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SHANGHAI JIAO TONG UNIVERSITY

学士学位论文

BACHELOR’S THESIS

论文题目：中国大学生英语/i/-/I/时长知觉研究

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学院(系)：外国语学院

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BACHELOR'S THESIS

IDENTIFICATION AND DISCRIMINATION OF ENGLISH /i/ AND /I/ AMONG CHINESE COLLEGE STUDENTS

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中国大学生英语/i/-/I/时长知觉研究

摘要

本课题在已知二语者与母语者对于英语/i/-/I/知觉模式不同的基础上，进一步研究中国大学生英语/i/-/I/的时长知觉,探究以音长为主要线索的知觉模式是否表现出边界效应的特征，以及中国大学生的英语学习经历是否对会对英语/i/-/I/知觉模式产生影响。实验选取 51 名中国大学生作为被试，根据英语学习经历的不同将其分为两组，包括 24 名大一年级的非英语专业学生与 27 名大四年级的英语专业学生。另选取 6 名母语为英语的美国被试作为参考。实验采用经典的识别和分辨实验范式，被试识别在语谱和时长两个维度上各有七步变化的 beat-bit 序列语音,并对其中三个语谱特征点上的不同时长语音对进行辨别。结果表明，对于英语学习经历较少的中国大学生，其以时长为主要线索的知觉模式展现出了边界效应，且边界效应的强弱依附于语谱特征的变化。中国大学生对于不同的语谱范围熟悉程度不同，/i/的频谱范围内边界效应强于/I/。当频谱范围处于中间值，无边界效应。此外，结果证明英语学习经历对二语感知起到了重要作用，不仅增强了中国大学生对于英语/i/-/I/的知觉能力，并改变了他们的语音线索使用。英语学习经历丰富的中国大学生改为依靠与母语者一致的语谱特征作为主要线索，时长的边界效应不再产生。

关键词：二语元音感知，元音时长，英语学习经历

IDENTIFICATION AND DISCRIMINATION OF ENGLISH /i/ AND /I/ AMONG CHINESE COLLEGE STUDENTS

ABSTRACT

The current study, based on the different use of acoustic cues in perceiving vowel contrast by L1 and L2 speakers, was a further analysis of the duration cue reliance in English /i/-/ɪ/ perception among Chinese college students. Boundary effect and the role of English learning experience in L2 vowel perception were examined here. A total of 51 Chinese college students, classified into two groups, namely, 24 inexperienced EFL learners and 27 Experienced EFL learners by their English learning experience, and 6 native speakers of American English, identified the vowels in a synthetic beat-bit continuum with vowel spectrum in 7 equal Mel steps and duration in 7 equal steps, and discriminated three sets of two-step duration pairs at different spectral values. The results revealed that sensitivity peak emerged in the perception test among the inexperienced group who relied primarily in duration cue, and it changed with regard to the L2 speakers' familiarity to the spectral regions. Boundary effect indicated by duration was more significant in spectral values of /i/ than /I/ and was not found in the ambiguous in-between spectral region. In addition, English learning experience was proved to exert great influence on the perceptual patterns of Chinese EFL learners in the way that it improved the perceptual ability of English /i/-/I/ contrast. Specifically, experienced EFL learners managed to develop a perceptual ability close to the native speakers with the adoption of a native-like perceptual strategy depending predominantly on spectral properties, therefore, duration no longer served as a major acoustic cue and yielded no boundary effect.

Key words: L2 Vowel perception, Vowel Duration, English Learning Experience

Contents

Chapter I INTRODUCTION

1.1 Studies on L2 Vowel Perception

Speech sounds are concerned with a number of acoustic dimensions and different groups of listeners pay unequal amounts of attention to each acoustic cue (Repp 1982, 81–110). With some acoustic cues being predominant and others secondary, the distinctive cue reliance will lead to different perception results and perceptual patterns. Previous studies proved that there were discrepancies between L1 and L2 speakers in vowel perception. Chinese participants, who learn English as a foreign language (EFL) encountered difficulties in distinguishing English vowel contrasts accurately. /e/-/ɛ/-/æ/ perception, where /æ/ was often misperceived as /e/, was the most difficult one in vowel perception for mainland Chinese students (Lin 2014, 14-20). An important fact was pointed out that although L2 learners are able to gradually develop perceptual abilities for a new vowel contrast in second language learning and manage to perform accurate discrimination, the strategies they employ often do not resemble those of native speakers (Bohn & Flege 1990, 37–56). In the perception and production of English front vowels specifically, the performance of some Brazilian EFL participants were nearly identical with that of native English speakers on a category formation test; however, the cue reliance differed among the two groups (Escudero 2006, 149–161). Although spectral quality predominated among native English speakers, the Brazilian EFL participants, in contrast, demonstrated the significant reliance on vowel duration in the formation of their English vowel categories.

In the English /i/–/ɪ/ contrast, two major acoustic cues exist, namely, vowel duration and spectral property. All else being equal, /i/ has a lower F1 and a higher F2 and its duration is longer than /ɪ/. In the perception of /i/–/ɪ/, native English speakers pay predominant attention to spectral property with duration change exerting very little influence while Chinese EFL learners, suggested by earlier studies through English /i/-/ɪ/ identification experiment (Bohn 1995, 279–304), were more likely to exhibit perceptual patterns distinct from native English speakers that they relied

exclusively on vowel duration. Such a perceptual pattern was also found among Spanish and Russian EFL learners when identifying the English /i/–/ɪ/ contrast (Escudero & Boersma 2004, 551–585).

L1 language experience has been proved to make a difference in cue weighting. A great number of studies suggest that acoustic cues are used in speech perception in a language-specific way (Kluender, et al 1998, 3568-3582), thus making native language experience an influential factor in L2 speech perception (Crowther & Mann 1992, 711-722). Results of previous studies on Spanish L1 speakers who learned Dutch as L2, revealed that in distinguishing Dutch /a;/-/A/, they followed the way they distinguished Spanish vowel contrast with a favor of vowel duration. (Escudero, Benders, Lipski 2009, 452-465).

The discrepancy between L1 and L2 speakers may also attribute to differences in cross-language speech system. Studies revealed that L2 learners are insensitive to certain phonemes which are realized as different allophones in L1 but are realized as independent phonemes in L2. An answer to the fact that Chinese EFL learners were less likely to distinguish the English contrast /ɛ/-/æ/ accurately but tended to blend them together was that /ɛ/-/æ/ are allophones of /a/ in Chinese, whose vowel system differs from that of English, making it more difficult for Chinese EFL learners to perform as well as native speakers in English vowel perception (Wang and Heuven 2004. 205-216). In terms of /i/-/I/, in English they are categorized as different phonemes, whereas Chinese has only one vowel category in the high-front area of acoustic vowel space. There is no /i/-/I/ vowel contrast but only /i/ as a phoneme, which is nearest in the phonetic space to both English /i/-/I/, causing difficulties for native Chinese speakers to perceive the comparatively fine spectral difference in English /i/-/I/ as the native speakers did (Yang, Liu, Zhao, et al 2015, 1-29). Chinese EFL learners, with a tendency to blend English /i/ and /I/ according to the spectral properties, had to rely on duration cues as an alternative.

Speech perceptual patterns may vary noticeably between individuals, even if L2 learners have the same L1 background (Smith & Hayes-Harb 2011, 2761). For example, although the majority of Spanish participants in general relied on temporal cues when distinguishing English /i/–/ɪ/ or Dutch /aː/–/ɑ/, spectral cue was also favored by a noticeable amount of participants who exhibited a

native-like preference, therefore the choice of acoustic cues vary widely among individuals (Escudero, Benders & Lipski 2009, 452-465). Such kind of individual variability was concluded as a common phenomenon in the nonnative speech perception (Ingvalson, Ettlinger & Wong 2012, 35-47).

There has been a variety of explorations into this field, attempting to explain why the performance of English learners who speak the same L1 differ so widely in L2 sound perception. A most discussed factor is the age of beginning to learn an L2. The results of a series of studies showed that compared to adults, children have a better performance in L2 learning (Flege, Mackay, and Meador 1999, 2973-87), meanwhile, there were arguments against the significance of age because other factors, such as social, educational and psychological variables may exert greater influence than the beginning age on the proficiency of L2 (Marinova-Todd, Marshall and Snow 2000, 9-34). Studies on the amount of experience with the target L2, another factor that has drawn plenty of interest, also named as "length of residence", which means the number of years spent in a community where the L2 is the predominant language, pointed out that speech perception tend to become identical with that of the native speakers as a result of the increasing L2 experience (Piske, MacKay, & Flege 2001, 191-215). Recent studies have covered other factors including different learning styles based on Kolb's experimental learning theory, which showed that participants with Kolb's assimilative and divergent learning styles, compared to those with convergent and accommodative learning styles, were more likely to present a native-like reliance on acoustic cue of spectral properties (Yang, Liu, Zhao, et al 2015, 1-29). Other studies also investigated language proficiency as a potential factor affecting vowel perception, and discovered that as language proficiency is enhanced, perception rage of English vowels became wider, and the correctness of front vowel perception is improved (Zhang, A., Feng H., Dang, J., et al 2015, 0651. 1-5).

The current study hence centered on the perceptual patterns of Chinese EFL leaners, aiming to explore the features of their vowel duration reliance in perceiving non-native English /i/- /ɪ/ contrast through identification and discrimination tasks. According to previous studies of the English speech perception, there has been a strong tendency for listeners to hear consonants in a categorical fashion, however, vowel perception is described as being relatively continuous (Fry, Abramson, Eimas, & et

al. 1962, 171-189). In contrast with consonants, vowel perception failed to meet the strict criteria of categorical perception because of the sensitivity to vowel stimuli within phoneme categories. Nevertheless, vowels have been proved to have phonemic boundary effects (Iverson & Kuhl 2000, 874-886). Sensitivity across a boundary between phoneme categories is superior to that within a phoneme category. Earlier studies dealt with only a single acoustic dimension, spectral properties, as phonemic differences. Within this limitation, there was little exploration on the boundary effect indicated by duration difference among L2 learners who did not have much awareness of spectral properties and instead relied on duration cue dominantly. Furthermore, the concept of learning experience was applied to the exploration of perceptual patterns for English /i/-/ɪ/ among Chinese EFL learners. By showing how perceptual patterns among EFL learners may vary with their learning experience, this study indicated the significance of teaching and training among EFL learners in nonnative speech environment.

1.2 The Current Study

The present study aimed to find out the sensitivity to duration change in English /i/–/ɪ/ perception among Chinese EFL learners and whether English learning experience would make a difference . The research questions and hypotheses for the current study were presented as follows.

Question 1: Are there duration boundary effect in the perception of English /i/–/ɪ/ contrast among Chinese EFL learners?

Based on the findings of previous studies that Chinese EFL learners relied on duration difference in their perception of English /i/–/ɪ/ contrast (Bohn 1995, 279–304), it was hypothesized here that there could be a boundary between the two /i/–/ɪ/, stimulus within which would be distinguished as /ɪ/ and beyond as /i/.

Question 2: If duration boundary effect was found in the perception of the English /i/-/ɪ/ contrast among Chinese EFL learners, then will it vary among participants with different English learning experience?

The question was based on the hypothesis that Chinese EFL learners' English learning experience would have an impact on the perception of English /i/–/ɪ/ contrast. Previous studies have proved that the increase of language proficiency facilitated the perception of English vowels among Chinese EFL learners in the way that English front vowels /ɪ/-/ɛ/ were more categorically perceived (Zhang, A., Feng H., Dang, J., et al 2015, 0651. 1-5). Although it did not measure the English /i/–/ɪ/ contrast, it was reasonable to assume that participants with different English learning experience, more or less, would show different levels of sensitivity to duration changes.

These two questions along with the hypothesis that aimed to answer them were tested in an experimental study. The research methods and results will be reported and discussed in the following chapters.

Chapter II METHODS

2.1 Participants

A total of 51 Chinese college students and 6 native speakers of American English participated. The Chinese participants consisted of 24 inexperienced English learners, who were non-English major freshmen and 27 experienced English learners, who were English major senior students. Though there ages of learning English was different, it should be noted that all participants were at the same level of English proficiency at the beginning of their freshman year, yet the English majors began to receive a great deal of intensive three-year training in English, which enabled them to have more experience in English learning than the freshman from other departments. The group of freshmen participants were classified as inexperienced Chinese EFL learners while the group of senior English majors as experienced Chinese EFL learners.

2.2 Materials

A series of synthetic beat–bit continuums were prepared for the identification and

discrimination experiments. The sounds were created using KLSYN (version 1.5) based on the parallel model of Klatt (Klatt 1980, 971-955) software synthesizer. Two parameters will be varied factorially with vowel spectrum in 7 equal Mel steps and duration in 7 equal steps, and thus a total of 49 stimuli were generated for the continuum. These durations increased progressively from 125 to 275ms (125, 150, 175, 200, 225, 250 and 275ms), including the formant transitions cueing the word-initial and word-final stops. In terms of the whole continuums, the vowel portion varied from values appropriate for English /i/ to those for /ɪ/. The setting of nominal frequency values for F1 to F3 in the endpoints /i/ and /ɪ/, based on the mean frequencies reported by Ladefoged (2001), were present in table 2.2. The word-initial /b/ and the final /t/ were synthesized in the way suggested by Bohn and Flege (1990, 37–56).

Table 2.2 Spectral Values of the Vowels in the Beat-bit Continuum

	F1		F2		F3	
Point	Hz	Mel	Hz	Mel	Hz	Mel
1(*bit*)	403	488	1916	1544	2550	1828
2	381	466	1969	1570	2605	1850
3	360	444	2023	1596	2660	1872
4	340	422	2078	1622	2717	1894
5	320	400	2134	1648	2774	1916
6	300	378	2191	1674	2832	1938
7(*beat*)	280	356	2250	1700	2890	1960

2.3 Procedure

The participants, ten at a time, completed two perception tests in a sound booth. Perception tests were carried out on computers using E-Prime 2.0. The stimuli were presented over Sennheiser headphones at a comfortable listening level. Before the test the participants were given both verbal and written instructions that they shall respond as quickly as possible, yet each trial was self-paced

with no limit on response time, and the next trial would only appear after participants have responded to the previous one. Furthermore, the participants were told to guess if uncertain and they were also informed that the first block was for practice, and its data would not be included in the final analysis.

2.3.1 Identification Task

The first part of the perception test was the identification test. As for the practice session, eleven randomizations of the 49 stimuli were presented binaurally. The participants identified each vowel by pressing one of two buttons marked “beat” and “bit.” There was a short pause of 500ms before the start of a new trial. In general, the Chinese participants spent about 15 minutes finishing the test, while it took the American participants no more than 12 minutes to complete the whole procedure. After completing the identification test, participants were required to take the discrimination test.

2.3.2 Discrimination Task

The AX same-different task was used to determine how well the listeners could discriminate the synthetic vowels. The subjects were presented with a total of 3*20=60 A-B pairs of stimuli, among which, the first stimulus (A) and the second stimulus (B) might either be the same or different. The discrimination trials were composed by three sets differing in spectral values (i.e. points 1, 4, 7 as listed in Table 2.2). In each set, five comparison unit of stimuli A and B which differ by two steps from each other in vowel duration (i.e. 1-3,2-4,3-5,4-6,5-7) were arranged in its all possible orders, namely AA, BB, AB and BA (e.g. 1-3 unit consists of four trials: 1-1,1-3,3-1,3-3), to counterbalance order or series effects, thus making a total of 20 AB pairs.

All the 60 pairs of stimuli were presented binaurally to the subjects in random order, with each appearing 5 times. The participants were asked whether the two stimuli were identical with each other, as a response, they were required to press the button “S” (same) or the button “D” (different).

No other responses were accepted and the subjects were asked to guess if necessary. Overall, the two groups of Chinese participants spent about 18 minutes finishing the test, while it took the American participants no more than 16 minutes to complete the whole procedure.

Chapter III RESULTS

3.1 Identification Results

Figure 3.1.1 shows the pooled responses of 56 participants, which were classified into three different groups, namely inexperienced, experienced Chinese EFL learners and native English speakers, to the vowel identification test. The continuous curve in each part of the figure indicates the percentage of identify the stimulus as "beat" in the test for all subjects. The stimuli in each figure were at the same frequencies, and ranged in seven equal steps in vowel duration from 125 to 275ms (125, 150, 175, 200, 225, 250 and 275ms). In the left penal, the formant of the 7 stimuli were set at point 1, the endpoint values for /I/; in the penal in the middle, the frequencies at point 4, the middle point; in the right penal , the formant at point 7, the endpoint values for /i/ (see Table 2.2*)*. This series of figures told us the different performance among each groups at three different steps of spectral values in the identification task.

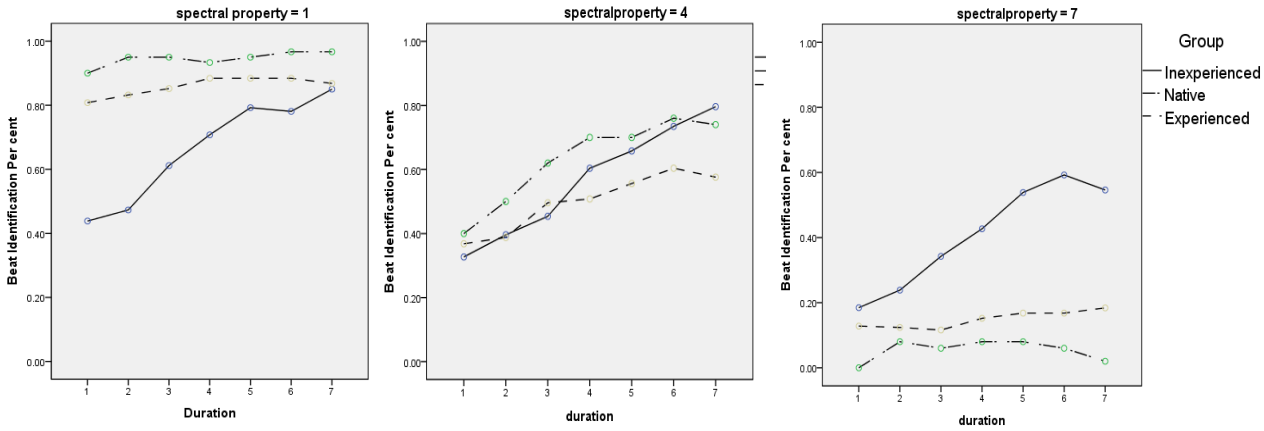

Figure 3.1.1 Identification of the synthetic vowel stimuli as English beat-bit

As for the left panel, the results from repeated measures ANOVA with duration as within-subjects factor and group as between-subjects factor showed significant main effects of duration, $F(6, 318) = 7.320$, $p < 0.001$, and group, $F(2, 53) = 6.911$, $p < 0.01$. The interaction effect of duration × group was also significant, $F(12, 318) = 5.867$, $p < 0.001$, indicating that duration change influenced the three groups of participants in a different way. From repeated measures ANOVA for each group, the main effect of duration was insignificant among the experienced Chinese EFL learner and native speakers, revealing that the participants identified the stimuli regardless of the duration change. The experienced group perceived the stimuli in a native-like way, and their identification percent remained quite constant (Mean=85.9%), which was close to that of native speakers (Mean=95.4%). As for the inexperienced group, repeated measures ANOVA demonstrated that the main effect of duration was significant, $F(6, 138) = 10.314$, $p < 0.001$. The labeling as beat at step 1 and 2, which were not significantly different from each other, were much lower than that of other steps, $p < 0.01$ for all pairwise comparisons (LSD). The identification percent as beat rose dramatically when the duration increased from step 2 to step 5. Identification results at step 5, 6 and 7 were rather similar to each other, and the stimuli were more frequently identified as 'beat' than other steps, $p < 0.05$ for all pairwise comparisons (LSD).

The middle panel indicated a distinct phenomenon. The results from repeated measures ANOVA with duration as within-subjects factor and group as between-subjects factor showed significant main effect of duration, $F(6, 318) = 16.479$, $p<0.001$, while group main effect and duration × group interaction effect was insignificant. The results revealed that when spectral properties were set in the region between the endpoint values of /i/ and /ɪ/, all the participants, including native speakers who used to rely predominantly on spectral properties, were influenced by duration change in the identification task. The identification percent as 'beat' rose in a rather linear way, along with the equal increase in the duration of the stimuli.

As for the right panel, from repeated measures ANOVA with duration as within-subjects factor and group as between-subjects factor we could see significant main effects of duration, $F(6, 318) = 5.255$, $p < 0.001$, and group, $F(2, 53) = 9.618$, $p < 0.001$. Duration × group interaction effect was also significant, $F(12, 318) = 4.147$, $p < 0.001$, indicating that duration change had a distinct impact

on three groups of participants. Based on repeated measures ANOVA for each group, the main effect of duration was insignificant among the experienced Chinese EFL learner and native speakers. Stimuli at step 7 of spectral properties were mostly labeled as “bit”, and the identification responses almost unchanged in the light of duration difference. By contrast, the inexperienced learners were proved to be under the influence of the significant duration main effect, $F(6, 138) = 7.865$, $p < 0.001$. The identification per cent as beat at step 5, 6 and 7 which were insignificantly different from each other, were much higher than all other steps, $p < 0.05$ for all pairwise comparisons (LSD).

It was clear that the identification results fluctuated based on the interaction effect of DURATION╳GROUP when the stimuli were set at both the endpoint values for /I/ and /i/. The performance of experienced EFL was similar to that of native English speakers with the same use of acoustic cue. In contrast, the inexperienced EFL leaners showed a reliance on durational cue and there was a dramatic rise in the identification per cent between step 2 and step 5. However, when the stimuli were set at the middle point between spectral values for /I/ and /i/, which might be viewed as spectrally “ambiguous”, native speakers and the experienced EFL leaners turned to duration change as an acoustic cue. Stimuli in this spectral region were more frequently labeled /I/ when long and /i/ when short. All groups of participants showed a rather linear rise in the identification per cent. When the duration of the stimuli increased by a step, the identification per cent also increased by a proportional degree.

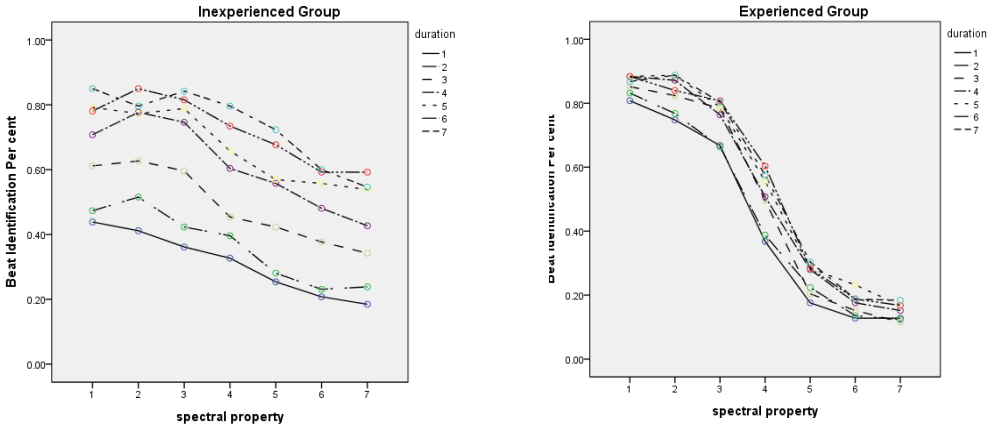

Figure 3.1.2 Identification Per cent as beat by Chinese EFL Learners

Figure 3.1.2 shows the identification per cent as beat at seven different spectral properties. The upper panel was the result of native speakers, the left panel the inexperience group and the right panel the experienced group. The mean change in beat judgment as vowel duration increased from 125 to 275ms was 42% (SD=0.40) for the inexperienced group, and 11% (SD=0.23) for the experienced group. Duration change played a minor role in labelling the stimuli for the experienced group, while it played a major role for the inexperienced group. It was clear that the majority of stimuli in duration step 1and 2 were identified as 'bit' and in step 4, 5, 6 and 7 as 'beat' while duration step 3 seemed to in the middle between bit and beat, for the per cent of identification as either bit or beat was close to 50 per cent.

3.2 Discrimination Results

3.2.1 Measurement of Discrimination Unit

Prior to analyze the discrimination curves, it is necessary to specify the way of computing the obtained discrimination correct per cent (P). Overall there were three discrimination sets (i.e. spectral value=1, 4, 7), each composed by five comparison unit of stimuli A and B with a 50ms interval. Trials in each unit were arranged in all possible orders, namely AA, BB, AB and BA. P for each comparison unit was calculated in the following way (Xu, Gandour and Francis2006, 1063-74).

$$P = P(\text{“S”} \mid S) \cdot P(S) + P(\text{“D”} \mid D) \cdot P(D)$$

Two conditional probabilities, P ("S" | S) and P ("D" | D), respectively stands for the percentages of correct responses to all the same (S) and different (D) trials in each comparison unit. The probabilities of S (AA or BB) and D (AB or BA) trials in each unit were represented by P (S) and P (D), which in this experiment both amounted to 0.5.

3.2.2 The Effect of Weber's Law on Discrimination

In discussing the discrimination data it is worth noticing that the longer the vowel duration, the less likely for the participants to make the correct discrimination. Not only for Chinese participants, but also for native English speakers, their per cent correct, regardless of the spectral values, had an overall tendency to decrease along with the linear increase in duration from step 1 to step 7 (125 to 275ms).

Furthermore, since the A-B sound pairs that consisted of two stimuli that differ by two steps were arranged in all possible orders to offset the sequence effects, the gradual falling of the percent correct, as suggested, may be signs that the Weber's law was playing an important role in discrimination. Weber's law indicates that the resolution of perception diminishes for stimuli of greater magnitude, that is to say, the just-noticeable difference between two stimuli is proportional to the magnitude of the stimuli. A behavioral study has verified that Weber's law governs time discrimination among adults that discriminability was determined by the ratio, not the absolute difference between the duration values (Droit-Volet, Clément, & Fayol 2008, 1827-46), which provides a possible explanation to the descending trend of the correct per cent. Therefore, the effect of Webber's law on the discrimination results should be considered in the analysis of the results.

3.2.3 Discrimination Results among the Participants

Figure 3.2.3.1 shows the per cent of correct responses of the three groups of participants in discriminating the two-step durational comparison pairs. The continuous curve in each part of the figure demonstrated the discrimination results at three different steps of spectral properties. In the left, middle and right panel of the figure, the formants of the five durational comparison pairs were set at point 1, point 4, and point 7 respectively (see Table 2.2). From this figure we could see the different performance among each groups and what kind of role duration and spectral values played in the discrimination task. A noticeable feature shared by all three parts of the figure is that the

overall correct per cent of the three subject groups fluctuated within a quite narrow range, roughly from 50% to 60%, and moreover, decrease by degrees when the stimuli became longer in duration. As suggested above, Weber's law partly explained the descending tendency, which shall be subtracted before the studying on the results.

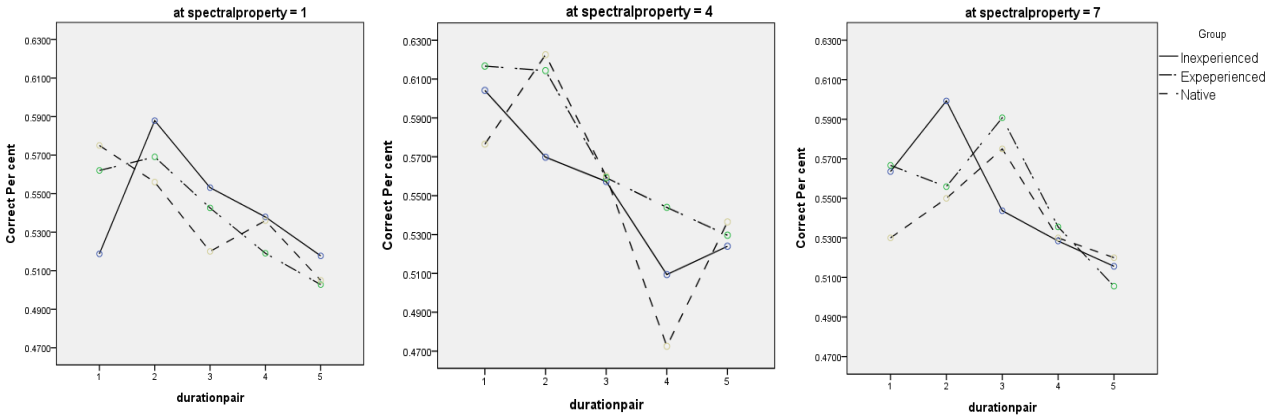

Figure 3.2.3.1 Results of Discrimination Task of Durational Comparison Units

A three-way analysis of variance revealed that duration pair × group × spectral property interaction effect was marginally significant, F (16, 424) = 1.664, p = 0.051, indicating that the discrimination performance of the participants varied along with the change of duration pairs, spectral property and groups. Therefore, it was necessary to make further analysis of the duration perception patterns of each group at different formant steps.

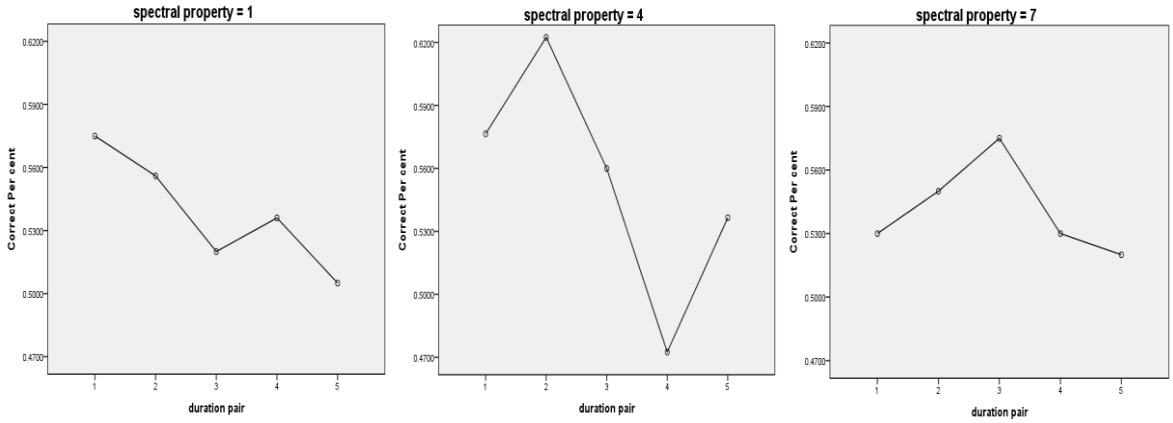

Figure 3.2.3.2 Results of Discrimination by Native Speakers

In terms of native English speakers, as figure 3.2.3.2 illustrated, their performance varied with the change of spectral properties. At both step 1 and step 4 of spectral values, little difference was found between neighboring units by pairwise comparisons (LSD), and the correct per cent gradually stepped down in line with the effect of Weber's law, with a mean of 53.8% (SD=0.06) and 55.4% (SD=0.09) respectively. It should be pointed out that at step 1 of spectral values, the first duration pair which had the shortest duration among all stimuli, were not familiar to native speakers as common "beat" sounds, thus it was very likely that native speakers did not perceive them as natural speech sounds were more sensitive to the duration difference. While at step 7 of spectral properties, the correct per cent of duration pair 3 (step 3 and 5) was much greater than that of duration unit 1 ($p < 0.05$) and unit 5 ($p < 0.001$). The peak of correct percentage was an indication of phoneme boundary effect. The first two pairs with shorter durations were typical sounds of "bit", therefore native speakers tend to view the pair as the same and the correct rate was low. When the duration reached the possible boundary (pair 3), the stimuli, unfamiliar to the listeners, were not perceived as the typical "bit" sound and the difference in duration was easier to notice, leading to a higher correct rate.

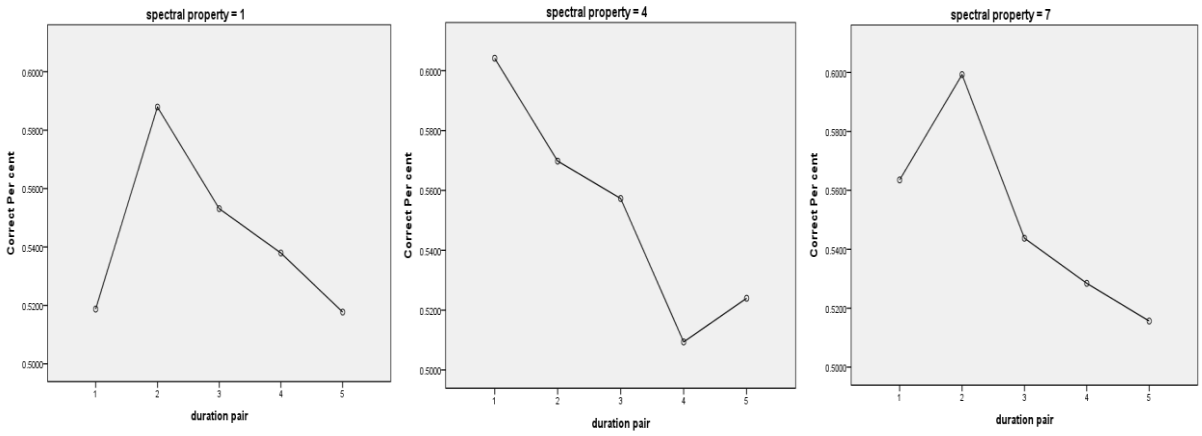

Figure 3.2.3.3 Results of Discrimination by Inexperienced Chinese EFL Learners

From an inspection of figure 3.2.3.3, the performance of inexperienced EFL learners differ from that of native speakers. At point 1 of spectral properties, through pairwise comparisons of the correct per cent of responses, inexperienced Chinese EFL learners performed much better in

discriminating duration pair 2 (step 2 and 4) than all the other pairs ($p < 0.05$). At step 4 of spectral properties, pairwise comparisons revealed that the difference between adjacent durational comparison units was insignificant. The accuracy of discrimination generally declined as the duration became longer. At step 7 of spectral properties, result from pairwise comparisons (LSD) could tell that correct per cent of durational pair 2 was significantly higher than that of pair 3 ($p < 0.05$), pair 4 ($p < 0.01$), and 5 ($p < 0.01$), which was not significantly different from each other. Overall, at both step 1 and 7 of spectral values, the inexperienced group who distinguished /i/-/I/ by duration, discriminated the stimuli pair most accurately when it crossed the duration boundary between 150ms and 175ms.

Although inexperienced EFL learners exhibited duration boundary effect in their perception, their performance varied with spectral values. Inexperienced learners were most familiar to the spectral region of step 1 because Chinese /i/ has similar spectral value, so the boundary effect was more significant in step 1. On the contrary, inexperienced EFL learners were less familiar to the spectral region of step 7, therefore, the boundary effect was less significant. At step 4, the falling of correct rate was in accordance with weber's law, and little boundary effect was found here.

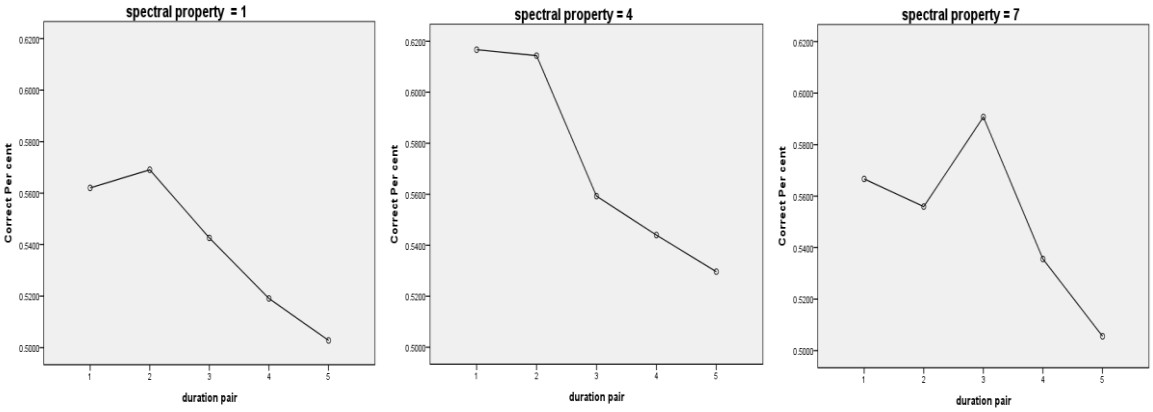

Figure 3.2.3.4 Results of Discrimination by Experienced Chinese EFL Learners

Figure 3.2.3.4 demonstrates the pooled results of 27 subjects form the experienced group. At step 1 of spectral properties, little difference was found between neighboring units by pairwise comparisons (LSD), and the correct per cent of duration pair 2 was a little bit higher than other pairs.

At point 4 of spectral properties, the correct per cent of responses decreased as the duration became longer. At point 7 of spectral properties, the accuracy of pair 3 was significantly higher than that of duration pair 2, 4 and 5 ($p < 0.05$). Since the experienced group has been proved by identification task that they had a native-like reliance on spectral properties, their discrimination results were also similar to those of native speakers.

Chapter IV DISCUSSION

On the evidence of the results presented in this paper, there are clearly grounds for believing that Chinese EFL learners perceive English /i/-/I/ in a way somewhat different from that of native English speakers while the experience of English learning also played a role in distinguishing different EFL learners from their perceptual patterns.

4.1 Duration Boundary Effect

Broadly speaking, based on the results of both identification and discrimination tasks, among inexperienced Chinese EFL learners there existed a duration boundary to classify the two vowels under certain conditions while the duration boundary effect did not appear among the experienced group

In the identification tasks it was clear that inexperienced Chinese EFL learners relied predominantly on duration cue rather than spectral property in differentiate non-native English /i/-/I/ contrast. The majority of stimuli in duration step 1 and 2 were identified as ‘bit’ and in step 4, 5, 6 and 7 as ‘beat’, leading to the assumption that duration step 3 seemed to be close to the boundary between /i/-/I/. Stimuli longer was identified as/i/ and shorter as /I/. The discrimination results also revealed a compatible boundary effect that the sensitivity peaked at the vowel boundaries. When the stimuli were set at either the endpoint spectral values for /I/ or /i/, the correct rate reached the highest point at duration pair 2 (step 2 and step 4). As assumed by the identification results that the possible duration boundary would be step 3, in the discrimination task, duration pair 2 which spanned the

possible boundary became the region of high sensitivity.

An inspection of the results of the discrimination task revealed that the phonetic boundaries indicated by duration difference varied with spectral properties. Boundary effect was more significant when close to the spectral endpoint of /i/ than /I/, and did not exist when the spectral values were set at step 4.

At step 1 of spectral values, the durational boundary effect was more significant due to a clear accuracy peak at duration pair 2. Inexperienced learners were most familiar to the spectral region of step 1 because Chinese /i/ has similar spectral values, so the boundary effect was more significant in step 1. Stimuli in this spectral region were labeled /I/ when long and /i/ when short. On the contrary, inexperienced EFL learners were less familiar to the spectral region of step 7, therefore, the boundary effect was less significant.

When the stimuli were set at the middle point between spectral values for /I/ and /i/, which might be regarded as spectrally "ambiguous", it was worth noticing that both the two groups of Chinese participants hardly showed the durational boundary effect. In the identification task, when the duration of the stimuli increased by a step, the identification per cent as beat also increased by a proportional degree. In the discrimination task, the decrease of the correct rate was compatible with the effect of Weber's law. It was reasonable to assume that the participants were a little bit confused in this part of the test because they hardly identified stimuli in the middle spectral region as a common English vowel that they had learned. They had to made responses based on what they would notice, consequently, they could only rely on the duration difference as a physical parameter. In the discrimination task, as long as they observed any duration difference, they responded as 'different'. Concerning the effect of Weber's Law, since the duration changed in equal steps, the longer the duration, the harder for the participants to perceive the physical difference, therefore, the correct per cent kept declining by degrees and there was no evidence for boundary effect.

The result that spectrally "ambiguous" stimuli were more frequently labeled /i/ when long and /I/ when short, was consistent with the experiment results of studies on perception of temporal and spectral information in French vowels contrast /o/ and /ɔ/ (Gottfried and Beddor 1988, 57-75). Since the native English listeners also had a particular reliance on the duration cue in spectrally ambiguous

region, the phenomenon seemed to run counter to the generally accepted view that native English listeners rely heavily on spectrum. Such a phenomenon discovered form the experiment results could be accounted for by Bohn's desensitization hypothesis that posited that spectral differences are insufficient to differentiate non-native vowel contrasts in that L1 experience did not sensitize listeners to these spectral difference (Bohn 1995, 279–304). Consequently, the hypothesis posited that L2 speakers would turn to duration cue as a substitute to differentiate the non-native vowel contrast. As mentioned in the cross-language difference, Chinese has only one category in the high front vowel while English has a relative large number of vowel contrasts, including /i/-/ɪ/ and /ɛ/-/æ/, in the front area of the acoustic vowel space. Native Chinese speakers, therefore, might be viewed as linguistically desensitized to spectral difference between vowels in the front vowel area. Bohn's hypothetical perceptual principle was developed only for non-native listeners, while from this experiment, it could be assumed that Bohn's hypothesis was also consistent with the results of native listeners. Since the participants were forced to make a response, when the spectral values were in an ambiguous in-between region, the commonly used spectral cue was no longer reliable, and therefore, an alternative must be used as a substitute in differentiating the vowel contrast.

As for the experienced group and native speakers, little boundary effect was found. As discussed in the result chapter that the effect of Weber's law was an explanation of the descending tendency of correct rate at step 1 of spectral property, another factor should be pointed out here, that perceptual magnet effect, (Kuhl 1991, 93-107) might also contribute to this phenomenon. It was based on a hypothesized mechanism that a single abstract exemplar that represents all members of a category and phonemes are perceived with regard to their distance from those exemplars (Iverson & Kuhl 2000, 874-886). At the spectral values of /i/, the experienced group, along with the native speakers, might have a good example of the 'beat' sound, whose duration falls in between step 5 and 7. The perceptual would shrink near best exemplars because the magnet effect would draw neighboring stimuli toward the prototype locations, which resulted in a poor discrimination performance. When the distances from the good example was very close, the discrimination would be harder and the correct per cent was low. Therefore, the sensitivity minima when the stimuli duration approached the exemplars of 'beat' sound. The integration of the two effects here explained

why the accuracy dropped quickly.

At step 7 of spectral values, the performance of experienced EFL were also found to be similar to that of native English speakers. In the identification task, the two groups relied dominantly on spectral values while the change in duration seldom changed their identification results, so no boundary effect emerged. In the discrimination task, on the other hand, when the spectral values were close to the endpoint value of /I/, correct per cent peaked at duration pair 3 (step 3-5). The results of the two experiments seemed paradoxical. It is possible that the discrimination results provided evidence for duration boundary effect which did not emerge in identification tasks, therefore, further analysis of the discrimination results was essential to verify whether boundary effect emerged. The presence of boundary effect has been proved by previous studies to vary with the design of experiments (Macmillan et al. 1988, 1262-1280). Particularly, experimental tasks that enhance demands on attention and memory provoked sensitivity peaks for vowel stimuli. Whereas in discrimination tasks with a high degree of trace variance, sensitivity peaks at vowel boundaries are more likely to emerge because of strategies that listeners adopt to compensate for their perception difficulty. Identification tasks have proved that in this spectral region, experienced EFL learners identified the majority of stimuli as 'bit', regardless of the duration change from step 1 to step 7. Therefore, it was unlikely for them to establish a boundary by duration.

With regard to the perceptual magnet effects, at the spectral values of /i/, the experienced group, along with the native speakers, might have a good example of the 'bit' sound, whose duration falls in between step 1 and 4, which led to a poor discrimination performance at duration pair 1 and 2. Thus, the sensitivity minima when the stimuli duration was close to the exemplars of 'bit' sound. Such perceptual magnet effect for native speakers was more significant. The result was not surprising because native listeners could perceive the /i/-/ɪ/ more naturally than L2 speakers and they had a better knowledge of good examples of 'bit' sound. Meanwhile, weber's law also yield effect on the discrimination performance as the duration increase, making the accuracy decline. Therefore it was assumed that the two effects above caused such a discrimination result that a sensitivity peak appeared. Although the results from the two experiments were not identical if judging by the surface, in general, the findings of discrimination task did not run counter to that of the identification task.

4.2 The Role of English Learning Experience

Since duration boundary effect has been found in Chinese college students' perception of the English /i/-/ɪ/ contrast, in order to answer the second research question that whether English learning experience made a difference in the perception, it was necessary to make comparison between the inexperienced and the experienced group.

The study was based on the assumption that all Chinese participants were at the same level of English proficiency at the beginning of their freshman year. The English majors, who were enrolled in an intensive program with all courses offered in English, had received systematic training in listening and speaking given by tutors who were native English speakers, and had taken courses in linguistics which covered phonology to help them established a better command of English phonological system. The group of freshmen, on the other hand, most of whom studied in engineering departments, only took 2 English classes (3 hours) a week with very little exposure to native English. Therefore, it was reasonable to classify the Chinese participants into two groups, namely, experienced and inexperienced EFL learners, and to introduce the concept of English learning experience here.

Going back to the basics, English learning experience altered the use of acoustic cues. Chinese EFL learners with less learning experience had an exclusive reliance on duration cue while the experienced learners were inclined to have a native-like use of spectral properties. There was a quite noticeable discrepancy between inexperienced and experienced Chinese EFL learners, that the latter had a better understanding of the acoustic difference between non-native English /i/-/I/ contrast and consequently relied mainly on temporal cues rather than spectral properties. In the identification task, the mean change in beat judgment as vowel duration increased from step 1 to step 7 of the inexperienced group was 4 times that of the inexperienced group. The development of perceptual abilities along with native-like strategies could be attributed to the role of English learning experience, which proved it is not necessarily the case that L2 speakers failed to acquire the same method or strategy in vowel perception as L1 speakers.

English learning experience improved the awareness of spectral difference, so the performance of the experienced group showed no evidence of the duration boundary effect. As for the inexperienced learners, the effect of boundary was related to their familiarity with the spectral regions. The boundary effect was more significant at step 1 because Chinese /i/ has similar spectral value and less significant at step 7 because they had limited exposure to this spectral region. With more learning experience, the experienced group performed almost the same with native speakers.

Moreover, as for Chinese EFL learners who had limited English learning experience, figure two showed that as the spectral values got close to the endpoint of /I/, they were more likely to identify the stimuli with the same duration as 'bit', indicating that they did have some knowledge on the different spectral properties between English /i/-/I/ that /i/ has a lower F1 and a higher F2, however, such knowledge was limited and the awareness of the spectral properties was overwhelmed by their reliance on duration which was established at the initial stage of English learning.

Therefore, although the spectral property had some impact on the inexperienced Chinese EFL Learners in their perception, it did not change the fact that they still regarded vowel duration as the major acoustic cue in English /i/-/I/. There emerged a duration boundary to classify the two vowels despite that the degree of the agreement or consistency failed to reach a high level. It is due to the accumulated English learning experience that Chinese EFL learners managed to develop their perception of formant changes in English /i/-/I/ and performed in a similar way as the native speakers in the two experimental tasks.

4.3 Limitations

Based on previous studies on perceptual patterns of English /i/-/I/ among L2 speakers, the current study was a tentative attempt to study whether the perception for English /i/-/I/ among Chinese EFL learners exhibited any boundary effect in their reliance on vowel duration and its correlation with English learning experience. Confined to certain experimental limitations, the results must be considered as being preliminary, and further improvements and suggestions for a

more in-depth analysis were presented below.

We have to admit that with a larger data pool, the results would be more convincing in the findings of boundary effect and the role of English learning experience in /i/-/I/ perception. In the current study a total of 51 Chinese participants and 6 native speakers of American English participated. Considering the difficulty in finding American participants, the number of native speakers was not big enough as a good reference for the performance of the Chinese participants. If the number of participants could be enlarged from 6 to around 30, making the results more convincing.

Furthermore, with regard to concerned with factors affecting the perception of L2 speakers, the Chinese participants were classified by their English learning experience, however, other factors, for instance, the dialect background, would also play a part in their perception. Future studies are expected to expand the research scope to cover other influential factors.

Hence, future studies on the vowel perception of L2 speakers are advised to focus on a wider range of dimensions with a larger data base to make the results more reliable and persuasive.

Chapter V CONCLUSION

To summarize, the current study provided evidence for the existence of boundary effect based on the duration cue reliance in the perception of English /i/–/ɪ/ contrast among Chinese EFL learners. The boundary effect was more significant in spectral values of /i/ than /I/ because Chinese EFL learners were more familiar to the /i/ spectral region. When the spectral values were in an ambiguous in-between region, sensitivity peak did not emerge because duration difference was regarded as a physical parameter rather than an acoustic cue to differentiate /i/ and /I/. Moreover, English learning experience was found to exert much influence in the perception of /i/ and /I/, that it altered the perception patterns of Chinese EFL learners. Specifically, learners with more learning experience who improved their awareness in the spectral difference between English /i/-/I/, not only developed the same perceptual ability of English /i/-/I/ contrast as native speakers, but also applied a native-like perceptual strategy of depending predominantly on spectral properties. Distinct from the

inexperienced learners who relied primarily on duration cue, thus, no sensitivity peak emerged in their discrimination results. Despite the limitations of the current study, it offered further insights into the features and development of vowel perception among Chinese EFL learners.

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