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# ON GESTURAL REDUCTION AND GESTURAL OVERLAP IN KOREAN AND ENGLISH /PK/ CLUSTERS

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## Abstract

The purpose of this paper is to investigate the distinct roles of gestural reduction and gestural overlap in consonant place assimilation. It is found that gestural overlap alone does not give rise to perceptual assimilation in Korean *pk* clusters; instead, gestural reduction of the labial does. It is also found that there is no significant difference in the degrees of overlap between Korean and English *pk* clusters. A marked difference is observed in the gestural reduction of the labial; it often reduces in Korean but does not reduce in English. The difference between Korean and English place assimilations is therefore not due to different degrees of gestural overlap, but to an asymmetry of gestural reduction. Consequently, all these findings support the hypothesis that gestural reduction, not gestural overlap, plays the main role in casual speech place assimilation.

## I. Introduction

The present study explores the mechanism of gradient place assimilation; more specifically, we investigate what articulatory process is responsible for deletion of a target segment in gradient place assimilation: gestural overlap, gestural reduction, or a combination of the two?

To investigate the distinct roles of gestural overlap and reduction in casual speech place assimilation, I explore *pk* clusters in Korean and English. It has been assumed in the literature on Korean phonology [1,2] that in casual speech, coronals assimilate in place to a following non-coronal (1a,b); labials assimilate only to a following velar (1c,d). This process is optional, and dependent on the style and the rate of speech.

| (1) | Korean Place Assimilation | | | |
|---|---|---|---|---|
| a. | /mit + ko/ | --> | [mikko] | 'believe + and' |
| b. | /cinan + pam/ | --> | [cinampam] | 'last night' |
| c. | /nup + ko/ | --> | [nukko] | 'lie + and' |
| but | | | | |
| d. | /nup + ta/ | --> | [nupta] | 'lie + Sentence Ender' |

English displays similar alternations in casual speech: coronals assimilate in place to following velar and labial consonants (2a,b). However, English place assimilation is different from Korean place assimilation in that labials rarely assimilate to a following velar consonant (2c).

| (2) | English Place Assimilation | | |
|---|---|---|---|
| a. | red car | /red ka:/ | [reg ka:] |
| b. | green paint | /gri:n peint/ | [gri:m peint] (from Nolan [2]) |
| but | | | |
| c. | leap quickly | /li:p kwikli/ | [li:p kwɪkli] *[li:k kwɪkli] |

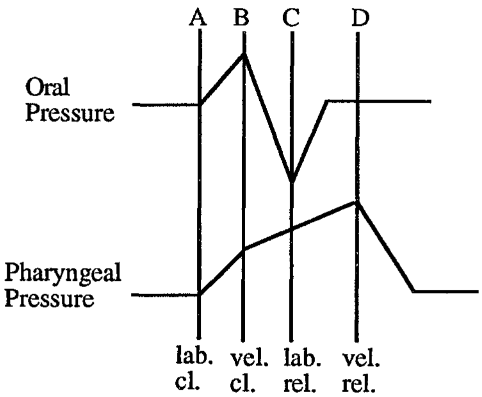
Regarding the difference between Korean and English place assimilations (Korean place assimilation is more extensive than the English process), overlap and reduction-based theories make different predictions. An overlap-based theory predicts that in Korean, labial stops should fully overlap with following velars, leading to the perceptual disappearance of the labials; but in English, labials do not overlap with following velars, or overlap only slightly. Thus, the difference between Korean and English place assimilations would be due to different degrees of articulatory overlap in labial-velar clusters. In contrast, a reduction-based theory predicts that in Korean, labials should often reduce before velars, but in English, labials should rarely reduce in the same environments. In other words, an asymmetry in the reduction process of the labial in labial-velar clusters would explain the difference between Korean and English place assimilations. These two different predictions may be tested if we can measure (i) the degree of gestural overlap in labial-velar clusters, and (ii) the extent of labial reduction in the same clusters.

## II. Method

To examine gestural overlap of *pk* and gestural reduction of *p*, I employ the methodology pursued by Silverman and Jun [4] for an aerodynamic analysis of Korean labial//velar clusters. In that study, oral airflow as well as pharyngeal and oral pressure were recorded in Korean [VCCV] sequences involving both labial and velar consonants, and front and back vowels: [ipki, upku, ipku, upki, ikpu, ukpi, ikpi, ukpu]. Recorded pressure changes demonstrate inter-consonantal overlap and reduced articulations.

Inter-consonantal overlap is prominent in the following figure, which schematises the pressure change of labial-velar clusters flanked by front-back vowel combinations, i.e. [ipku]:

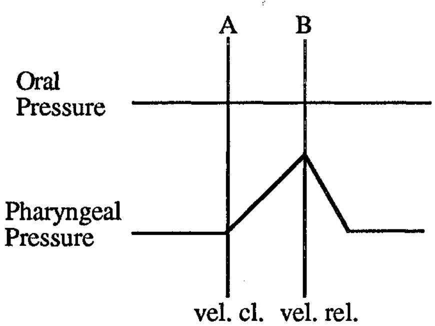
Figure 1.




Notice that after the initial increase (Point A), the oral pressure drops below the baseline (Point B). It was claimed by Silverman and Jun that this pressure rarefaction results from a combination of consonant co-production and trans-consonantal vowel coarticulation. While the tongue body moves backward due to the front-to-back vowel transition, simultaneous labial and velar closures for medial *pk* stops seal the oral cavity at both ends, lips and the soft palate. The tongue body backing across the soft palate expands the sealed oral cavity, leading to the negative pressure. Thus, an observed pressure rarefaction indicates that the labial-velar sequences are highly overlapped.

A pressure output which indicates labial reduction is schematised in Fig. 2:

Figure 2.




Here, the labial-velar sequence displays no changes in oral pressure. Because the labial closure is not completely achieved, no pressure builds up behind the lips. Thus, no change in pressure indicates that the labial gesture is reduced, completely or partially. Consequently, Silverman and Jun have demonstrated that both gestural reduction of a labial consonant (Fig. 2) and gestural overlap of a labial-velar cluster (Fig. 1) can be detected in oral pressure changes.

Applying this method, I investigated gestural overlap of labial-velar clusters and gestural reduction of labials in Korean and English.

## III. Experiment One: Korean *pk*

### III.1 Production

Subjects included graduate and undergraduate native Korean speakers of the Seoul dialect (seven females; seven males), living in Southern California. All the subjects were unaware of the purpose of the experiment.

The subjects were fitted with a mouth mask connected to pressure/flow transducers. The pressure tube was inserted behind the lips, thus recording oral pressure. Additionally, audio recordings were made. Air flow was not recorded.

Regarding experimental tokens, $V_1pkV_2$ sequences were employed; $V_1$ and $V_2$ represent front and back vowels, respectively. Real Korean words with these sequences were placed in phrasal/sentential contexts.

Control tokens ($V_1kkV_2$), which form a minimal pair with the test tokens ($V_1pkV_2$) were also recorded. The subjects were instructed to read each phrase in a casual way three times and in a careful, formal way three times, making six times altogether.

Four different patterns of oral pressure resulted. The first pattern displays a positive-then-negative change in oral pressure. As discussed above (section II), the pressure rarefaction indicates that the medial *pk* cluster is highly overlapped. This pattern of oral pressure reading will be called p^k, which is intended to suggest the overlap of the cluster.

Second, 52 out of 329 results displayed a positive-only pressure change. Let us provide a plausible interpretation for the observed positive-only pressure pattern. As mentioned above, Silverman and Jun [4] claim that the pressure rarefaction for $V_1pkV_2$ tokens, where $V_1$ is front and $V_2$ back, would be the result of a marked overlap of the medial *pk*. From this claim, it follows that the observed positive-only for the medial cluster *pk* may indicate either a non-overlapped or only slightly overlapped cluster. If closure phases of the *pk* cluster are not overlapped, velar closure would be made after the labial release. In this case, tongue body backing across the soft palate would occur only after the labial seal is broken, so pressure rarefaction would not result. Oral pressure changes are affected only by the labial closure, leading to a positive-only pressure contour.

If the closure phases of the *pk* cluster are only a little overlapped, the velar backing in the sealed oral cavity may not last long enough to produce negative pressure; therefore, pressure drops, but not below the baseline. These two interpretations for positive-only pressure pattern both seem plausible. However, either possibility involves a less overlapped *pk* than that represented by pressure rarefaction. Thus, the positive-only pressure pattern will be referred to as the symbol plk, which suggests inessential overlap of *pk*.

Third, 156 out of 329 results display no changes in oral pressure. As discussed above (section II), no change in pressure implies that the labial gesture of the relevant *pk* cluster was reduced; i.e. the labial closure which would obstruct the oral air flow was not made completely. This pattern will be called <p>k, a symbol intended to suggest the labial reduction.

Fourth, several tokens (13 out of 329) displayed a negative-only pattern in oral pressure. Only pressure rarefaction is observed for the medial cluster *pk*. This pressure rarefaction, together with the absence of a pressure rise, indicates that the labial closure is surrounded by the dorsal closure. If the dorsal closure is made first despite the underlying ordering of the *pk* cluster, then the following labial closure would result in the observed direct pressure drop, since the tongue body started retracting across the soft palate even before the labial closure; thus, there is no chance for the pressure to rise at the beginning of labial closure. Next, when the labial closure is released, the pressure returns to the base line. The following velar closure release cannot be seen in the oral pressure reading. Thus, the observed negative-only pressure pattern can result from the labial closure surrounded by the dorsal closure. I consider these *pk* clusters as cases of extreme overlap, and will refer to them with the symbol k^p^k.

(3) Results of Korean pk production

| | | p\|k | p^k | <p>k | k^p^k |
|---|---|---|---|---|---|
| Style | Casual | 29 | 31 | 105 | 1 |
| | Formal | 23 | 77 | 51 | 12 |
| Total | | 52 | 108 | 156 | 13 |

Several observations about production of Korean *pk* clusters can be made.

First, the labial in *pk* clusters often reduces: 47% of tokens displayed the <p>k pattern in oral pressure.

Second, 70% of tokens with unreduced *p* displayed the p^k pattern; that is, in most unreduced tokens, *pk* is highly overlapped.

Third, a marked difference between casual speech and formal speech is observed in the frequency of reduced labial (<p>k): when C1 is *p*, it reduces more often in casual speech than in formal speech.

## III.2 Perception of Korean *pk*

We will now consider the question of which articulatory outcomes result in perceived assimilation, making use of perceptual experiments. Six Korean-speaking listeners were employed. The subjects had never been phonetically trained.

The following segmental sequences were extracted from the audio recordings made in the production tests: various outcomes for $V_1pkV_2$ and $V_1kkV_2$ sequences. Listening through headphones to three repetitions (with a one-second inter-stimulus interval) of the same token, subjects were asked to determine whether they heard [$V_1pkV_2$] or [$V_1kkV_2$]. Subjects were instructed not to guess; if they could not decide, they were not allowed to respond. Subjects were given a second chance to listen to tokens for which they had not decided on the first hearing.

Eight tokens were culled from each of three canonical pressure patterns: p|k, p^k, and <p>k. Four out of the eight tokens were of the sequence ipko and the other four tokens were of ipkwa. Among the four tokens of each type, two were chosen from the casual speech sample and the other two from the formal speech sample. Also, control tokens ($V_1kkV_2$) which can form a minimal pair with chosen underlying *pk* tokens ($V_1pkV_2$) were selected.

Results of the perception test are shown in (4). The values in the table indicate the number of tokens identified by the subjects as involving a cluster beginning with a labial rather than a velar. The total number of tokens in each cell is four, if not otherwise indicated.

(4) Perception of *p* (Korean *pk*)

| | | number of cases (out of 4) heard as [pk] | | | |
|---|---|---|---|---|---|
| Fram | Sub | p\|k | p^k | <p>k | kk |
| i__o | 1 | 4 | 4 | 0 | 0 |
| | 2 | 4 | 4 | 0 | 0 |
| | 3 | 4 | 4 | 0 | 0 (3) |
| | 4 | 4 | 4 | 0 | 0 |
| | 5 | 4 | 4 | 0 (3) | 0 |
| | 6 | 4 | 4 | 0 | 0 |
| i__wa | 1 | 4 | 4 | 1 | 0 |
| | 2 | 4 | 4 | 0 | 0 |
| | 3 | 4 | 3 | 0 | 0 |
| | 4 | 4 | 3 (3) | 1 | 0 |
| | 5 | 4 | 4 | 1 | 0 |
| | 6 | 4 | 3 (3) | 0 (3) | 0 |

All subjects identified *p* in all the p|k tokens whose *pk* clusters, I assume, are not overlapped or are slightly overlapped. The same results can be observed from p^k tokens whose *pk* clusters are assumed to be highly overlapped, although a little variation can be seen. Thus, p|k and p^k are not very different in their tendency to induce identification of *p*.

In contrast, the subjects largely failed to identify *p* in tokens of <p>k which are assumed to have a reduced labial. These results are completely different from the results of tests with p|k and p^k tokens, but very much like results for the control tokens with underlying *kk* clusters: only one subject did not respond for one token. Consequently, it seems that *pk* clusters of the type p|k and p^k are perceived as such, whereas /kk/ and <p>k are perceived as [kk].

From these results, two important observations follow. First, *pk* clusters which are highly overlapped (p^k) are still perceived as *pk* just like those which are not or at most slightly overlapped (p|k). Second, *pk* clusters whose first labial gesture is reduced (<p>k) are perceived as kk. Thus, the categorial boundary between perceptual assimilation and non-assimilation can be characterised by gestural reduction, not by gestural overlap.

## IV. Experiment Two: English pk

American English native speakers (two females; six males), graduate and undergraduate students attending UCLA, were recorded. All of them were unaware of the purpose of the experiment.

The same methods used in the production experiment of Korean *pk* were adopted. $V_1p\#kV_2$ sequences were employed; $V_1$ and $V_2$ represent front and back vowels respectively. Real English words with these sequences were put with a carrier phrase "Say ____ again". (5) is a complete list of the phrases employed.

(5) a. cheap quality b. deep qualm
c. keep quiet d. sleep quickly
e. sheep quota

Control tokens ($V_1kkV_2$), which form a minimal pair with test tokens in (14) ($V_1pkV_2$), were also recorded:

(6) a. leek quality b. weak qualm
c. seek quiet d. peak quickly
e. teak quota

Each phrase was read by the subjects in a casual way three times.

Results of the production test of English pk are shown in (7).

(7) Results of English pk production

| | p\|k | p^k | <p>k | k^p^k |
|---|---|---|---|---|
| Total | 38 | 81 | 0 | 1 |

Several observations can be made from the above results. First, unlike the results in the production experiment for Korean *pk*, only three different patterns (p|k, p^k, k^p^k) of oral pressure resulted; <p>k outputs characterised by no-change were not attested. The absence of <p>k indicates that labial closure in the articulation of English *pk* is never reduced.

Second, p^k is the dominant pattern. Results of p^k (81 occurrences) are twice as common as those of p|k (38 occurrences). And of the rest, only a single token displays the k^p^k pressure pattern. Thus, these results indicate that English *pk* clusters are mostly highly overlapped.

Consequently, English *pk* clusters are not very different from Korean *pk* clusters in gestural overlap, since both clusters are usually highly overlapped (67% of English test tokens; 70% of Korean test tokens with unreduced /p/). In contrast, English *pk* clusters are completely different from Korean *pk* clusters with respect to reduction of *p*, in that the *p* never reduces in English, but it often does in Korean (47% of all Korean test tokens).

## V. Conclusion

In the present study, I attempt to find out the mechanism of place assimilation in consonant clusters by employing an experimental method. The results show that gestural reduction, not gestural overlap, plays the main role in casual speech place assimilation.

## References


[1] Y.-M. Y. Cho, *Parameters of consonantal assimilation.* Ph.D. dissertation, Stanford University, Stanford. 1990.

[2] Y.-K. Kim-Renaud, *Korean Consonantal Phonology.* Ph.D. dissertation, University of Hawaii. 1974.

[3] F. Nolan, The Descriptive Role of Segments: Evidence from Assimilation, in G.J. Docherty and D.R. Ladd (eds.), *Papers in Laboratory Phonology II: Gesture, Segment, Prosody.* Cambridge University Press: 261-280. 1992

[4] D. Silverman and J. Jun, Aerodynamic Evidence for Articulatory Overlap in Korean. To appear in *Phonetica* 51. 1994.