EFFECT OF EXPERIENCE ON CHINESE ASSIMILATION AND IDENTIFICATION OF ENGLISH CONSONANTS

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ABSTRACT

Two groups of Chinese listeners with different English experience participated in an English to Chinese consonant assimilation experiment and an English consonant identification experiment. The results show that listeners with high English experience had a more concentrated assimilation pattern than low experience listeners. However, the goodness ratings did not differ much between the two groups. These results support the idea of "rephonologization" raised by the theoretical model PAM-L2. The results also demonstrate that there was significant high correlation between assimilation overlap and confusion for the low experience group but not for the high experience group, indicating the assimilation pattern of the high experience group may not truthfully reflect the perceptual similarity between the two language sounds.

Keywords: experience, consonant perception, assimilation concentration, category identification

1. INTRODUCTION

For adult second language (L2) learners, the similarity between their native language (L1) and the target L2 strongly affects their success in L2 sound perception and production [1, 9]. Previous studies suggested that the perceived phonetic distance between two language sounds should be measured by using cross-language category mapping with goodness rating experiment, which is also called perceptual assimilation experiment [1, 10]. Typically in an assimilation experiment, listeners were asked to classify a non-native sound into one closest native category and rate the goodness of fit using a Likert scale. This kind of assimilation data then can be used to explain listeners' behaviour in some other kind of tests [15, 6, 20, 3].

Listeners' phonetic/phonological system is dynamic and may evolve especially during the learning process of another language [9]. This suggests that listeners' assimilation patten may also change during L2 learning due to the interaction of L1 and L2 systems [12]. Several recent studies provided evidences that learners' assimilation pattern do change as a function of experience increase. For example, [4] found that there was correlation between L1 Japanese learners' L2 English vowel assimilation patten and their English vocabulary size. [18]'s study showed different vowel assimilation patterns between English learners of French with different experience. [16] and [13] demonstrated intensive laboratory phonetic training may also change listeners' non-native to native assimilation patterns. However, in another study, no effect of experience was found for native Catalan speakers' English vowel assimilation [5].

The purpose of the current study is to further investigate the effect of experience on learners' L2 sound assimilation by extending it to the consonant aspect. More specifically, native Chinese learners with different English experience will be tested and their English to Chinese consonant assimilation will be examined. A large body of studies had put their research focus on the relation between listeners' assimilation pattern and their L2 sound discrimination. Another goal of the current study is to investigate the relation between learners' assimilation and their consonant identification performance. To sum up, current study will investigate the following research questions: (1) Do Chinese learners with different English experience have different English to Chinese consonant assimilation patterns? (2) Do Chinese learners with different English experience have different English consonant identification confusions? (3) If experience does have certain effect on assimilation, what is the relation between different assimilation patterns and the identification performances?

2. METHOD

2.1. Subjects

13 native Chinese listeners (5 males and 8 females), aged between 19 to 26 years (mean age 21.4 years), participated in this study. These listeners were all students from Jiangsu University of Science and

Technology, China, without reported hearing problem, and all originally from central-east Mandarin dialect spoken region. These listeners were further divided into two groups: a low experience (LE) group consisted of 8 listeners, all were second year undergraduate students studying computer science courses, and all had passed the College English Test-band 4; another high experience (HE) group consisted of 5 listeners, all were master degree students majored in English and all had passed the Test for English Majors-band 8.

2.2. Stimuli

The English stimuli used in the assimilation and identification experiments were naturally-produced vowel-consonant-vowel (VCV) sequences from the test set of Interspeech 2008 Consonant Challenge corpus [7], which consists of 384 tokens from 8 speakers, two for each of the 24 English consonant (/p, b, t, d, k, g, tʃ, ʤ, f, v, θ, ð, s, z, ʃ, ʒ, h, m, n, ŋ, l, r, j, w/, [19]). The vowel contexts for each VCV can be one of the 9 combinations of 3 vowels /æ, i, u/ in initial and final positions. A set of 48 tokens, 2 for each of the 24 English consonant, from the training set of the same VCV corpus, were used as practice items in the identification experiment. Another set of 30 tokens derived from a Chinese VCV corpus [14] were used as practice stimuli in the assimilation experiment.

2.3. Procedure

The assimilation and identification experiments were carried out in a quiet computer lab in Jiangsu University of Science and Technology. All listeners were tested simultaneously. Stimuli were presented via AC 97 sound cards and SALAR A522 headphones. A custom MATLAB program was used to control the stimulus presentation and response collection. All stimuli were normalised to have equal RMS energy prior to presentation. Listeners were allowed to adjust the volume to a comfortable listening level.

In the assimilation experiment, listeners were asked to first classify the VCV token they heard as an instance of one of the 24 Chinese consonant categories (/p, p^h, t^h, t, k^h, k, ts^h, ts, $t\underset{\sqcup}{ʃ}^h$, $t\underset{\sqcup}{ʃ}$, $tɕ^h$, tɕ, f, s, $\underset{\sqcup}{ʃ}$, ɕ, x, m, n, ŋ, l, $\underset{\sqcup}{ɹ}$, j, w/, [17]) by clicking the corresponding button on a 4×6 on-screen button grid. To reduce orthographic influence, Chinese characters with corresponding consonant in the syllable-initial position were shown on the buttons to represent different categories [14]. Consonant /ŋ/ was an exception because it can only occur in syllable-final position in Chinese. After the category classification task, listeners were also asked to move a slider bar below the button grid to rate the goodness of fit of the consonant they heard to the Chinese category they selected. The slider bar represented a 1-9 scale (1=bad exemplar, 9=good exemplar). The 30 Chinese practice VCV tokens were fixed at the beginning.

The identification experiment was carried out one week after the assimilation experiment. Similar to [8], capital letters in sample English words were used as symbols for the 4×6 button grid to represent the 24 consonant categories. Listeners were asked to identified the VCV token they heard to one of the English categories. The English VCV tokens used in the identification experiment were the same as those in the assimilation experiment, with an extra 48 tokens fixed at the beginning as practice items.

3. RESULTS

3.1. Assimilation

Table 1 and 2 demonstrate listeners' English to Chinese consonant assimilations and goodness ratings. It can be seen that LE group used an narrower scale of goodness rating than HE group, mostly from 3-7, while the rating scores of the latter group ranged from 3-8. Here for the LE group, we define 'high' similarity between assimilation source and target categories with goodness rating from 6-7, 'medium' similarity with goodness rating of 5 and 'low' similarity with goodness rating from 3-4. For the HE group, the goodness ratings for the three similarity categories are set at 7-8, 5-6 and 3-4 respectively.

Some similarities between the two groups can be observed: for those English consonants with good counterparts in Chinese, such as the plosives, some fricatives (e.g., /f, s/), nasals (except /ŋ/), approximants and lateral approximants, listeners assimilated them to one single Chinese category with relatively high percentages, and gave most of them high similarity goodness ratings; for those English sounds without good counterparts in Chinese, such as the affricates and most of the fricatives, the assimilation patterns were quite dispersed for both groups, and the goodness ratings varied.

If we take a close observation and focus on the affricates and fricatives, we can see that LE and HE group had similar overall patterns of assimilation targets for these sounds, and even the assimilation ranking orders (in percentages) were the same for some of them. However there still be two interesting differences: (1) for most of these sounds (except /f, θ, ʃ, h/), HE group had less assimilation tar-

gets than LE group did; (2) HE group's assimilations were more consistently set on the few major targets with higher percentages (e.g., /v, θ, z, ʒ/). These results are consistent with previous studies', where similar assimilation concentration were reported for more experienced L2 learners [16, 13, 4].

If the goodness ratings were taken into account, HE and LE group had similar 'high', 'medium' or 'low' similarity ratings for common assimilations on most of the consonants (e.g., /tʃ, ʤ, f, v, s, z, ʃ, h/), while on the rest of the sounds, HE group's ratings were lower than the LE group's. This is also consistent with [13]'s result that assimilation pattern changes may not necessarily have goodness rating changes accompanied in the same direction.

Table 1: Assimilation for LE group, in percentages. Rows represent (English) stimuli presented and columns represent listener (Chinese) responses. Goodness ratings are in parentheses. Only responses greater than 5% were shown.

	pʰ	p	tʰ	t	kʰ	k	tsʰ	ts	tʂʰ	tʂ	tɕʰ	tɕ	f	s	ʃ	ɕ	x	m	n	ŋ	l	ɻ	j	w
p	95(6)																							
b	12(5)	84(6)																						
t			85(6)																					
d			8(2)	84(7)																				
k					80(6)	9(4)																		
g						87(5)						5(3)												
tʃ			11(5)				5(4)		35(6)	5(5)	38(6)													
ʤ						10(5)			7(4)	19(6)		52(5)												
f													95(6)											
v							9(7)						30(5)									8(4)		41(5)
θ													35(6)	50(6)	5(3)									
ð								39(6)					13(5)	7(6)								16(5)		12(5)
s							5(4)							80(6)	9(4)									
z								59(5)		7(4)			13(3)									11(4)		
ʃ													13(5)	75(7)	10(7)									
ʒ										5(5)			7(3)	23(4)								48(6)		
h																86(6)								
m																	98(7)							
n																		80(7)		15(6)				
ŋ						70(6)						5(4)							13(6)					
l																				96(6)				
r																						83(6)		5(5)
j																						11(4)	79(5)	
w																						6(3)		87(6)

Table 2: Assimilation for HE group

	pʰ	p	tʰ	t	kʰ	k	tsʰ	ts	tʂʰ	tʂ	tɕʰ	tɕ	f	s	ʃ	ɕ	x	m	n	ŋ	l	ɻ	j	w
p	93(8)	5(5)																						
b	6(1)	94(8)																						
t			75(7)	5(8)			8(4)	8(5)																
d				96(8)																				
k					89(8)	10(5)																		
g						98(8)																		
tʃ									49(7)		39(7)													
ʤ									5(2)		45(6)		39(6)											
f													94(8)											
v													19(4)									9(4)		68(5)
θ							6(3)						20(7)	65(5)										
ð								40(6)						8(3)								25(4)		21(5)
s							18(4)							76(7)										
z								80(6)						5(3)								14(4)		
ʃ							5(1)							8(3)	78(7)	10(3)								
ʒ										16(3)					5(4)							68(6)		
h																95(8)								
m																	99(8)							
n																		95(8)						
ŋ						73(7)													23(7)					
l																				90(8)	9(4)			
r																						90(7)		8(4)
j																						9(3)	85(6)	
w																								96(7)

3.2. Identification

As expected, HE group's overall English consonant identification score (mean=83%, std=4.8) was higher than LE group's (mean=74%, std=5.0). One-way ANOVA confirmed the effect of experience between the two groups was significant [$F(1,11) = 9.6, p < .05$].

Table 3 and 4 show the consonant confusions for the two groups. It can be seen that for most of the consonants, HE group had higher scores than LE group, this is consistent with the overall result. One similar thing between the two groups was that they both had larger problems on affricates and fricatives, which is where the biggest difference between the two language consonant systems lies, while relatively better performances were seen on the rest of the sounds. Detailed confusion patterns demonstrated that contrasts such as /f-θ/, /v-ð/, /ð-z/, /ʒ-r/ and /ɡ-ŋ/ were among the most difficult for both groups. Chinese listeners' confusions between English fricatives was not a surprise because many of these sounds do not have good counterparts in Chinese. In fact, these contrasts were also among the contrasts showing the greatest assimilation overlaps (will explain in section 3.3).

Table 3: Consonant confusions for LE group, in percentages. Rows represent stimuli presented and columns represent listener responses. Only responses greater than 5% were shown.

	p	b	t	d	k	g	tʃ	ʤ	f	v	θ	ð	s	z	ʃ	ʒ	h	m	n	ŋ	l	r	j	w
p	93	5																						
b		99																						
t			91																					
d				93																				
k					85																			
g						94																		
tʃ			10				76	10																
ʤ				7		10		64								11								
f									94															
v									15	49				10										15
θ									26		31	6	33											
ð										12	13	16		46										
s											8		89											
z											13	19		60										
ʃ													8		90									
ʒ												5		9	25	24							30	
h																	94							
m																		100						
n																			80	8	8			
ŋ						60									6				6	23				
l																					96			
r																13						71		
j																							94	
w										18												5		77

Table 4: Consonant confusions for HE group.

	p	b	t	d	k	g	tʃ	ʤ	f	v	θ	ð	s	z	ʃ	ʒ	h	m	n	ŋ	l	r	j	w
p	97																							
b		99																						
t			86			6																		
d				91																				
k					96																			
g						100																		
tʃ							94																	
ʤ						9		82																
f									94															
v									8	57		11												13
θ									16		61		19											
ð										17	10	42		20										
s											11		86											
z												12		70		10						6		
ʃ															98									
ʒ																8	54					28		
h																		100						
m																			97					
n																				93	6			
ŋ						54														6	38			
l																						99		
r										8												84		
j																							93	
w										13														84

3.3. Relation between assimilation and identification

To investigate whether the difference of assimilation patterns between HE and LE group had certain

correlation with the difference of their identification patterns, we carried out an assimilation overlap analysis followed the procedures introduced in [11]. For example, Table 1 shows that listeners assimilated English /s/ and /ʃ/ to Chinese /s/ by 80% and 13% respectively, and they assimilated these two sounds to Chinese /ʃ/ by 9% and 75% respectively, then the assimilation overlap for English /s-ʃ/ was 13% + 9% = 22%. Table 5 lists 8 contrasts with the largest assimilation overlaps for the LE group, as well as the confusions for each of these 8 contrasts (which was defined as the sum of percentages of mis-identification to each other within each contrasts). As comparison, assimilation overlaps and confusions for the same contrasts from HE groups were also given in the table.

From Table 5 we can see that, for LE listeners, generally the higher the assimilation overlap, the higher the confusion. Statistical analysis confirmed that there was significant high positive correlation between assimilation overlap and confusion for LE listeners [$r = .82, p < .05$]. For HE listeners, their assimilation overlaps on /f-θ/, /f-v/ and /v-ð/ were lower than LE listeners' and their assimilation overlaps on /v-w/, /ʒ-r/ and /θ-s/ were higher than LE listeners', while for /g-ŋ/ and /ð-z/, the assimilation overlaps were almost the same for the two groups. However, HE listeners' confusions didn't go the same direction as their assimilation overlaps did, that is, most of their confusions were greatly smaller than LE listeners'. Therefore, the high correlation between assimilation overlap and confusion was not shown for HE listeners, where the correlation coefficient just approaching significance [$r = .69, p = .056$]. However, an very interesting result is that there was highly significant high correlation between LE listeners' assimilation overlap and HE listeners' confusion [$r = .96, p < 0.001$].

Table 5: Assimilation overlaps and confusions.

Contrasts	LE overlap	LE confusion	HE overlap	HE confusion
/g/ - /ŋ/	75%	60%	73%	54%
/ð/ - /z/	57%	65%	59%	32%
/θ/ - /s/	55%	41%	83%	30%
/ʒ/ - /r/	48%	43%	68%	28%
/v/ - /w/	47%	33%	68%	26%
/v/ - /ð/	42%	12%	30%	28%
/f/ - /v/	30%	15%	19%	8%
/f/ - /θ/	30%	26%	20%	16%

4. DISCUSSION

The current study investigated the effect of experience on native Chinese assimilation and identification of English consonants. Listeners with higher English experience significantly outperformed low experience listeners in English consonant identification test. However both HE and LE listeners demonstrated similar confusion patterns on those English sounds without good counterparts in Chinese (e.g., fricatives), indicating some common L1 influences and possibly some similar processing strategies for these sounds.

Although HE and LE group both showed similar assimilation dispersion on those sounds they worst identified, however a clear difference between the two groups is the HE group demonstrated a trend of assimilation concentration. The assimilation concentration for more experienced listeners were also reported in several previous studies [16, 13, 4]. [13] believed that this was the evidence of a "re-phonologization" process proposed by PAM-L2 [2]. Besides the assimilation concentration, [13] also found that the goodness ratings didn't change much for more experienced listeners. The author argued that this might indicate learner's L1 category prototype will not be influenced during the "re-phonologization" process. This view is supported by the results of current study that HE listeners' assimilation concentration was not accompanied with the increasing of goodness ratings.

Significant high correlation between assimilation overlap and confusion on some contrasts was observed on the LE group but not on the HE group. The HE listeners had higher identification scores, which indicates they were better aware of the differences between English consonant categories. This kind of awareness may be the outcome of the "re-phonologization" process, and it can trigger and reinforce the assimilation concentration. Consequently, for relatively more experienced learners, their assimilation patterns became a less reliable predictor for their identification confusion patterns. However, the significant high correlation between LE group's assimilation overlap and HE group's confusion indicates, possibly, the lower experience the listeners have, the better their assimilation pattern can truthfully reflect the similarities between the two languages and therefore can be better predictor for identification confusions. Further work is required to investigate this issue, and methods of incorporating goodness ratings in the analysis (such as "fit index", [15]) is necessary.

5. ACKNOWLEDGEMENTS

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