A Perception of Thai Tone in Chinese Students Using the Thai Tone Application: A Case Study of the Low Tone and the Falling Tone

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ABSTRACT

The use of education applications in language learning is rapidly increasing. This research aims to analyse the tonal perception ability of Chinese students using the Thai Tone Application with minimal pairs approach. The participants were divided into two groups, an experimental group (ones who studied in the class and used the application) and a control group (ones who studied in the class without using the application), of 20 students each. One-syllable words bearing low tone and falling tone were used to examine the participants' tonal perception ability. The findings revealed that the experimental group significantly outperformed the control group in terms of differentiating between low tone and falling tone. The result of the current study furthur indicatesthe use of the mobile-assisted language learning applicationsince supplemental material may effectively enhance Thai tone perception or Thai tone learning outcomes in some Chinese students. The significance of the minimal pair approach is also discussed.

Keywords: *Tones, thai, perception, application*

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INTRODUCTION

Speech sounds are arranged into contrastive units and they function as the means for distinguishing word meanings. Both children and adults learn these relevant distinctive units in their nativelanguagesand apply the speech sound differentiation ability while learning other languages (Bilbao, 2002; Singh et al., 2019). The process of learning other languages requires both speech production and speech perception. The speech production process is the process in which the speaker articulates sounds and the way humans produce meaningful speech (Docio-Fernandez & García Mateo, 2015). Perception is a way in which listeners decode the acoustic speech signals and transfigure them into linguistic-structure matching (Heald&Nusbaum, 2014).

During the past few decades, perception has gained importance in the process of learning a language. Several studies have shown that learning a language through the process of effective perception leads to effective language production. Escudero (2005), Leather (1999), and Llisterri (1995) confirmed that non-native perception influences language production. In other words, the practice of sound perception is crucial for the development of speech production (Keys & Walker, 2002; Levis, 2005; Lowenberg, 2002; Shanahan, 2006). Heald & Nusbaum (2014) also demonstrates that understanding spoken language depends on the language perception process.

Speech perception ability has been found to be increased in native phonological discrimination, yetdecreased in non-native phonological contrast discrimination.Therefore, speech discrimination difficulties in non-native languages continue tilladulthood (Hattori & Iverson, 2009; Poltrock et al., 2018).Consonants and vowels are primarilyattested in a number of previous research such the one by Hattori and Iverson (2009) who suggested that adult Japanese speakers' perception of the sounds of /r/ and /l/ is correlated with their ability to differentiate between the /r/ and /l/ in the Japanese language, though the very same perception correlates, to a moderate level, with the production of those sounds (r and l) in English. A study on learning Korean as a foreign language also yielded the same result (Kim &Park, 1995).Although these arguments are opposed to the conclusion that perception leads to speech production, Escudero (2005) insists that previous studies lacked rigorous control on the word tests. Therefore, it can still be inferred that speech perception develops before speech production.

Apart from extensive studies on segmental units comprising consonants and vowels, the tone, which is a suprasegmental feature, has been the key interest for linguists.Wanget al.(1999) and Wayland &Guion (2004) found that those whose native tongue is a non-tonal language are less able to perceive and differentiate lexical tones as compared to those whose native tongue is a tonal language. Recently, Intajamornrak (2017) found that Thai tones are problematic for the native speakers of a tonal language and also for those whose mother tongue is toneless. However, with practice, those whose native tongue is a tonal language can produce Thai tone better than those whose native tongue is a non-tonal language. This apparent controversy between the two sets of results has not yet been established. However, it seems that the results of Intajamornrak (2017) support the Perceptual Learning Model (Pisoni et al., 1994), which states that language experience is another factor that affects the effectiveness of learning non-native languages.

Currently, speech development depends upon the structure of word pairs used in practice (Crosbieet al., 2005; Ketkumbonk & Woragittanont, 2017; King, Hengst, & DeThorne, 2013; Uz Hasırcı & Ünal Logacev, 2021). Phonological contrast in the form of minimal pairs is gaining importance. Minimal pairs means two linguistic units with one distinctive phonetic feature on the identical syllable position and eventually differentiating meanings between the two units. For instance, if we consider the units /pin/-/bin/, their meanings are demonstrably differentiated by voiceless vs. voiced feature, /p/ vs. /b/, or by the initial consonant positon feature. Edgeet al.(2012) mentioned that technology-aid learning integrated with minimal pairs practice can elucidate the challenges in regular practice for those who learn non-native languages, whileTejedor-García (2020) found that the minimal pairspractice raise phonological contrast recognition. Therefore, in order to facilitate continued practice of perception of distinctive linguistic sound to enhance speech production, there is an attempt to integrate mobile-assisted language learning (MALL) application with the concept of minimal pairs. This leads to empirical evidence on segments,and less clarity in suprasegments. Edgeet al. (2012) has reported the effectiveness of MALL with minimal pairs in solving Mandarin tone perception accuracy problems of non-native learners. Extensive empirical data and results of implementing MALL integrated with minimal pairs are essential since MALL provides regular practice for non-native learners during the COVID-19 pandemic, especially for those who found tones to be the most difficult part in learning tonal languages.

For learners who speak other languages, some Thai tone levels, such as the mid and low tones, can be confusing, as well as certain contour tones, such as the high tone, the falling tone, and the rising tone. With regard to the Thai tone production, the relative fundamental frequency (F0) of a voicing unit in a syllable is a major clue in measuring the production of the five tones in Thai. Acoustically, Thai tone shapes are as follows:

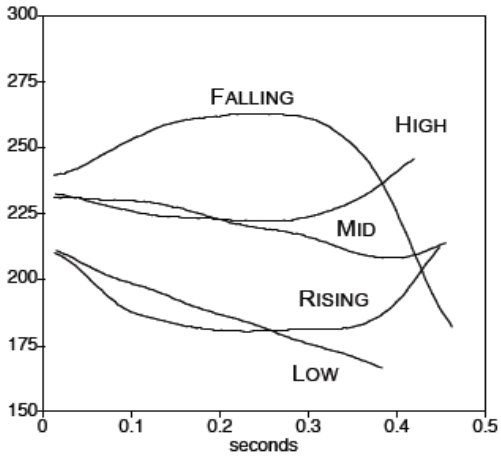

Figure 1. *Thai tone shapes (Zsiga & Nitisaroj, 2007).*

The mid and low tones are similar in shapes, which is mid level and low level, respectively. The low and falling tone shapes are clearly different. The low tone is low level in its shape, while the falling tone is mid or high falling.The high tone is high rising and the rising tone is low rising, as shown in Figure 1.

On the other hand, a Thai tone perception was conducted by Abramson (1962, 1975), who found that differentiating mid and low tones was problematic for native Thai speakers. Later, Gandour and Dardarananda (1989) and Nasanee (2003) revealed that native Thai speakers could barely differentiate between high and rising tones. These results were in line with the findings by Teeranon (2007).

Also, Chinese students studying Thai find it difficult to distinguish between low and falling tones.Kaan et al. (2008) found that the speakers with non-tone language (English) were sensitive to the falling tone in Thai. On the contrary, Putthasatien (2017) found that the most difficult tone for Chinese students in NakhonRatchasimaRajabhat University, Thailand was the low tone that is classified as a level tone in Thai. The sample of participants of Putthasatien (2017) was drawn from the students of the People's Republic of China (PRC) and their native tongue was Mandarin Chinese (Mandarin). It has been shown that after two years of studying the language using an exercise handbook developed by a linguistics process, all tone-related pronunciation problems are solved among Chinese students of Thai, except the low tone. However, the findings of Putthasatien (2017) from the study on the use of an exercise handbook to provide L2 exposure to Chinese learners studying Thai tones support the findings of Kaan et al. (2008), who mentioned that the sensitivity of F0 onset differences between the low tone and the falling tone in Thai was suppressed by language training. It can be concluded that the low and the falling tones are difficult to tell apart by non-native speakers of the Thai language. One possible factor behind the difficulty in differentiation between low and falling tone was mentioned in Onsuwanet al. (2012). The studies of Onsuwanet al. (2012)reported that the low and the falling tones are difficult to differentiate under the background noise,that is, the intensity or other external factors can affect lexical tone perception in Thai language.

From the above mentioned review, it is found that low and falling tones are not as well-studied by the linguists as the high tone and the rising tone, and their differentiation.

Currently, the use of MALLapplication to enhance the learning of a language is closely related to the promotion of users' language attitudes and skills (Cui & Wang, 2008 ;Kizito, 2012; Wang, 2017). Also, Buranasinvattanakul (2018) found that the Thai language is gaining popularity worldwide. However, Thai tones, especially the low and falling tones, are found difficult to be distinguished by the Chinese students of the Thai language. Many teaching tools, such as textbooks and others, have been used to help with these difficulties of Thai tone production. Also, the previous research on this subject was focused on the analysis of Thai tones produced by language learners, without the use of modern technology (e.g., e-books and applications). The literature on the use of MALLapplication to promote Thai tones is even more limited regarding their significance of learning speech perception by non-native speakers. Also, the Ministry of Education in Thailand is implementing the policy of promoting the use of technology to improve learning. As a result, the following questions have been raised: a)Do MALL applications enhance Thai tones' perception among Chinese students learning Thai, especially in terms of learning to distinguish between low and falling

tones? andb) Can MALL applications promote low tone and falling tone perception among Chinese students learning Thai as previous studies found these two tones to be problematic? The MALLapplication used in the present study is 'Thai Tone Application'. It is different from the other MALL applications in teaching the Thai language because it is based on previous linguistics research and the 'minimal pairs approach'. Its contents are mainly focused on practicing the minimal pairs of problematic tones for language learners, namely the mid-low, low-falling, and high-rising tones (e.g.,[khaa]+low tone 'galangal'-[khaa]+falling tone 'to kill'). Crosbieet al. (2005) have pointed out the importance of minimal pairs approach and advocated it for speech practice. The problem of distinguishing between low tone and falling tone in Thai cannot be solved by studying the exercise handbook (Putthasatien, 2017).Therefore, this study aims to investigate whether the problem can be effectively solved using the Thai Tone Application.

RESEARCH METHOD

Participants

All selected participantswere Chinese studentsstudying Thai language in a Thai public university (The name of the university was not allowed to be mentioned according to the ethic number 3/017/62) who did not suffer from verbal disability and possessed all the speech organs, such as the tongue, teeth, mouth, and pharynx. They spoke Mandarin Chineseas their native tongue. Using a purposive sampling technique, 40Chinese students of the age group 15–22 years were selected as the sample for this study.The participants were asked to take the Thai language proficiency test to measure their Thai language level. The test confirmed a low proficiency level in Thai language.

The participants were divided into two groups of 20 students each. The proportion of females and males was equal in both groups; there were 15 females and 5 males in each group. The experimental grouphad students who studied in the class and used the Thai Tone Application, and the control group included students who studied in the classwithout the Thai Tone Application.

Language background of the participants

The language data used for the test tokens were drawn from standard Thai. The Thai language has a collection of 18 consonants: /p, pʰ, b, t, tʰ, d, k, kʰ, m, n, ŋ, r, f, s, h, tɕ, tɕʰ, j/; 18 monopthongal vowels: /ɪ, ˩, ʊ, ɛ, ↔, o, E, ɑ, □, ɪ˥, ˩˥, ʊ˥, ɛ˥, ↔˥, o˥, E˥, ɑ˥, □˥/; and 3 triphthongs /ɪɑ, ʊɑ, ˩ɑ/. Its five tones are mid-33, low-21, falling-31, high-45, and rising-323. However, all the test words contained the vowel /ɑɑ/ to avoid the effects of F0 differences in vowels.

The Chinese language has a repertoire of 21 consonants (Duanmu, 2007; Hu, 2009; Sun, 2006; Zhou & Li, 2009): /p, pʰ, t, tʰ, k, kʰ, m, n, ŋ,f, s,ɕ,ʂ,ʐ, ξ,t͡sʈ͡ʂʰʈ͡ʂt͡ɕ, t͡ɕʰ,l/; seven monophthongs/ɪ, ψ, ʊ, ⊗, o, ɛ, ɑ/, diphthongal and triphthongal vowels /ɑɪ, ɛɪ, ʊɛɪ, Aʊ, ↔ʊ, oʊ, ɑv, ↔v,ɪv, ʊ↔v, ψv, ɪɛ, ψE, ↔ʐ, ɪɑ, ʊɑ, AN, ↔N, ɪN, ʊN, ʊɑɪ, ɪɑv, ʊɑv, ψɑv, ɪ↔ʊ, ʊAN, ʊ↔N, ɪAN, ɪʊN/; and four tones: Tone 1 (a high level -55), Tone 2 (a rising-35), Tone 3 (a mid falling-rising-214), and Tone 4 (a falling-51). Although there is one more tone in an unstressed syllable, which is the neutral tone (Zhang, 2006), this study counts on the Chinese tones in the stressed syllables.Previous studies on the Chinese phonological system is relatively varied according to the researcher's approach (Hu, 2009).

Data Collection Tool

1) The Thai Tone Application was created under thephonological concept of minimal pairs of problematic tones for language learners, namely the mid-low, low-falling, and high-rising tones (e.g.,[khaa]+low tone 'galangal' vs. [khaa]+falling tone 'to kill') (Kaan et al., 2008; Nasanee,2003; Teeranon, 2007). The application was modified to contain 100 one-syllable words and more than 60 minimal pairs of Thai tones. The application contained both pictures and sounds. Each image was described by a monosyllabic word printed underneath it. Pictures were also used to illustrate the meaning of each sentencein the application. Students were able to press a buttonin the applicationin order to hear the pronunciation of the word and thereby practice their pronunciation through a live correctionfuntion in the application.

2) The application used by the experimental group contained an additional feature that was consistent with the minimal pair approach. For example, the application contained the following sentence:

'[κηααN]+falling [ναα]+falling [τηι]+falling [ναα]+mid [πλυυκ]+low [ν□ι]+high.[ναα]+low [ωαi]+high [μααακ]+falling [μααi]+mid

There are plenty of custard apples planted in front of the rice field.

This kind of practice is deliberately attested as the minimal pair approach in clinical therapy. The approach has long been claimed to promote speech development in low proficiency children (e.g., children with speech disorders) and help them acquire the target language faster (Pamplona et al.,1999; Saben&Ingham, 1991).This also helped in the regular and spontaneous pronunciation.

3) The application is applicable onthe Android platform. Earphones and microphones of each participant can be applied during the study period.

4) Twentyminimalpair words were prepared for a perception test. The 20 words were one-syllable words grouped into sets of tonal sounds containing both live syllables and checked syllables, as shown in Table 1.

Table 1. *Thai Word for Testing*

No.	Low	Falling
1	[κηαˆα]'galangal'	[κηα⇓α] 'value'
2	[φαˆακ] 'to deposit'	[φα⇓ακ]'on the other side'
3	[κηαˆατ] 'to be torn'	[κηα⇓ατ]'to wear a headband'
4	[σ→ˆ↔] 'mat'	[σ→⇓↔] 'shirt'
5	[παˆα] 'forest'	[πα⇓α] 'aunt'
6	[σαˆν] 'to shake'	[σα⇓ν]'short'
7	[παˆν] 'to ride'	[πα⇓ν] 'to craft'
8	[κηαˆω] 'knee'	[κηα⇓ω] 'to enter'
9	[μαˆφ] 'new'	[μα⇓φ]'to burn'
10	[νυˆ↔τ]'beard'	[νυ⇓ατ]'to massage'
11	[κηαˆαφ] 'net'	[κηα⇓αφ]'camp'
12	[πηαˆα] 'to dissect'	[πηα⇓α] 'cloth'
13	[κηαˆφ] 'egg'	[κηα⇓φ] 'fever'
14	[λαˆˆφ] 'shoulder'	[λα⇓φ] 'to chase'
15	[νυˆ↔N] 'one'	[νυ⇓↔N] 'to steam'
16	[παˆω] 'to blow'	[πα⇓ω] 'target'
17	[σαˆφ] 'to put into'	[σα⇓φ] 'intestine'
18	[βαˆα] 'shoulder'	[βα⇓α] 'crazy'
19	[κηυˆυ] 'to threat'	[κηυ⇓υ]'pairs'
20	[κηαˆαω] 'news'	[κηα⇓αω] 'rice'

5) A native Thai speaker was asked to pronounce the 20 word pairs, which were recorded with a SONY IBC BX140. The participants listened to the recorded pronunciations. Then, both the experimental and the control groups were tested on their tone perception (Pre-test) before using the applicationand after (Post-test) using the application. The pre-test and the post-test comprised 20 items, each with two choices. As the objective of the application was to solve low and falling tone difficulties, the item and choices of the test comprised low and falling tones only.

In item 1, the student heard [κηαˆφ]'egg', which contains the low toneand was provided with the following two choices:

a.  (low tone) b.  (falling tone)

Figure 2. *Example of Choices for a Perception Test*

Collection of Data

1) The participants were separated into two groups. The experimental groupattended class regularly for five weeks and practiced Thai tonal sounds using the application (App.). Each day, the participants of the experimental group studied in the class and used the application. The process was conducted according to a research-based learning concept (Mayolo-Deloisa et al., 2019). The control group also attended class regularly, but they did not use the application (Non-App.), though there were some minimal pairs taught in class, but this group of students were less exposed to regular minimal pairs compared to the experimental ones.The two groupswere taught by the same teacher.

2) For testing sound perception, the participants listened to the 20 tonal words once and completed the tonalperception test. In the test, the participants chose the tonal sounds they heard according to the examples shownin Figure 2. Each item contained a choice of answers with pictures representing the sounds; for example, while listening to the sound [ναα]+falling tone'face', the choices were pictures of custard apples and a face, as shown in Figure 2. Using the pictures as choices in the listening test,it confirmed the listeners' ability to capture the true meanings of the sounds.

3) The perception test was conducted in the classroom of the university.

Data Analysis

1) As required for achieving the aim of this research, the low tone and the falling tone perception on the pre-test and post-testof both the experimental and control groups werechecked, and the scores of each Chinese student were marked and compared.

2) Comparisons of the differences between before and after using the application and the following in-class learnings were analysed. The statistical analyses included descriptive statistics (mean and percentage), and t-tests were calculated.

3) After the tone perception scoresin terms of before and after using the Thai Tone Application were analysed, the relationship between Thai tone perception in the experimental group and the control groupas well as the differences in perception scores between the two groups were examined.

Validity and Reliability

1) The Thai Tone Application was tested for reliability by three experts: an IT lecturer, a developer, and a Thai language lecturer. An evaluation form was created based on the Technology Acceptance Model (TAM). The experts were asked to rate the following three aspects: innovations, process, and innovation values. A Likert three-point scale (Kumar, 2014) was used as follows:

0–1.66 means the application value is low

1.67–2.33 means the application value is moderate

2.34–3.00 means the application value is high

The Thai Tone Application had a mean score of 2.75, which was rated as a high value.

2) On account of the perception test paper shown in Figure 2, the Item-Objective Congruence (IOC) was used to evaluate each item based on the scores: –1 (Incongruent), 0 (Questionable), and +1(Congruent). All items had scores higher than 0.5 and were reserved.

3) Reliability of the sound and choices was also determined. The 20 words shown in Table 1 were applied in the test process. Ten Chinese students who were not the participants listened to the sounds and chose the answers.They were then asked to rate each item. George &Mallery (2010)applied the value of Cronbach'sCoefficient Alpha as the following: ≥ (greater than or equal to) 0.9meansexcellent, ≥ 0.8meansgood, ≥ 0.7meansacceptable, ≥ 0.6meansquestionable, ≥ 0.5means poor, and ≤ (less than or equal to) 0.5 means unacceptable. The value of Cronbach'sCoefficient Alpha in the present study was 0.81, which was acceptable.Then, the perception test was carried out.

4) Mean scores, standard deviation (SD), and ANCOVA (Analysis of Covariance) were implemented.The ANCOVA was performed to analyze the pre-test,that is, whether the scores affected the post-test scores of the experimental and control groups or not. If it affected the post-test scores in both the groups, the F-value and p-value or sig. from ANCOVA was interpreted.

5) A linear regression line was drawn to compare the low and the falling tone differentiation performance of the experimental and control groups.

FINDINGS

This research sought to compare the difference between low and falling tone perception in Thai before and after using the Thai Tone Application in a classroom setting among Chinese students. Specifically, Thai tone perception before and after using the Thai Tone Application was analysed;relationship between the Thai tone perceptions in the group, andthe differences between the groups wereexamined.Participants used the application in class for five weeks, and the results were as follows:

Table 2 shows the perception scores of the Chinese students in the low and falling tones differentiation. The experimental group data shown in Table 2 and Figure 3 indicates that 11 participants increased their scores, 8 decreased, and the score of 1 student remained the same. Overall, the mean of the perception scores raised by 3.25%.

Table 2. *Perception Scores of the Experimental Groupand the Control Group in the Low And Falling Tones Differentation*

Student number	The experimental group (App.)			Student number	The control group (Non-App.)		
	Pre-test/ 20 scores	Post-test/ 20 scores	Change (%)		Pre-test/ 20 scores	Post-test/ 20 scores	Change (%)
1	15	12	-15	21	14	13	-5
2	16	18	10	22	16	14	-10
3	11	15	20	23	15	17	10
4	10	12	10	24	13	12	-5
5	12	15	15	25	17	13	-20
6	11	12	5	26	12	14	10
7	10	9	-5	27	9	11	10
8	14	16	10	28	16	12	-20
9	13	12	-5	29	6	8	10
10	15	14	-5	30	14	11	-15
11	14	12	-10	31	10	13	15
12	10	16	30	32	5	9	20
13	18	17	-5	33	15	10	-25
14	17	17	0	34	17	14	-15
15	12	16	20	35	18	14	-20
16	13	11	-10	36	15	12	-15
17	17	15	-10	37	10	7	-15
18	16	18	10	38	14	12	-10
19	10	13	15	39	12	10	-10
20	17	14	-15	40	10	14	20
Mean	**13.55**	**14.20**	**3.25**	**Mean**	**12.90**	**12.00**	**-4.50**

Among the participants in the control group shown in Table 2 and Figure 3, improvements in tonal perception were less than that in the experimental group, the change of perception scores comparing the post-test to the pre-test was decreased for 4.50%. The result showed that the scores of 13 participants

increased, while the scores of 7 participants decreased.

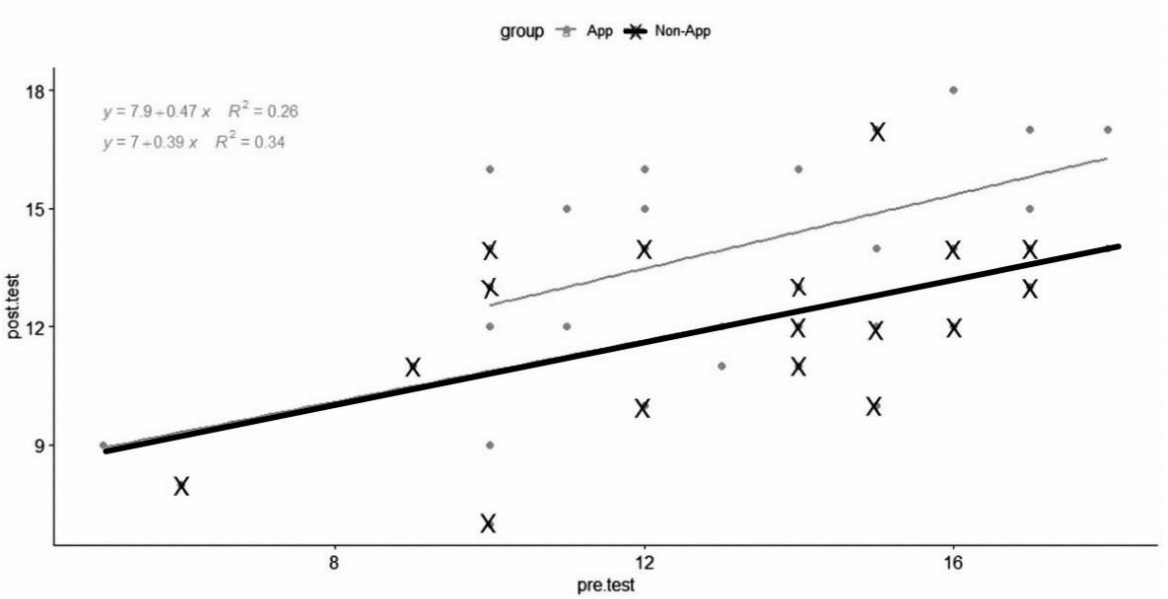

Figure 3. *A Comparison of Pre-Test Scores and Post-Test Scores of the Experimental Group (App.)And the Control Group (Non-App.)*

Figure 3 showsthat theregression line for the experimental group is higher than that of the controlgroup. This shows that the two groups differ in terms of their tonal perception performances, with the experimentalgroup experiencing a better performance.

Table 3. *A Comparison of the Mean Perception Scores with Sdof the Experimental Group and the Control Group*

Group	N	Pre-test	Post-test
		Mean ± SD	Mean ± SD
The experimental group(App.)	20	13.55±2.72	14.20±2.51
The control group(Non-App.)	20	12.90±3.61	12.00±2.38

N=20*Sig at0.05 level

It was aptly demonstrated in Table 3that the mean of the pre-test scores of the experimental group (Mean = 13.55, SD = 2.72) is higher than that of the control group (Mean = 12.90, SD =3.61), and the post-test scores of the experimental group (Mean = 14.20, SD = 2.51) is also higher than that of the control group (Mean = 12.00, SD = 2.38). The extremely low value of SD or Standard Deviation shows that the data set is close to the mean.

Table 4. *ANCOVA of the Chinese Students' Perception Scores*

Source	Sum of Squares	df	Mean Squares	F-value	P-value/ Sig.	Partial Eta Squares
Intercept	140.31	1	140.307	32.475	0.000	0.467
Pre-test	67.34	1	67.342	15.587	0.000**	0.296
Group	36.83	1	36.83	8.524	0.005**	0.187
Error	159.86	37	4.32			
Corrected Total	204.16	40				

Data in Table 4 indicates that the pre-test scores significantly relate to the post-test scores between the experimental and control groups ($F=15.587$, $df=1$, $p<0.05$).Therefore, the post-test scores of the experimental group were significantly different from that of the control group ($F=8.524$, $df=1$, $p<0.05$).

DISCUSSION AND CONCLUSION

Apart from the difficulty for non-native speakers in differentiating between the high tone and the rising tone in Thai, the low tone and the falling tone is another suprasegmental pair that was indicated to be problematic for a non-native Thai. Consequently, thisstudy compared the differencesofthe low and falling tone performance of theChinese students before and after using the Thai Tone Application containing minimal pairs of the tones for regular practice.

The results showed that, in the experimental group, the Chinese students tend to increase their tonal perception scores in distinguishing the low tone and the falling tone, while less students in the control group increased their tonal perception scores in distinguishing the low tone and the falling tone. Statistically, the results of the experimental group, which used the application revealed a significant difference in the perceptive ability of Chinese students. The current study shows results that are in line with the results found by Kim (2013), who noted that the use of the application helped learners develop their English listening skills,as well as the findings of Suwantarathip&Orawiwatnakul (2015), who also showed that university students significantly improved their tonal perception after using the application. These results suggest that the use of the Thai Tone Application with minimal pairs helped improve, to some extent, the Thai tonal perception of the low tone and the falling tone of some Chinese students.The findings provesan empirical evidence in implementing MALL with minimal pairs in solving low and falling Thai tone discrmination. This confirmed the explanation ofEdgeet al.(2012)andTejedor-García (2020), who found that continued practice affects perceptual performance.MALL with minimal pairs supports 'linguistic bath' immersion (Baleghizadeh&Oladrostam, 2010),in which it provides various forms of tone contexts in both monosyllabic word examplars and sentence structure examplars for the Chinese students to optimize their opportunity to interact with rich meaningful contexts of Thai tones. MALL with minimal pairs undoubtedly enhance the psychological process in minimizing the attempt of mapping phonological structures in non-native Thai.

The current results significantly confirmed that speech discrimination difficulties in non-native continue till adulthood (Hattori & Iverson, 2009; Kim & Park, 1995; Poltrock et al., 2018), as shown in Table 2 and Figure 3;the fact that not all Chinese students using the application can enhace the low and falling tone differentiation. Therefore, MALL with minimal pairs is a language learning tool to foster an amenable change during adulthood language experience.

Nonetheless, it is still doubted how precisely the Chinese students' experience with tones interfere with the Thai low tone and the falling tone discrimination. It has been found in Wang et al. (1999) and Wayland &Guion (2004) that a language learner whose mother tongue is a non-tonal language is less capable torecognize lexical tones as compared to those whose native tongue is a tonal language, whileIntajamornrak (2017) insisted that Thai tones are problematic for the native speakers of a tonal language as well as for those whose mother tongue is a non-tonal language. However, with more practice, tonal production in leaners can get better. This study's finding is in linewith the aforementioned research results — the tonal language learning experiences through the use of Thai Tone Application seem to enhance tone perception in Chinese students. This finding complianced with the Perceptual Learning Model (Pisoni et al., 1994) that language experience in native language is another factor that affects the effectiveness of learning non-native language. However, longer period of implementation of the application is required to be conducted in future studies.

Also, the results were congruent with the findings of Kaan et al. (2008), who mentioned that the sensitivity of F0 onset differences between the falling tone and the low tone in Thai was suppressed by language training.The other possibility might be that the Chinese students' performance of this study is not due to the lack of learning experience but the lack of one on one mapping between the native and non-native tones. Tones in Mandarin Chinese mightcause some mismatch between the two tonal systems and cause confusion for the Chinese students. Similar but not identical native tones can interfere with the perceptual identification of non-native tones. This fact can be supported by previous studies on non-native perception at segmental level, whichstated that native and non-nativesound systems interact with each other during the process of learning (Flege, 1995; Flege et al., 2003). This result highlights that little is known in terms of native and non-native interaction and the interference in the suprasegmental level.

Regarding the minimal pair approach integrated into the Thai Tone Application, this study verified that the phonemic contrast in the tone position is effectivesince the experimental group perception ability

significanltly outperformed those of the control group. This is in line with the findings ofBarlow &Gierut (2002) and Gierut (1992) who noted that perception can be facilitated by treating phonemes that differ maximally in major class properties, such as a low tone vs. a rising tone (a low tone is of a low level in shape, while a rising tone is mid-low-rising in shape). This can be a potential point for future research. However, the results of this research partiallyconfirm that the minimal pair approach applies to the suprasegmental features as well as the segmental units. The results also support Tejedor-García (2020),whofound that the minimal pairs practice raise phonological contrast recognition.

The tone differentiation ability improved in the case of only some of the Chinese students in the experimental group.This can be explained by the studies ofThornton & Houser (2005) and Wu (2015),which stated that there might be technological deficiencies in using MALL application such as small content or access problem. The other factor that affected the low tone and the falling tone differentiation is the makingsound mentioned in Burston (2011), Kukulska-Hulme et al. (2011), andOnsuwan et al. (2012) also suggested that MALL applications' constraints should be reduced to a minimum for the effectiveness of enhancing the learning experience. In addition, besides practical technological aspects, pedagogical methodologies grounded in second language acquisition research (Burston, 2011) is another important basis for creating learning lessons in MALL.Another reason could be that the time the students spent using the application to practice their language skills may not have been sufficient.

Regarding the Thai tone differentiation, apart from the high and rising tone in Thai that is well-attested to be difficult to perceive for both native and non-native Thais (Reid et al., 2015; Teeranon, 2007); the results have shown low tone and falling tone in Thai as another pair of Thai tone that is difficult for non-native speakers.In case of perceptual difficulty in high-rising tone perception, the two tone shapes are similar for they are rising in tone shape. However, regarding the low-falling tone differentiation, the tone shapes are absolutely contrasting; the low tone is a static tone while the falling tone is a contour tone. This could lead to the interpretation that the perception cue lies in the pitch heightand not the shape of the tone, as reported in a number of previous research (Chen& Tucker, 2013; Tong et al., 2014). The low tone pitch height is at a low level, similar to that of the falling tone.

The research results in some Chinese students in the experimental group imply that mobile-assisted learning applications or MALL should be utilised as a learning material in classrooms as they can motivate students and help them understand the language being studied more easilysince they gained higher perception scores after using the application. The Thai Tone Application actsas a certain motivational tool in the application, such as live correction and a spelling game, which aid memorizing and learning how to spell correctly in a way that may interest the users. According to Viberg&Grönlund (2012), mobile learning may help students enjoy the process of learning and lead to the acquisition of greater language proficiency.

In conclusion, the MALL application with minimal pairs practice used in this study can enhance Thai tone perception in some Chinese students. Therefore, the MALL application is suitable and plausible for some students. Therefore, the application offers an alternative option for language learning.

Suggestions

The current study has some strengths, including the use of integrated methods (i.e., the minimal pairs approach in the application, and linguistic research methods) that enabled this study to show another perspective on the acoustic study and the perception test of Thai tones. The results can be generalised because of the larger number of participants in this study. However, the period of using Thai Tone Application was relatively short, which might have affected the learning process of the Chinese students learning Thai tones. Further investigation is necessary to determine whether a longer period of the use of the application can further enhance tone perception and production.

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