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Vowel Duration and the Feature of the Following Consonant

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ABSTRACT

Duration of the preceding vowel is known to vary as a function of the (phonological or phonetic) voicing feature of the following consonant. This study raises a question against this general belief. A spectrographic experiment using 14 Korean obstruents (three sets of stops: /p, p', p^h/, /t, t', t^h/, /k, k', k^h/; one set of affricates: /c, c', c^h/; one set of fricatives: /s, s'/) reveals that (1) phonetic voicing in the intervocalic lax consonants /p, t, k, c, s/ has nothing to do with the duration of the preceding vowel; (2) vowel length is significantly shorter before tense consonants than before their lax cognates while tense consonants are significantly longer than their lax cognates. Importantly, Korean obstruents are all phonologically voiceless. Therefore, the voicing feature is rejected as the cause of preconsonantal vowel shortening in Korean both phonetically and phonologically. It is suggested that the temporal phenomenon is basically a kind of physiologically-motivated coarticulation though it is restricted by the phonology of a given language. To meet this assumption, the feature voicing should be replaced with the feature tenseness as the cause, which will enable us to explain the temporal phenomenon on the same basis irrespective of language.

Keywords: Preconsonantal vowel shortening, feature, voicing, tenseness, coarticulation

1. Introduction

With reference to preconsonantal vowel shortening, a controversial problem arises from the feature of the following consonant, which exerts its effect on the preceding vowel duration. The literature ascribes the variation of the preceding vowel duration to the function of the feature voicing in the following consonant. That is, it is generally believed that in many languages, a vowel followed by a voiced consonant is longer than that followed by a voiceless consonant, whereas a voiced consonant is shorter than its voiceless cognate. These opposite temporal variations occurring within a syllable or across a syllable boundary offset each other and keep the duration of the VC unit relatively constant (Chen, 1970; Port, Al-Ani & Maeda, 1980; Port & Dalby, 1982; Port, Dalby & O'Dell, 1987; Sato, 1993). However, it is of great interest that the voicing feature in the following consonant has been known as the cause of the temporal compensation with no physical (phonetic) evidence. As mentioned earlier, most books and papers of phonetics and phonology simply explain the phenomenon, relying on the contrast of voicing in the following consonant. Therefore, preconsonantal vowel shortening, which is allegedly due to the feature voicing of the following consonant, has long been a kind of knowledge to have to be taught and learned by teachers and students in the area of phonetics and phonology rather than an issue to be questioned. For instance, Chen (1970, p. 129) described the purpose of his research as "to examine the variations of vowel length as a function of the [±voice] feature of the following consonant." After he tentatively hypothesised that the vowel shortening before voiceless consonants is language universal, Chen (1970) tried to account for the phenomenon physiologically, but never questioned the feature voicing of the following consonant. Though there are a great number of other studies concerning the phenomenon, most of them are just using the term "voicing effects" or "voicing feature," etc. of the following consonant without careful insight (e.g., House & Fairbanks, 1953; Zimmerman & Sapon, 1958;

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Peterson & Lehiste, 1960; House, 1961; Fintoft, 1961; Sharf, 1962; Lehiste, 1970; Klatt, 1973, 1976; Raphael, et al., 1975; Suomi, 1976; Fox & Terbeek, 1977; Flege & Port, 1981; Walsh & Parker 1981; Mack, 1982; Port & Mitleb, 1983; Kluender, et al., 1988; Davis & Summers, 1989; Hiramatsu, 1990; Crowther & Mann, 1990; Flege, et al., 1992; Sato, 1993). Even some researchers (e.g., Walsh & Parker, 1981) who found no cause and effect relationship between phonetic voicing in the following consonant and duration of the preceding vowel eventually attribute preconsonantal vowel shortening to the "abstract voicing feature" in the following consonant. Here, we should ask what "abstract voicing feature" or "underlying voicing feature" is. They say the feature voicing has a clear-cut definition, i.e., full voicing appears in voiced consonants. However, the definition is not well observed in some languages whose obstruents are said to be phonologically differentiated by the [±voice] feature. The typical example is English in which phonologically voiced obstruents are hardly voiced in word initial position, frequently partially or fully devoiced in word final position, and frequently partially devoiced in word medial position. However, the preceding vowel undergoes shortening before phonologically voiceless obstruents regardless of the absence/presence of the real phonetic voicing. Therefore, many studies indicate that phonetic voicing is not necessarily the perceptual cue to discriminate English voiced/voiceless consonants. Rather than that, the durational ratio between the preceding vowel and the following consonant (e.g., Denes, 1955; Lisker, 1957; Port & Dalby, 1982) and the manner of termination of the preceding vowel (Parker, 1974), etc. have been proposed as an alternative cue. Now, someone may suspect that the "abstract voicing feature" is another expression of tenseness feature, not the original voicing feature.

Provided duration is a reflection of force of articulation, we should raise a question of why the feature tenseness has not been accepted as the cause of preconsonantal vowel shortening phenomenon instead of the feature voicing which does not manifest itself as the physical cause. Perhaps because the two features voicing and tenseness are accompanied by each other in many languages and especially because the feature voicing has been regarded as the primary feature across many languages (e.g., Lisker & Abramson, 1964, 1967), we appear to have had a serious misunderstanding as to the cause of the temporal phenomenon. What is more, the feature tenseness has not been widely accepted as an autonomous distinctive feature, on the grounds that consistent and reliable correlates of a tense/lax dimension have not been found especially in English. This must have discouraged linguists and phoneticians to acknowledge the feature tenseness as the cause of preconsonantal vowel shortening. Through a deep review of the literature, however, Yun (2003) investigated strong and weak points of each of voicing and tenseness features and suggested that the autonomy of tenseness as a feature should be acknowledged to enhance naturalness and generality in phonology. In particular, Yun (2003) proposed that tenseness is **a complex and indirect feature** due to its intrinsic abstractness while voicing or aspiration is **a simple and direct feature**. That is, one phonetic correlate is the feature itself in voicing or aspiration, but multiple correlates can only reflect tenseness. It can be indicated that all correlates of tenseness do not always accompany the feature. But Yun rejected the indication, stating that the inconsistency and diversity of correlates is the nature rather than the weakness of the feature tenseness.

Korean obstruents have three- or two-way dimensional distinctions within three sets of stops (/p, p', p^h/, /t, t', t^h/, /k, k', k^h/), one set of affricates (/c, c', c^h/) and one set of fricatives (/s, s'/) except /h/ which does not have its cognates. Yet they are all phonologically voiceless. Only the features tenseness and aspiration phonologically distinguish them. Therefore, basically the feature voicing can not be the cause of preconsonantal vowel shortening from the phonological point of view. Nevertheless, according to the literature, researchers are not likely to distinguish languages with respect to the cause of preconsonantal vowel shortening (e.g., Chen, 1970). Though Korean obstruents do not have a voicing contrast, lax stops /p, t, k/ and affricate /c/ tend to become partially or fully voiced in intervocalic position. This may be the theoretical basis on which voicing is regarded as the cause of the temporal phenomenon in Korean as well. But we should ask a question of what the relationship of phonetic voicing in the following consonant and duration of the preceding vowel is. If it is the case that voicing causes the temporal variation, a significant positive correlation should be found between the duration of the preceding vowel (or syllable) and the duration of voicing in the following consonant, i.e., the longer the voicing in the following consonant, the longer the preceding vowel. Our study will identify this, using Korean speech materials. Although some researchers have already reported no cause and effect relationship between phonetic voicing in the following consonant

and duration of the preceding vowel in English (e.g., Walsh & Parker, 1981), we could add to new data to confirm it in Korean and go further to clarify whether or not even phonological voicing could remain the cause of the temporal variation. Besides, we will investigate vowel length before tense *vs.* lax consonants, and also the duration of tense/lax consonants. It has already been reported that a vowel or syllable before a lax consonant is longer than that before a tense consonant while a lax consonant is shorter than its tense cognate(s) in Korean (Chen, 1970; Sato, 1993; Yun, 2004). Thus, the investigation of the durational variation of the preceding vowel and the following tense/lax consonant will firstly confirm the previous studies and secondly help us judge which is the cause of the vowel length variation between voicing and tenseness feature.

2. Methods

12 native speakers of Korean (six males and six females) served as subjects. They were in their twenties or thirties at the time of recording. No one had reportedly any hearing or speaking disorders. The target word frame was /maCa/ where C was one of Korean stops (/p, p', p^h, t, t', t^h, k, k', k^h/), affricates (/c, c', c^h/) and fricatives (/s, s'/). The words embedding Korean obstruents were phonetically either real words (e.g., /mata/ "every"; /maka/ "to block" or "a surname ma"; /maca/ "to be beaten"; /masa/ "a kind of sand"; /mac^ha/ "a cart") or nonsense words (e.g., /mapa/, /mak^ha/), but all of them were natural to pronounce. They were inserted into a sentence frame, "yeki /maCa/-do issta." (= Here is /maCa/, too.).

A reading list was prepared where the 14 sentences containing each of the 14 target words were written in six different orders within individual sets. The 12 subjects delivered it at their normal speech rate, yielding a total of 1,008 tokens (14 items (sentences) × 6 repetitions × 12 subjects). Recording was performed using a high quality recorder and a microphone in the sound treated recording room of the Speech Research Laboratory at Reading University. The recording was digitised onto a Sun Sparcstation at a sampling rate of 16 kHz with 16 bit resolution and saved as files to be processed by the software package WAVES+/ESPS. From the files, waveforms and spectrograms were generated. The targets of measurements include preceding vowel duration (PVD), consonant duration (closure duration in stops, closure duration plus affrication in affricates, and frication in fricatives), and voice cessation time (VCT) during the consonant duration. Based on consonant duration (CD) and VCT, PCT (VCT as percentage of consonant duration) was obtained. It could sometimes be difficult to segment an utterance into discrete linguistic units. Closure duration in stops was the interval from the end (the offset of the regular pulse of vowels and/or the end of the first and second formants of vowels) of the preceding vowel /a/ to the release of the stops. Durations of affricates and fricatives were the interval from the end of the preceding vowel /a/ to the onset of the following vowel /a/.

3. Results

Is the preceding vowel duration associated with the phonetic voicing in the following consonant? If this is the case, PVD should have a significant negative correlation with VCT or PCT of the following lax consonants, which showed inconsistent PCT, i.e., from full devoicing to full voicing. In order to answer this question, correlation coefficients were examined between the preceding vowel duration (PVD) and VCT, and between PVD and PCT in lax stops /p, t, k/, affricate /c/ and fricative /s/. A hypothesis was established as this: the longer VCT the longer PVD or the higher PCT the longer PVD. The correlation coefficients obtained are presented in Table 1.

Table 1. Correlation coefficients between PVD and VCT, and between PVD and PCT in three lax stops /p, t, k/, one lax affricate /c/ and one lax fricative /s/ (ns: not significant: $-0.31 < r < +0.31$) (12 subjects, n = 72)

Type	/p/	/t/	/k/	/c/	/s/
PVD : VCT	−0.073 ns	−0.373*	−0.113 ns	−0.083 ns	−0.125 ns
PVD : PCT	−0.116 ns	−0.374*	−0.182 ns	−0.103 ns	−0.123 ns

ns: not significant, *: $p < 0.05$ **: $p < 0.01$

As seen in Table 1, the correlations are generally negligible, though some significant correlations are observed in lax alveolar stop /t/. Moreover, even the slightly significant correlations in /t/ deny rather than support the hypothesis (i.e., the longer VCT the longer PVD or the higher PCT the longer PVD), because the two correlation coefficients are all negative. The negative correlations mean the longer VCT the shorter PVD or the higher PCT the shorter PVD, which, of course, contradicts the hypothesis.

We also examined correlation coefficients between the same variables as the above (in each consonant and across all consonants) for each speaker. The individual results generally accorded to the overall results. First, for PVD : VCT in each consonant were significant only four (Spk 3: 0.910* in /k/; Spk 4: 0.870* in /t/; Spk 5: −0.920** in /t/; Spk 10: −0.878*: in /s/) out of 60 correlations, and for PVD : VCT across all consonants was significant only one (Spk 3: 0.455*) out of 12 correlations. Second, for PVD : PCT in each consonant as well were significant only six (Spk 2: 0.871* in /c/; Spk 3: 0.930* in /k/; Spk 4: 0.926** in /t/; Spk 6: 0.878* in /p/; Spk 8: −0.815* in /s/; Spk 10: −0.875* in /s/) out of 60 correlations, and for PVD : PCT across all consonants was significant only one (Spk 3: 0.470**) out of 12 correlations. It should be noted that even the few significant correlations are not consistently positive or negative. All the other non-significant correlations were not, either. All in all, the individual statistical results also generally confirm that there are no significant and consistent correlations between PVD and VCT or PCT.

Let us take some real tokens directly from the data of one subject who produced very contrastive PCT (or VCT). In the case of a female subject (Spk 4), four out of six tokens of velar stop /k/ were fully voiced, whereas the remaining two were fully devoiced. If the hypothesis works properly, the mean PVD of the four fully voiced tokens would be significantly longer than that of the two fully devoiced tokens. However, the average (111.5 ms) of the preceding vowel durations (116 ms, 114 ms, 116 ms and 100 ms) of the four fully voiced tokens was even shorter than that (115 ms) of the two fully devoiced tokens (112 ms, 118 ms) though the difference may not have statistical significance. The correlations also were not significant (−0.100 ns for PVD : VCT and −0.277 ns for PVD : PCT). The hypothesis (i.e., the longer VCT the longer PVD or the higher PCT the longer PVD), therefore, is rejected by the individual data again.

Table 2. F-ratios and p-values for the phoneme type (tense/lax) effects on PVD (12 subjects; n = 216 in stops and affricates; n = 144 in fricatives)

Type	/p, p', p^h/	/t, t', t^h/	/k, k', k^h/	/c, c', c^h/	/s, s'/
F-ratios	362.84***	369.93***	472.30***	511.97***	133.80***

***: $p < 0.001$

On the other hand, PVD markedly varied with the feature tenseness of the following consonant. The ratio between the average vowel durations was 1 (109 ms) : 0.75 (82 ms) : 0.78 (85 ms) before /p, p', p^h/; 1 (117 ms) : 0.74 (86 ms) : 0.76 (89 ms) before /t, t', t^h/; 1 (121 ms) : 0.71 (86 ms) : 0.71 (86 ms) before /k, k', k^h/; 1 (121 ms) : 0.74 (90 ms) : 0.77 (93 ms) before /c, c', c^h/; 1 (116 ms) : 0.82 (95 ms) before /s, s'/. By contrast, the ratio between the average consonant durations was 1 (52 ms) : 2.4 (125 ms) : 2.08 (108 ms) in /p, p', p^h/; 1 (46 ms) : 2.65 (122 ms) : 2.17 (100 ms) in /t, t', t^h/; 1 (44 ms) : 2.59 (114 ms) : 2.14 (94 ms) in /k, k', k^h/; 1 (73 ms) : 1.9 (139 ms) : 2.18 (159 ms) in /c, c', c^h/; 1 (90 ms) : 1.47 (132 ms) in /s, s'/. Analyses of variance in the vowel durations yielded significant main effects for the factor Phoneme Type (tense *vs.* lax) in every set of consonants (see Table 2), and Post-hoc Tukey's HSD tests ($p = 0.05$) also showed that with no exception the length of vowel /a/ was significantly shorter before tense consonants than their lax cognates, but the vowels preceding tense (unaspirated *vs.* aspirated) consonants were similar in duration. Individual data also agreed with the pooled data. These results support those of the previous studies (Chen, 1970; Yun, 2004).

In summary, all the results show that there is no significant and consistent correlation between the phonetic (acoustic) voicing

during the following lax consonants (three stops, one affricate, one fricative) and the preceding vowel duration even if the intervocalic lax stops /p, t, k/ and lax affricate /c/ show considerably longer VCT and higher PCT than their tense counterparts. Rather, PVD significantly varied with the feature tenseness of the following consonants. Therefore, phonetic voicing is rejected as the cause of the significant variation of PVD and the feature tenseness of the following consonants remains the only alternative. In particular, when it comes to the two Korean fricatives /s, s'/ that are not discriminated as a function of voicing both phonologically and phonetically, voicing is basically excluded as a plausible factor for the significant durational difference in the preceding vowel.

4. Conclusion

We have generally believed that duration of the preceding vowel varies as a function of the feature voicing of the following consonant. However, the results of this study are opposed to the belief. That is, our Korean data clearly indicate that phonetic voicing in the following consonants has nothing to do with the preconsonantal vowel duration. Phonological voicing is also rejected as the cause of the durational variation of preceding vowel at least in Korean that does not have a voicing contrast between cognate consonants. Moreover, the tenseness feature of the following consonants led PVD to significantly vary while the tense/lax consonants themselves varied inversely (see also Chen, 1970; Yun, 2004). It is, therefore, natural to conclude that the feature tenseness of the following consonants causes the PVD variation in Korean. Some phonologists and phoneticians (e.g., Lisker & Abramson, 1964, 1967) may still insist that the primary distinctive feature in consonants be voicing and the cause also be the feature voicing. Such an idea may be acceptable when it comes to languages that have both a phonological and phonetic voicing contrast in their consonants. However, voicing cannot explain everything in all languages. The so-called "abstract voicing," which is frequently used as an alternative of the inconsistent and unreliable phonetic voicing in English obstruents, only weakens voicing as a distinctive feature rather than strengthens (Yun, 2003). Phonological voicing that, against its definition, exists without reference to real (phonetic) voicing is unlikely to be appropriate as the cause of the preconsonantal vowel shortening. As we suspected above, therefore, it seems that the [±voice] feature of the following consonant or "abstract voicing" that is believed to trigger the preconsonantal vowel shortening is practically tenseness feature. It will be more desirable to explain in the same way presumably the same linguistic phenomenon across many languages. In addition, this will give the language universal grammar more generality (Yun, 2003). More than a half century ago, some scholars such as Delattre (1941) and Belasco (1953) had already claimed that the reverse relationship between a preceding vowel and a following consonant comes from different force of articulation (muscular efforts) for the following tense/lax consonants. The vowel shortening before tense consonants is suggested to be basically a kind of physiologically-motivated coarticulation even though phonology in each language controls the degree or pattern of the coarticulation (Yun, 2004; see also Chen, 1970; Maddieson, 1985). Couldn't we expect that our textbooks of phonetics and phonology describe there is a cause and effect relationship between the preceding vowel duration and the feature tenseness, not voicing in the following consonants?

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