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Phonetic variation in the Korean liquid phoneme

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Abstract. Most discussions of the Korean liquid phoneme /l/ identify two allophones: a flap, [ɾ], in the onset of syllables, and an alveolar lateral approximant syllable-finally and in geminates. However, some research paints a more complex picture indicating a wide range of interspeaker variation for the precise articulatory realization of these allophones. The present research affirms that recent findings are on the right track and shows that the retroflex variant is particularly prevalent near pauses, suggesting that retroflexion may be a secondary cue to prosodic boundaries.

Keywords. Korean, lateral, F3, retroflex, palatal, liquid

1. The Korean liquid phoneme. Korean has a single phonemic liquid /l/, that is usually described as having two allophones. Most commonly it is realized syllable-initially as a flap, [ɾ], and syllable-finally and in geminates as an alveolar lateral approximant, [l], with variable behavior before /h/, being realized as [ɾ] when /h/ is elided and [l] when it is not (Sohn 1999; Sin, Kaier & Cha 2012; Kim 2015; Sin 2015). However, some authors have argued that /l/ is more phonologically complex. Kang (2017) describes a third realization, a palatal lateral, /ʎ/, that is realized when /l/ precedes the palatal vowel /i/, or palatal glide /j/, while Lee (1999) describes /l/ as varying in strength of articulation intervocalically, on a scale from a short stop to a fricative, to an approximant. Although Lee (1999) does not give specific IPA symbols for the articulations beyond [ɾ], they would presumably map to [d], [z] and [ɹ] respectively. Recent articulatory evidence shows a wide variety of variation in the realization of the word-final liquid, identifying four separate places of articulation: apico-dental, lamino-postalveolar, lamino-alveolar, and retroflex (Hwang, Charles, and Lulich 2019). The retroflex articulation can be frequently heard in the Korean media at the end of utterances. This suggests that the retroflex articulation is favored utterance-finally, and the other coronal articulations are favored elsewhere.

2. Lateral acoustics. To examine the acoustics of the Korean lateral's various places of articulation, this paper will follow Tabain et al. (2016) who examined the acoustic correlates of four lateral consonants in Central Arrernte, Pitjantjatjara, and Warlpiri. Tabain et al. (2016) found that the apical retroflex /ɭ/ was associated with a lower F3 and F4 than the other laterals (/l̪/, /l/, and /ʎ/) in the languages under study. They also found that the laminal palatal lateral /ʎ/ was associated with a higher F2 than other laterals. The former finding was supported by Tabain and Kochetov (2018) who found a lower F3 and F4 for retroflex laterals than for alveolar laterals in Kannada and Malayalam.

3. Research Questions. The current study aims to examine the following research questions:

- Does the articulation of the Korean liquid phoneme match previous descriptions?
- Does syllable position or presence of a pause predict the use of the retroflex variant found in Hwang et al. (2019)?

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4. Methods.

4.1. PARTICIPANTS. The speakers for this study were 6 female and 6 male speakers of standard Korean all under the age of 40.

4.2. RECORDING. Recording took place through the internet conferencing software Zoom (https://zoom.us/), due to the Corona-19 pandemic. Participants were allowed to use whatever recording device they wished (computer, tablet, or smartphone) and were recorded at a sampling rate of 24kHz with 16-bit quantization using Zoom's default settings. The data was saved .m4a and converted to .wav using the websites Zamzar (https://www.zamzar.com/convert/m4a-to-wav/) and CloudConvert (https://cloudconvert.com/m4a-to-wav).

4.3. STIMULI. The stimuli consisted of 74 target words and 74 distractor words and a carrier sentence. The target words were chosen such that a word contained each liquid in word-initial, inter-vocalic singleton, inter-vocalic geminate, pre-coronal obstruent, pre-/h/, and word-final position. A word was selected for each environment such that at least one vowel for each of Korean's 10 prescriptive vowel phonemes (/i/, /y/, /e/, /ø/, /ɛ/, /ɯ/, /u/, /ʌ/, /o/, and /a/), occurred adjacent to the target position where applicable and where such a word was identified in the Institute of Korean Language's *"Hyentay Kwuke Sayong Pinto Cosa 2" [Modern Korean Usage Frequency Study 2]* (2005). The carrier sentence presented in (1) was constructed to end in a liquid phoneme in order to test the difference between utterance medial and utterance-final realizations of the liquid. For the purposes of this study the first 40 instances of the final liquid of the carrier phrase were used for data analysis.[1]

(1) Carrier-phrase

그	사람이	다시	'__________'	(이)라고	했을	걸.
kɯ	salami	tasi	'__________'	(i)lago	h.eṣ͈.ɯl	kʌ.l
that	person	again	'__________'	QUOT	did.PST.IRR	NMLZ.OBJ

'that person probably said '_______' again.

4.4. PROCEDURE. The word list and carrier sentence were presented to the participant on Zoom. Target words were presented in pseudo-random order, such that target bouns containing the liquid phoneme appeared no more than twice in a row. Participants were asked to insert the word into the blank in the carrier sentence and repeat it twice.

4.5. MEASUREMENTS. Tokens of the Korean liquid were first classified as a tap or a liquid using the phonetic analysis software Praat (Boersma & Weenik 2013). The liquid was identified as a tap if there was a short lightening in intensity between vowels, as in Figure 1 below and a lateral otherwise.

[1] The /e/ preceding a consonant position was accidently omitted from the data and replaced with an extra instance of /a/ preceding a consonant.

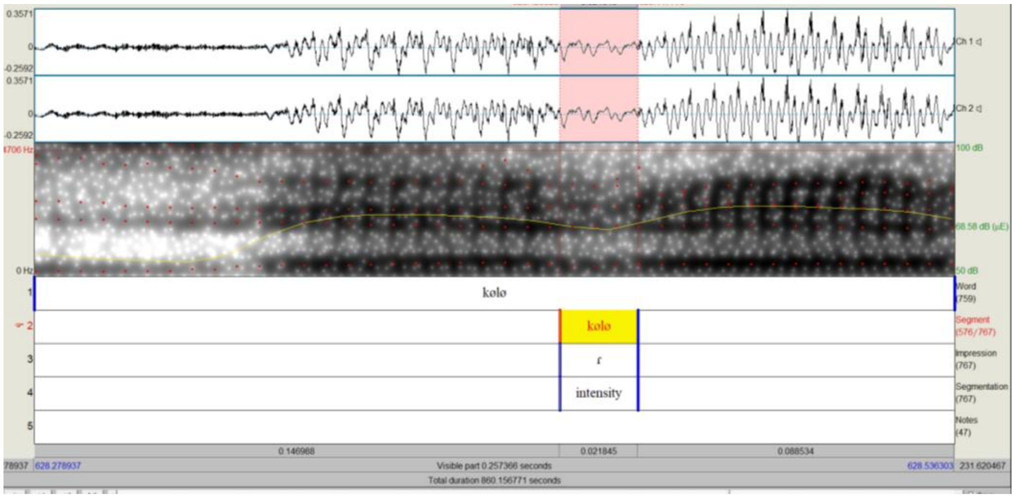

Figure 1. Spectrogram of a tap in the word /kølø/ ‘puppet’

In the case of a lateral, an impressionistic place of articulation aided by spectrogram[2] was identified (palatal, retroflex, or other coronal) and measurements of the first to fourth formants (F1, F2, F3, F4) were taken at the midpoint of the lateral using a Praat script (adapted from Brown, 2014) and checked by hand for errors. The onset and offset of the lateral were determined as follows: if there was a clear decrease in the spectral energy near the onset of the expected lateral, that was taken to be the onset, as in Figure 2.

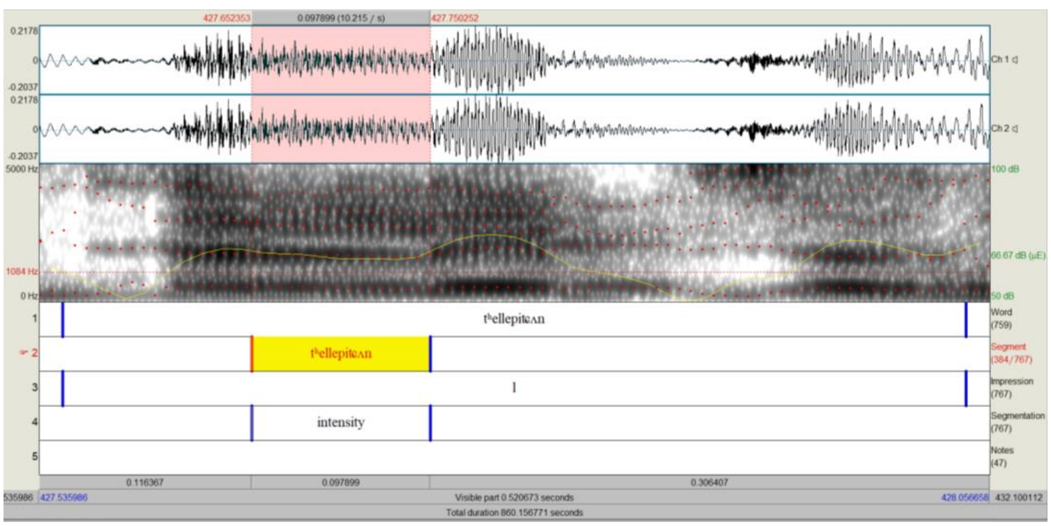

Figure 2. Spectrogram of a (geminate) lateral in the word /tʰellepitɕʌn/ ‘television’ segmented using intensity for onset and offset

If there was not a clear decrease in energy, a drop in the first formant (F1), (a property associated with non-pharyngeal consonants: Thomas 2011: 101), was taken as the onset of the liquid, as in Figure 3.

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[2] Raised F2 was used as an indication of a palatal and lowered F3 as indication of a retroflex in accordance with Thomas (2011: 101)

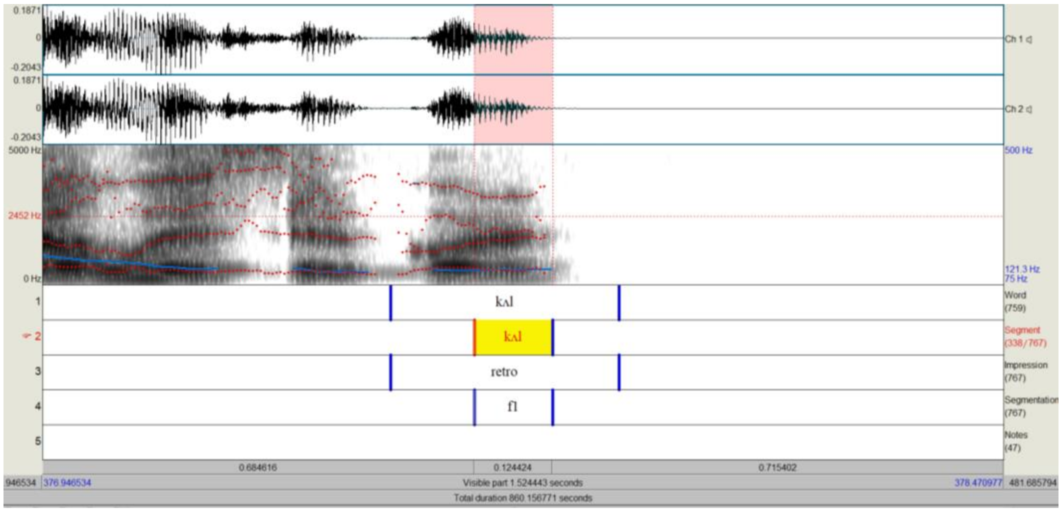

Figure 3. Spectrogram of a lateral in the word /kʌl/ 'probably' segmented using F1 for onset and pitch for offset

In the rare case that neither of these was definitive (which only happened following the vowel /ʌ/ at the end of the carrier phrase), a rise in the second formant (F2) was used to demarcate the beginning of the lateral, F2 rise being a diagnostic for place of articulation of coronal and palatal consonants (Thomas 2011: 101), was considered to be the onset of the lateral as in Figure 4. The offset of the lateral was marked at the loss of voicing bands at the end of a phrase and preceding stops and affricates.

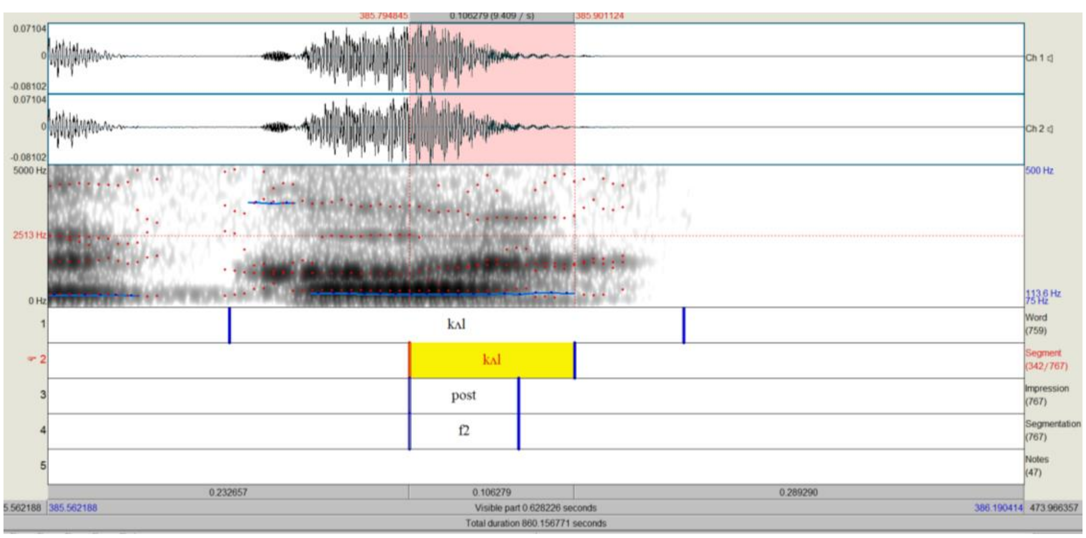

Figure 4. Spectrogram of a lateral in the word /kʌl/ 'probably' segmented using F2 for onset

Preceding vowels the offset of the lateral was marked at the darkening in the spectrogram as in Figure 2 and before fricatives it was taken to be the onset of frication as in Figure 5.

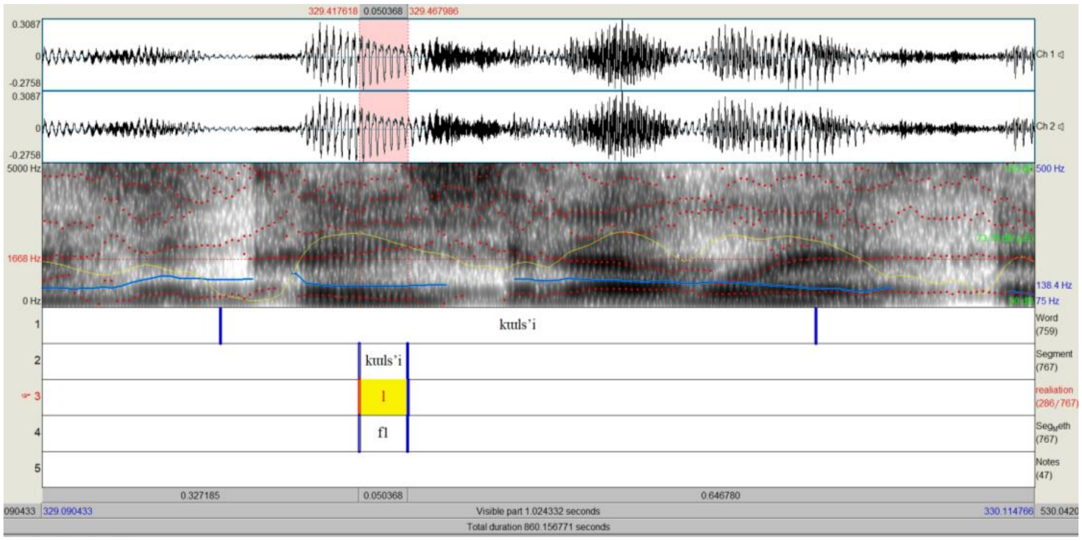

Figure 5. Spectrogram of a lateral in the word /k͈ɯls͈ i/ ‘writing’ segmented frication as the offset.

Finally, laterals were coded for their position relative to a pause: before a pause, after a pause, or not pause adjacent. A pause was defined as a break in Praat’s pitch tracker not due to a following consonant closure, as in Figure 6.

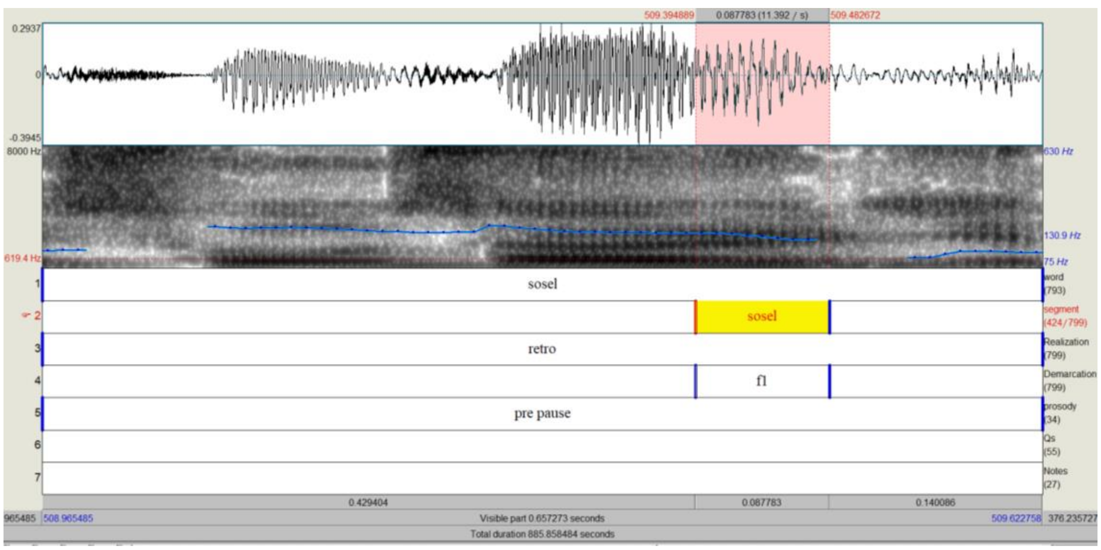

Figure 6. Spectrogram of a lateral in the word /sosʌl/ ‘novel’ segmented followed by a pause

4.6. Statistical models. Three statistical models were built to test the place of articulation of laterally realized liquids: two linear mixed-effects regressions, one with F2 as the dependent variable to test palatalization (Model 1) and one with F3 as the dependent variable to test retroflexion (Model 2) and one binomial logistic regression with place of articulation (retroflex, other-coronal) as the dependent variable. Model 1 included *Presence of a following high front vocoid* as the independent variable and Models 2 and 3 included *syllable position* (word-initial, word-final, geminate, pre-consonantal, pre-/h/) and *pause adjacency* (non-pause adjacent, pre-pause, post-pause) as IVs. Flaps (and consequently the intervocalic position) were excluded from Models 2 and 3, and word-initial laterals (and consequently the word-initial and post-pause positions) were excluded from Model 3, because this position exhibited no variation in the realization of the lateral.

5. Results.

5.1. TAPS VS. LATERALS. In terms of tap versus lateral realization, the liquid was nearly categorically realized as a tap intervocalically at 99.3%, as in Table 1. It alternated between the tap at 59.8% and the lateral at 40.2% of the time before /h/.[3] It was realized as a tap word-initally 69% of the time and a lateral 31% of the time. The liquid was realized (near) categorically as a lateral, in geminates, before pauses, and before non-/h/ consonants. Word-finally without a pause the lateral was realized roughly equally as a tap (54.5%) and a lateral (45.5%).

	Tap	**Lateral**	**Percent Taps**	**Percent Laterals**
Word-initial	127	57	69%	31%
Intervocalic	422	3	99.3%	0.7%
Geminate	2	276	0.7%	99.3%
Noun-Final (pre-pausal)	0	478	0%	100%
Noun-Final (non-prepausal)	97	81	54.5%	45.5%
Pre-consonantal (non-/h/)	0	222	0%	100%
Pre-/h/	153	103	59.8%	40.2%

Table 1. Taps vs. laterals

5.2. PALATALIZATION. F2 of target laterals depending on the high front vocoid status of the following segment is shown in the box plot in Figure 7.

Figure 7 shows that laterals preceding high front vocoids have an average F2 that is 262.552 Hz higher than laterals that did not precede high-front vocoids. Data were fitted to a linear regression, as shown in Table 2, with *Participant* as a fixed effect, revealing a main effect for F2 of laterals followed by a high front vocoid, such that laterals followed by a high front vocoid had an F2 that was 254.49 Hz higher than those that were not.

	Odds Ratio	Lower CI	Upper CI	p-values
Intercept	1750.32	1610.000	1890.645	0.000***
Following High Front Vocoid	254.49	213.932	295.061	0.000***
Note. **** = p < .0001, *** = p < .001, ** = p < .01, *= p < .05				

Table 2. Linear regression model for F2 by high-front vocoid status

[3] This was mostly due to the lenition of /h/ such that /l/ was essentially being realized between vowels although in some cases the flap realization had following frication noise (this was even the case occasionally in some words without underlying /h/ such as /ilɯm/ ‘name’, which was frequently realized as [iɾʰɯm].

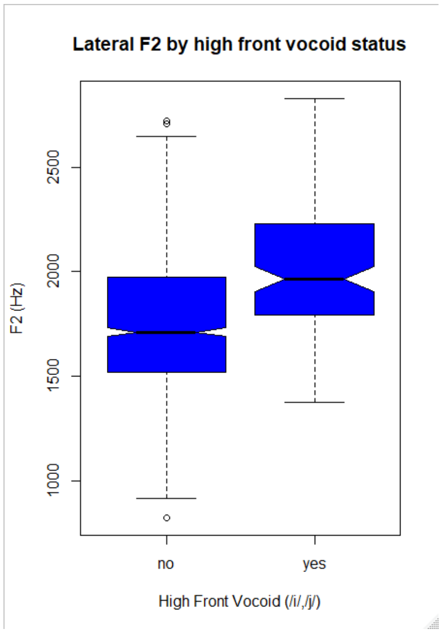

Figure 7. F2 by high-front vocoid status

5.3. RETROFLEXION. F3 of target laterals by presence of a pause and segmental position is shown in Figures 8 and 9, respectively.

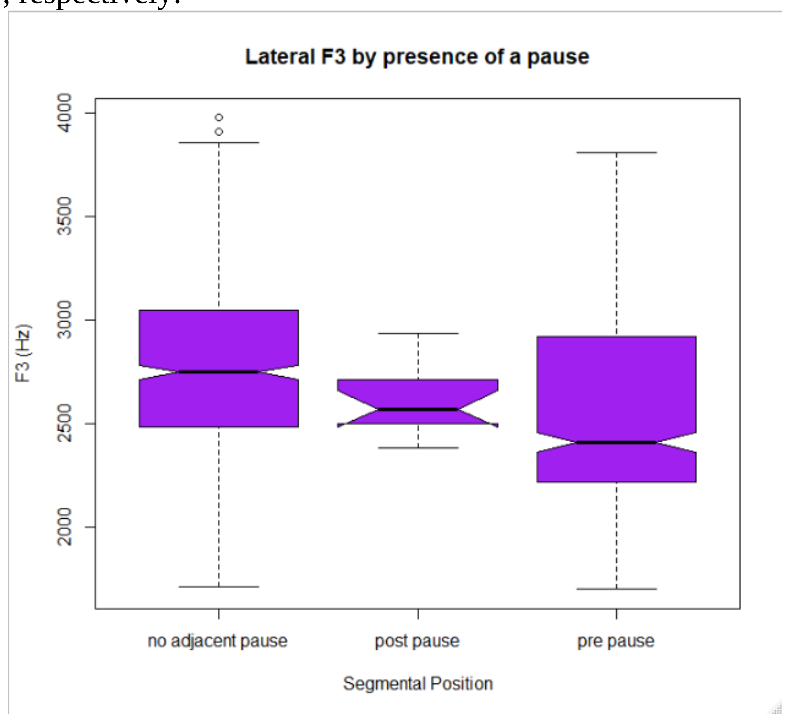

Figure 8. F3 by presence of a pause

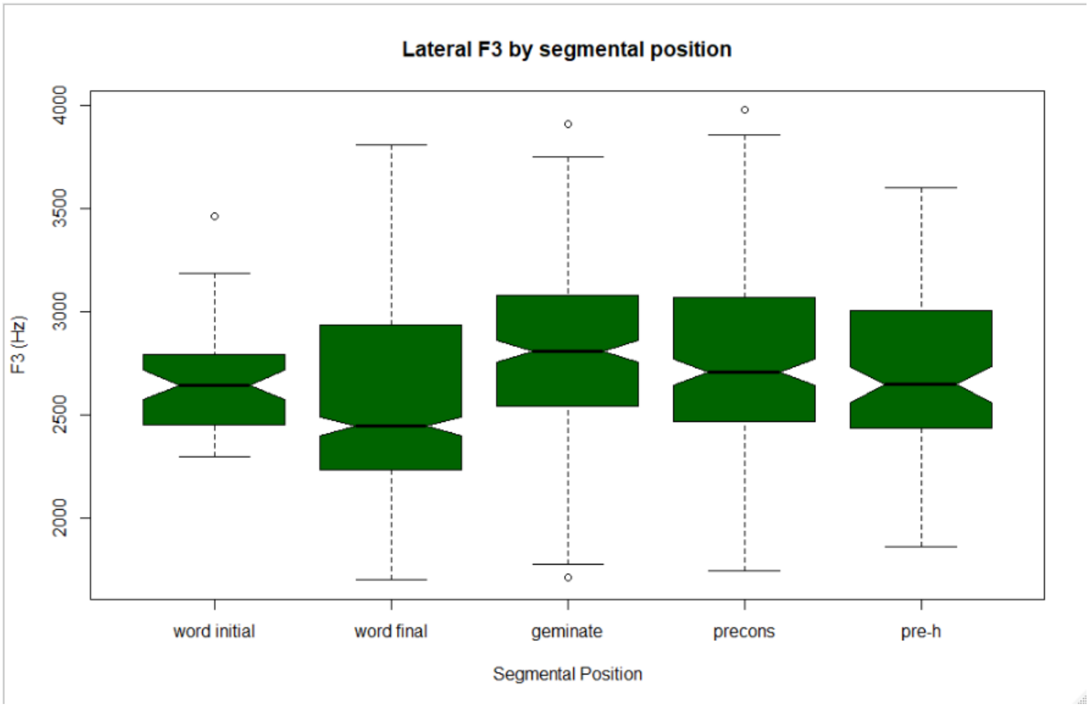

Figure 9. F3 by segmental position

The best fitting model for F3 shown in Table 3 revealed a main effect (p<.0001) for presence of a pause such that laterals before a pause had an F3 of 399.17 Hz lower than laterals which had no adjacent pause (p<0.0001). The model also revealed main effects for geminate preconsonantal and pre-/h/ structural positions such that lateral F3 was 129.86 Hz lower in geminates (p=.0174), 148.21 Hz lower before consonants (p<.01), and 240.74 Hz lower before /h/ (p<.0001) than in the reference word-initial position.

	Odds Ratio	Lower CI	Upper CI	p-values
Intercept	2908.24	2711.121	3106.322	0.000***
Pause: Post pause	-58.47	-249.7139	132.802	0.550
Pause: Pre pause	-399.17	-494.059	-304.107	0.000***
Position: Word-final	28.91	-105.690	163.867	0.675
Position: Geminate	-129.86	-236.330	-22.842	0.0174*
Position: Preconsonantal	-148.21	-256.137	-39.726	0.00745**
Position: Pre-/h/	-240.74	-359.975	-120.919	0.000***
Note. **** = p < .0001, *** = p < .001, ** = p < .01, *= p < .05				

Table 3. Linear regression model for F3 by adjacency of pause and vowel rounding

5.4. PLACE OF ARTICULATION. A contingency table of place of articulation of lateral and presence of a pause and position is given in Table 4.

count	Palatal	Retroflex	Other-Coronal
Pause: No adjacent pause	53	35	604
Pause: Post-pause lateral	0	0	15
Pause: Pre-pause lateral	1	263	245
Position: Word-initial	0	0	57
Position: Word-final	15	265	279
Position: Geminate	30	6	239
Position: Preconsonantal	7	15	200
Position: Pre-/h/	2	12	89

Table 4. F4 by presence of a pause and preceding vowel roundedness

Figure 10 shows the number of palatal, retroflex, and other coronal laterals depending on presence of a pause and whether the laterals is after or before a pause.

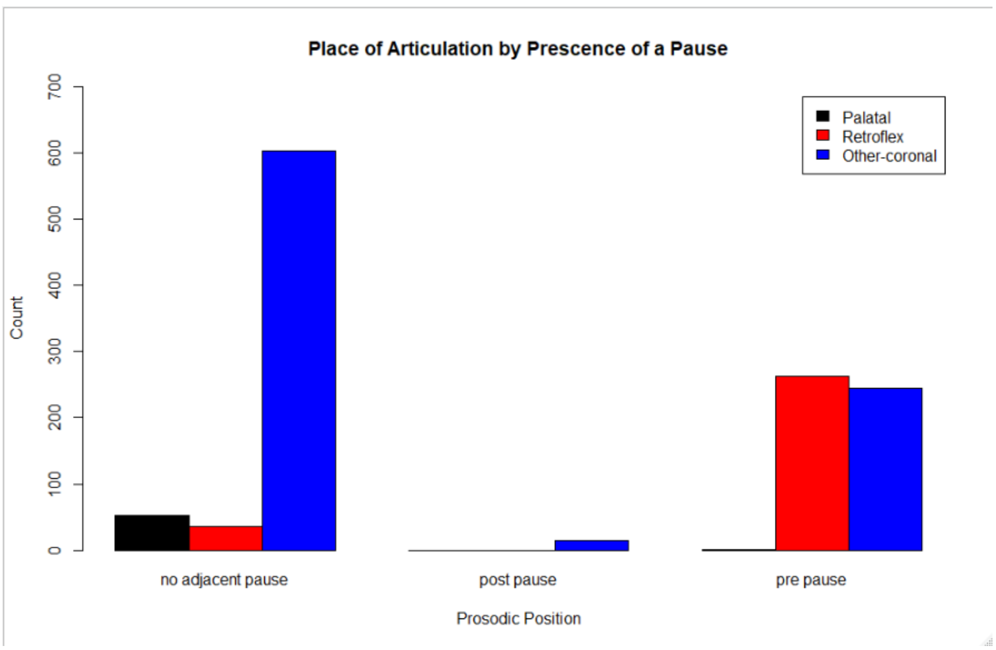

Figure 10. Place of articulation by presence of a pause and preceding vowel roundedness

Figure 11 shows the number of palatal, retroflex, and other coronal laterals depending on their segmental position: word-initial, word-final, geminate, preconsonantal and pre-/h/.

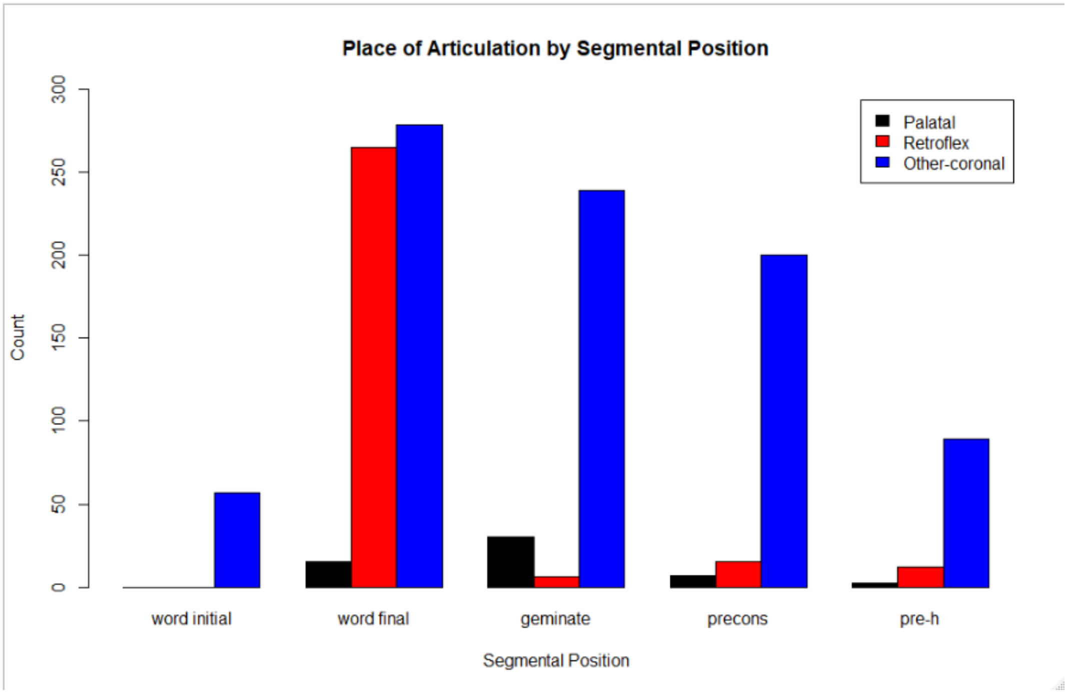

Figure 11. F4 by presence of a pause and preceding vowel roundedness

The best fitting model for place of articulation shown in Table 5 revealed a main effect (p<.0001) for presence of a pause such that laterals preceding a pause were 54.839 times more likely to be retroflex (as compared to other coronal laterals) than those not adjacent to a pause (p<.0001). The model also revealed a main effect for structural position such that preconsonantal laterals were 3.204 times more likely to be retroflex and pre-/h/ laterals were 6.972 times more likely to be retroflex than to be other coronals.

	Odds Ratio	Lower CI	Upper CI	p-values
Intercept	0.0112	0.00298	0.0371	0.000***
Pause: Pre-pause lateral	54.839	15.370	351.963	0.000***
Position: Word-final	1.570	0.219	7.391	0.597
Position: Preconsonantal	3.204	1.250	9.281	0.0204*
Position: Pre-/h/	6.972	2.486	21.576	0.000***
Note. **** = p < .0001, *** = p < .001, ** = p < .01, *= p < .05				

Table 5. Linear regression model for F3 by adjacency of pause and vowel rounding

6. Discussion. The distribution of the liquid in terms of taps and laterals generally corroborated previous literature, especially in its realization as a tap intervocalically and as a lateral in geminates and syllable-finally. The exception to this is in noun-final position when it is followed by a vowel-initial quotative marker resulting in a roughly even distribution between laterals and taps. However, in contrast to some previous literature (Sohn 1999; Sin, Kaier & Cha 2012; Kim 2015; Sin 2015), which suggests that the liquid is realized as a tap categorically in word-initial position, in the present data, it was only realized as a tap word-initally 69% of the time. This may be due to influence from other languages, however, as all words with initial /l/ were loanwords, due to South Korean varieties lacking word-initial /l/ in native and Sino-Korean words.

Similarly, in terms of palatalization the significantly higher F2 in laterals occurring before high-front vocoids supports Kang's (2017) previous finding that there is coarticulatory palatilization of the lateral in this position, as F2 has been shown to be much higher in palatal-laterals than in coronal laterals in other languages (Tabain et al. 2016).

However, the F3 model which has significantly lower F3 for laterals in pre-pausal position and before consonants. Lowered F3 is a property of retroflex laterals, as Tabain et al. (2016) and Tabain and Kochetov (2018) have shown for languages retroflex laterals that contrast with other coronal-laterals. Thus, the models suggests that the retroflex realization of the Korean lateral is more wide-spread than suggested in Hwang et al. (2019), occurring not only word-finally but in word-internal syllable-final positions, as well. However, F3 was lowest preceding a pause, suggesting that this is the primary triggering environment for retroflexion.

The auditory place of articulation model supports these findings on retroflexion, finding it to be particularly likely before a pause but also occurring at a statistically higher rate in preconsonantal positions. Additionally, the occurrence of the retroflex variant in more than half of the pre-pausal tokens, suggests that the retroflex lateral may be the default surface realization of the lateral before a pause.

7. Conclusion. The current research largely confirms previous findings about the tap/lateral distribution of the Korean liquid. However, it suggests that the retroflex lateral may be a more widespread and prominent realization of the lateral than previously suggested. The fact that the retroflex occurs in over half of pre-pausal liquids suggests that a re-evaluation of the phonology of the Korean liquid is warranted. Retroflexion may also be of interest from a language variation perspective, given that there was a great deal of variation from speaker to speaker in this study, with percentages of variation in the utterance-final particle /kʌl/ ranging from 2.5% to 100%.

However, limitations and findings in the current research point to several directions to advance the study of the Korean liquid. First of all, given that there was some unexpected free-variation between stops and liquids in word-initial position, a more precise method of differentiating between them than spectrogram appearance may be warranted. A way to do this may be to compare the slope of intensity change between the liquid and a surrounding vowel. Taps in the present data showed a much sharper and shorter drop in intensity than liquids.

Secondly, the only preceding vowel that was systematically tested here when the lateral occurred before a pause was /ʌ/, with other instances occurring when speakers place a pause after the target word within the carrier sentence. This precluded statistical testing. However, Hwang et al. (2019) reported that the lateral did not retroflex before /i/, and the data here only found two instances of retroflexion before front vowels at all, compared to 41 for back vowels among target words. This suggests that a more systematic testing of the lateral before pauses could be warranted.

Thirdly, although Hwang et al. (2019) identified four possible place-of-articulation realizations of the syllable-final liquid, the testing here was simply designed for retroflex or non-retroflex, and other measures, such as spectral moments, might help to differentiate further where these realizations might be favored.[4]

Fourthly, other than syllable structure and presence of pause, the current study did not investigate how prosodic structures, such as the accentual phrase and intonational phrase, could affect the realization of the Korean lateral.

[4] Tabain et al. (2016) used spectral moments as a diagnostic to differentiate between lateral place of articulation in Arrente, Pitjantjatjara, and Walpiri.

Finally, a more controlled in-person environment would facilitate the capture of more high-quality data and allow the use of other measures, such as F4, that were occasionally not picked up via the current recording method.

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