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Comparisons of the Rhythm and Speech Rate in Paragraph Reading between Native, Chinese, and Korean Speakers of English*

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I. Introduction

Currently, an increasing number of nonnative English learners are demanding higher standards for their English pronunciation, attempting to mimic the Received Pronunciation (RP) or General American (GA) accent as closely as possible to acquire native-like fluency. However, many of these individuals retain a marked foreign accent at the utterance level long after they have learned English pronunciation. Prosodic elements such as rhythm, duration, fluency, focus, intonation, and stress are important in determining the meaning of the sentence, the attitude of the speakers, and the naturalness of the utterances (Lee 2019a, b; Sohn 2017). Among them, fluency is vastly studied along with some acoustic measures. Fluency is basically a temporal phenomenon of speech, which refers to continuity, smoothness, rate,

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* The present study is the revised version of the first author's unpublished doctoral dissertation (Xue 2022).

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and effort in speech production. Temporal features of speech such as articulation rate (Bosker, Pinget, Quené, Sanders, and De Jong 2012), mean length of runs, speech rate, and pause duration (Ghanem and Kang 2018; Kormos and Dénes 2004), as well as stress, rhythm, and intonation (Chung, Jang, Yun, Yun, and Sa 2008), seem to significantly affect the fluency of the language learner's utterance.

In general, the temporal characteristics inherent in various languages frequently impede the acquisition of appropriate fluency by L2 learners. As predicted by Contrastive Analysis Hypothesis (CAH), the difficulties of L2 are mainly caused by differences in the phonological systems of the L1 and L2. When the L1 and L2 have different structure, the learning process will be most likely to be hampered by the L1 transfer. There is convincing research that compares a variety of temporal measures in L1 and L2 speech of the same speakers and finds that there is a strong relationship between the speakers' L1 and L2, as well as evidence that the differences in the L1 of L2 speakers also carry over to similar differences in L2 fluency (Chen, Wee, Tong, Ma, and Li 2016; De Jong, Groenhout, Schoonen, and Hulstijn 2015; Derwing, Munro, Thomson, and Rossiter 2009; Segalowitz 2010; Towell, Hawkins, Bazergui 1996). Also, Bradlow, Kim, and Blasingame (2017) showed that L1 speaking rates (speech rate and articulation rate) substantially predicted L2 speaking rates. Trofimovich and Baker (2006) proposed that the fluency of the adult learners' L2 speech (stress timing) was associated with the learners' amount of experience, which may depend on the different degrees of the learners' L1 and L2.

For Chinese and Korean speakers, previous research has demonstrated that the realization of rhythmic patterns and rates in Chinese (Grabe and Low 2002; Yu 2013) and Korean (Jang 2009; Kim 2008) differs from that of English. In addition, there are many acoustic studies in the literature reporting that Chinese and Korean speakers have difficulties with English rhythm and rate. For instance, Lim (2005) discovered that certain post-lexical phonological processes used by native English speakers, such as weakening, deletion, and contraction, make Korean learners' English pronunciation unnatural in terms of speech rate. Mok and Dellwo (2008) proposed that Cantonese and Mandarin speakers have a different rhythm than native English speakers when they read in English because they lack reduced unstressed syllables. Kim (2012) suggested that native speakers speak English faster than Chinese speakers. The reason for this is that the rhythm of English spoken by native speakers is different from nonnative speakers in connected speech. Overall, the pronunciation errors in these studies can be seen as a result of the L1 transfer.

However, there is a dearth of research comparing Chinese and Korean speakers' speech rhythm and rate when reading in L1 and L2. This study examines whether the rhythm and rate of the two speaker groups' L1 is transferred to L2 or whether it would be accommodated to L2. We surveyed undergraduate students, some of whom majored in English and others who had taken English as an elective course. This study will comprehensively assess whether Chinese and Korean undergraduate students in pronunciation are fluent or have problems when learning English according to their native language systems and explore ways that they can get closer to the rhythm and rate of native English speakers.

II. Literature Review

1. Rhythmic Patterns of English, Chinese, and Korean

According to the definitions provided by Abercrombie (1967) and Pike (1945) and others, English rhythm is obviously a stress-timed language, where stressed syllables tend to recur at roughly equal intervals in time (isochronous). To maintain the equal interval between stressed syllables, unstressed syllables are more likely to be read quickly, reduced, or even dropped. In general, vowels in function words tend to be weakened and reduced. In contrast, stressed vowels in content words usually have full vowels and are lengthened. English also tries to avoid having stresses too close together, which is called eurhythmy. At the sentence level, "very often, stresses on alternate words are dropped in sentences where they would otherwise come too near one another (Ladefoged and Johnson 2015, p. 124)."

When compared to English, the rhythm of Chinese and Korean are often regarded as syllable-timed language, where the duration of successive syllables is almost the same. In Chinese and Korean, because there is no distinction in the duration of function and content words, speakers display little or no reduction in vowel duration in an unstressed position. Thus, reducing the duration of segments in unstressed syllables is one of the main features used to distinguish English rhythm from Chinese and Korean rhythm.

In addition, Chinese emphasizes tones and is even referred to as a tone language. Each character is represented by one syllable, together with one of the four tones (recognized as a stressed syllable) and a neutral tone (recognized as a light syllable). That is, vowel reduction can occur when the syllable contains neutral tones that can be found in particles such as 吧 [bɑ], the last syllable of a reduplicated word such as 媽媽 [mā mə], and question markers such as 嗎 [mə] (Duanmu 2011). Stress is not as obvious in Chinese as it is in English; while the neutral tone in Chinese causes an alternation of stressed and unstressed syllables, this feature is not as common in Chinese as in English. In Korean, however, there are no such complicated changeable tones in sentence, and there is no lexical stress (Jun 2005). Therefore, Korean does not exhibit alternations in the degree of stress. Furthermore, the duration of syllables in Chinese varies slightly depending on tone. In contrast, because the Korean rhythm is relatively monotonous, the duration of each syllable is approximately the same. The frequent tapping and strong lengthening of the final syllable (Mok and Lee 2008) and the phrase-initial lengthening that is localized to the syllable onset (Cho and Keating 2001) may make the Korean language sound more similar to a stressed-timed language.

2. Speech Rate of English, Chinese, and Korean

Speech rate is a measurement of how quickly a speaker pronounces utterances. It can be divided into two measures, namely, speech rate (SR), which is calculated by dividing the total number of syllables produced in a given utterance by the total utterance duration including pauses, and articulation rate (AR), which is calculated by dividing the total number of syllables produced in a given utterance by the total utterance duration excluding pauses. Because the silent intervals are removed from the speech sample, the measure of AR provides a more sensitive estimate of actual speech execution time than SR (Miller, Grosjean, and Lomanto 1984).

In fact, it is difficult to find research on the differences in the speech rate of English, Chinese, and Korean. Therefore, we will compare the rates through speaker-specific factors. English permits multiple clusters in an onset or coda position. However, more than half of the syllables in Chinese and Korean have simple CV (consonant-vowel) and CVC structures, and open syllables are obviously more dominant than closed syllables (Na 2019). Korean words such as “삯 [sag]” or “닭 [dag]” are considered to have the structure of CVCC phonologically, but consonant clusters in the coda position never occur in the same syllable phonetically. Open syllables occur just as frequently in Korean as they do in Chinese. However, unlike Chinese, Korean places no restrictions on the types of consonants that can appear in the coda position. In English, a syllable may contain a monophthong or a diphthong and a short or long vowel as its syllable nucleus. In Standard Chinese, a pre-nucleus glide could be transcribed as a high vowel (Třísková 2011). However, when the nucleus branches in Korean, a glide approximant /w/ or /j/ appears in the nucleus’s initial timing slot, forming an on-glide diphthong with the following vowel (Chung 2012). The quantity of phonemes and the proportions of nuclei in these three languages may lead to some degree of difference in AR.

In terms of linguistic features, English is a connected language in which syllables can be compressed and stretched. Chinese is an isolated language in which each word is usually pronounced separately, with syllables rarely linked. The syllables are clearly and completely realized by the recurrence of strong and weak syllables, as well as pauses and the collocation of the tones. However, because Korean is an agglutinative language with a connected pronunciation, syllables are closely connected to form a rhythmic group (or fragment) (Shin 2005). Thus, it is possible for liaison, assimilation, and tense sounds to occur in the connected speech. The speed of speech rate may depend on the way in which speakers distribute their speech and pauses.

In brief, English, Chinese, and Korean represent three distinct rhythmic types, namely, stress-timed language, tone language, and non-stressed language, respectively. A Chinese or Korean speaker learning English might tend to show syllable-timing characteristics in English according to the rules of their L1 phonology. As a result, the L1's interference with English rhythm and speech rate clearly contributes to many of the difficulties Chinese and Korean speakers encounter in learning English. The nPVI-V (normalized vocalic pairwise variability index) is used as an acoustic measure to predict the rhythmic pattern of each language and speech rate (speech rate and articulation rate) is used as an acoustic measure to predict the fluency of each language in this study. This study was designed to address the following three research questions: 1) Does the L1 background of native, Chinese, and Korean speakers of English affect the rhythm and rate of their speech when they read English? 2) Are the speech rhythm and rate different from each other when native, Chinese, and Korean speakers read in their L1? 3) When Chinese and Korean learners of English read in English, are the rhythm and rate of their speech different from when they read in their L1?

III. Method

1. Participants

50 participants participated in this study: 20 Chinese speakers (10 males and 10 females) from H University in China, 20 Korean speakers (7 males and 13 females) from K University in South Korea, and 10 (7 males and 3 females) native English speakers. All subjects took part in the experiment voluntarily and received a small payment.

Chinese students and Korean students, all of whom were undergraduate students from a variety of grades and majors, were invited at random. The ages of the Chinese and Korean students ranged from 19-26 years, with a mean age of 23.4 (SD = 1.7) years. Each student had been learning English for an average of 12.3 (SD = 2.1) years. They were asked to report their scores on official English tests. The Chinese students passed the college English tests (CET-4) with scores between 426-564, with a mean of 474. The minimum requirement to pass the CET-4 is 425 out of 710. The Korean students who had taken a TOEIC test received scores ranging from 810-975, with a mean of 909. None of the students had been to any English-speaking country, except for one Korean student who had been to the UK for three months of language training. In addition, the participants selected in this study spoke with the standard accent of their L1, Chinese students spoke with Beijing Mandarin and Korean students spoke with Seoul standard accent.

Ten native English participants were composed of two from the USA, two from the UK, and the other six from Canada. All the speakers lived in their own countries, except for one American who has lived in Korea for 25 years as an English teacher trainer at a Korean university. The native English speakers ranged in age from their twenties to their fifties, with an average age of 28.1 years. All of them had completed a college education and had distinct professions, i.e., two English teachers, a piano teacher, a financial analyst, an actor, a research assistant, two graduate students, and two PhD students. All native English speakers were monolingual, speaking no language other than English. They were told that their sounds would be compared to those of nonnative English speakers in this study. As a result, they paid special attention to reading in standard English with clear sound.

2. Materials and Recordings

The English reading material used in this study, namely, "*The North Wind and the Sun*", is a standard text of the International Phonetic Association (1999). This material was selected since each English phoneme is present and proportionate. The passage is segmented into five sentences of 21-40 syllables (14 to 36 words) in length and contains a total of 113 words and 143 syllables (Appendix A). It was recorded by the three groups of speakers. A total duration of 2,213 seconds (388 seconds from native speakers, 955 seconds from Chinese speakers, and 870 seconds from Korean speakers) and a total of 7,150 syllables were extracted from the recording.

In addition, the English version of the passage has been translated into Chinese and Korean. The Chinese translation (Appendix B) is composed of six sentences with 177 syllables, and the Korean translation (Appendix C) is composed of five sentences with a total of 168 syllables. The Chinese and Korean speakers recorded these translations. A total duration of 1,438 seconds (880 seconds from Chinese speakers and 558 seconds from Korean speakers) and a total of 6,900 syllables were extracted from the recording.

3. Data Collection and the Procedures

An English script was sent to native speakers of English and both an English script and the translation were sent to Chinese and Korean speakers, respectively. To avoid affecting temporal variations, the English version and the L1 version for Chinese and Korean English learners were both read simultaneously. Before the recording, each participant had sufficient time to read and familiarize themselves with the passage. To assure the quality of the recordings, the participants were instructed to record the passage aloud and fluently on their smartphones in a quiet environment and at their own pace. If there was a lot of hesitation or noise in the recorded samples, they were asked to rerecord. Then, all of the recordings were gathered and loaded into the Praat speech analysis software version 6.1.33 (Boersma and Weenink, 1992-2022). Finally, the values from 50 participants' recordings were statistically analyzed with the help of SPSS 26.0.

Annotation of the English data was carried out using Praat and Python scripts[1]. The sentence tier contained the orthographic transcription of the entire passage. Then, forced alignment was used to identify individual segments, and if necessary, the segment boundaries were modified. The syllable boundaries were determined manually. Once the alignment was completed, the speech rhythm value was calculated automatically. SR and AR were automatically obtained by using a Praat script (De Jong and Wempe 2009). In the script, peaks in intensity (dB) that were preceded and followed by dips in intensity were considered potential syllable nuclei. The script not only counted syllables but also counted and measured silent pauses. Along with the pausing information, this script automatically calculated SR and AR.

The annotation of the Chinese data was done manually because the researcher did not have access to an automatic labeler. First, all Chinese recordings of the Chinese speakers were extracted and manually annotated on Praat TextGrid in three tiers. Sounds, spectrograms, and waveforms were utilized to annotate each segment

1) It was written and provided by Professor Tae-Jin Yoon of Sungshin Women's University.

and boundary. Finally, the rhythm, SR, and AR were measured automatically using Praat scripts.

The annotation of the Korean data was carried out using Praat and kPhonetica version 2.08 (Seong, Gim, and Kwon 2018). First, each sentence's sound wave was imported into kPhonetica. The sentence was then forced-aligned and exported in Praat format. Following segmentation, manual correction was performed in Praat, using sound, spectrogram, and waveform to verify the segment boundaries. If an error in the segmentation was discovered, it was manually corrected. Finally, using Praat scripts, rhythm, SR, and AR were calculated automatically.

4. Data Analysis

First, to measure the rhythm, this study used the normalized vocalic PVI (nPVI-V) proposed by Low, Grabe, and Nolan (2000), which calculates the durational variability between adjacent vowels while disregarding any intervocalic consonants.

$$nPVI = 100 \times \left[\sum_{k=1}^{m-1} \left| \frac{d_k - d_{k+1}}{(d_k + d_{k+1})/2} \right| / (m-1)\right]$$

(where m is the number of vocalic intervals in a passage of speech, d is the duration of the kth interval, and k and k+1 are the two adjacent vocalic intervals.)

The normalized vocalic PVI (nPVI-V) was calculated by first obtaining the vocalic duration from the speech and then calculating the absolute difference between consecutive vowels. The difference was then divided by the mean vowel duration and multiplied by 100. The overall average determined the phrase's or sentence's nPVI-V. Acoustically, the nPVI-V value for the duration of vowel intervals is expected to be close to zero in a perfect isochrony of syllable timing, where no duration difference exists between successive vowels. In contrast, the value should be significantly greater in stress timing. Therefore, the nPVI-V contributes to the rhythm dichotomy between stress-timed and syllable-timed languages.

Second, this study adopted the speech rate calculation proposed by Grabe and Low (2002), which calculates the average number of syllables spoken per second.

a. *SR* = number of syllables/seconds
b. *AR* = number of syllables/seconds (excluding internal pauses)

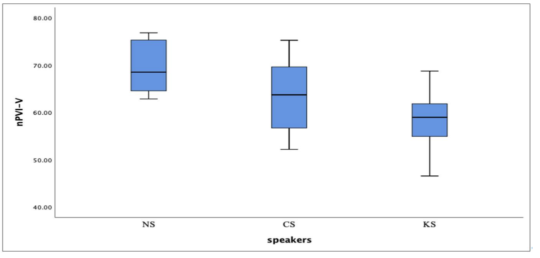
The SR was calculated by dividing the number of syllables by the duration(s), whereas the AR is calculated by dividing the number of syllables by the phonation time(s). Due to the inclusion of pause length in the denominator of the speech rate calculation, SR is always less than the matching AR. Acoustically, the greater number of syllables per second in the utterance means that it is read at a faster speech rate. In contrast, the value should be lower when speaking slowly. A speaker's high speech rate reflects that the speaker has less difficulty reading fluently (Lennon, 1990; Munro and Derwing, 1998).

IV. Results

1. Analysis of the Speech Rhythm and Speech Rate of Native, Chinese, and Korean Speakers' English

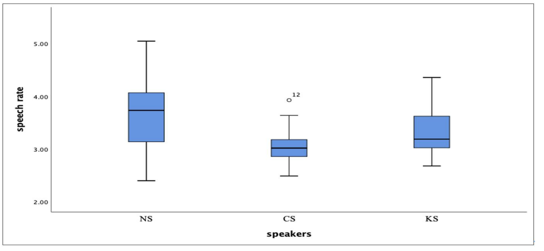
To answer the first research question, a one-way ANOVA was employed to investigate whether different L1 backgrounds affect the rhythm and rate of the three participant groups' English reading. The Shapiro Wilk test indicated that the nPVI-V, SR, and AR were normally distributed ($p > .05$), which is due to our small sample size (50 samples). NS represents native speakers; CS represents Chinese speakers; KS represents Korean speakers.

<Figure 1> A boxplot of nPVI-V for the three groups' English reading



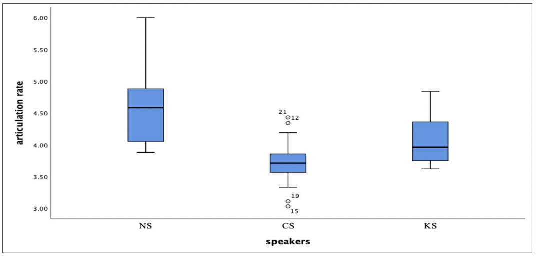
The distribution of the nPVI-V for English reading by the three groups indicated that the mean for NS (Mean = 69.51) was the highest, followed by that for CS (Mean = 63.29) and KS (Mean = 58.44), as shown in Figure 1. Additionally, the distribution of CS and KS scores revealed a greater disparity between speakers with high and low scores than the distribution of NS scores. Levene's test showed that the variances of the nPVI-V were equal ($F(2, 47) = .678$, $p = .513$). Therefore, a one-way ANOVA was conducted to further compare the differences among the three groups. The results show that the means of the three groups were significantly different, $F(2, 47) = 10.626$, $p < .001$. Multiple comparisons were carried out using Tukey's HSD. Post hoc multiple comparisons indicated that the mean difference between NS and KS ($p < .001$) and that between NS and CS ($p < .05$) were significant. Interestingly, the difference between CS and KS ($p < .05$) was also found to be significant. That is, the rhythm of each of the three groups was significantly different from the others. From the results, we can see that speech rhythm can be quantified in terms of the nPVI-V difference between the three groups of English readers. Overall, CS is considered more fluent than KS because the score of CS is closer to that of NS.

<Figure 2> A boxplot of SR for the three groups' English reading



The distribution of SR for English reading by the three groups indicated that the mean for NS (Mean = 3.71) was the highest, followed by that for KS (Mean = 3.34) and CS (Mean = 3.04), as shown in Figure 2. Levene's test showed that the variances of SR were equal, ($F(2, 47) = 3.889$, $p = .027$), assuming a significance level of less than .01. Therefore, a one-way ANOVA was conducted to further compare the differences among the three groups. The results show that the means of the three groups were significantly different, $F(2, 47) = 5.633$, $p < .01$. Multiple comparisons were carried out using Tukey's HSD. Post hoc multiple comparisons revealed that the mean of NS was obviously higher than the mean of CS ($p < .01$). There was no significant difference between NS and KS ($p = .174$) or between CS and KS ($p = .170$). The findings of this study indicate that the fluency of CS was lower than that of NS. On the other hand, the SR of Korean speakers is almost at the same level of fluency as that of Chinese speakers but appears to be similar to that of native speakers.

<Figure 3> A boxplot of AR for the three groups' English reading

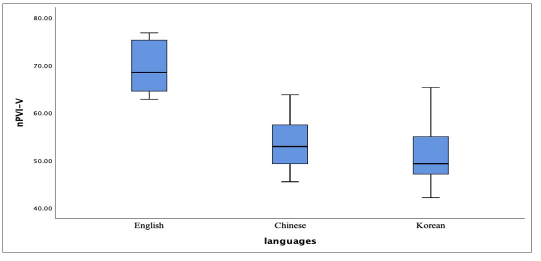


The distribution of AR for English reading by the three groups indicated that the mean for NS (Mean = 4.66) was the highest, followed by that for KS (Mean = 4.06) and CS (Mean = 3.72), as shown in Figure 3. Levene's test showed that the variances of AR were equal ($F(2, 47) = 3.095$, $p = .055$). Therefore, a one-way ANOVA was conducted to further compare the differences among the three groups. The results show that the means of the three groups were significantly different, $F(2, 47) = 14.243$, $p < .001$. Multiple comparisons were carried out using Tukey's HSD. Post hoc multiple comparisons indicated that the mean of NS was significantly higher than CS ($p < .001$) and KS ($p < .01$). However, there was no significant difference between CS and KS ($p = .058$). In this study, the fluency of CS and KS was found to be lower than that of NS. It also revealed that the fluency of CS was similar to that of KS.

2. Analysis of the Speech Rhythm and Speech Rate of Native, Chinese, and Korean Speakers' L1

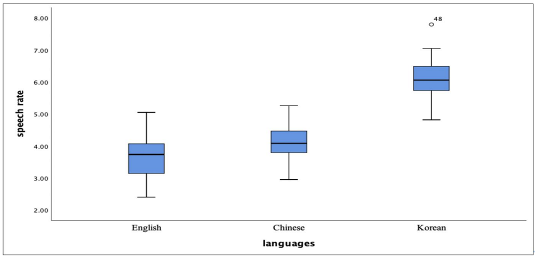
To answer the second research question, a one-way ANOVA was also used to investigate whether the rhythm and rate are different from each other when the participants read the passage in their L1. The Shapiro Wilk test indicated that the nPVI-V, SR and AR were normally distributed ($p > .05$), which was most likely due to our small sample size (50 samples). English represents native speakers' English reading; Chinese represents Chinese speakers' reading of Chinese translation; Korean represents Korean speakers' reading of Korean translation.

<Figure 4> A boxplot of nPVI-V for the three Groups' L1 reading



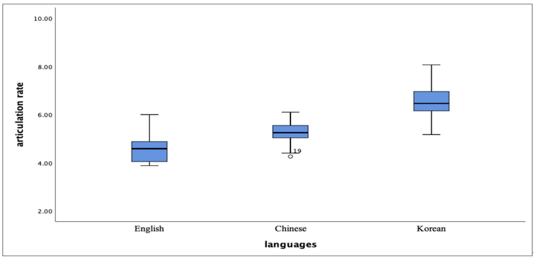
The distribution of the nPVI-V for the three groups' readings in their L1 indicated that the mean for English (Mean = 69.5) was the highest, followed by that for Chinese (Mean = 53.25) and Korean (Mean = 51.52), as shown in Figure 4. Additionally, the distribution of Chinese and Korean scores revealed a greater disparity between speakers with high and low scores than the distribution of English scores. Levene's test showed that the variances of nPVI-V were equal ($F(2, 47) = .426$, $p = .656$). Therefore, a one-way ANOVA was conducted to further compare the differences among the three languages. The results show that the means of the three languages were significantly different, $F(2, 47) = 38.108$, $p < .001$. Multiple comparisons were carried out using Tukey's HSD. Post hoc multiple comparisons indicated that the mean of English was significantly higher than Chinese ($p < .001$) and Korean ($p < .001$). However, there was no significant difference between Chinese and Korean participants ($p = .591$). The results show that the rhythm of English is obviously different from that of Chinese and Korean, while Chinese and Korean have similar rhythms.

<Figure 5> A boxplot of SR for the three Groups' L1 reading



The distribution of the SR for the three groups' readings in L1 indicated that the mean for Korean (Mean = 6.11) was the highest, followed by that for Chinese (Mean = 4.09) and English (Mean = 3.71), as shown in Figure 5. Levene's test showed that the variances of SR were equal ($F(2, 47) = .914$, $p = .408$). Therefore, a one-way ANOVA was conducted to further compare the differences among the three languages. The results show that the means of the three languages were significantly different, $F(2, 47) = 60.095$, $p < .001$. Multiple comparisons were carried out using Tukey's HSD. Post hoc multiple comparisons indicated that the AR of Korean was significantly faster than English ($p < .001$) and Chinese ($p < .001$). Due to the lack of a statistically significant difference in SR between English and Chinese ($p = .325$), it is reasonable to assert that English and Chinese have nearly the same SR.

<Figure 6> A boxplot of AR for the three groups' L1 reading



The distribution for the three groups' AR in their L1 readings indicated that the mean for Korean (Mean = 6.53) was the highest, followed by that for Chinese (Mean = 5.25) and English (Mean = 4.66), as shown in Figure 6. Levene's test showed that the variances of AR were equal ($F(2, 47) = .914$, $p = .408$). Therefore, a one-way ANOVA was conducted to further compare the differences among the three groups. The results show that the means of the three languages were significantly different, $F(2, 47) = 37.818$, $p < .001$. Multiple comparisons were carried out using Tukey's HSD. Post hoc multiple comparisons indicated that the AR values of Korean were significantly faster than those of English ($p < .001$) and Chinese ($p < .001$), and the AR values of Chinese were significantly faster than those of English ($p < .05$). In terms of AR, the results reveal that the three languages have distinct language characteristics.

3. Analysis of the Speech Rhythm and Speech Rate of English Reading and L1 Reading by Chinese and Korean Speakers

To answer the third research question, a two-way mixed ANOVA was employed to investigate whether or not Chinese and Korean speakers' rhythm and rate of their L1 reading of the translated script differed from the rhythm and rate of their English reading.

1) nPVI-V

A two-way mixed ANOVA was used to examine any statistically significant effects on the nPVI-V of the speaker's L1 (i.e., Chinese and Korean) and the language of the reading script (i.e., L1 and English). The language of the reading script serves as a within-subjects variable in this analysis, while speaker's L1 serves as a between-subjects variable. The descriptive statistics for nPVI-V are presented in Table 1. L1 refers to the speaker's L1, nPVI_L1 refers to nPVI-V for L1 reading, and nPVI_E refers to nPVI-V for English reading.

<Table 1> Descriptive statistics of nPVI-V for L1 reading and English reading

	Speaker	Mean	SD	N
nPVI_L1	Chinese	53.25	5.11	20
	Korean	51.52	6.14	20
	Total	52.39	5.65	40
nPVI_E	Chinese	63.29	6.87	20
	Korean	58.44	6.03	20
	Total	60.86	6.84	40

<Table 2> Two-way mixed ANOVA of nPVI-V for L1 reading and English reading

	Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Within Subjects	Script	1437.11	1	1437.11	42.82	.000	.53
	Script*L1	48.438	1	48.44	1.44	.237	.04
	Error	1275.37	38	33.56			
Between Subjects	L1	216.58	1	216.58	5.39	.026	.12
	Error	1526.95	38	40.18			

Table 2 presents a summary of the two-way mixed ANOVA. Script refers to the language of the reading script (L1 and English), and L1 refers to the L1 of the speaker (Chinese and Korean). The results show that there were significant main effects of the language of the reading script ($F(1, 38) = 42.82$, $p < .001$, $\eta_p^2 = .53$) and the speaker's L1 ($F(1, 38) = 5.39$, $p < .05$, $\eta_p^2 = .12$) on nPVI-V. The mean nPVI-V in English (Mean = 60.86, SD = 6.84) was significantly higher than the mean nPVI-V in L1 (Mean = 52.39, SD = 5.65). The mean nPVI-V of Chinese speakers (Mean = 58.27, SE = 1.34) was significantly higher than the mean nPVI-V of Korean speakers (Mean = 54.98, SE = 1.36). There was no significant interaction between the language of the reading script and the L1 of the speakers ($F(1, 38) = 1.44$, $p = .237$, $\eta_p^2 = .04$). The findings suggest that the reading script's language has an effect on the rhythm of the two groups of readers. However, the rhythm difference between these two groups is constant across the languages of the reading script, indicating that the languages of the reading script have little effect on the nPVI-V difference between Chinese and Korean speakers.

2) Speech rate (SR)

A two-way mixed ANOVA was used to examine any statistically significant effects on the SR of the speaker's L1 (i.e., Chinese and Korean) and the language of the reading script (i.e., L1 and English). The descriptive statistics for SR are presented in Table 3. L1 refers to the speaker's L1, SR_L1 refers to SR for L1 reading, and SR_E refers to SR for English reading.

<Table 3> Descriptive statistics of SR for L1 reading and English reading

	Speaker	Mean	SD	N
SR_L1	Chinese	4.09	.54	20
	Korean	6.11	.73	20
	Total	5.10	1.20	40
SR_E	Chinese	3.04	.38	20
	Korean	3.34	.45	20
	Total	3.19	.44	40

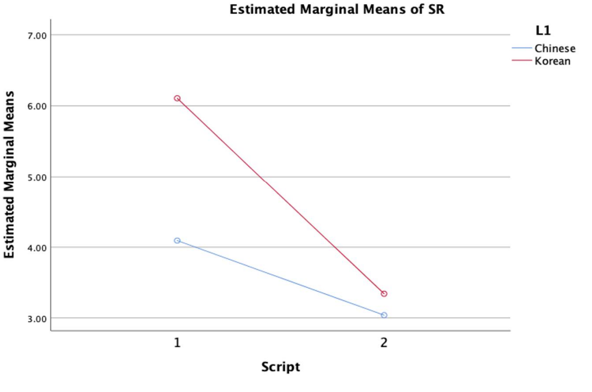
<Table 4> Two-way mixed ANOVA of SR for L1 reading and English reading

	Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Within Subjects	Script	72.94	1	72.94	442.35	.000	.92
	Script*L1	14.63	1	14.63	88.71	.000	.70
	Error	6.27	38	.17			
Between Subjects	L1	26.83	1	26.83	63.86	.000	.62
	Error	15.97	38	.42			

Table 4 presents the summary of the two-way mixed ANOVA. The results show that there were significant main effects of the language of the reading script ($F(1, 38) = 442.35$, $p < .001$, $\eta_p^2 = .92$) and the speaker's L1 ($F(1, 38) = 63.86$, $p < .001$, $\eta_p^2 = .62$) on SR. The mean SR in L1 (Mean = 5.10, SD = 1.20) was significantly higher than the mean SR in English (Mean = 3.19, SD = .44). The mean SR of Korean speakers (Mean = 4.73, SE = .13) was significantly higher than the mean SR of Chinese speakers (Mean = 3.57, SE = .10). There was also a significant interaction between the language of the reading script and the L1 of the speakers ($F(1, 38) = 88.71$, $p < .001$, $\eta_p^2 = .70$).

As shown in Figure 7, while the SR of Korean speakers (Mean = 6.11, SE = .16) was much higher than the SR of Chinese speakers (Mean = 4.09, SE = .12) when they read the passage in their L1, the difference decreased when they read it in English (Korean: Mean = 3.34, SE = .10; Chinese: Mean = 3.04, SE = .08).

<Figure 7> A two-way interaction between script and L1 on SR



3) Articulation rate (AR)

A two-way mixed ANOVA was used to examine any statistically significant effects on the AR of the speaker's L1 (i.e., Chinese and Korean) and the language of the reading script (i.e., L1 and English). The descriptive statistics for AR are presented in Table 5. L1 refers to the speaker's L1, AR_L1 refers to AR for L1 reading, and AR_E refers to AR for English reading.

<Table 5> Descriptive statistics of AR for L1 reading and English reading

	Speaker	Mean	SD	N
AR_L1	Chinese	5.25	.56	20
	Korean	6.53	.70	20
	Total	5.89	.87	40
AR_E	Chinese	3.72	.37	20
	Korean	4.06	.38	20
	Total	3.89	.41	40

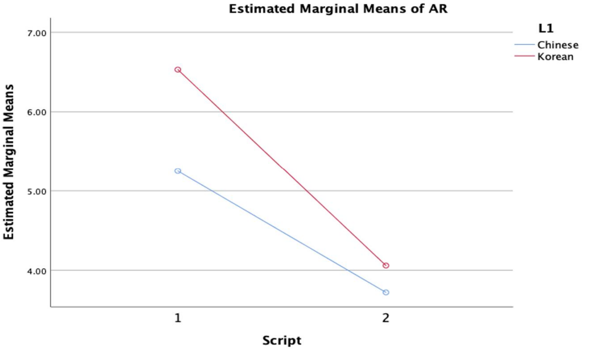
<Table 6> Two-way mixed ANOVA of AR for L1 reading and English reading

	Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Within Subjects	Script	80.06	1	80.06	597.16	.000	.94
	Script*L1	4.44	1	4.44	33.13	.000	.47
	Error	5.10	38	.13			
Between Subjects	L1	13.10	1	13.10	36.67	.000	.49
	Error	13.57	38	.36			

Table 6 presents the summary of the two-way mixed ANOVA. The results show that there were significant main effects of the language of the reading script ($F(1, 38) = 597.16$, $p < .001$, $\eta_p^2 = .94$) and the speaker's L1 ($F(1, 38) = 36.67$, $p < .001$, $\eta_p^2 = .49$) on AR. The mean AR in L1 (Mean = 5.89, SD =.87) was significantly higher than the mean AR in English (Mean = 3.89, SD = .41). The mean AR of Korean speakers (Mean = 5.30, SE = .13) was significantly higher than the mean AR of Chinese speakers (Mean = 4.49, SE = .09). There was also a significant interaction between the language of the reading script and the L1 of the speakers (F(1, 38) = 33.13, p < .001, η_p^2 = .47).

As shown in Figure 8, while the AR of Korean speakers (Mean = 6.53, SE = .16) was much higher than the AR of Chinese speakers (Mean = 5.25, SE = .10) when they read the passage in their L1, the difference decreased when they read it in English (Korean: Mean = 4.06, SE = .09; Chinese: Mean = 3.72, SE = .08).

<Figure 8> A two-way interaction between script and L1 on AR



V. Discussion

1. Differences in Speech Rhythm and Speech Rate of English Reading Among Native, Chinese, and Korean Speakers

Overall, we found that nPVI-V, SR, and AR are good predictors of fluency for assessing the three groups' English pronunciation. For starters, the results suggest that native English has a more stress-timed rhythm than Korean English, whereas Chinese English is intermediate between native and Korean English. Native English speakers demonstrated greater variability in adjacent vowel intervals and appeared to have a higher nPVI-V, whereas Chinese and Korean speakers did not vary in the duration of adjacent vocalic intervals as much as native speakers. In other words, vowel recurrence did not appear to be as regular in native speakers as it was in Chinese and Korean speakers of English. In this study, it was discovered that the Chinese and Korean speakers pronounced the vowels in the non-prominent syllables as full as the stressed syllables, which prevented these speakers from achieving isochrony between stresses.

In addition, the results indicate that Chinese English exhibits a higher degree of stress timing than Korean English. Korean speakers did not appear to distinguish between stressed and unstressed syllables, demonstrating their L1's syllable-timed properties. This finding supports prior findings, such as those of Lee and Kim (2005) and Jang (2009). Chinese speakers, on the other hand, appeared to shorten unstressed syllables more than Korean speakers but created less durational contrast between adjacent vowels than native speakers. Thus, nPVI-V in Chinese speakers' English was neither stressed-timed nor syllable-timed. The nPVI-V values for Chinese speakers in this study are consistent with Low's (2010) findings of 61.62 for the same passage. However, this contradicts prior findings, including those of Mok and Dellwo (2008), who found that Chinese English tends to be syllable-timed.

Second, speech fluency is typically correlated with fewer and shorter pauses, and other disfluency markers (Derwing and Munro 2015). If learners produce utterances without frequent or long pauses, then the SR is high. When there are frequent or many lengthy pauses, then the SR may be low. Because the reading included many complex clauses (e.g., those that contain which, when, that, who), this study also investigated the relationship between pauses at grammatical junctions and English fluency. The results revealed that the reason Chinese speakers' English had a slower SR value than that of native speakers' English could be attributed to a failure to naturally link sounds at word boundaries when reading English, resulting in frequent pauses or disfluent pauses. In contrast, the results also showed that Korean speakers appeared to be more skilled at word junctions and did not display frequent pauses or disfluent pauses.

Third, when the pauses were removed, Chinese and Korean speakers differed significantly from native speakers, suggesting that they may inappropriately apply the reduction rule when reading English utterances, resulting in decreased fluency. Chinese and Korean speakers tend to pronounce an unstressed vowel with a full vowel, resulting in a slightly longer duration in the vowel. In addition, segmental characteristics of native speakers, such as phonetic deletion, assimilation, weak form, or elision, may also affect the results of their rapid AR. Phonetic rules such as those used by native speakers appear to result in a shorter duration of utterance, which increases the AR of native speakers' utterances. Kim (2017) proposed that L2 learners speak more slowly than native speakers due to articulatory difficulties, which leads to the incompletely developed production of prosodic features. However, Chung (2013) showed that the AR of Korean speakers is faster than that of native speakers, which suggests that fast speakers frequently employ syllable-timed rhythms.

When reading English, Chinese speakers have a much slower SR and AR, while Korean speakers, similar to Chinese speakers, have a much slower AR than native speakers. Korean and Chinese speakers do not exhibit a distinct stress pattern, and the prominence of syllables within a word or sentence is relatively constant. This trend toward a greater degree of syllable timing may also cause Chinese and Korean speakers' reading in English to sound slower than native speakers'. Furthermore, the difference in speech rate is not simply because speakers with different L1s implement suprasegmental features differently. As Detey, Fontan, Le Coz, and Jmel (2020) noted, fluency issues, whether at the segmental or suprasegmental level, can be difficult.

2. Differences in Speech Rhythm and Speech Rate Among Native, Chinese, and Korean Speakers' L1

From the second research question results, we can see that nPVI-V, SR, and AR provided acoustic evidence for rhythm and rate differences across the three different languages. In terms of speech rhythm, the results in this study also support the conventional rhythmic category of Chinese and Korean as syllable-timing languages. When Chinese and Korean speakers read the passage in their L1, their L1 background had no effect on their rhythm. One of the primary explanations for the differences in rhythmic patterns between the three language groups can be found in the three languages' phonological differences. English has a complicated syllable structure, whereas changing the duration of segments, especially vowels, is not as prevalent in Chinese and Korean as it is in English, resulting in their less variable rhythm than that of English. Native speakers vary the segmental duration pattern, as well as the pitch and loudness difference, to control the syllable's emphasis. Chinese and Korean speakers, on the other hand, tend to emphasize each syllable with the same duration. Due to these temporal characteristics of Chinese and Korean, the durations of adjacent vowel intervals are relatively equal.

In addition, the low nPVI-V values of Chinese and Korean speakers may be attributed to the failure of accurate syllabification by less-proficient nonnative English speakers. Because multiple clusters are not allowed in onset or coda positions in Chinese and Korean, they tend to distort the syllable structure of English by inserting an extra vowel in the consonant cluster of English. Therefore, the insertion of segments in certain contexts certainly poses a problem for segmental duration. This is also due to the syllable structure differences between the three languages. According to Deterding (2011), both foot and syllable measurements are significant when evaluating rhythm. However, the effect of syllable count on rhythm should be further investigated in a future study.

When the features of L2 do not appear in L1, learners may take action to force the features of L2 to conform to L1 restrictions. Chinese and Korean speakers are more likely to end their words with an additional vowel [ɨ], lengthen both functional words and content words, frequently employ lengthened words in various positions arbitrarily, and have less contrast between long and short vowels. Thus, pronunciation habits may have a noticeable effect on the temporal characteristics of Chinese and Korean speakers. In terms of subjective impression, both Chinese and Korean are considered syllable-timed languages. When Chinese and Korean speakers read English, the rhythm of Chinese speakers' English is more similar to that of native speakers than to that of Korean speakers. This could be a result of some degree of vowel reduction found in Chinese. In addition, Korean SR is, in fact, faster than Chinese SR. This could be due to the fact that Korean has a greater degree of liaison and less pause.

3. Differences in Speech Rhythm and Speech Rate Between English Reading and L1 Reading by Chinese and Korean Speakers

When reading English, both Chinese and Korean speakers fall somewhere between their L1 and the target language in terms of the realization of adjacent vowel interval variability. Although Chinese and Korean speakers' L1 interference in their English-speaking rhythm is minimal, it is somewhat difficult for them to acquire proper English rhythm due to the differences between their L1's syllable structure and that of English. This indicates that both Chinese and Korean speakers can acquire some rhythm when reading English, but both have an obvious nonnative accent, particularly Korean speakers. That is also why the nPVI-V of the L1 reading of the Chinese and Korean speakers is lower than that of the native English speakers.

It could be assumed that the close geographical, phonological, and rhythmic pattern similarities between China and Korea would result in a similar speech rate for Chinese and Korean speakers when reading a passage in their L1. The results, however, indicate that there is a significant difference in the speech rate between the two language groups when they read in their L1 but no difference when they read in English. While there are numerous similarities in pronunciation between these two languages, the relatively independent formation of each language may account for observed differences in features of their L1, such as SR and AR.

In contrast to the results obtained when the three groups of speakers read English, the SR and AR of Chinese and Korean speakers were significantly higher than those of native English speakers when they read the passage in their L1. Chinese and Korean speakers appeared to be more at ease reading the passage in their native tongue; the related cognitive load would be significantly reduced compared to when they read in English. This is not true for nPVI-V. Native speakers' nPVI-V was significantly greater than that of Chinese and Korean speakers, regardless of whether they read the English passage or its translation in their L1. This strongly implies that each acoustic parameter, namely, nPVI-V, SR, and AR, is self-contained. That is, stress timing does not always imply a rapid speech rate or vice versa.

VI. Conclusion

Temporal characteristics pervade all facets of speech production and have the potential to alter linguistic output. Indeed, the majority of students who participated in the study's recording were non-English majors. Their English courses, in particular, rarely discussed pronunciation norms, and it may have been difficult for them to devote sufficient time to the systematic acquisition of English rhythm and rate. Therefore, these students were more likely to use their L1 pronunciation habits without additional practice and assistance from EFL teachers. One main reason for this omission is that temporal aspects, which involve subjective impressions, make it difficult for EFL teachers to perceive students' fluency just by listening to utterances. For this reason, it is necessary to arm teachers with adequate knowledge of speech's temporal characteristics and to assist them in designing effective methods and techniques for teaching English rhythm and rate.

For example, mini-lessons on English pronunciation could be designed to teach students the intrinsic characteristics and differences in rhythm and rate between English and their L1. A mini-lesson is a five- to fifteen-minute session during which language learners are introduced to necessary pronunciation concepts, skills, and strategies. When listening to students read the assigned utterance, the teacher can determine whether English learners correctly recognize the rhythm and rate differences between their L1 and English in a brief period of time. In general, the order of instruction would be "presentation-practice-use-feedback." First, teachers should help learners build new categories in their minds rather than allowing L1 knowledge to obstruct L2 learning. Second, teachers should thoroughly familiarize students with pronunciation rules and then have them practice reading them according to the rules. Third, once students are familiar with prosodic features, they should be trained to assign perceived highlights in discourse. Finally, speech analysis programs such as Praat, SFS, Wavesurfer, Audacity, and so on can be used in English instruction to provide students with specific contrastive feedback. EFL teachers should identify the intrinsic issue and provide explicit instructions to help students focus on their areas for improvement. As a result of this practice, students may develop a greater sensitivity to temporal variations in connected speech.

In conclusion, while this study yields some significant findings about the temporal characteristics of the three languages, it also has some limitations. Because read speech has a limited sentence structure, it was impossible to include all of the rhythmic patterns in the current study. As a result, it is necessary to further explore the English rhythmic patterns of Chinese and Korean English learners using resources other than read speech, such as a narrative or a conversation. Additionally, the current study is limited to an examination of temporal characteristics. Prosodic elements such as pitch and intonation have an effect on speech production. Therefore, it is necessary to explore the relationship between these elements and intelligibility. Finally, it should be acknowledged that the participants selected in this study were analyzed as a whole. Therefore, future research may include a comparison according to the participants' English proficiency levels.

▢ Appendices

A: English Reading

The North Wind and the Sun were disputing which was the stronger, when a traveler came along wrapped in a warm cloak. They agreed that the one who first succeeded in making the traveler take his cloak off should be considered stronger than the other. Then the North Wind blew as hard as he could, but the more he blew the more closely did the traveler fold his cloak around him; and at last the North Wind gave up the attempt. Then the Sun shone out warmly, and immediately the traveler took off his cloak. And so the North Wind was obliged to confess that the Sun was the stronger of the two.

B: Chinese Speakers' reading of Chinese Translation

有一回，北風跟太陽在那儿爭論誰的本事大，爭來爭去就是分不出高低來。這時候，路上來了个走道儿的，他身上穿着件厚大衣。他們倆就說好了，誰能先叫這个走道儿的脫下他的厚大衣，就算誰的本事大。北風就使勁儿的刮起來了。不過，他越是刮的厲害，那个走道儿的把大衣裹的越緊，后來，北風沒法儿了，只好就算了。過了一會儿，太陽出來了，他火辣辣的一晒，那个走道儿的馬上就把那件厚大衣脫下來了，這下，北風只好承認他們倆当中還是太陽的本事大。

C: Korean Speakers' reading of Korean Translation

바람과 해님이 서로 힘이 더 세다고 다투고 있을 때, 한 나그네가 따뜻한 외투를 입고 걸어 왔습니다. 그들은 누구든지 나그네의 외투를 먼저 벗기는 이가 힘이 더 세다고 하기로 결정했습니다. 북풍은 힘껏 불었으나 불면 불수록 나그네는 외투를 단단히 여몄습니다. 그 때에 해님이 뜨거운 햇빛을 가만히 내려 쬐니, 나그네는 외투를 얼른 벗었습니다. 이리하여 북풍은 해님이 둘 중에 힘이 더 세다고 인정하지 않을 수 없었습니다.

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☐ Abstract

Comparisons of the Rhythm and Speech Rate in Paragraph Reading between Native, Chinese, and Korean Speakers of English

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The goal of this study is to look into the speech rhythm and rate of native English speakers, Chinese speakers, and Korean speakers when reading in English, with a particular emphasis on the nPVI and speech rate, which are critical timing variables used to predict which differences between English and the English learner's L1 cause difficulty. The study discovered that the rhythm of native English speakers had the most stress-timing of any reader, regardless of reading language, and that the rhythm of Chinese speakers had more stress-timing than that of Korean speakers. Furthermore, native English speakers had the fastest speech rate and articulation rate during English reading, whereas Korean speakers had the fastest speech rate and articulation rate during L1 reading. When reading the passage in their L1, Chinese and Korean speakers were the overall fastest in terms of speech rate and articulation rate. These findings demonstrate the fundamental differences in rhythm between English, Chinese, and Korean speakers. It was revealed that the temporal characteristics, segmental structure, and syllable structure of Chinese and Korean speakers' L1 are frequently transferred to the rhythm and rate of English reading.

Key Words: articulation rate, fluency, nPVI, rhythm, speech rate/ 조음 속도, 유창성, 연속 단위 변동성 표준화 지수, 리듬, 발화 속도

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