CONSONANT-LABIOVELAR GLIDE COMBINATIONS IN SPANISH AND KOREAN

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ABSTRACT

This paper investigates the acoustic properties of the combinations of a consonant and a labiovelar glide (C*w* combinations), and shows that the universally favored and disfavored consonant places for C*w* combinations provide acoustically the most and the least salient C-C*w* contrast, respectively. Spanish and Korean, different in how they phonetically implement the C*w* combinations (one a consonant cluster and the other a labialized consonant), are used as subject languages.

Keywords: Korean, Spanish, Stop burst frequencies, Labiovelar glide, Labialization

1. INTRODUCTION

It is reported that languages disfavor labial consonants in C*w* clusters, and prefer velar place for contrastive labialization (Kawasaki [4], Ladefoged and Maddieson [5]). Contrary to the well-known formal constraints on two adjacent place features (OCP), Flemming [2] proposes that the rarity of labials in C*w* cluster is due to the insufficient distinctiveness between singleton C and C*w* clusters in acoustic factors, though he provides no experimental evidence in support of his proposal.

This paper uses acoustic measures to test the distinctiveness of CV-C*w*V contrast, using data from Spanish and Korean. The phonological status of the C*w* combinations in these languages is similar, *i.e.*, *w* is considered to be a non-syllabic allophone of a high vowel /u/ when followed by another vowel, or on-glide of a diphthongal vowel (Hualde [3], Sohn [6]). However, the two languages seem to differ in the phonetic status of the C*w* combination. In Spanish C*w* combination is understood to be a sequence of a consonant and a glide, hence a consonant cluster, like other complex onsets in the language (*e.g.*, C*l* or C*r*). For Korean, Ahn [1] suggests a syllable structure in which a consonant and a glide branch from a single consonant slot, thus form a consonant with the secondary articulation of labialization. However, little or no attention has been paid to which acoustic properties can best characterize this timing difference. Therefore this study also aims at showing how two types of C*w* combinations differ in acoustic measures.

2. METHODS

2.1. Recording

Recording was done in a sound treated room, using Marantz digital recorder PMD 660 and Shure SM 48 microphone, at sampling rate 44100Hz. 4 Argentinean Spanish speakers (2 males and 2 females) and 4 Standard Korean speakers (2 males and 2 females) of age 24 to 35 participated. 24 Spanish and 24 Korean bisyllabic nonsense words, beginning with a plain C or C*w* combination, were recorded. The initial consonants were voiced and voiceless stops /b, p, d, t, g, k/ for Spanish, and lenis and fortis stops /p, p*, t, t*, k, k*/ for Korean. The C or C*w* combination was followed by /a/ or /e/. The second syllable started with a labial stop in both languages. Each token was produced in the initial position of a carrier sentence.

2.2. Measurements

Flemming [2] argues that the second formant (F2) of vocoid onset and the spectral properties of the consonant at the release are the acoustic factors that provide auditory cues for the CV-C*w*V contrast. In C*w*V syllables, the lower F2 at the onset of vocoid is the cue for the presence of *w*, as opposed to the higher F2 at the CV vocoid onset. It has been reported that the release burst noise spectral mean frequency for English alveolar and velar stops is significantly lower in stop+*w* clusters than in singleton stops (Zue [7]). In addition to the onset F2 and stop burst noise spectral cues, the direction and degree of F2 change from the onset toward the syllable nuclei are examined in this study, under the hypothesis that dynamic properties might be as important in cuing the contrast as the stative characteristics such as F2 at vocoid onset.

Praat version 4.4.16 was used for all analyses. F2 at vocoid onset was measured by aligning the left edge of a 25 ms window to the beginning of vocoid. F2 was also measured later in the vocoid to assess the F2 change direction and degree: the F2 maximum (when F2 rises out of C) or the steady state F2 (when it falls). When the F2 fell from the onset and then rose toward the vowel (*e.g.*, Spanish T*w*V), both F2 minimum and maximum were measured. Formant measurement was done by Praat script and checked by eye. Stop release burst noise spectrum was computed from 30 ms window centered at the onset of the stop burst. Spanish voiced stops were not included in the burst noise spectral analysis, due to the frequent fricativization by some speakers. Prior to the FFT the signal was downsampled to 22050 Hz, and filtered through pass Hann band filter (500-9000 Hz). Spectral mean, defined as the mean of the frequency values weighted by their amplitudes, was calculated from each spectrum.

3. RESULTS

3.1. F2 at vocoid onset (onset F2)

Average and standard deviation of F2 measured at the vocoid onset of CV and C*w*V syllables are shown in Figures 1 and 2 (P, T, and K are used to represent both voiced and voiceless, and fortis and lenis, bilabial, dental/alveolar, and velar stops, respectively). The cross-linguistic comparison suggests that the F2 lowering effect of *w* is stronger in Spanish than in Korean. Two-way ANOVA showed that the interaction between the factor *w* (*i.e.*, whether the syllable is CV or C*w*V) and the factor language was significant ($F(1,749)=98$, $p<0.001$). After a velar stop the effect of *w* was the strongest in Spanish. Two-way ANOVA carried out separately on each language showed that the interaction between place and *w* was significant in Spanish ($F(2,374)=74$, $p<0.001$), but not in Korean ($F(2,374)=2$, $p=0.12$). Comparing P and T, we can find that PV and P*w*V are no less distinctive from each other than TV and T*w*V are. For example, in Spanish the difference between PV and P*w*V average onset F2 was 810 Hz versus 743 Hz for TV and T*w*V. Therefore contrary to Flemming's ([2], 177) prediction, the F2 at vocoid onset measure does not prove that the contrast between P and P*w* is the weakest.

Figure 1: Average F2 at vocoid onset of Spanish.

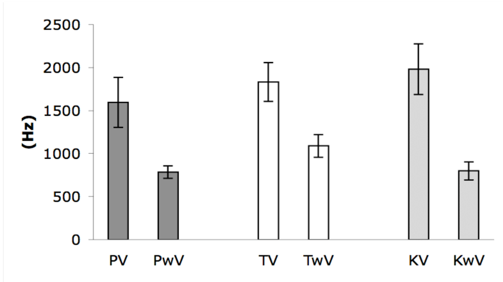
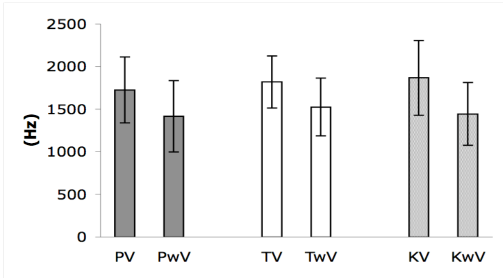


Figure 2: Average F2 at vocoid onset of Korean.



F2 at vocoid onset reflects the different phonetic status of the glide *w* in the two languages. When the effect of *w* was compared between two different vowel contexts, the F2 at vocoid onset in Spanish C*wa* and C*we* did not vary significantly in ANOVA ($F(1,189)=2.68$, $p=0.1$). This is not surprising considering that Spanish C*w* combination is a consonant cluster. The vocoid onset is the beginning of the labiovelar glide, which should not be affected by the backness of the following vowel. In Korean, in contrary, C*wa* and C*we* vocoid onsets differed significantly ($F(1,183)=221.12$, $p<0.001$) in their F2. This would not be expected if the C*w* combinations in Korean form a consonant cluster as in Spanish. However, if the *w* component of Korean C*w* combination is added to the consonant as a secondary articulation, the vocoid onset is the beginning of the vowel, and thus it is natural that its F2 is determined by the backness of the vowel.

Figures 3 and 4 below are the sample spectrograms of Spanish *twe* and Korean *t*we*, respectively.

Figure 3: Spectrogram of Spanish *twe*. F2 falls from the vocoid onset and then rises toward the maximum.

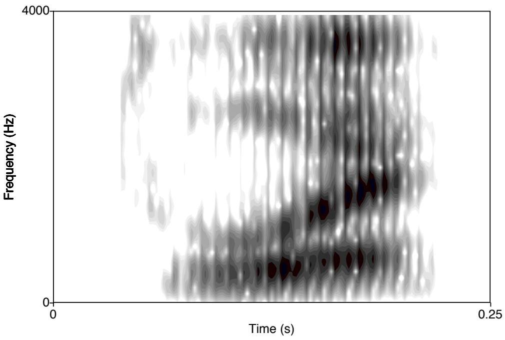
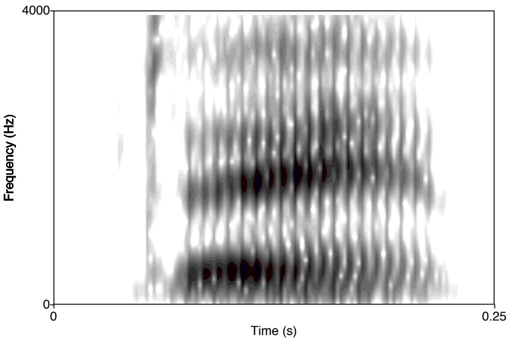


Figure 4: Spectrogram of Korean *t*we*. F2 rises from the vocoid onset toward the maximum.



3.2. F2 change direction and degree

As described in 2.2 above, F2 was measured at two or three different time points in each token. To characterize the F2 change direction as *rising, falling* or *level*, one-way ANOVA was carried out on the F2 values at two adjacent time points ($F2t_i$ and $F2t_{i+1}$) in tokens of the same syllable. If the $F2t_i$ was significantly higher or lower than $F2t_{i+1}$ ($p<0.05$), F2 change direction was labeled *falling* or *rising*, respectively. If $F2t_i$ and $F2t_{i+1}$ did not vary significantly, F2 change direction was labeled *level*. The F2 change direction within each syllable is shown in Tables 1 and 2 below, as well as the comparison between CV and C*w*V. F2 change direction did not distinguish between Spanish PV and P*w*V, since both exhibited rising F2. Spanish KV and K*w*V showed different F2 change directions: the former falling or level and the latter rising. Spanish T*w*V syllables exhibited F2 contour (See Figure 3 above) unlike other syllables, and were analyzed as having both falling and rising components. This made them distinctive from their TV counterparts in both vowel contexts.

Table 1: F2 change direction in CV and C*w*V of Spanish.

F2 change direction				CV-CwV comparison
Pa	rising	Pwa	rising	same
Ta	falling	Twa	falling	different
			rising	
Ka	falling	Kwa	rising	different
Pe	rising	Pwe	rising	same
Te	rising	Twe	falling	different
			rising	
Ke	level	Kwe	rising	different

Table 2: F2 change direction in CV and C*w*V of Korean.

F2 change direction				CV-CwV comparison
Pa	level	Pwa	rising	different
Ta	falling	Twa	level	different
Ka	level	Kwa	rising	different
Pe	level	Pwe	rising	different
Te	level	Twe	rising	different
Ke	level	Kwe	rising	different

The consonant place effect on CV-C*w*V contrast was not visible in Korean (Table 2), since the F2 change directions of CV and C*w*V were different from each other in all contexts. However, a significant consonant place effect was observed in the F2 change degree ($F2t_{i+1}$ - $F2t_i$) difference between Korean CV and C*w*V (Table 3).

Table 3: Average F2 change degree in CV and C*w*V of Korean (Hz). Inside parentheses are the standard deviations.

Pa	81 (107)	Pwa	304 (108)
Ta	-184 (134)	Twa	-35(117)
Ka	-93 (65)	Kwa	348(154)
Pe	144 (94)	Pwe	368 (175)
Te	109 (156)	Twe	323 (112)
Ke	-90 (108)	Kwe	408 (254)

The difference between CV and C*w*V was the greatest when C was K; Two-way ANOVA showed that the interaction of place and *w* were significant in both /a/ ($F(2,85)=12$, $p<0.001$) and /e/ ($F(2,91)=8$, $p<0.001$) contexts. Thus, K induces bigger CV-C*w*V contrast than other consonant places in terms of F2 change degree in Korean.[i]

3.3. Stop release burst spectral mean

In stop release burst spectral mean measure (Figures 5 and 6), Spanish KV-K*w*V ($F(1,61)=26$, $p<0.001$), Korean PV-P*w*V ($F(1,118)=17$, $p<0.001$) and K-K*w*V ($F(1,124)=115$, $p<0.001$) showed significant effect of *w* in one-way

ANOVA of each CV-C*w*V pair. Spanish PV-P*w*V, and Spanish and Korean TV-T*w*V difference did not reach the significance level. The effect of *w* was bigger for Korean KV-K*w*V than for PV-P*w*V; Two-way ANOVA on Korean PV, P*w*V, KV and K*w*V revealed that the interaction of place and *w* was significant ($F(1,254)=117$, $p<0.001$). Thus we can say that in both languages the difference between CV and C*w*V in stop burst spectral mean frequencies is the biggest for K. Unlike English /t/ release burst reported in Zue [7], the lowering effect of *w* on the spectral mean frequency was not obvious for Spanish and Korean T. This may be because Zue's spectrum included smaller frequency range (~5000 Hz) than the present study (~9000 Hz), and thus highlighted the effect of *w* in lower frequency range.

Figure 5: Spanish voiceless stop burst spectral mean (Hz).

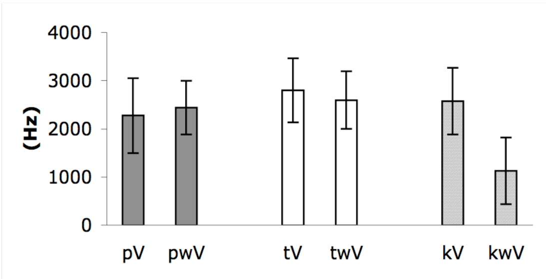
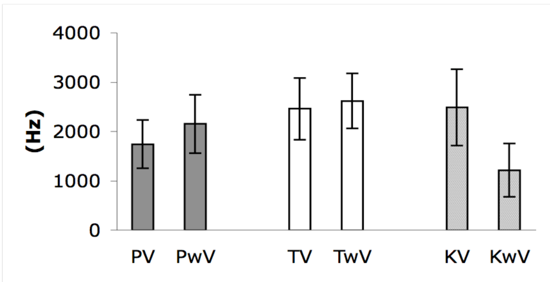


Figure 6: Korean stop burst spectral mean (Hz).



4. DISCUSSION

The results of F2 change and stop burst spectral measures suggest that the clearest acoustic distinction between plain C and labialized C in Korean is induced when C is velar, which is the most common consonant place for labialization contrast. In Spanish of which the C*w* combination is a consonant cluster, labials, the least common consonants for C*w* clusters, exhibit the smallest CV-C*w*V contrast, as PV and P*w*V are differentiated neither by F2 change direction nor by the stop burst spectral mean.

Assuming that the acoustic distinctiveness of CV and C*w*V discussed above determines the salience of the C-C*w* contrast, overall results support the view that the commonly observed consonant place restrictions on C*w* combinations are closely related to C-C*w* contrast salience. However, an acoustic factor that differentiates between CV and C*w*V is not necessarily relevant in their perception. Also, the same acoustic cue may have less perceptual weighting in one type of C*w* combination than the other. Therefore a further study should investigate the perceptual importance of each acoustic factor in signaling the C-C*w* contrast.

5. CONCLUSION

This study tested the acoustic-contrast-based account of the consonant place restrictions in C*w* combinations observed in languages, namely the avoidance of labials and preference of velars, following the insights of Flemming [2]. The results show that there is a correlation between acoustic distinctiveness and crosslinguistic patterns in C*w*V preferences. Further research is needed to prove that such distinctiveness has crucial impact on the perception of the C-C*w* contrast.

6. REFERENCES

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[i] Similar result was obtained for Spanish, for which only P and K contexts were compared.