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Acquisition of Korean Stop Sounds by L2 Learners and the Role of Proficiency
: an ERP Study

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I. Introduction

Korean stop sounds have a complex plosive system, which varies depending on the manner of articulation; a lax stop (lenis) (e.g. /p/, /t/, /k/), an aspirated stop (e.g. /p^h/, /t^h/, /kh/), and a tensed stop (fortis) (e.g. /p'/, /t'/, /k'/) (Abramson & Lister, 1971). The difficulty of learning the three-way contrast of Korean stop sounds by L2 learners of Korean has been frequently reported in previous studies (Hwang et al., 2002; Kim et al., 2002; Kim, 2007; Kim & Kim, 2013; Kwon, 2013; Yang & Kim, 2014; Zhou & Kim, 2014). Nonetheless, the findings are based on behavioural data, which sometimes are found to be different from neural response. Hence, in this study, we used event-related potentials (ERPs) as well as behavioral measurements to investigate the acquisition of Korean stop sounds (/t/, /t^h/, and /t'/) by Chinese learners of Korean.

In particular, we focused on the ERP component MMN (Mismatch Negativity) to explore the learners' phonological perception of the Korean stop consonants. MMN, which is a negative deflection that peaks around 100-250 ms, is elicited when the listener detects infrequent deviant sound stimuli among more frequent standard sound stimuli (Linnavalli et al., 2017; Näätänen et al., 2004; Näätänen et al., 2007). Due to this characteristic, MMN has been used as a measure of phonemic knowledge in both native language and second language.

In addition, we compared the performance of advanced learners and intermediate learners in order to investigate the development of L2 phonemic knowledge in accordance with the proficiency level.

II. Background

1. L2 phonological perception

Existing models of L2 phonological perception attribute perceptual difficulties to the relation of L2 learners' L1 and L2. Flege's (1995) Speech Learning Model (SLM) argues that inaccurate perception and production of L2 sounds result from L2 learners' assimilating L2 sounds to L1 categories. According to Flege (1988), the relation of L1 and L2 sounds can be described in three ways: "identical", where L2 vowels are consistently identified as a good instance of an L1 vowel category, "similar", where L2 vowels are identified as one of L1 category but not rated as good instances of that category, and "new", where one L2 vowel is identified as multiple L1 categories but is not rated good for any of the categories. Flege (1988) hypothesizes that "similar" L2 sounds are produced and perceived less accurately than other cases of L2 sounds, because in the former case, the existing L1 category blocks the formation of a new L2 category.

Perceptual Assimilation Model-L2 (PAM-L2) (Best & Tyler, 2007) also accounts for L2 phonological perception in terms of L2 learners' L1. According to PAM-L2, there are four possibilities where L2 minimal pairs are perceived in relation to L1. First, only one of two different L2 sounds is assimilated to a L1 category. Second, two different L2 sounds can be assimilated to the same L1 category, but one of them is perceived to be more deviant. Third, two different L2 sounds are perceived as the same L1 category, with the same degree of goodness ratings. Finally, both of the two given L2 sounds can be identified as a mixture of several L1 categories but are not assimilated to a single L1 category. In this model, it is hypothesized that the third case would cause more perceptual difficulties than the first and the second cases, because it requires learners to eventually recognize phonetic differences between the two sounds to form a new L2 category. In the final case, if the two sounds are converged together as a single new category and do not split over the course of L2 acquisition, it would also lead to difficulties discriminating them.

2. Stop sounds of Korean and Chinese

The Korean stop sound system is well known for its unique three-way contrast characterized by manner of articulation: lax (lenis), aspirated, and tense (fortis) stops (Abramson & Lister, 1971). They are all voiceless, but are distinguished from each other with different phonetic features; tense and aspirated stops are distinguished from lax stops by their [+tensity] feature, and aspirated stops are distinguished from others by their [+spread glottis] feature (Kim, 1965; Kim et al., 2005). Accordingly, the three types of stops have different VOT, F0 and closure duration. Among the three-way contrast, aspirated stops have the longest VOT, followed by lax stops and tense stops. In terms of F0, aspirated stops have the highest F0, followed by tense stops and lax stops. In addition, lax stops have a shorter closure duration than tense and aspirated stops.

As Korean stops, Chinese stop consonants are all voiceless. However, they have a two-way contrast, not three, with aspiration as a distinctive feature: voiceless unaspirated stops /p/, /t/, /k/ and voiceless aspirated stops /p^h/, /t^h/, /kh/. Aspirated stops have a longer VOT compared to their unaspirated counterparts (Liu et al., 2000). This different set of stop consonants in Korean and Chinese leads one to expect difficulties for Chinese speakers to accurately produce and perceive the three-way contrast of Korean stops. In particular, it is predicted from both the SLM model and the PAM-L2 model that the acquisition of the Korean lax stops and distinguishing them from Korean aspirated or tense stops will be difficult, given that Chinese speakers identify Korean aspirated stops as Chinese aspirated stops and Korean tense stops as Chinese unaspirated stops, but identify Korean lax stops as either of them (Jang, 2002).

In fact, previous studies report that Chinese learners of Korean experience difficulties in acquiring the three-way contrast of Korean stop sounds. For instance, Kwon (2013) conducted a phoneme discrimination task of the three Korean stops where Chinese speakers and English speakers participated. Both groups, whose native language has only a two-way contrast in its stop consonants, demonstrated a low performance in differentiating the three stop sounds. In Kim (2007), Chinese learners of Korean showed a lower accuracy rate of (54.3%) in a Korean stop sounds identification task compared to Korean native speakers (98.9%). The accuracy rate was particularly low for Korean lax stops (27.0%), followed by tense (41.0%) and aspirated stops (73.0%).

Meanwhile, learners' ability to discriminate Korean consonant sounds may develop as their proficiency increases. For example, Zhou and Kim (2014) found that Chinese speakers' pronunciation of Korean lax, tense and aspirated stops became more accurate as the duration of learning Korean increased. In regards to perception, the ability to distinguish among the three contrasts, especially lax and aspirated consonants, developed as a function of the learners' Korean proficiency (Jang, 2014). Similar results were found in Park and Kim (2018), where the learners showed difficulties in distinguishing lax and aspirated stops at the beginning level but less so at a more advanced level.

Given this stream of research, this paper attempts to add neurological data to the behavioral results presented in previous studies on the role of language proficiency on the acquisition of Korean stop sounds.

3. MMN: an indicator of neural representation of phoneme

A recent trend of studies on phonological perception is to use neurological methods such as event-related potentials (ERPs), fNIRS (functional near infra-red spectroscopy), and MEG (Magnetoencephalograpy) that allow us to explore brain responses to linguistic stimuli. In ERPs, MMN (Mismatch Negativity) is a commonly used component in phonological perception studies. It is a negative polarity component which is elicited when listeners distinguish any change in a flow of repeating sounds (Linnavalli et al., 2017; Näätänen et al., 2004; Näätänen et al., 2007). That is, it is observed when a person detects a deviant sound among a stream of more frequent sounds. The MMN usually peaks at around 100-250ms with its largest amplitude at the fronto-central scalp areas. Most importantly, MMN is elicited even when the listeners are not paying any attention to the sound they hear, which makes it appropriate for speech-sound processing experiments.

MMN can be used to measure phonemic knowledge of not only native but also non-native speakers. For example, Näätänen et al. (1997) compared MMN responses to the Finnish prototype sound /ö/ and the Estonian prototype sound /õ/ by Finnish speakers and Estonian speakers. For Finnish speakers, the MMN amplitude was larger when the deviant stimuli were /ö/, which exists in the participants' native language. Similarly, for Estonian speakers, the MMN amplitude was enhanced when the deviant stimuli was /õ/. Other studies (Winkler et al. 1999 for L2 Hungarian; Hisagi et al. 2014 for L2 Japanese) report similar results, with a smaller MMN for L2 phonemes.

Recently, Lee et al. (2018) showed native speakers' sensitivity to the three-way distinction of Korean stop sounds not only in the behavioural task (high accuracy rates of 96.35%) but also in an ERP experiment that elicited MMN. The current study uses the same method as Lee et al. (2018) to investigate Korean L2 learners' phonemic knowledge of the three stop consonants and a possible change of

MMN amplitude by the increase of the learners' proficiency of Korean.

4. Research goals of the current study

This study examined the acquisition of Korean stop sounds /t/, /t'/ and /t^h/ by advanced and intermediate Chinese learners of Korean using data from neural responses as well as behavioural responses. The specific research questions addressed in the study are as follows:

1) Is there an effect of proficiency among Chinese learners of Korean in differentiating Korean lax and aspirated stop sounds?

2) Is there an effect of proficiency among Chinese learners of Korean in differentiating Korean lax and tense stop sounds?

III. Method

1. Participants

A total of 27 Chinese learners of Korean (25 females, age: 24.62 (19-35)) participated in the study. Two participants were excluded from analysis due to high signal-to-noise ratio (above 50%). As a result, 25 participants (24 females, age: 24.73 (19-35)) were divided into two groups according to their score on the Test of Proficiency in Korean (TOPIK) (Advanced: 15 with TOPIK Level 6, score range = 237-303; Intermediate: 10 with TOPIK Level 3-5, score range = 146-214). Participants were all right-handed, with normal hearing. They had no history of mental disorder.

2. Stimuli

The audio stimuli were monosyllabic sounds consisting of a stop consonant and a vowel /a/: /ta/, /tʰa/, and /t'a/. The sound files were recordings of a female speaker, provided by National Institute of Korean Language. Since the audio files are distributed for the purpose of Korean education for foreigners, each syllable was produced in isolation with clear distinction from each other, with no reflection of the merging trend of the lax and aspirated stops.[1] The VOT (Voice onset Time) and F0 of the stimuli are presented in Table 1.

Table 1. VOT and F0 of stimuli

	/ta/	/tʰa/	/t'a/
VOT (ms)	46	91	23
F0 (Hz)	229	301	276

3. Behavioural task: AX (same-different) Discrimination task

A pair of speech sounds with seven conditions (ta/-/ta/, /ta/-/tʰa/, /tʰa/-/ta/, /tʰa/-/tʰa/, /ta/-/t'a/, /t'a/-/ta/, /t'a/-/t'a/) were presented over headphones. Participants were asked to judge whether the two sounds were the same or different by pressing the buttons (either "M(=same)" or "N(=different)") as quickly and accurately as possible. Each condition had 5 tokens, so each participant heard 35 trials of the two randomized sounds.

4. ERP experiment

An oddball paradigm was used, where the stimuli are divided into two categories, i.e. standard and deviant stimuli. The MMN is expected to be elicited when the auditory perceptual system detects

1 Recent studies on Korean consonants (Kang, 2014; Bang et al., 2015) have reported that the VOT difference between the lax consonant and the aspirated consonant is becoming less distinct. The audio stimuli that were used in the study, however, had distinct VOTs for the lax and the aspirated stop sounds.

a mismatch between a neural representation of a frequently repeated stimulus (standard) and a stimulus deviating in at least one parameter (deviant). In the current study, there were four blocks with different conditions (Table 2), whose order was counterbalanced across participants. Each block consisted of 250 standard and 50 deviant stimuli and lasted for five minutes. Each sound stimulus was played for 600 ms with a 400 ms interval.

Table 2. ERP experiment stimuli

Condition	Standard	Deviant
Condition 1	/ta/(다)	/t^{h}a/(타)
Condition 2	/t^{h}a/(타)	/ta/(다)
Condition 3	/ta/(다)	/t‘a/(따)
Condition 4	/t’a/(따)	/ta/(다)

For EEG recording, participants were introduced to a sound-attenuated shield room and sat approximately 70 cm in front of a computer screen. They watched the silent movie “Oggy and the Cockroaches (2013)” while the series of sounds were played via the headphone.

The EEG was recorded with Brainamp (Brain Products GmbH, München, Germany) from 32 Ag/AgCl electrodes placed according to the 10-20 system. To detect the eye movements more precisely, 4 electrodes were used as vertical electro-oculogram (VEOG) and horizontal electro-oculogram (HEOG) attached below and beside the left and right eyes. Online filters were set between 0.1 Hz – 70 Hz with the sampling rate of 500 Hz and the electrode impedance was kept below 15 kΩ. During the EEG recording, the participants were told to ignore the series of sounds and to concentrate on the silent movie.

Then the EEG was re-referenced to the averaged lest/right mastoids and filtered with a 0.1-30Hz band-pass filter using the Brain Vision Analyzer 2.0 software (Brain Products GmbH, München, Germany). It was further examined for eye movements and other artefacts, using ocular ICA correction and artefact rejection. The baseline was corrected with 100ms pre-stimulus interval.

As there were four different conditions, the data were analyzed separately for each condition and for each group (Advanced vs Intermediate). For statistical analysis, repeated-measures ANOVAs were conducted on 6 representative lateral (F3, F4, C3, C4, P3, P4) and 3 midline (Fz, Cz, Pz) electrodes in the time window of 100-200 ms, where the MMN is expected to be elicited. Stimuli (standard, deviation) and Electrode (F3, Fz, F4, C3, Cz, C4, P3, Pz, P4) as within-groups factors were included as independent variables in the analysis. The Greenhouse-Geisser correction was applied when the assumption of sphericity is violated.

IV. Results

1. Behavioural results

The participants' accuracy rates and reaction times on the behavioral AX discrimination task are presented in Figures 1 and 2. For each dependent measure, a repeated measures ANOVA was conducted with Group (advanced, intermediate) and Condition (ta/-/ta/, /ta/-/t^ha/, /t^ha/-/ta/, /t^ha/-/t^ha/, /ta/-/t'a/, /t'a/-/ta/, /t'a/-/t'a/) as independent variables.

The mean accuracy rate for all participants was 78.9% (SD = 0.24). The mean accuracy rate of the advanced group was higher (83.8%, SD = 0.19) than the intermediate group (72.2%, SD = 0.28). In ANOVAs, the main effect of Group was significant in the condition /ta/-/t'a/ (t = 2.49, p = 0.03).

The average of reaction times for all participants was 433.84 ms (SD = 0.22). The mean reaction time for the advanced group was

423.28 ms (SD = 0.24) and the mean reaction time for the intermediate group was 448.24 ms (SD = 0.19). Repeated measures ANOVA revealed no significant main effect of Group or Condition.

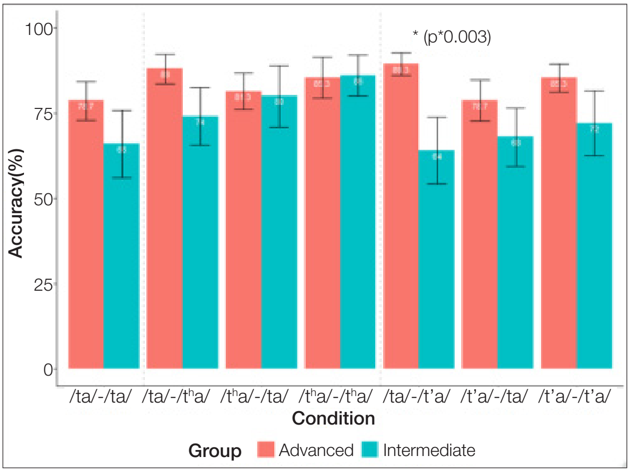

Figure 1. Accuracy rates by condition and group

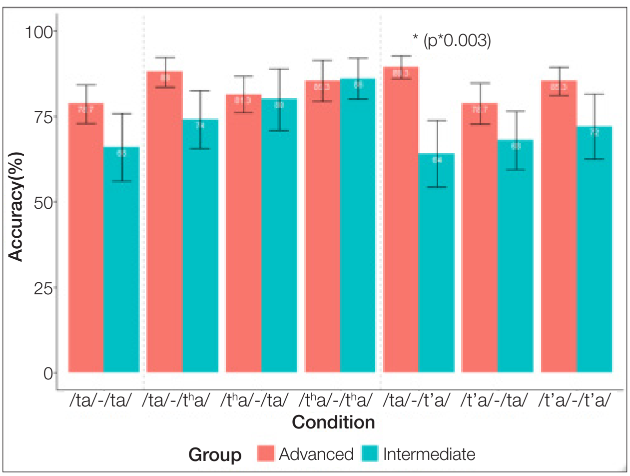

Figure 2. Reaction times by condition and group

2. ERP results

1) Condition 1. standard /ta/ with deviant /tʰa/

In Condition 1, the main effect of Stimuli was significant only for the advanced group (F (1, 14) = 7.34, p = 0.018, $\eta 2G$ = 0.17). The intermediate group did not show any significant effect of Stimuli. In other words, only the advanced group was sensitive to the difference between /ta/ and /tʰa/.

2) Condition 2. standard /tʰa/ with deviant /ta/

In Condition 2, the main effect of Stimuli was not significant for both the advanced group and the intermediate group. In other words, both groups were insensitive to the /tʰa/-/ta/ distinction when the standard stimuli was /tʰa/.

3) Condition 3. standard /ta/ with deviant /t‘a/

In Condition 3, only the advanced group showed a significant effect of Stimuli in left and middle frontal and central electrodes ([F3] F (1, 14) = 9.27, p = 0.009, $\eta 2G$ = 0.25, [Fz] F (1, 14) = 9.24, p = 0.009, $\eta 2G$ = 0.30, [C3] F (1, 14) = 7.66, p = 0.016, $\eta 2G$ = 0.21, [Cz] F (1, 14) = 6.27, p = 0.026, $\eta 2G$ = 0.23). The main effect of Stimuli did not reach significance for the intermediate group. In sum, in Condition 3, only the advanced group showed a significant MMN effect, which indicates their sensitivity to the difference between /ta/ and /t‘a/.

4) Condition 4. standard /t’a/ with deviant /ta/

In Condition 4, the main effect of Stimuli was significant for the advanced group in the electrode F3 (F (1, 14) = 5.20, p = 0.04, $\eta 2G$ = 0.08). For the intermediate group, the main effect of Stimuli was significant in frontal and central electrodes ([F3] F (1, 9) = 24.14, p = 0.001, $\eta 2G$ = 0.49, [Fz] F (1, 9) = 31.40, p < 0.001, $\eta 2G$ = 0.43, [F4] F (1, 9) = 25.14, p = 0.001, $\eta 2G$ = 0.51, [C3] F (1, 9) = 20.90, p = 0.002, $\eta 2G$ = 0.42, [Cz] F (1, 9) = 16.24, p = 0.004, $\eta 2G$ = 0.33, [C4] F (1, 9)

$= 12.13$, $p = 0.008$, $\eta 2G = 0.35$). In short, in condition 4, both the advanced and the intermediate group were sensitive to the difference between /ta/ and /t'a/, with the effect shown over broader areas for the intermediate group.

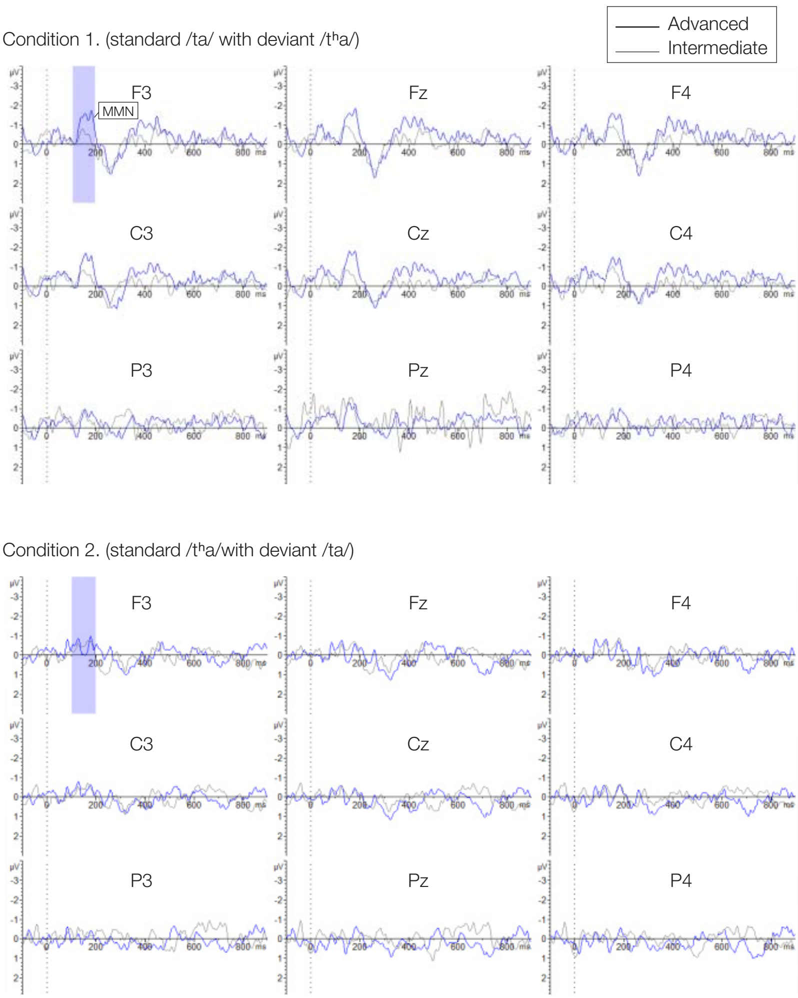

Figure 3. Difference waveforms (deviant-standard) of the advanced group and the intermediate group in Condition 1 and Condition 2

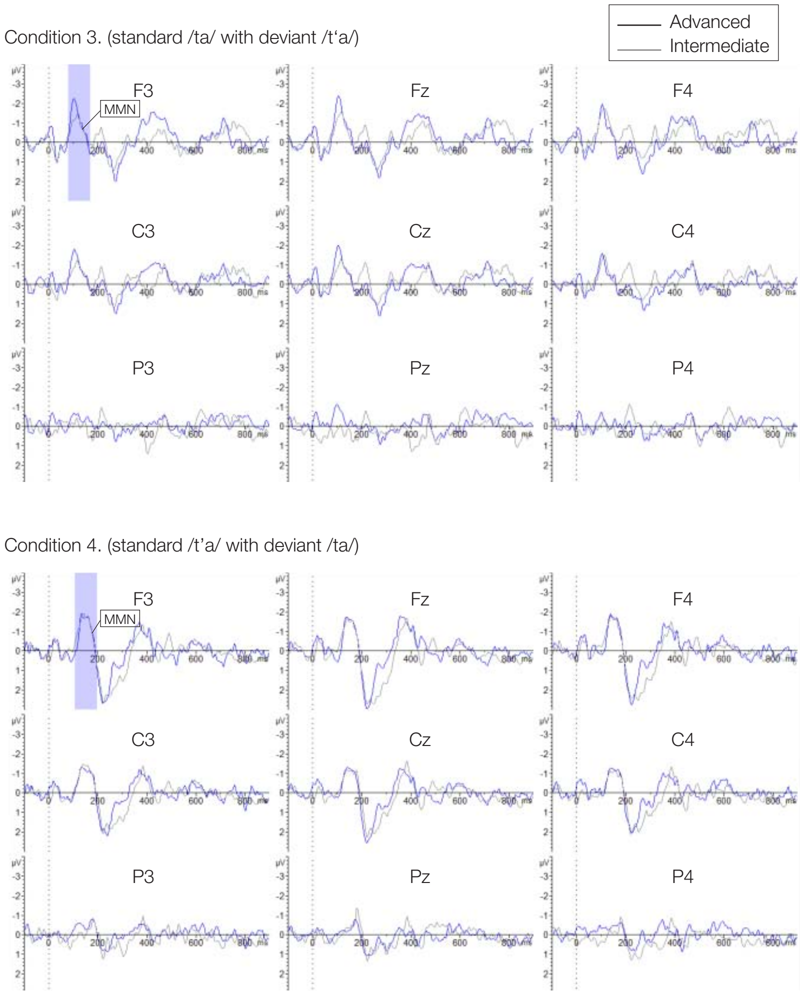

Figure 4. Difference waveforms (deviant-standard) of the advanced group and the intermediate group in Condition 3 and Condition 4

V. Discussion

This paper used behavioral and neural measures to find out whether there is any effect of proficiency among Chinese learners of

Korean in differentiating 1) Korean lax (/t/) and aspirated (/t^h/) stop sounds and 2) Korean lax (/t/) and dense (/t'/) stop sounds. Surprisingly, the behavioral results and the ERP results point to a different picture; while the advanced and the intermediate groups did not show much difference in the behavioral AX discrimination task, the advanced group showed prominently better sensitivity to the different stop sounds in the ERP experiment.

The first research question addressed in the study was whether there is any proficiency effect among Chinese learners of Korean in differentiating Korean lax (/t/) and aspirated (/t^h/) stop sounds. Despite the expected difficulties for Chinese speakers in distinguishing the two sounds, both the advanced and the intermediate groups showed fairly high accuracy rates (above 70%) in the behaviroal task with no significant effect of proficiency. On the other hand, the ERP responses of the two groups showed a different pattern. Whereas the advanced group showed the MMN response in Condition 1 (/ta/-/t^ha/), the intermediate group did not show such effect.

The second research question was whether there is any proficiency effect for Chinese learners of Korean in differentiating Korean lax (/t/) and tense (/t'/) stop sounds. Again, the difference between two groups was more prominent in the ERP results than the behavioral results. In the behavioral AX discrimination task, the only condition where the two groups showed significantly different performance was /ta/-/t'a/. Although the accuracy rate of the advanced group was higher than that of the intermediate group in other conditions (/t'a/-/ta/, /t'a/-/t'a/), the difference was not significant. Conversely, in the ERP experiment, while both groups showed the MMN in Condition 4 (/t'a/-/ta/), only the advanced group showed the MMN in Condition 3 (/ta/-/t'a/).

Put together, the difference between the advanced and the intermediate Chinese learners of Korean in distinguishing Korean stop sounds is more clearly evident in the ERP results than the behavioral results. This is the case for both Korean lax (/t/)-aspirated (/t^h/) and lax (/t/)-tense (/t'/ pairs. This indicates that L2 phonemic discrimination is affected by the type of measurement that is used and that it develops to occur in more various contexts as learners' proficiency increases. The Automatic Selective Perception (ASP) model (Strange, 2011) provides explanation for such task effect on L2 learners' phonemic discrimination. According to this model, speech perception is a purposeful activity where listeners actively seek for information from a series of speech signals. Whereas native speakers are able to automatically perceive phonemic contrasts by using habituated *selective perception routines*, L2 learners need more attentional resources distinguish phonemes because they lack such perception routines. Therefore, it follows that L2 discrimination is more likely to be successful when listeners have full attention to the phonological information, but fails in other cases. Indeed, the intermediate Chinese learners of Korean in the current study showed this pattern; although their performance was generally comparable to that of the advanced learners in the behavioral discrimination task that directed their focus to phonetic details, they showed no signal of sensitivity to the phonemic contrasts in three out of four conditions in the ERP experiment, where their focus was on the silent movie rather than the displayed sounds.

Meanwhile, the fact that the advanced learners exhibited the MMN response to both lax-aspirated (/t/-/t^h/) and lax-tense (/t/-/t'/) contrasts indicates that L2 phonemic discrimination can be automaticized, at least partially, as L2 proficiency increases. White et al. (2015) reports a similar result, with high-proficiency learners showing better neural sensitivity to L2 phonemic contrasts than low-proficiency learners when their attention was directed to semantic, rather than phonological information of the audio stimuli. In their study, French learners of English with high or low English proficiency participated in two ERP experiments that used an oddball paradigm. In the first experiment, participants were told to click a button when they heard deviant sounds among a series of English sounds (/ha/-/a/) that does not exist in their native language; in the second experiment, they were told to attend to the meaning of aurally presented words (e.g. *happy*-*'appy*), and to click a button when they heard a fruit or vegetable word. While both high and low proficiency learners showed neural sensitivity to the deviant sound in the first experiment, only high proficiency learners showed neural response to the deviant sound in the second experiment. Likewise, in the present study, the advanced Chinese learners of Korean showed both behavioral and neural response to the distinction of Korean lax and aspirated stops, a contrast that does not exist in their L1, whereas the intermediate learners did only in the behavioral task. These results suggest that such interaction of task and proficiency effect reported for English L2 phonological acquisition can be extended to Korean stop sounds.

A final remark is due on the asymmetry in the ERP response of the advanced learners in Condition 1 and Condition 2, and Condition 3 and Condition 4. While the advanced group showed the MMN in Condition 1 (/ta/-/t^ha/), they did not show such effect in Condition 2 (/t^ha/-/ta/) when the standard stimuli and the deviant stimuli were switched. Similarly, the intermediate group showed the MMN in Condition 4 (/t'a/-/ta/), but not in Condition 3 (/ta/-/t'a/).

In fact, the pattern shown by the advanced learners is the same with that of native Korean speakers in 50s (Lee et al., 2018); the MMN was elicited when the standard stimuli were /ta/ and the deviant stimuli were /t^ha/, but not when the order was switched. This kind of asymmetric MMN can be caused by several factors: MMN is reported to be smaller when the deviant sound is missing a feature than the standard sound (Czigler et al., 2014), when the deviant sound has a more central articulation (Polka & Bohn, 2011), or when the deviant sound does not have any lexical meaning (Shtyrov & Pulvemüller, 2002). MMN is also smaller when the standard sound has a relatively weak representation compared to the deviant sound: for example, when the standard sound is an atypical member of a phoneme (Ikeda et al., 2002) or when the standard sound has an underspecified feature (Politzer-Ahles et al., 2016). Since the MMN is a neural response to a clash of memory trace caused by deviant stimuli with the long-term memory representation of standard stimuli, if standard sounds form less clear representation, it can lead to attenuated MMN response. Therefore, one possible reason for the asymmetric MMN observed between /t/ and /t^h/ in this study is the absence of the features [+spread glottis] and [+tensity] for /t/ compared to /t^h/ (Kim, 1965; Kim et al., 2005). This may have led to the MMN response when the deviant stimuli are /t^ha/ that has additional features than the standard stimuli /ta/, but not when the order is switched and the deviant stimuli /ta/ has less features than the standard stimuli /t^ha/.

Another possibility is that the asymmetric MMN is due to tonogenesis that is taking place in recent Korean, where the VOT distinction between lax and aspirated stops is becoming smaller. (Kang, 2014; Bang et al., 2015). Therefore, at the same time as they are being merged, it may be the case that the presence of MMN in Condition 1 (/ta/-/t^ha/) but not in Condition 2 (/t^ha/-/ta/) reflects the asymmetric representation of the two sounds in Korean speakers in 50s and advanced Chinese learners of Korean—that the aspirated stop /t^h/ is relatively weakly represented than the lax stop /t/.

On the other hand, it seems that the asymmetric MMN shown by the intermediate learners is not due to acoustic nature of the standard versus deviant sounds; it may rather reflect the unstable status of Korean lax stops for the intermediate learners. If it were the case that the asymmetry shown by the intermediate learners was triggered by presence of an additional feature of the deviant stimuli, the MMN would have been larger for Condition 3 (/ta/-/t'a/) than Condition 4 (/t'a/-/ta/), because the tense stop /t'/ has [+tensity] feature that is absent in the lax stop /t/ (Kim, 1965). The intermediate learners, however, showed the opposite pattern, where the MMN was elicited in Condition 4 but not in Condition 3. This may relate to the unstable status of Korean lax stop /t/ when one compares the Chinese and Korean consonant systems. Chinese speakers tend to map Korean aspirated stops to Chinese aspirated stops, and Korean tense stops to Chinese unaspirated stops. Korean lax stops, however, do not correspond to one single Chinese phonemic category; they are mapped to either Chinses aspirated stops or Chinese unaspirated stops (Jeng, 2002). Therefore, it might have been the case that the relatively more concrete representation of the Korean tense stop (/t'/) that has one-to-one mapping to a Chinese consonant compared to the Korean lax stop (/t/) was reflected in the intermediate learners' neural response, leading to the MMN response only when the tense stop is used as standard stimuli.

In conclusion, in the current study, the proficiency effect was present in distinguishing both Korean stops /t/ and /t^h/, and /t/ and /t'/ among Chinese learners of Korean, especially in the ERP results; the advanced Chinese learners of Korean were able to distinguish Korean stops /t/, /t'/, and /t^h/ to the similar extent with native Korean speakers, whereas intermediate learners were not able to do so. The results indicate that the neural data can reveal not only the proficiency effect of L2 phonological acquisition that is not clear in the behavioral data, but also the possible asymmetric representation of L2 sounds in learners' brains. In other words, MMN can be used as a useful tool to investigate L2 phonological acquisition that provides a more fine-grained picture.

VI. Conclusion

The present study investigated the role of proficiency in the acquisition of Korean stop sounds /t/, /t^h/, and /t'/ among Chinese learners of Korean. Whereas the advanced learners and the intermediate learners showed similar accuracy rates in the behavioral task except for the condition /t'a/-/ta/, the intermediate learners showed clearly less sensitivity to the distinction of lax and aspirated, and of lax and tense stops than the advanced learners in their neural response. In other words, although the proficiency effect is not very prominent in the behavioral task that requires learners' full attention to the phonemic details, it is clearly shown in the ERP results that measure L2 learners' inattentive phonemic discrimination. The findings of this study provide a new piece of neurophysiological evidence for L2 learners' perception of Korean stop sounds, broadening our understanding of L2 phonology in general.

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ABSTRACT

Acquisition of Korean Stop Sounds by L2 Learners and the Role of Proficiency

: an ERP Study

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This study examined the acquisition of Korean stop sounds /t/(ㄷ), /t'/(ㄸ) and /t^h/(ㅌ) by Chinese learners of Korean using Event-related potentials (ERP). Fifteen advanced learners and ten intermediate learners participated in both a behavioural and an ERP experiment. The intermediate learners were significantly less accurate than the advanced learners in discriminating /t'/ from /t/. The overall ERP result also showed less sensitivity of the intermediate learners compared to the advanced learners to the distinction between different stop sounds. The results indicate that the phonemic acquisition of Korean stop sounds by L2 learners develops as the learners' proficiency increases.

KEYWORDS Korean stop sounds, ERP, Chinese learners of korean, Mismatch negativity