Context-sensitive lingual gestures in the Korean tap /ɾ/

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ABSTRACT

The present electropalatographic study reports the production of the allophones, i.e., [l] and [ɾ], of Korean tap /ɾ/ and their coarticulatory characteristics in /Cáɾ#g/ and /Cáɾ#i/ sequences. The finding that tap /ɾ/ involves a complete oral closure with less lingual contact, i.e., apico-frontalveolar coupling, than lateralized /ɾ/ which involves apico-bladealveolar coupling and tongue dorsum lowering for adequate airflow through either side and/or both of the tongue body suggests that the two allophones of the tap /ɾ/ have different lingual gestures. Moreover, in comparison with the tap, the lateral exerts longer lingual contacts. The mean ratio between them is 3.7. In the sequences /Caɾ#g/, the two adjacent antagonistic segments (i.e., /ɾ/ and /g/) show mutual coarticulation effects taking on features of adjacent segment, but either of them is precisely constrained without blocking the formation of involved major lingual gestures for the other segment. In sequences /Caɾ#i/ occurs anticipatory V-to-C coarticulation but not vocalic carryover effects. In both sequences, the allophones reveal insignificant word-initial consonantal carryover coarticulatory effects and insignificant speaker-specific lingual contacts.

Keywords: Korean, EPG, context-sensitive coarticulation, lingual gestures, tap

1. INTRODUCTION

In general, the Korean tap /ɾ/ is phonetically realized as a tap [ɾ] in syllable-initial position as seen in (1). However, the tap becomes a lateral [l] ("light" [l]) when it occurs in syllable-final position followed by either consonant or utterance boundary (Kim, 2000) as seen in (2). In the same position as in (2), is the tap realized as a tap [ɾ] when followed by vowel as seen in (3).

(1) /igə-sɨn daɾi da/ [igə-si̥n daɾ̠i da] (This is the bridge.)
(2) /daɾ gwa t'aɾ/ [dal̠ gwa t'al̠] (The moon and daughter.)
(3) /igə-sɨn daɾ ida/ [igə-si̥n daɾ̠ida] (This is the moon.)

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Thus, it is postulated that the two allophones of /ɾ/ involve different lingual gestures, the phonetic implementation of which depends on context, and it is required to take an electropalatographic investigation of the production of the tap to characterize how the tongue is constrained for both allophones in sequences of /ɑɾ#g/ and /ɑɾ#i/ (see speech items in section 2). A first topic of investigation is to determine the degree of lingual contact for different tongue regions during the production of the two varieties of Korean tap /ɾ/. The context for the Korean lateralized tap (i.e., "light" [l]) appears to be different from other languages, such as English (Stroat & Fujimura, 1993), Catalan and German (Recasens, Fontdevila and Pallares, 1996). English has articulatory differences between allophones of /l/ (syllable-initial non-velarized "light" /l/ and syllable-final velarized "dark" /l/) and Catalan /l/ is a complex segment (involving two lingual gestures, i.e., apicoalveolar and postdorso-velopharyngeal). Catalan syllable-final "dark" /l/ occurs in inter-vocalic position as in /ili/, while German has a simple segment (i.e., "light" /l/) involving an apicoalveolar gesture only in syllable-final position.

In an electropalatographic study with speakers of Catalan, Recasens and Pallares (1999) reported that consonantal lingual gestures (e.g., trill /r/) override vowel gestures (e.g. /i/) when the two are highly constrained and antagonistic and that in /V1ɾV2/ sequences (i.e., /iCi/ and /ɑCɑ/) vocalic coarticulation is predominantly carryover, whereas consonantal coarticulation is mainly anticipatory. In the /V1ɾV2/ sequences the prominence of V1-dependent carryover effects takes place freely when articulated with adjacent vowels (i.e., /i/ and /ɑ/) since /ɾ/ does not require the formation of a dorsal constriction and tongue dorsum lowering. The lingual gestures for /ɾ/ do not block the formation of a dorsal constriction for /i/ and a tongue dorsum lowering for /ɑ/. If it is universal, it is assumed that in the sequence /Cɑɾ#i/, vocalic carryover effects on Korean lateralized tap /ɾ/ may be allowed freely since the vowel /ɑ/ involves no apico-blade raising movement. This assumption is supported in part by the production constraint data (Dart, 1991) showing that apical involvement for the tap co-occurred with tongue dorsum retraction and a more concave predorsal shape. A second aim of this paper is to see whether in the sequence /Cɑɾ#i/, vocalic coarticulation is predominantly carryover or not.

In the sequence /Cɑɾ#i/ and /Cɑɾ#g/, the C is one of unaspirated lax /d/, unaspirated tense /t'/ and aspirated tense /t^h/. A third aim of this study is to know whether or not in the sequences /Cɑɾ#i/ and /Cɑɾ#g/ the type of C influences the degree of lingual contact and the duration of lingual contact in the articulation of the two allophones of /ɾ/.

In the sequence /Caɾ#g/, phonetically is the lateralized /ɾ/ articulated with the adjacent velar stop /g/ without word-boundary. A consonantal lingual gestures overrides a vowel gestures (e.g. /i/) when the two are highly constrained and antagonistic (Recasens and Pallares, 1999). If so, how is the tongue constrained for the two antagonistic consonantal segments when they are highly constrained and antagonistic? A fourth purpose of this paper is to determine how the tongue is constrained for the two antagonistic consonantal segments /ɾ/ and /g/ when the two are highly constrained and antagonistic.

The EPG data, obtained from an informal experiment, indicate that tap [ɾ] exerts shorter lingual contacts than light [l]. It is interesting to see, in comparison with [ɾ], how long the [l] exerts lingual contacts. A fifth goal of this paper is to characterize the timing variable, i.e. the duration of lingual contact, in the articulation of the two phonetic varieties of /ɾ/. Five issues related to the production of the two allophones will be discussed in the present study.

2. METHOD

Electropalatographic (EPG) data on linguopalatal contact were recorded for the sequences /C1ɑC2#C3/ and /C1ɑC2#i/ where the C1 is one of /d/ (unaspirated lax), /t^{h}/ (aspirated tense) and /t'/ (unaspirated tense), C2 /ɾ/ and C3 /g/ and stress on /ɑ/, as seen in the following speech items:

(1) /**dɑ́ɾ** gwɑ t'ɑ́ɾ/ [**dɑ́l** gwɑ t'ɑ́l] (The moon and the daughter)
(2) /**t^{h}ɑ́ɾ** gwɑ dɑ́ɾ/ [**t^{h}ɑ́l** g̊wɑ dɑ́l] (The mask and the moon)
(3) /**t'ɑ́ɾ** gwɑ dɑ́ɾ/ [**t'ɑ́lgwɑ** dɑ́l] (The daughter and the moon)
(4) /igəsin **dɑ́ɾ** idɑ/ [igəsin dɑ́ɾidɑ] (This is the moon.)
(5) /igəsin **t'ɑ́ɾ** idɑ/ [igəsint'ɑ́ɾidɑ] (This is the daughter.)
(6) /igəsin **t^{h}ɑ́ɾ** idɑ/ [igəsin t^{h}ɑ́ɾidɑ] (This is the mask.)

These speech materials were read five times by two Korean speakers with near Seoul accent, that is, the standard Korean, giving (6 sequences x 5 times x 2 speakers) 60 tokens for sequence analysis. This study is focused mainly on the context-dependent lingual gestures rather than the position-sensitive lingual gestures and the analysis of utterance-final tap related to position-sensitive lingual gestures (utterance-medial and utterance-final) is excluded. A further investigation in position-specific lingual gestures for the articulation of the two phonetic varieties of tap /ɾ/ will follow on.

Lingualpalatal contact was gathered every 10 ms through each speech item using artificial palates equipped with 62 electrons (Reading EPG system: Hardcastle, Jones, Knight, Trudgeon & Calder, 1989). As shown in Figure 1, the artificial palate is equipped with electrodes arranged in eight horizontal rows (R1, ⋯, R8) and four vertical columns on each half of the palatal surface (C1, ⋯, C4). The

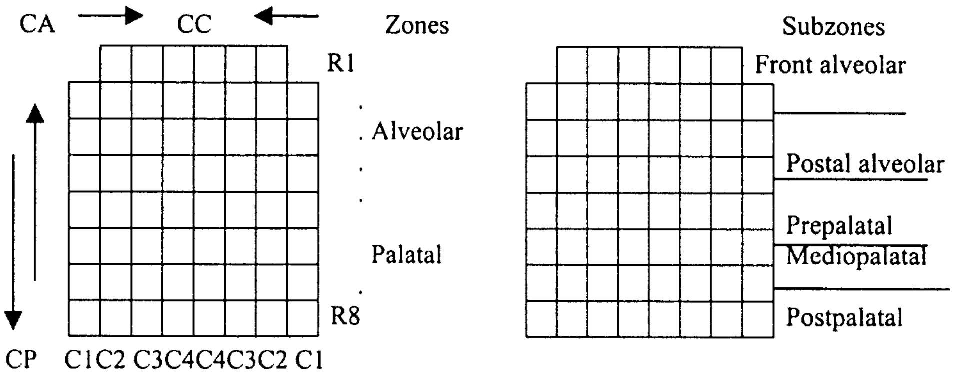

Figure 1. Left: Distribution of rows R1 through R8 along the anteriority (CA) and postteriority (CP) dimensions, and of columns C1 through C4 along the centrality (CC) dimension on both sides of the electropalate. Right: Articulatory zones and subzones on the electropalate.

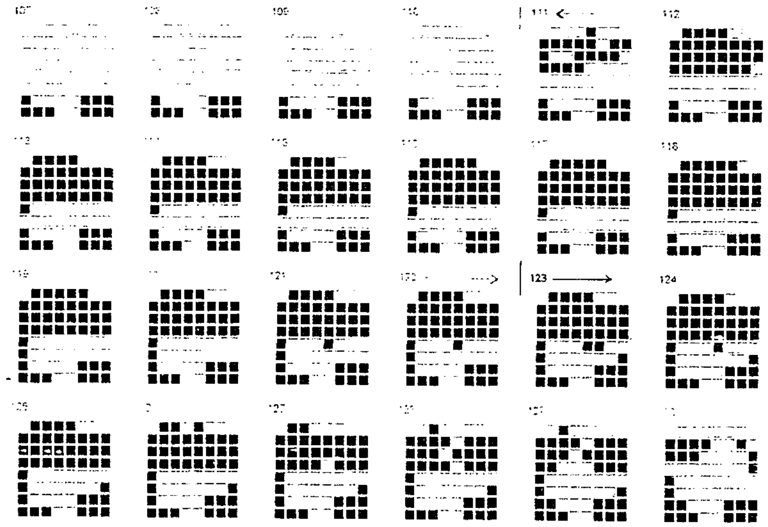

Figure 2. Full lingual contact configurations for the lateralized /ɾ/ (i.e., "light" [l]) in the sequence /Caɾ#g/ where twelve frames (111-122) are for the lateralized /ɾ/ and /g/ starts from frame number 123.

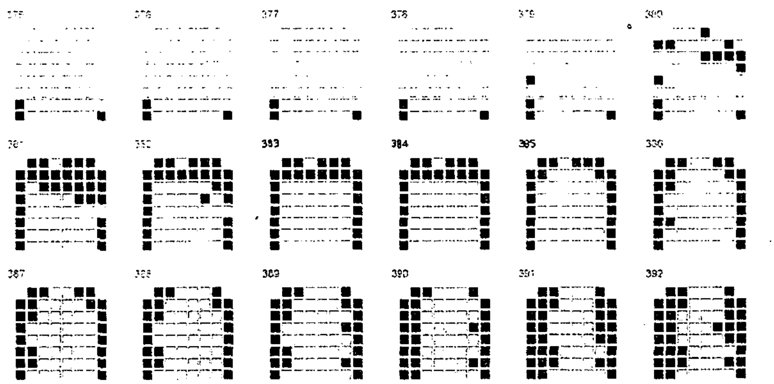

Figure 3. Full lingual contact configurations for the tap /ɾ/ in the sequence /Caɾ#i/ where two frames (383-384) are for /ɾ/ and /i/ starts from frame number 385.

alveolar zone includes the 4 front rows and the palatal zone includes the 4 back rows; the distance between adjacent rows is much smaller at the former

zones than at the latter. This EPG system allows display of one pattern of contact every 5 ms. Figure 2 and 3 display sample linguopalatal.

A phoneme has a set or group of related phonetic segments, and Korean has a phonemic alphabet system in which syllable-initial segment is used generally to represent the phoneme. Considering this, it seems to be more reasonable to transcribe the Korean tap as /ɾ/ rather than /l/ since the tap [ɾ] occurs in syllable-initial position and the lateral [l] in syllable-final position.

3. RESULTS AND DISCUSSIONS

3.1 The degree of lingual contact

As seen in Table I, the maximum on-electrons is remarkably greater for [l] than [ɾ]. The mean ratio between them is 1.5. The results indicate that the two allophones are realized by means of different lingual gestures. The maximum on-electrons for [ɾ] ranges from 14 to 25, giving 19.6 averaged across 3 sequences, 5 repetitions and 2 speakers, while the maximum on-electrons for [l] ranges from 25 to 30, with mean 28.6 altogether. Table I shows statistically insignificant ($p \leq 0.621$) effects of word-initial consonant (i.e., unaspirated lax stop, unaspirated tense stop and aspirated tense stop) on the maximum on-electrons for the two allophones, i.e. [l] and [ɾ], of the tap /ɾ/. The results suggest that in the sequences /Caɾ#g/ and /Caɾ#i/, there are insignificant consonantal carryover coarticulatory effects on both allophones showing insignificant inter-speaker-specific lingual contact.

Table I. Mean maximum lingual contact, i.e., the number of on-electrons, and standard deviations at the alveolar zone for [l] and [ɾ] in the sequences /daɾ#C/, /t'aɾ#C/, /tʰaɾ#C/, /daɾ#V/, /t'aɾ#V/ and /tʰaɾ#V/ (N = 5).

S1	dal#C	t'al#C	tʰal#C	Total	daɾ#V	t'aɾ#V	tʰaɾ#V	Total
Mean	29.4	29.2	29.4	29.3	20.2	19.6	20.4	20.0
SD	0.54	0.83	0.89	0.75	3.56	1.14	1.14	2.05
S2								
Mean	28.3	27.5	28.1	27.9	19.7	18.8	19.2	19.2
SD	0.83	0.63	0.75	0.74	1.95	1.45	1.25	1.55

Table II. Mean duration of lingual contact in ms and standard deviations at the alveolar zone for [l] and [ɾ] in the sequences /daɾ#C/, /t'aɾ#C/, /tʰaɾ#C/, /daɾ#V/, /t'aɾ#V/ and /tʰaɾ#V/ (N = 5).

S1	dal#C	t'al#C	tʰal#C	Total	daɾ#V	t'aɾ#V	tʰaɾ#V	total
Mean	94.0	88.0	94.0	92.0	25 ms	20	26	23.6
SD	19.49	13.03	11.40	14.6	13.73	7.07	15.16	12.00
S2								
Mean	85.7	90.5	88.5	88.2	26 ms	22	24	24.0
SD	15.40	10.04	9.50	11.94	12.02	8.34	10.05	10.13

3.2 Production constraints and coarticulations

In the sequence /Caɾ#g/, the lateralized /ɾ/ (i.e., "light" [l]) exerts a complicated coordination process. In the articulation of the lateralized /ɾ/ (Frame number 111 to 122 in Figure 2), apico-bladealveolar coupling co-occurs with mediodorsum lowering for adequate airflow, tongue postdorsum raising and retracting when articulated with adjacent velar consonant /g/ involving tongue postdorsum raising and closure retraction. On the other, postdorsumvelar coupling for the velar consonant /g/ co-occurs with apico-blade alveolar coupling and tongue dorsum lowering when articulated with preceding tap /ɾ/. The formation of inter-articulator coordination suggests that either of adjacent antagonistic consonantal segments is predominant over the other. Both are precisely constrained without blocking the formation of involved major lingual gestures for adjacent antagonistic segment. In the sequences /Caɾ#g/, the two antagonistic adjacent segments exert mutual (i.e., anticipatory and carryover) coarticulation taking on features of adjacent segment.

In /Caɾ#i/ sequences occur negative vocalic carryover effects on tap /ɾ/ (see Figure 3). The figure shows an anticipatory V-to-C coarticulation resulting in a complete oral closure. In the articulation of the tap /ɾ/ (Frame number 383 to 384), apico-frontalveolar coupling co-occurs with dorsopalatal contact by raising both sides of the tongue body in a concave shape and tongue dorsum fronting when articulated with adjacent vowel /i/ involving tongue dorsum raising and fronting. The complete oral closure may be an output of the inter-articulator coordination involving apico-frontalveolar coupling for /ɾ/ and tongue dorsum raising and fronting for /i/. The anticipatory V-to-C coarticulation is disagreeable with Catalan data (Recasens and Pallares, 1999) showing predominance of vocalic carryover coarticulation over anticipatory vowel coarticulation in /VɾV/ sequences (i.e. /iCi/ and /aCa/). The results suggest that the direction of the degree of coarticulation in /VɾV/ sequences appears to be language-specific. Two frames (20 ms) prior to the complete closure show apicoalveolar coupling and tongue dorsum raising with a small hole on the right side of the tongue (see Figure 3). The former lingual gestures are in the process of getting ready for /ɾ/ involving apico-frontalveolar coupling and the latter (i.e. complete closure) seems to have something to do with vocalic anticipatory coarticulation effects.

3.3 The duration of lingual contact

As shown in Table II, for tap [ɾ], a complete oral closure lasts average 2.4 frames (i.e., 24 ms) on the apico-frontalveolar zone, while the lateral [l] lasts mean 9 frames (i.e., 90 ms) altogether. The mean ratio between the two allophones is 3.7. In the sequences /Cɑɾ#g/ and /Cɑɾ#i/, the speakers show not only insignificant effects of speakers on the duration of lingual contact but also insignificant effects of the stop types of /C/ on the duration of lingual contact for the two allophones of /ɾ/.

4. CONCLUSIONS

Tap /ɾ/ in /Cɑɾ#i/ involves a complete oral closure with less lingual contact, i.e., apico-frontalveolar coupling, than lateralized /ɾ/ (i.e., "light" [l]) involving apico-bladealveolar coupling and tongue dorsum lowering for adequate airflow through either side and/or both of the tongue body. The results suggest that the two allophones of the tap /ɾ/ have different lingual gestures. Moreover, in comparison with the tap, the lateral exerts longer lingual contacts. The mean ratio between them is 3.7 In the sequences /Cɑɾ#g/, the two adjacent antagonistic segments (i.e., /ɾ/ and /g/) show mutual coarticulation effects taking on features of adjacent segment, but either of them is precisely constrained without blocking the formation of involved major lingual gestures for the other segment. In the sequences /Cɑɾ#i/ occurs anticipatory V-to-C coarticulation but not vocalic carryover effects. In both sequences, the two allophones reveal insignificant word-initial consonantal carryover coarticulatory effects and insignificant speaker-specific lingual gestures. The data obtained may be used for the clinical treatment in speech therapy and the programming for a machine-human being communication system.

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