be fundamentally different. It is speculated that their asymmetric performance in the two contexts can be attributed to their representation of stress, which primarily contains the phonetic information of high pitch. The tendency of Mandarin speakers to equate strong stress with [+high] tone and weak stress with [-high] tone has been reported in several studies (e.g., Cheng 1968; Juffs 1990).

Yet, this then raises the question as to what enables the experienced learners to categorize stress under the marked pitch accent context even though their ability is not native-like. Our explanation is that an increase in the length of learning may bring about the awareness that stress is not signaled only by high pitch. Therefore, the experienced learners may

³ Intensity is regarded as the least effective cue to English stress (Mattys 2000; Morton and Jassem 1965; Sluijter and van Heuven 1996).

have developed the ability to discern the two phonetic categories of stress in the marked pitch accent pattern to some extent. This assumption provides grounds for further investigation as to what phonetic cue enables them to do so. The phonetic measurements conducted on the stimulus items, as presented in Figures 1 and 2, provide two candidates: (i) the duration of the first syllable and (ii) the pitch difference of the second syllable. Further studies that can better control for the possible variables that are needed to determine what cue is actually employed. One study that used the synthesized stimuli of non-words, *maBA* and *MAba*, found that among the relevant phonetic correlates of stress, high pitch is a more effective cue to stress, whereas duration is the least effective in L1 Mandarin speakers' perception of English stress (Chrabaszcz, Winn, Lin, and Idsardi 2014). However, the question of whether the finding also applies to the perception of real words with real pitch accent patterns awaits further investigation.

Whereas the inexperienced learners were unable to distinguish stress in the ABX task, they outperformed the experienced learners in the identification task. It is argued that this good performance is spurious based on a double-check of their accuracy rates, which are high when the stress pattern is iambic but relatively low when the stress pattern is trochaic (see Table 3). As was stated, the inexperienced learners tend to rely on pitch height as the cue to stress position (Cheng 1968; Juffs 1990). Because the second syllable with the marked pitch accent is always higher in pitch, it is therefore not surprising that the rates of accuracy of inexperienced learners for finally stressed words are higher than expected. This result replicates the findings of Ou (2010).

Finally, a finding that is also worth further discussion is the sensitivity of inexperienced learners to both within- and across-category stress differences in the marked pitch accent context in the AX discrimination task. This finding leads to the assumption that their discrimination is more psycho-acoustically based and is compatible with the findings reported by Hallé et al. (2004), who found that French speakers show sensitivity to the differences along the continua of Mandarin lexical tones despite their failure to categorically perceive the tonal contrasts. The findings of the current study and those of Hallé et al. both indicate that even though the phonological representations of stress

and tone are impaired, the ability of inexperienced learners to perceive such differences at the phonetic level remains intact.

6. CONCLUSION

This study has investigated L1 Mandarin speakers' perception of English lexical stress by manipulating both the level of the difficulty of the task and the type of pitch accent pattern wherein the test words were embedded. The contribution of the study is twofold. First, the findings contribute to our understanding about the types of "stress deafness" experienced by non-native speakers. In a comparison of the results of the current study with those of Dupoux et al. (1997) and Dupoux et al. (2008), it is found that the stress deafness suffered by the inexperienced Mandarin learners of English is different from that of French speakers in the sense that the stress deafness of Mandarin learners has to do with pitch accent contexts, whereas that of French speakers involves different levels of cognitive processing. These factors of stress deafness are investigated together in the present research, involving Mandarin-speaking learners of two English proficiency levels. When stress was placed in the falling pitch pattern, where the stressed syllable is associated with a high nuclear pitch accent, neither group of Mandarin learners was deaf to stress at the phonetic or phonological levels. Nevertheless, when the stress position coincided with the marked pitch accent (i.e., L*) in the rising pitch accent pattern, experienced learners were not deaf to stress at the two levels, although their newly formed categories still lacked the information regarding lexical classes. On the other hand, the inexperienced learners were deaf to stress at the phonological level, but their sensitivity to stress at the phonetic level was robust. In summary, stress deafness can be investigated via the control of different types of tasks to identify the level at which the problem occurs. Moreover, stress deafness may involve other aspects, as well. The current study has presented evidence that stress deafness may occur when a more marked pitch accent pattern is present.

Second, the study also offers insights into specific problems that adult English learners may have experienced, which may be taken as a

reference for English pronunciation teaching and learning. In the framework of English as an international language, Jenkins (2000, 2002, 2006) has proposed several key pronunciation features of English to help English teachers and learners overcome problems that arise in communication. Among the problems, stress misplacement and inaccurate nuclear stress are regarded as threatening the intelligibility of the speech of international users of English to a significant extent. Given the complicated interaction between lexical stress and the pitch patterns it may take, it is further suggested that English instructors should be equipped with the phonological knowledge about these components so that attempts can be made to design a method or proper syllabi for enhancing learners' productive and receptive skills.

Some limitations of this study must be acknowledged. First of all, among the common pitch accents in English, only two have been studied. Future studies may include more pitch patterns to explore the possible problems faced by learners so that the suggestions for English teaching and learning may be founded on a better basis. Second, only disyllabic words that contrast in the position of stress are included. Longer words should also be studied to enrich our understanding about the role of stress and pitch accent patterns in real speech, either native or non-native.

For future studies, there are several issues that are noteworthy. For instance, is the inability to perceive stress in marked pitch accent contexts restricted to L1 tone speakers only, or does it also occur in the case of speakers of other languages? Will the inability in these contexts be overcome via explicit instruction or laboratory training? To what extent would such instruction or training improve non-native speakers' English oral communication, including perception and production? All of these points are worth exploring further in the future.

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華語母語人士對有標音高語境下英語詞彙重音的感知

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本研究探討在有標音高語調(marked pitch accent)環境下，華語母語人士對英語詞彙重音在音韻和語音層次的感知。研究採用三項聽覺實驗，材料為重音對比的英語雙音節名詞和動詞(如：*PERmit* (n.) vs. *perMIT* (v.))。結果顯示，以華語為母語的英語學習者在無標的語境下表現與英語母語人士雷同，在有標的語境下則非如此。但較具經驗的學習者仍可區分不同重音型態，較無經驗者則無法。然而，後者仍具在語音層面上對重音的敏感度。

關鍵詞：英語韻律感知、重音失聰、英語字重音語調互動