Age Effects on L2 Phonological Perception and Production

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Piao, Meizi. 2013. Age Effects on L2 Phonological Perception and Production. *SNU Working Papers in English Linguistics and Language 11, 86-106.* According to "interaction hypothesis" (IH), it is likely that the L1 and L2 always influence each other to some degree in all learners. However, the nature of the L1-L2 interaction changes as a function of the state of development of the L1 phonetic system at the time L2 learning begins. Hence, the present paper tried to link learners' perception of the relationship between sounds in the L1 and L2 to the accuracy with which they produce and perceive L2 sounds, as well as to find out whether or not age influences L2 phonological perception and production. **(Seoul National University)**

Keywords: interaction hypothesis, L2 phonological perception and production, age effects

1. Introduction

Previous studies of speech perception and production have shown considerable evidence that, overall, children are more successful at learning a second language (L2) than are older adolescents and adults (Birdsong & Molis, 2001; Flege, Yeni-Komshian, & Liu, 1999; Johnson & Nweport, 1989), especially in the realm of phonetics and phonology (Flege, MacKay, & Meador, 1999; Guion, Flege, Lin, & Yeni-Komshian, 2000; Munro, Flege, & MacKay, 1996).

Based on Flege's Speech Learning Model (Flege, 1995), one possible explanation in which child-adult differences, at least in the realm of L2 phonological learning, is through the interaction (bidirectional influence) of learners' native language (L1) and their L2. More specifically, learners' L1 and L2 are believed to interact in a different manner depending on age at which the L2 is learned. This tenet of the

Speech Learning Model has been termed the "interaction hypothesis[1]," or IH (Flege 1992, 1999; Walley & Flege, 1999).

According to "interaction hypothesis", as the L1 categories develop, they become stronger "attractors" for L2 sounds, i.e., L2 vowels and consonants become increasingly likely to be treated as variants of an L1 category as the L1 phonetic system develops, even when L1-L2 differences can be auditory detected (see Kuhl, Williams, Lacerda, Stevens, & Lindblom, 1992). Many studies to date have demonstrated that the L1 indeed exerts a powerful influence on adults' ability to learn L2 sounds, and that adults' variation from native L2 speaker perception and production is often traceable to their L1 (e.g., Flege, Bohn, & Jang, 1997; see Best, 1995, and Flege, 1995, for reviews). Since L1 categories develop, they become more robust, leading to more accurate performance in L1 speech processing tasks by older adolescents and adults, with fully-developed L1 categories, older adolescents and adults seems less likely to detect between-language phonetic differences, and thus are more likely to perceive L2 sounds as instances of L1 sound categories (Guion, Flege, Akahne-Yamada, & Pruitt, 2000). However, the influence of the L1 on children's ability to learn L2 sounds is often less apparent. The "interaction hypothesis" is founded on the observation that L1 categories develop slowly. Previous research has shown that children learning their L1 display a strong preference for the sounds of their L1 early in life, demonstrating a change from language-general to language-specific processing of vowels at around six months (Kuhl et al., 1992) and consonants at around 10 months of age (e.g., Werker & Tees, 1984). However, it appears that children's categories for specific L1 sounds and their allophonic variants continue to become refined throughout childhood and perhaps into adolescence (Hazan &

[1] It is likely that the L1-L2 always influence each other to some degree in all learners (Baker & Trofimovich, 2005; Mack, 1990), although, the degree of L1-L2 interaction differs as a function of the state of development of the L1 phonetic system at the time L2 learning begins.

Barrett, 2000; Walley & Flege, 1999). For example, native English children become increasingly more adept between the ages of 6 and 12 years at discriminating English consonants, although they do so less accurately than adults (Hazan & Barrett, 2000). When compared with adults, children also have been shown to display less sensitive in their discrimination of L1 sounds (Walley & Flege, 1999). These findings suggest that children's and adolescents' L1 phonetic systems and representations are less mature and not fully adult-like. Hence, the degree of L1 influence is weaker in younger L2 learners, and children overall appear more likely than older adolescents and adults to overcome L1 influences and to approximate native L2 speaker perception and production more closely (Baker & Trofimovich, 2005; Flege, MacKay et al., 1999; Flege, Yeni-Komshian et al., 1999).

2. The present study

In Mandarin, there is no sounds equivalent to English /θ/, /ð/ and /ʃ/ sounds, which are unvoiced dental fricative, voiced dental fricative, and postalveolar fricative. Therefore, many Chinese English speakers usually substitute /s/ where a Standard English speaker would use /θ/, and produce the voiced dental fricative /ð/ as voiced alveolar /z/ (/ts/ alveolar affricative) or /d/ (/t/ alveolar plosive). In addition, they also hardly distinguish English postalveolar fricative /ʃ/ with Chinese retroflex fricative /ʂ/. Based on "interaction hypothesis", one possible reason for above problems is that L2 (English) consonants are treated as variants of L1 (Chinese) consonants categories, even though L1-L2 differences can be auditory detected. However, the ability of perceiving and producing L1-L2 similarity may be different depending on the age at which the L2 is learned.

Hence, based on previous studies, the present paper tried to link learners' perception of the relationship between sounds in the L1 and

L2 to the accuracy with which they produce and perceive L2 sounds, and to find out whether or not age influences L2 phonological perception and production.

3. Research questions

3.1. Are Chinese adults who have learnt English after CPH (Critical Period Hypothesis) more likely associate L2 (English) sounds with L1 (Chinese) sounds than those who have learnt it before the CPH?

3.2. Are Chinese adults who have learnt English before CPH more likely to produce L2 sounds accurately than those who have learnt it after the CPH?

4. Experiment 1 (Consonant perception)

The purpose of Experiment 1 was to test the "interaction hypothesis" that L2 (English) learners who have learnt English after CPH (with more mature L1 phonetic system) are more likely than those who have leant it before CPH (with less mature L1 phonetic system) to perceive L2 sounds as instances of L1 sound categories. Native Chinese participants were asked to classify English consonants as instance of similar Chinese standard consonants categories, and then to rate its goodness of fit to the selected category.

4.1 Methodology

4.1.1 Participants

There were two groups of participants in Experiment 1. In Group A, participants were randomly selected 10 Chinese adults (5 males, 5 females), who were 18-year old and had learnt English at an age of 8 (before CPH, from primary school), while in Group B, participants were randomly selected 10 Chinese adults (5 males, 5 females), who were 25-year old and had learnt English at an age of 15 (after CPH, from middle school). All participants' L1 were Mandarin, and they had never been to English speaking countries. They had learnt English in China only as part of regular classroom instruction for 10 years, and none of them were English majors. Hence, all participants had quite similar English proficiency level.

4.1.2 Materials

This experiment only focused on participants' perception of English sounds /θ/, /ð/, /ʃ/ plus two distractors /f/ and /m/. 15 English words containing above stimulus consonants (in initial position) were as follows.

(1) **f**ive, face, for
(2) **th**in, thick, thud
(3) **m**ay, more, mom
(4) **th**at, this, them
(5) **sh**ip, she, shy

In addition, there were 7 Chinese words, which included 7 standard Mandarin consonants, i.e., m /m/, f /f/, d /t/, z /ts/, s /s/, zh /tʂ/, sh /ʂ/ in Chinese words 妈 (ma), 发 (fa), 大 (da), 咱 (zan), 洒 (

sa）, 炸（zha）, 沙（sha）. Among them, English consonants f /f/ and m /m/ sounds as well as Chinese consonants f /f/ and m /m/ sounds are exactly same. However, Chinese consonants d /t/, z /ts/, zh /tʂ/, are voiceless alveolar plosive, voiceless alveolar affricate, and voiceless retroflex affricate respectively, which are the most similar corresponding consonant categories of English consonant /ð/, voiced dental fricative. Besides, Chinese voiceless alveolar fricative s /s/ and voiceless retroflex fricative sh /ʂ/ are the most similar corresponding consonant categories of the English voiceless dental fricative /θ/ and voiceless palate-alveolar fricative /ʃ/ sounds respectively.

4.1.3 Procedures

In this experiment, participants were tested individually on line in a quiet room, using a personal computer. 15 stimulus English words were played by video twice with pictures on the monitor. After hearing the English words twice, participants were asked to identify each English stimulus in terms of one of the 7 Chinese words, if these Chinese words include the similar sound category. [2]

Then, after the classification was provided, the participants' task was to rate the similarity of the token they had just heard in terms of its goodness of fit to the selected Chinese category. They used a 7-point scale (1=sounded very dissimilar, 7=sounded very similar). Ratings of this kind are often obtained in conjunction with cross-language identification responses (Guion et al., 2000). They provide a gradient of similarity (or difference) for a perceptual match between an L2 sound token and the chosen L1 sound category. Typically estimated on an ordinal scale, goodness-of-fit judgments may in fact underlie cross-

[2] Hence, the question was to ask "Is there any Chinese word 'starts with' similar sound as the English word? Pick the word" (see Appendix 1)

language identification response, which suggests that listeners use the same information in each token for both perceptual identification and goodness-of-fit rating (Takagi, 1995).

After calculating frequencies of the mapped consonant categories, the dependent variable (similarity scores) was examined in (2) Age × (5) Matched consonant categories analyses of variance (ANOVA).

4.1.4 Prediction

Started learning English with mature L1 phonetic system, participants from Group B (after CPH) rate the stimulus English consonants as being more similar to their modal Chinese response alternatives than Group A do.

4.1.5 Results

In the cross-language identification task, frequencies of matched English-Chinese consonant categories were calculated.

Table 1 *Frequencies of matched English-Chinese consonant categories*

EC	**/f**	**/m/**	**/ θ/**	**/ð/**		**/ʃ/**
CC	f /f/	m /m/	s /s/	d /t/	z /ts/	sh /ʂ/
Group A	10	10	10	6	4	10
Group B	10	10	10	8	2	10

In Table 1, first row is English consonant (EC) categories, and second row is matched Chinese consonant (CC) categories which were chosen by participants. Seen from the Table 1, all participants from Group A and B matched English consonant /f/, /m/, /θ/, and /ʃ/ to their most similar Chinese consonants sounds f /f/, m /m/, s /s/, and sh /ʂ/, respectively. Since sounds of English and Chinese consonants /f/ and

/m/ are alike, respectively, all participants' choices of matched English consonant /f/ and Chinese consonant /f/, as well as English consonant /m/ and Chinese consonant /m/ show that all participants understood the undergoing experiment.

However, English consonant /ð/ seemed harder to identify, since 6 participants from Group A matched it to the Chinese consonant d /t/, while the other 4 participants matched it to the Chinese consonant z /ts/. In Group B, 8 participants matched the English consonant /ð/ to the Chinese consonant d /t/, while the other 2 participants matched it to the Chinese consonant z /ts/. In a word, there were 5 English-Chinese matched consonant categories, which were /f/-f /f/, /m/-m /m/, /θ/-s /s/, /ð/-d /t/ or z /ts/, and /ʃ/-sh /ʂ/.

Then, dependent variable (English-Chinese consonant similarity scores) was examined in (2) Age × (5) Matched consonant categories analyses of variance (ANOVA).

Table 2. Tests of Between-Subjects Effects

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	136.526	9	15.170	36.908	.000	.787
Intercept	2527.073	1	2527.073	6148.430	.000	.986
Age Differences	19.981	1	19.981	48.614	.000	.351
Consonant Categories	102.746	4	25.686	62.496	.000	.735
Age Differences * Consonant Categories	13.800	4	3.450	8.394	.000	.272
Error	36.991	90	.411			
Total	2700.590	100				

Corrected Total	173.517	99				

Note: R Squared = .395 (Adjusted R Squared = .334)

Table 2 shows that there are significant age effects on similarity scores, since F (1, 90) =3.95, p=.000 (p<.05), η_p^2= .351, and significant matched consonant category effects on similarity scores, since F (4, 90) =2.47, p=.000 (p<.05), η_p^2= .735. What's more, interaction effects on similarity scores is also significant, since p=.000 (p<.05), η_p^2= .272.

It was not necessary to consider Post Hoc Test of age effects, because there were only two groups divided by the age factor. However, significant differences of 5 matched consonant categories needed further observation with the Tukey HSD.

Table 3. Multiple Comparisons

(I) Types	(J) Types	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
/f/- f /f/	/m/- m /m/	.105	.2027	.985	-.459	.669
	/θ/- s /s/	1.650*	.2027	.000	1.086	2.214
	/ð/- d /t/ or z /ts/	2.710*	.2027	.000	2.146	3.274
	/ʃ/ - sh /ʂ/	1.350*	.2027	.000	.786	1.914
/m/- m /m/	/f/- f /f/	-.105	.2027	.985	-.669	.459
	/θ/- s /s/	1.545*	.2027	.000	.981	2.109
	/ð/- d /t/ or z /ts/	2.605*	.2027	.000	2.041	3.169
	/ ʃ / - sh /ʂ/	1.245*	.2027	.000	.681	1.809
/θ/- s /s/	/f/- f /f/	-1.650*	.2027	.000	-2.214	-1.086
	/m/- m /m/	-1.545*	.2027	.000	-2.109	-.981
	/ð/- d /t/ or z /ts/	1.060*	.2027	.000	.496	1.624

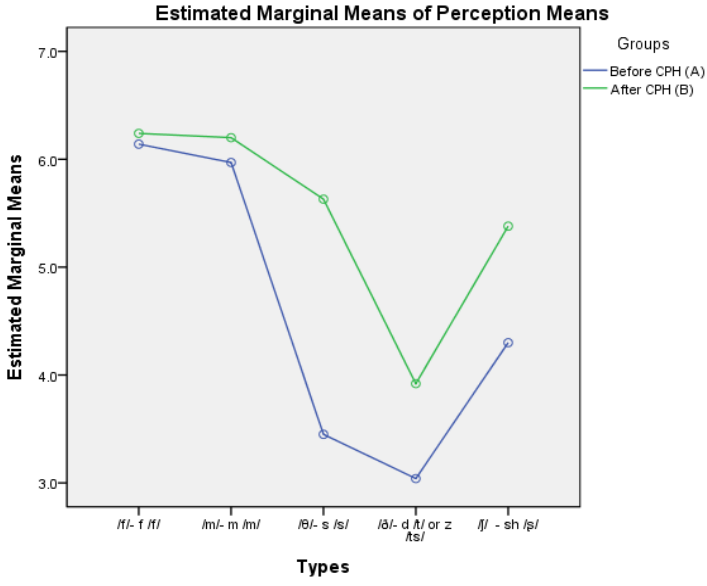
	/ʃ/ - sh /ʂ/	-.300	.2027	.578	-.864	.264
/ð/- d /t/ or z /ts/	/f/- f /f/	-2.710*	.2027	.000	-3.274	-2.146
	/m/- m /m/	-2.605*	.2027	.000	-3.169	-2.041
	/θ/- s /s/	-1.060*	.2027	.000	-1.624	-.496
	/ ʃ / - sh /ʂ/	-1.360*	.2027	.000	-1.924	-.796
/ʃ/ - sh /ʂ/	/f/- f /f/	-1.350*	.2027	.000	-1.914	-.786
	/m/- m /m/	-1.245*	.2027	.000	-1.809	-.681
	/θ/- s /s/	.300	.2027	.578	-.264	.864
	/ð/- d /t/ or z /ts/	1.360*	.2027	.000	.796	1.924

Note: The error term is Mean Square (Error) = .411. (p>.05)

Based on Table 3, matched consonants categories showed significant differences among each other, except for the categories of /f/-f /f/ versus /m/-m/m/, and /θ/- s /s/ versus /ʃ/- sh/ʂ/. It means that different English-Chinese matched consonants categories exert significant effects on different consonant similarity perception scores.

Furthermore, interaction effects of the age and the matched consonant categories were also further observed by the plot.

Figure 1. *Perception Plot*



According to the Figure 1, there was an interaction between the two independent variables. However, two groups were changed with the same pattern. Significant findings of the plot were that having learnt English with less mature L1 sound categories, participants from Group A (before CPH) rated all English consonants as being less similar to their corresponding Chinese response alternatives than Group B (after CPH) did. Participants from Group B, who had learnt English with mature L1 phonetic systems, gave much higher goodness ratings than Group A in response to English consonants /θ/and /ʃ/, although the ɛnglish sounds /θ/ and /ʃ/ and their corresponding Chinese sounds /s/ and /ʂ/ are quite different. However, Group B gave relatively low goodness ratings in respond to English consonant /ð/ and its corresponding Chinese consonants d /t/ or z /ts/.

5. Experiment 2 (Consonant production)

The purpose of Experiment 2 was to determine whether judgments of cross-language similarity obtained in Experiment 1 may predict the accuracy with which participants from Group A and Group B produce these same English consonants.

5.1 Procedure

Same participants from Group A and B were asked to pronounce each word (English words from the Experiment 1) as pictures of each were displayed by video images. During the first elicitation, the participants heard the English word of the picture was displayed. For the next two elicitations, the participants were asked to remember the corresponding English words on the pictures and to say them upon seeing the picture, and their pronunciation was recorded. The participants were thus not merely shadowing (imitating) the native speaker but were attempting to retrieve their own phonological representation for each word.

Then, two native speakers of American English rated the accuracy of participants' pronunciation using 7-point scale (1=very poor pronunciation, 7= near-native pronunciation). Finally, the dependent variable (production scores) was examined in (2) Age × (5) Matched consonant categories analyses of variance (ANOVA).

5.2 Prediction

Consonants produced by participants from Group A (before CPH) receive higher scores than those produced by the Group B (after CPH).

5.3 Results

A Pearson correlation coefficient revealed a high correlation between the rated consonant production scores from the two native speakers, r = .784, p =.000 (p<.01).

Table 4. Tests of Between-Subjects Effects

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	17.21	9	1.91	6.52	.00	.40
Intercept	2669.79	1	2669.79	9099.14	.00	.99
Age Differences	7.56	1	7.56	25.77	.00	.22
Consonant Categories	9.29	4	2.32	7.92	.00	.26
Age Differences Consonant Categories	.36	4	.09	.31	.87	.01
Error	26.41	90	.29			
Total	2713.41	100				
Corrected Total	43.62	99				

Note: R Squared = .395 (Adjusted R Squared = .334)

Table 5. **Multiple Comparisons**

(I) Types	(J) Types	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
/f/- f /f/	/m/- m /m/	.09	.17	.99	-.39	.56
	/θ/- s /s/	.38	.17	.18	-.10	.86

	/ð/- d /t/ or z /ts/	.87*	.17	.00	.39	1.35
	/ ʃ/ - sh /ʂ/	.38	.17	.18	-.10	.86
/m/- m /m/	/f/- f /f/	-.09	.17	.99	-.56	.39
	/θ/- s /s/	.30	.17	.43	-.18	.77
	/ð/- d /t/ or z /ts/	.79*	.17	.00	.31	1.26
	/ʃ/ - sh /ʂ/	.30	.17	.43	-.18	.77
/θ/- s /s/	/f/- f /f/	-.38	.17	.18	-.86	.10
	/m/- m /m/	-.30	.17	.43	-.77	.18
	/ð/- d /t/ or z /ts/	.49*	.17	.04	.01	.97
	/ ʃ / - sh /ʂ/	.00	.17	1.00	.48	.48
/ð/- d /t/ or z /ts/	/f/- f /f/	.87*	.17	.00	1.35	.39
	/m/- m /m/	.79*	.17	.00	1.26	.31
	/θ/- s /s/	.49*	.17	.04	.97	.01
	/ ʃ / - sh /ʂ/	-.49*	.17	.04	.97	.01
/ʃ/ - sh /ʂ/	/f/- f /f/	.38	.17	.18	.86	.10
	/m/- m /m/	.30	.17	.43	.77	.18
	/θ/- s /s/	.00	.17	1.00	.48	.48
	/ð/- d /t/ or z /ts/	.490*	.17	.041	.013	.97

Note: The error term is Mean Square (Error) = .293. (p <.05)

Based on the Table 4, there are significant age effects on production scores, since F (1, 90) =3.95, p=.000 (p<.05), η_p^2= .223, and significant matched consonant category effects on production scores, since F (4, 90) =2.47, p=.000 (p<.05), η_p^2= .260. Yet, there is no significant interaction effects on production scores, since p=.874 (p<.05), η_p^2= .013.

It was not necessary to consider Post Hoc Test of age effects, because there were only two groups divided by age factor. However, significant differences of 5 matched consonant categories needed further

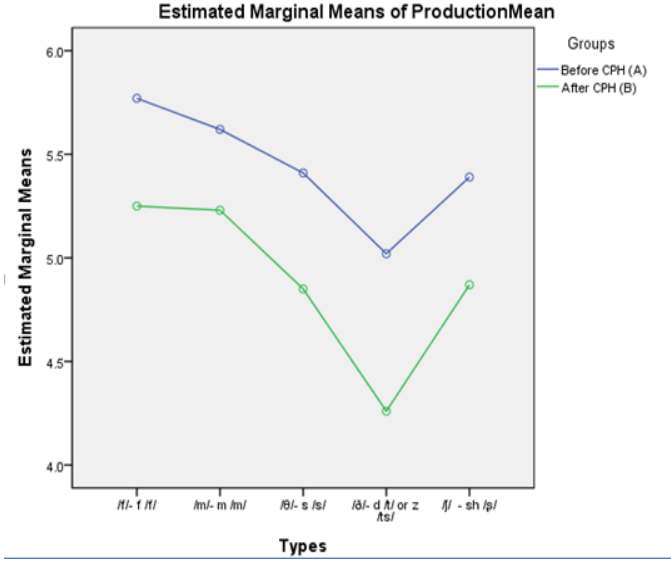
observation with the Turkey HSD.

Table 5 reveals that matched consonants categories showed significant differences among each other, except for the categories of /f/-f /f/ versus /m/-m/m/, /θ/- s /s/, and / ʃ / - sh /ʂ/ː /m/- m /m/ versus /θ/- s /s/, and / ʃ / - sh /ʂ/ː /θ/- s /s/ versus / ʃ / - sh /ʂ/. The results show that different English-Chinese matched consonants categories exerted significant differences on the L2 (English) consonant production scores.

Without significant interaction between the two independent variables, scores of Group A and B changed in parallel. All participants' production scores for the English consonants /f/ and /m/ were high, and they decreased in the English consonants /θ/ and /ʃ/ sounds. Yet, production scores were relatively low in the English consonant /ð/ sound.

As predicted previously, by less perceiving English (L2) sounds as instances of L1 (Chinese) sound categories, participants from Group A (before CPH) produced English consonants /θ/, /ð/, /ʃ/ more accurately than those from Group B (after CPH) did.

Figure 2 *Production Plot*



6. Discussion

The purpose of the present paper was to link learners' perception of the relationship between sounds in the L1 and L2 to the accuracy with which they produce and perceive L2 sounds, as well as to find out whether or not age influences L2 phonological perception and production.

The obtained results of this paper provided evidences in support of the "interaction hypothesis", i.e., Started learning English (L2) with mature L1 phonetic system, participants from Group B (after CPH) rated the stimulus English consonants as being more similar to their modal Chinese response alternatives than Group A (before CPH) did. In addition, by less perceiving English (L2) sounds as instances of L1

(Chinese) sound categories, participants from Group A (before CPH) produced English consonants /θ/, /ð/, /ʃ/ more accurately than those from Group B (after CPH) did.

However, there was an interesting finding. Low scores in Group B's (After CPH) production of the English consonants /θ/ and /ʃ/ can be well explained with 'interaction hypothesis', since participants from Group B highly perceived those sounds as instances of Chinese sound categories, however, low scores in perception and production of the English consonant /ð/ from participants of Group B cannot be reasonably explained by the 'interaction hypothesis'. As far as I am concerned, one possible reason was that if there were no corresponding sounds categories in L2 learners' L1 phonetic systems, L2 learners should learn these productions from the beginning. However, these sounds were not learned by L2 learners during their L1 acquisition periods, thus, they cannot produce these sounds accurately, even though the L1-L2 sounds differences can be auditory detected.

7. Conclusion

The age effects on relationship between the ability to perceive L1–L2 differences and L2 production should be examined in future research in greater extent, with a goal of finding out more possible theories and explanations. One such factor may pertain to neurobiologically based age-related changes in the plasticity of brain structures underlying language learning and use. For example, Mechelli et al. (2004) demonstrated that younger learners appeared to have a larger composition of grey matter in areas of the brain devoted to language processing than did older learners. In another study, Kim et al. (1997) documented that the brain areas involved in the processing of L1 and L2 overlapped in younger learners but did not do so in older learners. As these previous findings show that younger L2 learners, as compared

to older L2 learners, may rely on different language processing and learning mechanisms and/or may draw on different brain structures in the course of language learning and use.

In consideration of limited number of participants in the present study, findings in this study may lack of reliability. Hence, in future study, I will analyze more data to find out more meaningful and reliable results.

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Appendix

1. First Name (姓): ___ when did you start learning English ?(age) _____
2. Which one is your first language? (Mandarin or other languages?) _____
3. Do you learn English in China only as part of regular classroom instruction? ____
4. Are you English major? _____
5. Have you ever been to English speaking countries? _____.

6. (1) **f**ive, face, for_____
   (2) t**h**in, thick, thud _____
   (3) **m**ay, more, mom _____
   (4) **th**at, this, them _____
   (5) **Sh**ip, she, shy _____
   (6) Pick one Chinese word that "starts with" the similar sound as the above English words

   （请在下面汉语单词中找出开头音跟上面英语单词的开头音相近的单词）

   妈妈 （ma ma），发 （fa），大（da），咱 （zan），洒 （sa），炸 （zha），沙 （sha）

   (7) Rate the sound similarity of the English word and the chosen Chinese word with 7-point scale (1=sounded very dissimilar, 7=sounded very similar)

   （找出相近音的汉语单词后，看一下它们的开头音有多相近，给出1-7分内的分数。1分=完全不相近，7分=很相近）

7. Read each word twice (录音) as pictures of each were displayed by

video images.

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