Phoneme Discrimination Between Native Mandarin and Native English Speakers

by

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A Thesis Presented in Partial Fulfillment
of the Requirements for the Degree
Master of Science

Approved April 2021 by the
Graduate Supervisory Committee:

Jose Nanez, Co-Chair
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ABSTRACT

Anecdotally, native Mandarin speakers have difficulty distinguishing between the "s" (as in sink) and the "th" (as in think) sounds as well as between the "a" (as in dad) and "ea" (as in dead) sounds. Here, 29 native English speakers, 52 native Mandarin speakers who live in China, and 34 native Mandarin speakers who have been living in an English language dominant environment were recruited to serve as participants. To assess the phoneme contrasts that may occur in native Mandarin speakers in China, and possible improvement in native Mandarin speakers living in an English environment, relative to Native English speakers living in America, a phoneme discrimination test was administered, three paired phonemes were used in the current study: /b/ paired with /p/ as a control pair, /æ/ paired with /ɛ/, and /θ/ paired with /s/. The results showed that native English speakers have significantly higher accuracy rates for the three paired phoneme discrimination tasks than the native Mandarin speakers who live in China. But there was no significant difference between the native English speakers and native Mandarin speakers who have lived in an English environment on the phonemes or words discriminations tasks.

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INTRODUCTION

Phonetic differences that correlate with phonemic contrasts may exist in a native language and make the adult speaker more sensitive to the language process (Werker et al., 1981; Werker & Tees, 1984; Best, 1994; Weber & Cutler, 2004). However, it is difficult to distinguish phonemes that do not exist in the speaker's native language (Goto, 1971; MacKain et al., 1981; Werker et al., 1981; Best and Strange, 1992; Pater et al., 2004). Many studies have addressed the issue that second-language learners have difficulty distinguishing non-native language phonemes. Several approaches have been suggested to improve participants' ability to distinguish non-native contrasts (Polka, 1992; Bohn, 1995; Iverson et al., 2003). Thus, discriminating between phonemes is the basis for sound discrimination. Discriminating phonemes is easier with phonemes from the native language than phonemes from the non-native language.

Language environment

For some time, Chinese have been learning English as a second language on a large scale. Today, there are more than 81 million English speakers in China, and the number is rising rapidly ("List of countries by English-speaking population", 2019). Unlike English, Mandarin is a tonal language with a very constrained phonological structure (Zhu, 2006). There is a simple syllable template, which includes Vowel and Tone as obligatory parts of the syllable, and Consonant and Glide as non-obligatory components. Traditionally, in Mandarin, syllables are divided into initial, final, and tone (Chen, 1999; Hu, 2008; Roger, 2005). Most features of English's phonological system such as stress and intonation patterns are different from Mandarin's, which causes some difficulties for Chinese who are learning English. For example, there are no vowels like

/æ/ and no consonants like /θ/ in Mandarin (Zhang & Yin, 2009). Therefore, native Mandarin speakers have trouble distinguishing these phonemes and may substitute such phonemes with the nearest equivalents.

Moreover, as previous researches have noted, native Japanese speakers who have lived in an English speaking environment or intensively trained in English showed similar but slightly lower phoneme discrimination results as native Americans and show much better performance compared to those Japanese who had very little or no experience with English (MacKain et al. 1981; Flege, Takagi & Mann 1995, 1996; Best & Strange 1992). In the current study, there were two subgroups of native Mandarin speakers: group 1: Participants learned English in China and have continuously used English as international college or university students in the U.S. Alternatively Group 2 participants remained in China. It is assumed that these participants have had limited English exposure beyond that obtained in their classroom experiences in China. A third group, (Group 3) consisted of Native English speakers. This group served as a control group for comparison purposes relative to Groups 1 and 2. It was hypothesized that native Mandarin speakers who have lived in an English speaking environment (Group 1) would have similar but slightly poorer performance on distinguishing the phonemes than the native English speakers (Group 3), and perform significantly better than Group 2, who have never lived in an English-speaking environment.

Three paired phonemes were used in the current study: /b/ paired with /p/ as a control pair, /æ/ paired with /ɛ/, and /θ/ paired with /s/. For the control group, paired phonemes (/b/-/p/) are exist in both Mandarin and English. In the experimental group (/æ/-/ɛ/ and /θ/-/s/), each of them contains a phoneme that only exists in English, and

another phoneme that exists in both Mandarin and English. Also, three paired words-bound paired with pound, dead paired with dad, and think paired with sink. All word pairs were identical except for the tested phonemes within each pair. It was further hypothesized that the native English speakers would show the highest accuracy rates than the other two groups in the phonemes/words discrimination tasks which contain /æ/ and /θ/. It was further hypothesized that the native Mandarin-speakers (Group 1) who have lived in an English environment will exhibit greater phoneme discrimination accuracy than native Mandarin speakers who live in China in the phonemes/words discrimination test that contains the /æ/ and /θ/ pairing. Finally, it was hypothesized that all participants would show similar accuracy rate in discriminating phonemes and words pairs that contain the /b/ and /p/ phoneme pairs.

A central purpose for conducting the current study was to first, determine whether increased English-speaking experiences lead to improved English phoneme and word discrimination performance (Group 1). If verified, the finding is evidence that continuous, consistent high exposure to an acquired second language contributes to brain plasticity/malleability relative to individuals without this environmental opportunity. Such data-driven findings could inform design of future perceptual learning and cognitive paradigms. In the long-term, such learning paradigms will help people from different home language backgrounds to improve their understanding and production abilities in acquisition of subsequent languages, leading to social benefits, including better integration into other cultures, improved second-language mastery, and to express their ideas more eloquently and accurately, making them more likely to succeed in their academic and professional careers.

METHODS

Participants

Participants (N = 115), (43 male, 68 female, 4 other), M age = 22.10 years, SD= 5.87 years, age range from 16 to 53 years, were recruited for this study. Specifically, there were 29 native English speakers who are undergraduate students enrolled at Arizona State University. These participants received course credit for their participation. A second group consisted of 52 native-Mandarin-speaking college students who live in China and have never lived in an English environment. A third group (34 Participants) consisted of native-Mandarin-speakers who are international students and live in an English-speaking environment also participated in this study. All participants signed a consent form as approved by Arizona State University Research Integrity and Assurance Office. The tenets of the Geneva Convention for the ethical treatment of human subjects were adhered to. The study was conducted during the COVID-19 pandemic, and thus the study was administered remotely through Qualtrics using participants' own equipment.

Procedure

Phoneme discrimination test. The phoneme discrimination test consists of three groups of phonemes, /æ/ paired with /ɛ/, /θ/ paired with /s/, /b/ paired with /p/, and three groups of words, dad paired with dead, think paired with sink, bound paired with pound. Participants randomly heard each pair of phonemes, a total of 4 times for each pair. During the auditory process, participants were asked to watch plus (+) sign on the screen. Participants were given forced-choice options as to whether two phonemes/words

are the same or not. Phonemes discrimination trials and demographic questions were presented in a customized survey through Qualtrics.

Data analysis

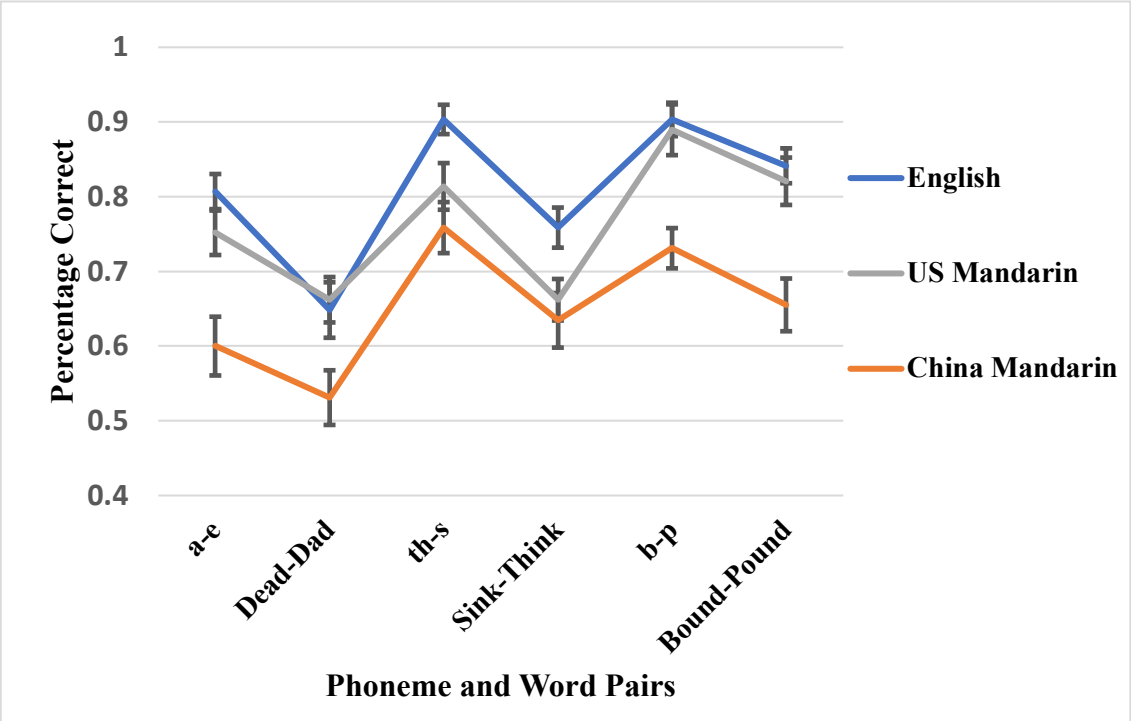
The results were analyzed using a two-way ANOVA, in which the mean accuracy for phoneme and word pairs discrimination changes according to the participants' group (native English speakers, native Mandarin speakers who live in China, and native Mandarin speakers who live in an English-speaking environment). Post Hoc t-Tests were used to make comparisons between the three groups to determine significant between-group differences.

RESULTS

The main hypothesis was examined by a two-way ANOVA (Figure 1). There was a statistically significant interaction between participants' language group mean percentage accuracy on phoneme and word pair discrimination, F (5, 2295) = 21.18, p < .001, $\eta 2$ = 0.035.

Figure 1

Mean Percentage Correct for Distinguishing Between Phoneme Pairs

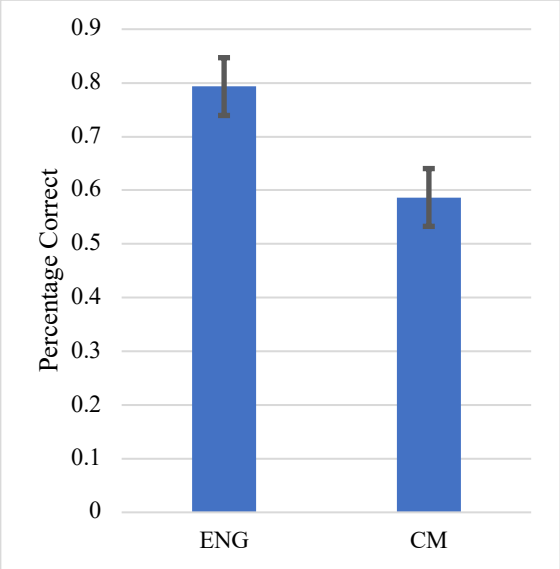


Note. Mean percentage correct for phoneme and word pair discrimination between native English speakers, native Mandarin speakers who live in China, and native Mandarin speakers who have lived in an English-speaking environment.

Post hoc t-Tests showed that native English speakers (ENG) (t (322) = 3.84, p < 0.001, *Cohen's d* = 0.45, R^2 = 0.04) exhibited significantly higher mean percentage correct for distinguishing between /æ/ and /ɛ/ than native Mandarin speakers who live in China (CM) (figure 2).

Figure 2

Mean Percentage Correct for Distinguishing Between /æ/ - /ɛ/

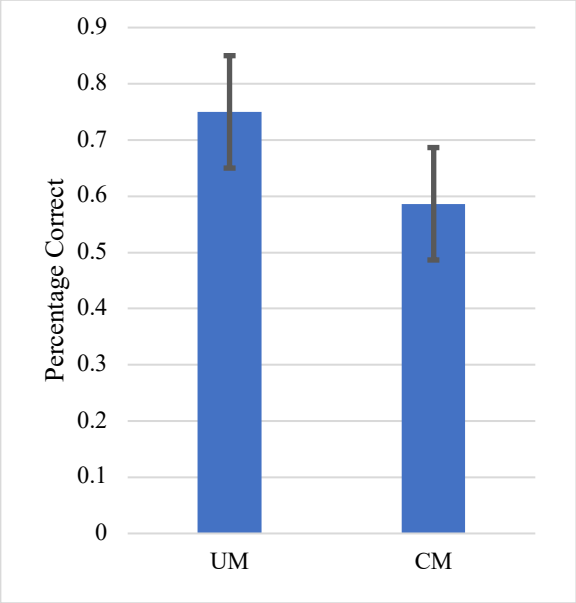


Note. The comparison of mean correction rate of distinguishing /æ/ - /ɛ/ between native English speakers (ENG) and native Mandarin speakers who live in China (CM).

Native Mandarin speakers who live in an English-speaking environment (UM) ($t(342) = 3.15$, $p < 0.01$, *Cohen's d* = 0.35, $R^2 = 0.03$) also exhibited significantly higher mean percentage correct for distinguishing between /æ/ and /ɛ/ than native Mandarin speakers who live in China (CM) (figure 3).

Figure 3

Mean Percentage Correct for Distinguishing Between /æ/ - /ɛ/



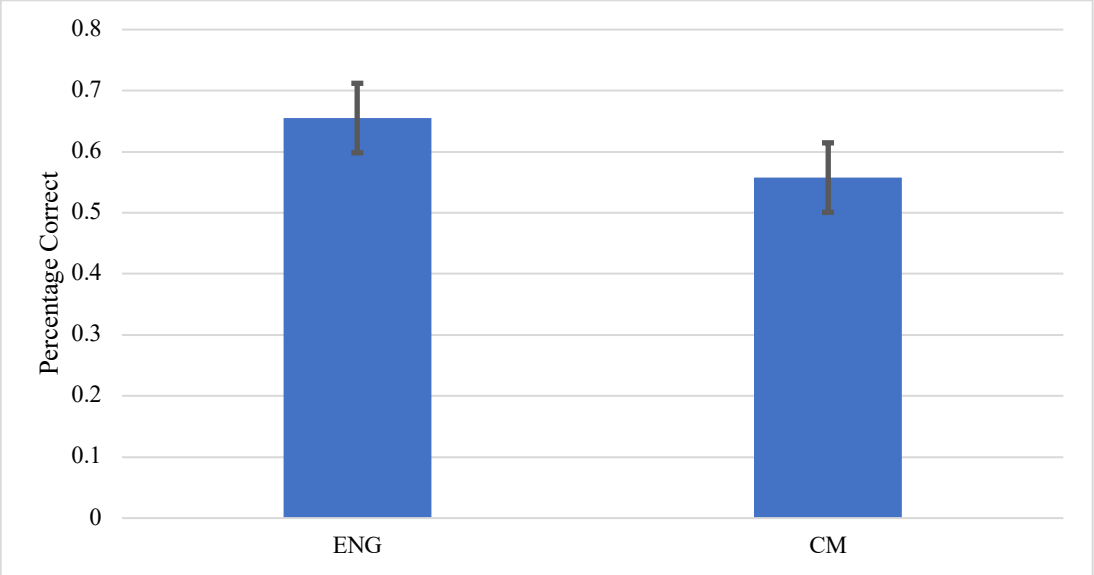
Note. The comparison of mean correction rate of distinguishing /æ/ - /ɛ/ between native Mandarin speakers who live in an English-speaking environment (UM) and native Mandarin speakers who live in China (CM).

For the word pair Dad and Dead which respectively contains phonemes /æ/ and /ɛ/, it was found that the native English speakers showed a strong (non-significant) higher accuracy rate on distinguishing this word pair than the native Mandarin speaking groups

($t(322) = 1.71$, $p = 0.08$, *Cohen's d* = 0.2, $R^2 = 0.009$). However, Figure 4 below suggests that by increasing the number of data points there is a strong possibility of achieving statistical significant results for this word pair.

Figure 4

Mean Percentage Correct for Distinguishing Between Dad -Dead

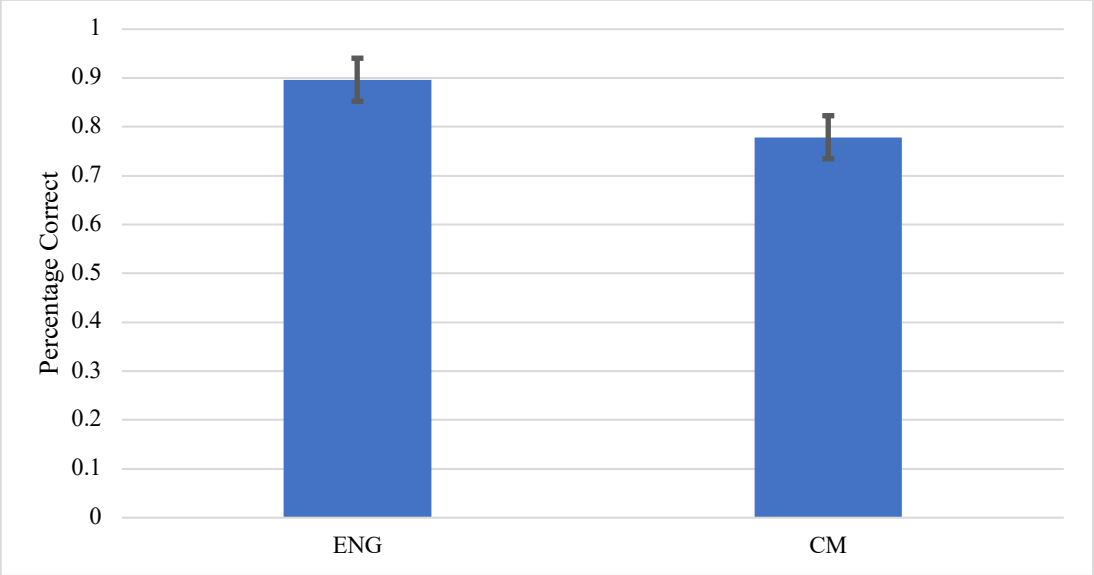


Note. Comparison of percentage correct rates for distinguishing Dad – Dead between native English speakers (ENG) and native Mandarin speakers who live in China (CM).

For the phoneme pair /θ/ - /s/ (Figure 5), it was found that native English speakers have significantly higher accuracy rate on this paired phonemes discrimination task than native Mandarin speakers who live in China ($t(322) = 2.67$, $p = 0.01$, *Cohen's d* = 0.31, $R^2 = 0.02$).

Figure 5

Mean Percentage Correct for Distinguishing Between /θ/ - /s/

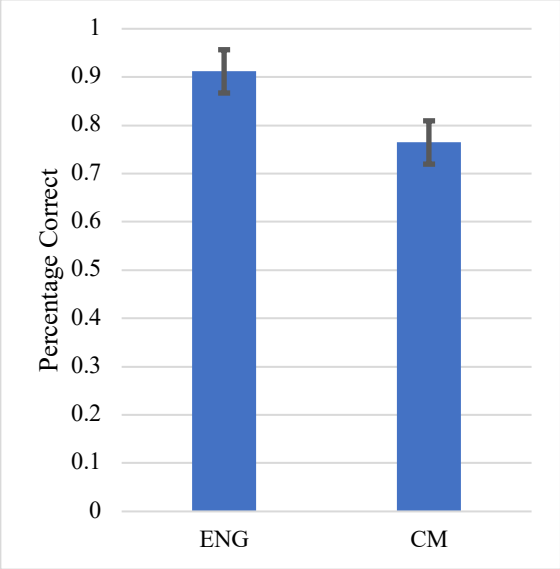


Note. The comparison of mean percentage correct rate for distinguishing /θ/ - /s/ between native English speakers (ENG) and native Mandarin speakers who live in China (CM).

Finally, for the phoneme pair /b/ - /p/, where both phonemes contain Mandarin and English components, it was found that native English speakers ($t(322) = 2.95$, $p < 0.01$, *Cohen's d* = 0.38, $R^2 = 0.03$) have significantly higher mean percentage correct scores for distinguishing this paired phonemes than native Mandarin speakers who live in China (Figure 6).

Figure 6

Mean Percentage Correct for Distinguishing Between /b/ - /p/

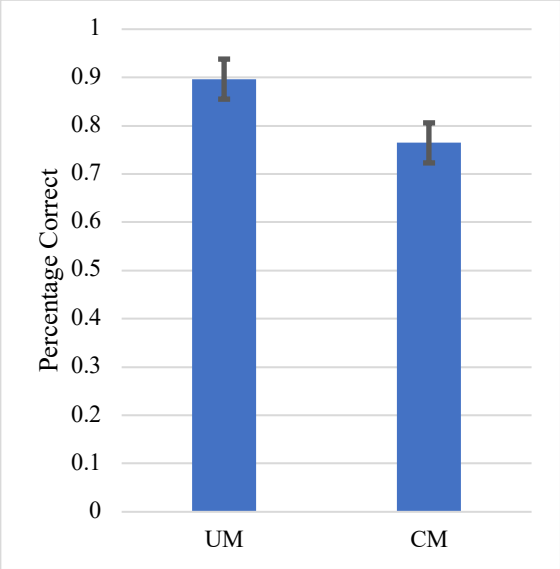


Note. The comparison of mean percentage correct rates for distinguishing /b/ - /p/ between native English speakers (ENG) and native Mandarin speakers who live in China (CM).

Results also indicate that native Mandarin speakers who live in an English-speaking environment ($t(342) = 3.55$, $p < 0.001$, *Cohen's d* = 0.39, $R^2 = 0.04$) have significantly higher mean percentage correct scores for distinguishing this phoneme pair than native Mandarin speakers who live in China (Figure 7).

Figure 7

Mean Percentage Correct for Distinguishing Between /b/ - /p/

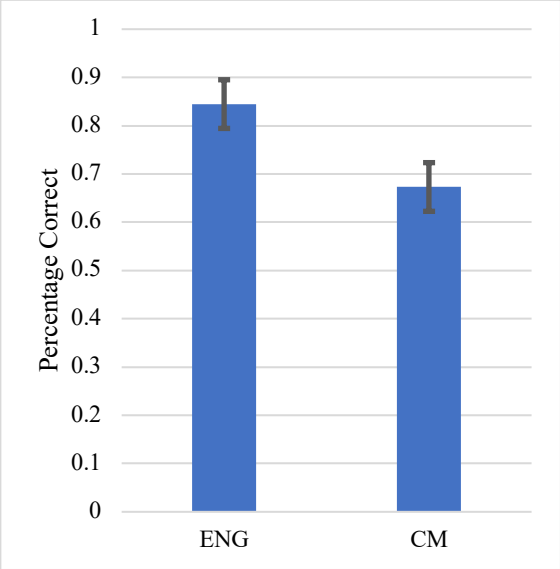


Note. The comparison of mean percentage correct rates for distinguishing /b/ - /p/ between native Mandarin speakers have lived in an English-speaking environment (UM) and native Mandarin speakers who live in China (CM).

For the word pair bound and pound, there was a significant difference between language groups; native English speakers ($t(322) = 3.41$, $p < 0.001$, *Cohen's d* = 0.39, $R^2 = 0.03$) had significantly higher mean percentage correct scores for distinguishing this paired words than native Mandarin speakers who live in China (Figure 8).

Figure 8

Mean Percentage Correct for Distinguishing Between Bound - Pound

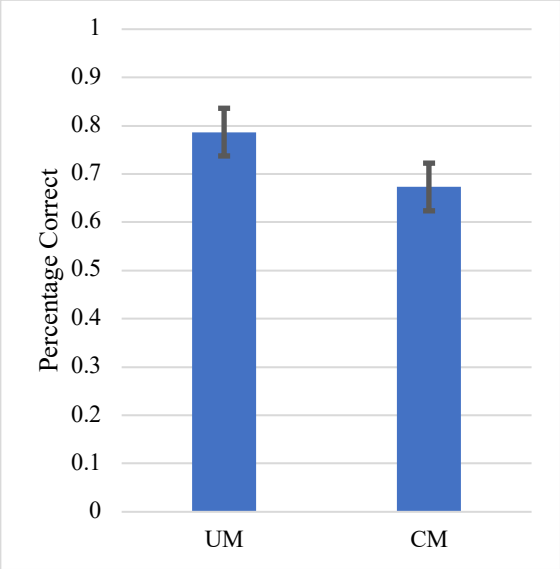


Note. The comparison of mean percentage correct rate for distinguishing bound – pound between native English-speakers (ENG) and native Mandarin speakers who live in China (CM).

Native Mandarin speakers who live in an English-speaking environment ($t(342) = 2.3$, $p < 0.05$, *Cohen's d* = 0.25, $R^2 = 0.02$) also had significantly higher mean percentage correct scores for distinguishing this words pair than native Mandarin speakers who live in China (Figure 9).

Figure 9

Mean Percentage Correct for Distinguishing Between Bound - Pound



Note. The comparison of mean percentage correct rate for distinguishing bound – pound between native Mandarin speakers have live in an English-speaking environment (UM) and native Mandarin speakers who live in China (CM).

DISCUSSION

For the phonemes that exist in both English and Mandarin, such as /b/ and /p/, the native Mandarin speakers who live in an English-speaking environment and the native English speakers both performed significantly better than the native Mandarin speakers who live in China. This may be because the native Mandarin speakers with greater exposure in an English-speaking environment are more adept at distinguishing phonemes within an English word and their pronunciation than those who have remained in their native, non-English-speaking environment.

The results indicate that even though the native Mandarin speakers who live in an English-speaking environment didn't perform as well on the tasks as the native English speakers, they have a significantly higher percentage correct rate on distinguishing all the phoneme pairs than the native Mandarin speakers who live in China. From Bradlow's research (2008), the non-native English speakers' performance on phonemes discrimination varies with the time that they have been exposed to an English-speaking environment (pp. 287-308). The native Mandarin speakers who have longer exposure to, and therefore, greater experience speaking the English language and interacting in predominantly English-speaking environment and culture are more likely to master the second language overall, as well as its phonological, word, and speech intricacies. Eventually, such individual may attain near-native English-speaker language ability. Thus, this demonstrated experience-dependent learning plasticity should be investigated in great detail when planning and conducting future research.

Theoretically, the performance difference on the corresponding phoneme pair and word pair (e.g. /a/-/e/ and /dead/-/dad/) across participant groups should be consistent with

the other results. However, for the pair /dead/-/dad/, the mean performance of the native English speakers was slightly lower than the international students, which is inconsistent with the results for the phoneme pair /a/-/e/. The possible reason for this result may be a technical flaw in the audio recording of the word pair, making the pair less distinguishable. Increasing the clarity of the audio recording so that it is more flawless and increasing the number of research participants (increasing the power to detect differences) would likely resolve this issue.

This study was originally planned to be conducted as a well-controlled face-to-face laboratory experiment. A potential major weakness of this study was uncontrolled external interference. Due to the COVID-19 pandemic, all the research surveys had to be conducted online and all the participants completed the questionnaire with their own devices and accessories. Therefore, various sound qualities could induce an unexpected performance difference within the same group. Future research will need to be conducted in a controlled laboratory environment, to limit possible external interference factors, such as participants' ambient environments and auditory quality, experimenter control of the experimental environment. Moreover, future studies should increase the number of research participants and the number of phoneme and word trials per participant.

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APPENDIX A

UNIVERSITY HUMAN SUBJECTS INSTITUTIONAL REVIEW BOARD (IRB)

APPROVAL DOCUMENTS

ASU Knowledge Enterprise Development

EXEMPTION GRANTED

Jose Nanez
NCIAS: Social and Behavioral Sciences, School of (SSBS)
602/543-6012
jnanezsr@asu.edu

Dear Jose Nanez:

On 12/10/2020 the ASU IRB reviewed the following protocol:

Type of Review:	Initial Study
Title:	PHONEMES DISCRIMINATION FOR NATIVE MANDARIN SPEAKERS
Investigator:	Jose Nanez
IRB ID:	STUDY00012617
Funding:	None
Grant Title:	None
Grant ID:	None
Documents Reviewed:	• CITI completion report, Category: Other; • Consent form, Category: Consent Form; • Consent form translation , Category: Translations; • IRB phonemes, Category: IRB Protocol; • Phonemes list, Category: Other; • recruitment letter, Category: Recruitment Materials; • recruitment letter Chinese version, Category: Translations; • survey questions , Category: Measures (Survey questions/Interview questions /interview guides/focus group questions); • survey questions in Chinese , Category: Translations; • Translation certification form, Category: Translations;

The IRB determined that the protocol is considered exempt pursuant to Federal Regulations 45CFR46 (2) Tests, surveys, interviews, or observation on 12/10/2020.

In conducting this protocol you are required to follow the requirements listed in the INVESTIGATOR MANUAL (HRP-103).

If any changes are made to the study, the IRB must be notified at research.integrity@asu.edu to determine if additional reviews/approvals are required. Changes may include but not limited to revisions to data collection, survey and/or interview questions, and vulnerable populations, etc.

Sincerely,

IRB Administrator

cc: Hao Chen
Hao Chen
Steven Holloway
Jose Nanez