The effect of immediate feedback on the perception of Mandarin lexical tones by non-native speakers of Mandarin

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Cong Zhang is a first-year DPhil student in Linguistics. Her research interest in the prosody of Mandarin Chinese has motivated this paper on the effectiveness of immediate feedback on the perception of lexical tones by non-tonal language speakers with no previous knowledge of Mandarin.

Lexical tone is one of the most difficult issues in learning Mandarin as a foreign language. Various efforts have been made by training non-native speakers to improve the perception of Mandarin lexical tones. Immediate feedback, as an essential and efficient way of perceptual learning, however, has been understudied. An AX discrimination task is used to test whether the participants' perception of Mandarin lexical tones improves after being given immediate feedback. The result shows an evident effect of immediate feedback on the perception of Mandarin lexical tones, both within the experiment groups as well as between the experiment group and the control group.

1. Introduction

Lexical tone, an important feature in Mandarin Chinese, is one of the most difficult features for non-native speakers of Mandarin to acquire (e.g. Francis et al. 2008; Wang 1999) due to the differences in pitch patterns, functions and distributions between English and Mandarin (Chen 1974; White 1981). Efforts have been made to improve either the perception or production of Mandarin lexical tones by previous studies, with various training methods used. However, hardly any study has examined the effect of immediate feedback on tone perception or production. The present study therefore will investigate the effect of immediate feedback on the perception of Mandarin lexical tones by non-native speakers of Mandarin, aiming at exploring a more effective

and efficient perceptual learning method and acting as a pilot study to prepare for better-controlled future research on tone perception.

Tones belong to suprasegmental phonology (Leben 1973; Yip 1980), which is different from segmental phonology, such as consonants and vowels. Goldsmith (1979) advanced the Autosegmental Theory, in which he contended that tonal and segmental phonology are separate. Zeng & Mattys (2011) investigated the separability of Mandarin tones and rhymes by way of the perceptual-migration paradigm and supported Autosegmental Theory by concluding that native Mandarin speakers automatically perceive lexical tones separately from the tone-bearing rhyme, while speakers of non-tonal languages cannot. Therefore, difficulty in perceiving lexical tones for non-native speakers of Mandarin is due to their inability to separate suprasegmental tones from segmental vowels and consonants.

1.1 Perceptual learning

Non-native speakers of Mandarin, however, are not tone-deaf. One way of improving their perception is through perceptual learning. Perceptual learning is "extracting previously unused information" (Gibson & Gibson1955), which can be divided into four different mechanisms: "stimulus imprinting", "differentiation", "unitization" and "attentional weighting". (Goldstone 1998) The last mechanism, "attentional weighting", means that more "weight" can be given to relevant features as experience increases. (Samuel & Kraljic 2009) For example, non-tonal language speakers do not pay attention to lexical tones because tones do not make any difference in their native language; nevertheless, after having more experience, such as receiving training or feedback, their perception of tones will improve. Training, as the most common perceptual learning method, has

been employed in many studies that investigated the effect of perceptual learning on music perception and speech perception, especially on segmental phonology perception (e.g. Bradlow et al. 1997; Iverson et al. 2003; Kraljic and Samuel 2006). Recently, a few studies have also been done on training non-native speakers of Mandarin to perceive or produce Mandarin lexical tones (e.g. Francis et al. 2008; Wang et al. 1999; Wang et al. 2003). However, feedback, as a more efficient perceptual learning method, has been understudied.

1.2 Feedback

Feedback can be divided into two types according to the timing of the feedback: immediate feedback, and delayed feedback. Scholars have been arguing about which is more effective since the 1920s.

The scholars who supported the immediate feedback argued that errors should be corrected before the students remember them (Pressey1932; Mason and Bruning 2001) and the correct response should be reinforced immediately (Skinner 1954; Renner 1964); the scholars who supported delayed feedback, however, believed that delayed feedback could reduce proactive interference so that the incorrect information could be forgotten before inputting the correct information (Kulhavy and Anderson 1972).

Some studies, mostly early studies, were in favour of delayed feedback. For example, Kulhavy and Anderson (1972) claimed that delayed feedback was superior to immediate feedback with evidence from a multiple-choice test. Kulhavy (1977) again supported his previous claim with evidence from a writing task. Bardwell (1981) also found delayed feedback was more effective than immediate feedback in terms of a school related learning.

1.3 Present study

Based on all the aforementioned studies, the current study focuses on evidencing that immediate feedback is efficient. The research question therefore is: will immediate feedback improve the perception of Mandarin lexical tones by non-native speakers of Mandarin? This study hypothesizes that the error rate of the perception of Mandarin lexical tones by non-native speakers of Mandarin will decrease as more feedback is received.

In order to exclude the influence of the native languages of the participants from the results, participants with two different L1 backgrounds were chosen, namely, native English speakers and native Arabic speakers. The participants were asked to accomplish an AX discrimination task and the error rate of each participant was calculated. The results showed that the average error rate of the participants who received feedback was lower than that of the participants who did not. Moreover, as the participants received more feedback, the error rate kept decreasing. These results clearly showed that immediate feedback did affect tone perception.

2. Background: a brief introduction to Mandarin phonology

Traditionally, a Mandarin syllable is considered to consist of three parts: the initial, the final and the tone (Cheng 1973; Huang 1992). However, more and more scholars tend to categorize them as onset, rhyme and tone. (Duanmu 2007) The difference between these two categorization methods lies on the glide. In the first categorization, the glide belongs to the final, while it belongs to the onset in the second categorization (Triskova 2011). Regardless of the names, the onset (or the initial) and the rhyme (or the final) are composed of consonants and vowels. They are therefore segmental features. The tone, which is indisputably

separate in both methods, is a suprasegmental feature. The present study will adopt the names of "onset" and "rhyme" for the segments.

2.1 Segmental features of Mandarin syllables

Mandarin is a monosyllabic language. A Mandarin syllable usually has an onset and a rhyme. The onset is either a consonant (C) or it is omitted; the rhyme can be monophthongs, diphthongs, or vowel (V) + nasal ([n] or [ŋ]) or vowel+ liquid ([ɻ]). Therefore, the syllable structure of Mandarin could be V, VC (nasal/ liquid), CV, CVV, CVC (nasal/ liquid), or CVVC (nasal/ liquid).

2.1.1 Onsets

Most of the onsets in Mandarin exist in English, for example, [m], [n], [p^h], [k^h], etc. Some others have subtle differences with those in English, such as /f/ is pronounced as [f^h] in Chinese, which is different from [f] in English. These subtle differences are on the level of allophones, which will not influence the perception of the syllable. However, there are a few onsets that the English speakers find difficult to perceive and produce, for instance, the alveolar-palatals ([tɕ], [$tɕ^h$], [ɕ]), the fricatives ([ts], [ts^h]) and the affricates ([tʂ], [$tʂ^h$], [$ʂ^h$], [ʐ]). These sounds will be excluded in the present study since the focus is on the suprasegmental features rather than the segmental features. /w/ and /j/, considered by the scholars who support the Onset-Rhyme Model as glides, are also excluded.

2.1.2 Rhymes

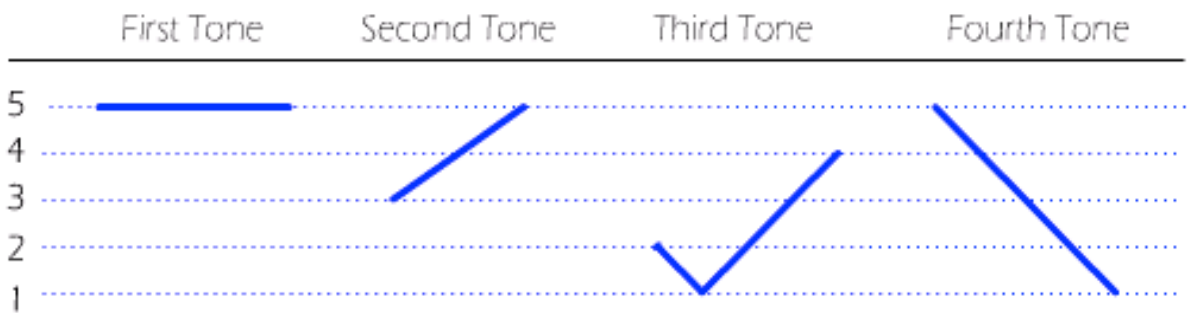
Mandarin has a small repertoire of vowel phonemes, /a/, /o/, /i/, /u/ and /y/. Except for [y], the other four phonemes all

exist in English, including their allophones. As for the V + nasal and V+ liquid, such combinations are legal in English phonology. The most difficult rhymes for the English speakers are the apicals, [ɿ] and [ʅ].Therefore, in the design of present study, [y], [ɿ] and [ʅ] are excluded. /u/ and /i/ are also excluded, but only when they are in positions in which the scholars supporting the Initial-Final Model consider them as glides.

2.2 Suprasegmental features of Mandarin syllables

The lexical tone is the only suprasegmental feature on syllable level in Mandarin. There are five lexical tones, high level, rising, dipping, falling, and neutral (Li and Thompson 1977). The first four are the most important ones for comprehension; the neutral tone, however, only occurs when the syllable is unstressed. Chao (1930) designed a tone letter system that could represent the tones according to their relative pitch levels. In this system, the lowest level is "1" and "5" is the highest. The pitch levels of the four tones are 55, 35, 214 and 51 respectively. When the syllables are pronounced in isolated syllables under ideal circumstances, the first four tones will have the contours as shown in Figure 1. The

Figure 1: Four Mandarin lexical tones (Chao 1930)



four tones resemble music notes to some extent, but the pitches of music tones are absolute, while those of Mandarin lexical tones are

comparatively relative. In this study, neutral tone, which is commonly referred to as "no tone", is excluded, due to its many allotones, which vary according to the tone of the preceding syllable.

Tone plays an important role in the semantics of a syllable. In Mandarin, one character may have one or several pronunciations. But it is always monosyllabic no matter which pronunciation it adopts. Each syllable has one of the five lexical tones. Change of lexical tones of a syllable may result in either referencing another character, or varying the meaning of the same character altogether. Different characters may have the same syllable and the same tone. The corresponding relationship between the tones and characters may be many-to-one or one-to-many. For example, in Table 1, a syllable of a certain tone can have more than one corresponding characters; one character can also have different tones with the same syllable, such as "吗" has the second, third and neutral tones; one character can have different syllables with different tones as well, for instance, "抹" can also be pronounced as *mǒ* [mo]214 ('erase'), or *mò* [mo]51 ('plaster').

Table 1: Example of the relationship between tone and character in Mandarin

(*Pinyin*: Romanized representation of Mandarin pronunciation)

Pronunciation		Chinese characters
Pinyin	IPA	
mā	[Ą] 55	妈('mother'), 抹(wipe)[2]
má	[Ą] 35	麻('hemp'), 吗('what')[1]
mǎ	[Ą] 214	马('horse'), 吗('morphine')[1]
mà	[Ą] 51	骂('scold')

ma	[Ą]	吗(a particle used at the end of questions)[1]

Yang et al. (1988) calculated that there are approximately 1300 syllable sounds in Mandarin, while more than 50,000 characters are used in the writing system. If there are no tones, only 411 syllable sounds are left in Mandarin. Therefore, perceiving the lexical tones correctly is an important task in learning Mandarin.

2.3 Summary

A Mandarin syllable is composed of segmental features and suprasegmental features. Segmental features include onsets and rhymes. In the current study, some segmental sounds in both onset and rhyme positions that may cause too much perceptual difficulty for English speakers are excluded. The suprasegmental feature on syllable level only consists of lexical tones. Lexical tones are closely related to the meaning of Mandarin characters; therefore, the perception of lexical tones is a very important issue.

3. Experiment design

3.1 Participants

12 native speakers of British English and 12 native speakers of Arabic, all with no known hearing or speech problems, participated in the experiment. The randomness of the choice of participants was assured since the recruitment was through various means such as in a campus activity or through emails. All participants were undergraduate or post-graduate students at Newcastle University. None had any knowledge of or experience with Mandarin or any other tonal language.

The participants were divided into four groups: six English speakers and six Arabic speakers formed two experiment groups respectively, while the other six English speakers and six Arabic speakers acted as two control groups. The experiment groups received feedback after each judgment, while the control groups did not.

3.2 Stimuli and apparatus

A total of 80 pairs of monosyllabic Mandarin morphemes were selected, every one of which were composed of an onset and a rhyme. In order to avoid the influence of non-native syllable structure or non-native phonology on the perception, phonemes that do not exist in English were excluded. The rhymes included both monophthongs and diphthongs, which were evenly numbered and distributed in the stimuli list (see Appendix). The full list of onsets and rhymes is as shown below.

Table 2: full list of onsets and rhymes in *pinyin*

onsets	b p m f d t n g k h
rhymes	a o e i u ao ai ou ei an en in ang eng ing ong

The stimuli were divided into two categories according to their onset contexts in the experiment, i.e. stimuli with the same consonants but different rhymes (SCDR) and stimuli with different consonants and different rhymes (DCDR). In each category, 20 of the stimuli pairs were of the same tone, and the other 20, different. Since the third tone (214) was the most difficult tone to perceive

for non-Mandarin speakers (Zeng 2008), this experiment included more contrasts with the third tone, with those between the second and the third doubling others as previous studies suggested that the non-native speakers of Mandarin were most confused between the second tone and the third tone in both perception and production (Lee et al 2010; Zeng 2008). Table 3 shows the stimuli design and the numbers of each tone pair. "55", "35", "214" and "51" are pitch values of the four mandarin lexical tones.

Table 3: numbers and categories of stimuli

	Same tone (20)				Different tones (20)		
CD R (40)	55+55 (5)	35+35 (5)	214+214 (5)	51+51 (5)	55+214 (5)	35+214 (10)	51+214 (5)
CD R (40)	55+55 (5)	35+35 (5)	214+214 (5)	51+51 (5)	55+214 (5)	35+214 (10)	51+214 (5)

All the stimuli pairs were recorded by a female native Mandarin speaker with Sony ICD-PX312 digital voice recorder. An ASUS U36J laptop was used for playing the stimuli, and the judgments were taken down with pen and paper.

3.3 Procedures

The experimenter first explicitly introduced what lexical tones were in Mandarin, using "a 55", "a 35", "a 214" and "a 51" as examples and then compared the lexical tones to musical notes.

Having had a thorough idea of what Mandarin lexical tones were, the participants were asked to perform an AX discrimination task. The participants heard a trial of two stimuli at a time and they needed to make a judgment on whether the tones of the two stimuli were the same, ignoring the consonants and vowels.

The experimenter gave the participants in the experiment groups a feedback after each judgment by telling the participants whether the judgment was "right" or "wrong". For the control groups, however, the experimenter would immediately play the next trial without giving any feedback. The experimenter took notes of the correctness of the judgments of both the experiment groups and the control groups for data analysis.

4. Results

4.1 Average error rate

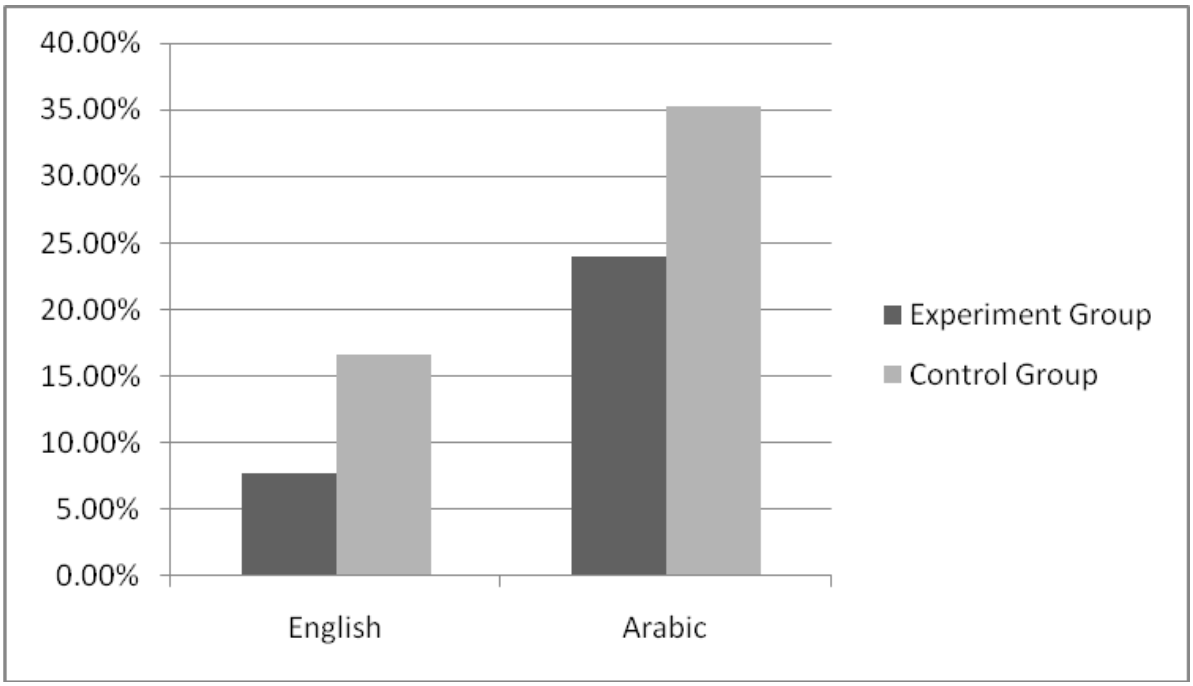
The average error rate of the English control group was 16.67% while that of the English experiment group was 7.71% (Figure 2). The significant improvement indicated that feedback did have an effect on the perception of Mandarin lexical tones. The Arabic experiment group, with an error rate of 23.96%, also showed significant improvement over the Arabic control group, whose error rate was 35.21%.

The Arabic speakers made more mistakes on average than the English speakers. The Arabic experiment group, which made fewer mistakes than the Arabic control group, still had a higher error rate than the English speakers.

4.2 Average error rates by blocks

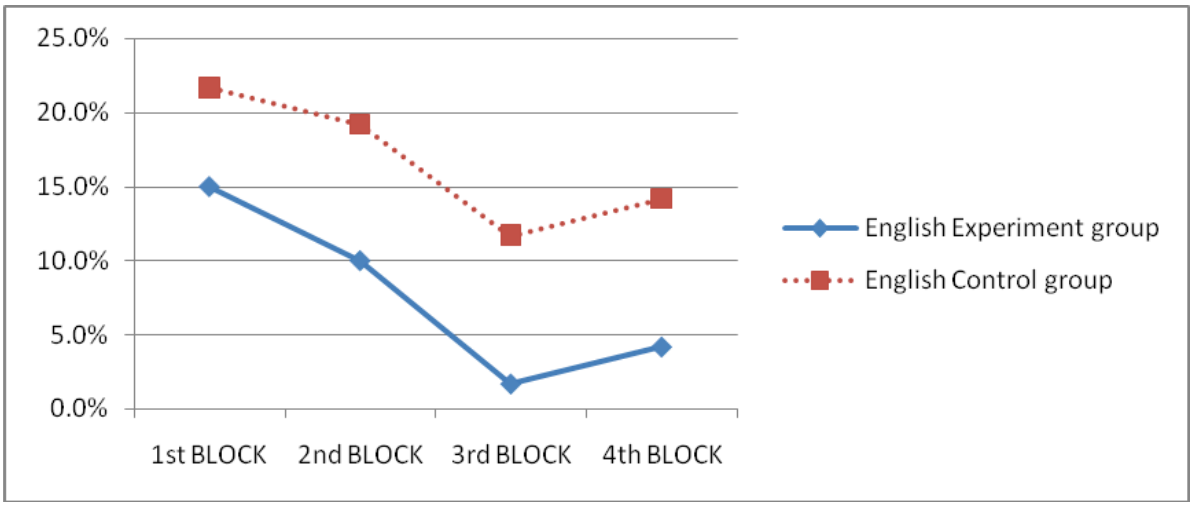
With the stimuli divided into four blocks (i.e. First Block: the first 20 pairs of stimuli; Second Block: the second 20 pairs of

Figure 2: Average error rates



stimuli; Third Block: the third 20 pairs of stimuli; Fourth Block: the fourth 20 pairs of stimuli), the average error rates by blocks of the English control group were 21.7%, 19.2%, 11.7% and 14.2% respectively while those of the English experiment group were15.0%, 10.0%, 1.7% and 4.2% respectively (Figure 3). These results indicated that as receiving more feedback, the perception

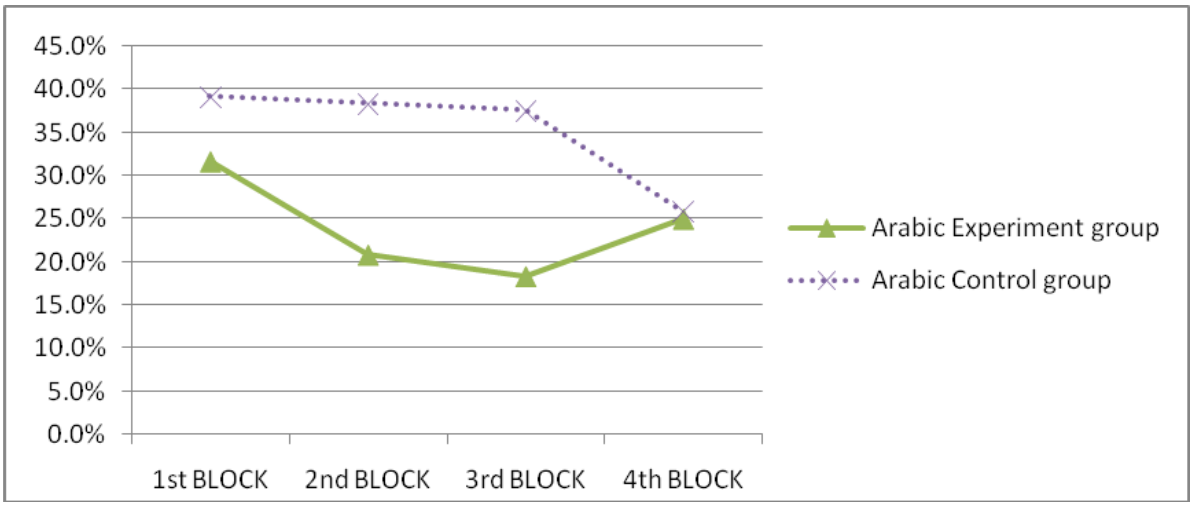
Figure 3: Average error rates by blocks (English speakers)



abilities of both groups were improving; moreover, the experiment group improved at a higher speed and reached a higher level than the control group. Further discussion will be made on the fourth block rebound.

For the Arabic groups, the average error rates by blocks of the Arabic control group were 39.2%, 38.3%, 37.5% and 25.8% respectively while those of the Arabic experiment group were 31.7%, 20.8%, 18.3% and 25.0% respectively (Figure 4).

Figure 4: Average error rates by blocks (Arabic speakers)



The English control group and the English experiment group showed similar curve: the error rates decreased from Block 1 to Block 3 and rebounded in Block 4. The Arabic experiment group revealed similar trend. However, for the Arabic control group, the error rate basically remained at the same level while in Block 4, it had a sudden plunge.

5. Discussion

The results were overall in accordance with the hypothesis: the error rates generally decreased within the experiment groups themselves as the participants received more feedback; the error

rates of the experiment groups, who received feedback, were lower than the control groups, who did not receive feedback. These results indicated that feedback had some positive effects on tone perception.

However, there were three unexpected results, namely the low error rates compared with the data from previous studies, the fourth-block rebound for the experiment groups and the much higher error rate of the Arabic speakers than the English speakers.

The data from Zeng (2008) showed that English speakers generally made more than 50% errors and even the native Mandarin speakers had an average error rate of 21.5%. However, in this study, the English control group, who made more mistakes than the English experiment group, only had 16.67% of errors; the Arabic groups made higher error rates, i.e. 35.21% for the Arabic control group and 23.96% for the Arabic experiment group, which were still much lower than expected. This issue can be attributed to the different experiment methods used in the literature and this pilot study. In Zeng (2008), the AX discrimination task was performed on a computer with DMDX software, the stimuli durations, stimuli display time and intervals between trials were strictly controlled; whereas in the current pilot study, a simple AX discrimination task without controlling the abovementioned factors. The participants sometimes thought about the decision for more than 10 seconds, which made the judgments more like processing rather than perception. Therefore, the future researches should have stricter control over such factors as the stimuli durations, stimuli display time, intervals between trials and so on.

The second unexpected result was the rebound in the fourth block. The error rates of the fourth block were expected to be the lowest among all four blocks; however, both experiment groups had a fourth-block rebound: the English experiment group

increased from the 1.7% in the third block to 4.2% in the fourth block, while the Arabic experiment group increased from 18.3% in the third block to 25.0% in the fourth block, which was almost as high as the 25.8% of Arabic control group. The rebound of the English speakers' error rate might be due to the fixed stimuli order since the control group had the same curve as shown in Figure 3. However, the curves of the two Arabic groups were different. The error rate of the control group remained at the same level while decreased in the fourth block, which showed normal cognition and perception process. The fact that Arabic experiment group revealed decreasing trend in the first three blocks and performed better than the Arabic control group in general displayed the effect of the immediate feedback. Other than the fixed stimuli order, the unexpected rebound might be attributed to the concentration span of the participants, small sample size of this pilot study, or a possible ceiling effect. To avoid all these factors, the future researches should randomize the stimuli order, give breaks after each block, recruit more participants and detect the ceiling effect.

That the Arabic speakers made notably more incorrect judgments than the English speakers was the third unexpected result. Both Arabic and English are non-tonal and have intonations while the results showed that Mandarin lexical tones were more difficult for the Arabic speakers than the English speakers. There were studies on comparing the perceptions of tones by tonal language speakers and non-tonal language speakers (e.g. Kaan et al. 2008) and the results showed that tonal language speakers achieved better results than non-tonal language speakers. However, the perception difference of speakers from different language backgrounds within non-tonal languages was understudied. The current pilot study therefore has provided a research topic that is worth studying in the future.

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Appendix: Pilot Stimuli List (Fixed order)

No. 1	mo55	mi55
No. 2	gang55	gong214
No. 3	mu214	fa214
No. 4	mo214	ga51
No. 5	ge35	gu214
No. 6	du55	ta55
No. 7	fei51	fen214
No. 8	bo55	ning214
No. 9	po35	pin214
No. 10	du35	da35
No. 11	dou51	hao51
No. 12	nin35	da35
No. 13	du51	di51
No. 14	nan55	mao55
No. 15	hou35	di214
No. 16	du55	dou55
No. 17	ba35	hu214
No. 18	ha214	hou35
No. 19	kou214	hai35
No. 20	ken214	kai214
No. 21	ke55	ka55
No. 22	bi55	tou55
No. 23	heng35	han214
No. 24	pi214	po51
No. 25	ka214	mai214
No. 26	nong35	nao35
No. 27	mo214	ge35

No. 28	ku51	kan51
No. 29	hao214	hu214
No. 30	mo35	ti35
No. 31	mu214	mo35
No. 32	bao51	pa51
No. 33	de55	ti214
No. 34	fo35	fang35
No. 35	fan35	ning214
No. 36	dong51	pao214
No. 37	fang35	ping35
No. 38	bing214	hu35
No. 39	ge214	gen35
No. 40	pin214	pan55
No. 41	hu214	he55
No. 42	tao51	ting51
No. 43	ni35	na214
No. 44	fang55	deng55
No. 45	mai35	mei35
No. 46	he35	ba35
No. 47	pa51	ku51
No. 48	nei214	nin35
No. 49	di214	ge214
No. 50	te51	ti214
No. 51	ba214	bi214
No. 52	gen35	ku214
No. 53	ni214	nan55
No. 54	tu214	pin214
No. 55	hang55	heng55
No. 56	kan214	bei51
No. 57	tu214	na35
No. 58	ba214	gu55
No. 59	fan214	fou214

No. 60	mao55	kai214
No. 61	tan35	ni35
No. 62	na51	fu214
No. 63	bao35	bing214
No. 64	dei214	dan51
No. 65	mei214	bang214
No. 66	pi51	pai51
No. 67	nan51	gen51
No. 68	ti55	ting55
No. 69	pu214	geng51
No. 70	kou51	ke214
No. 71	gei214	dao35
No. 72	nen214	ni214
No. 73	tong214	pin55
No. 74	mi35	meng214
No. 75	hou55	bu55
No. 76	men35	mo35
No. 77	bo55	bi214
No. 78	men51	fu51
No. 79	mo51	ma51
No. 80	fen214	pi35