Glottalized Sonorants in Gitksan

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Um, Hye-Young. 1999. Glottalized Sonorants in Gitksan. *Studies in Phonetics, Phonology and Morphology* 5.2, 385-399. The purpose of this paper is to describe the phonetic details of Gitksan glottalized sonorants that occur in various contexts. In particular, the main focus is on word-initial occurrences of glottalized sonorants which are hard to distinguish from their plain counterparts. Whereas there are evident acoustic manifestations in word-medial and syllable-final glottalized sonorants, namely creaky voicedness and complete glottal closure, word-initial glottalized sonorants are not realized as creaky voice. In the acoustic study, it is found that a short duration and an abrupt onset are the main properties of word-initial glottalized sonorants. That is, without the evident presence of creaky voice, the duration and quality of the onset are the cues for the glottalization of the sonorant in word-initial position. Therefore, it may be harder to perceive the glottalization of sonorants in word-initial position than in medial or final position where the complete glottal closure or creakiness is evident, and the preceding vowel also carries the glottalization cues of the sonorant. **(Korea University)**

Keywords: glottalized sonorants, Gitksan, acoustic cues, phonetic, creaky voice

1. Introduction

Laryngeal articulations such as glottalization and aspiration are not commonly used in the production of sonorants. This is reflected in the typological distribution of glottalized and voiceless sonorants. Languages that are reported to have at least one glottalized sonorant (liquid, nasal or semi-vowel) constitute 6.0% (19/317) of Maddieson's (1984) sample and 4.3% (30/693) of the larger sample of Ruhlen's (1976) 693 languages. Languages that are reported to have at least one voiceless sonorant take up 5.0% (16/317) of Maddieson's sample. Thus, glottalized and voiceless sonorants are very rare compared to their plain, namely voiced, counterparts. Glottalized sonorants are found mostly in American indigenous languages. However, they serve as phonemes also in some African, Mon-Khmer, Afro-Asiatic and Sino-Tibetan languages.

Kingston (1985) claims that glottal articulations bind more tightly to oral articulations in stops than in continuants: the glottal articulation of a stop occurs close to the release of that stop; on the other hand, in continuants, the glottal articulation is more variable in its timing relative to the oral articulation. If Kingston is correct, we should expect glottalization to be freely realized anywhere in the production of a continuant segment. In fact, Ladefoged and Maddieson (1996) mention various phonetic realizations of glottalized sonorants. According to them, in some languages the laryngeal constriction gesture is centered at the same point in time as the oral closure, so that creaky voice characterizes the middle part of the sonorant, but in other languages the laryngeal constriction occurs at the beginning or the end of the sonorant. However, in the typological survey of glottalized sonorants, I (Um, 1998) show that there is a relationship between the position where the glottalized sonorants occur and their phonetic realizations. First, glottalized sonorants are mostly preglottalized, and never postglottalized in word-initial or syllable-initial position. Second, glottalization is variably realized on any part of the sonorant in syllable-final position.

In this paper, as an example of glottalized sonorants, I examine in detail the phonetic characteristics of glottalized sonorants in Gitksan. Gitksan is a Tsimshian language spoken on the Skeena River Valley in British Columbia. The purpose of this study is to describe the phonetic details of glottalized sonorants that occur in various contexts, i.e., word-initial, medial, and final position. In particular, the main focus is on word-initial occurrences of glottalized sonorants. Gitksan word-initial glottalized sonorants are preglottalized and they are hard to distinguish from their plain counterparts. I try to find the acoustic cues involved in word-initial glottalized sonorants.

2. The Data

The data were provided by Barbara Sennott and recorded by Nicola Bessell[1]. A digitization of the data was made at the sampling rate of

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[1] I am grateful to Nicola Bessell who allowed me to use the data she collected

22,050 Hz using a Mac program 'Sound Scope'.

The word list used for this study is given in (1):

(1) Words illustrating the Gitksan glottalized sonorants

Word-initial occurrences

		Hindle and Rigsby's (1973) transcription
m'al	'canoe'	m'al
m'itx^{w}	'dust storm'	m'itxw
n'aX	'bait'	n'a<u>x</u>
n'it	'yes, it is so'	
w'a	'to find, arrive'	w'a
w'in	'tooth'	w'in
y'ans	'leaf'	y'ans
y'imq	'whiskers, beard'	

Word-medial occurrences

hum'al	'canoes'	hum'al
sim'oykit	'woman's name'	
timhaw'niy'	'I am going to go home'	dim haw'niy'
se:l'aX	'needle'	seel'a<u>x</u>

Word-final or syllable-final occurrences

haw'	'go home'	haw'
hat'al'	'cedar bark'	hat'al'
qaqen'da	'they are chewing'	
qen'	'to chew'	gen'
ma:y'	'berries, fruit'	
t'imɬa:m'	'shin'	tim hlaam'

In medial or final position, glottalized sonorants are sometimes

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during her fieldwork trip.

realized as creaky voice. Most of the time, however, they are realized as a glottal stop (glottal closure) followed by the sonorant. Especially when in the syllable-final position, the duration of the glottal closure is quite long, such that they look like a sequence of a glottal stop and a sonorant. Laryngealization or creakiness is evident in some cases both in preceding vowels and in the first part of the sonorant itself. That is, they are usually preglottalized. However, in some cases of final glottalized glides, glottalization occurs in the middle of the glides. The pronunciation, even by a single speaker, is also variable.

3. Word-initial glottalized sonorants

Even though there are evident acoustic manifestations in glottalized word-medial and syllable-final glottalized sonorants, namely creaky voicedness and complete glottal closure, word-initial glottalized sonorants are not realized as creaky voice. Wickstrom (1974) reports that glottalized sonorants in Gitksan in all positions can be termed 'preglottalized', the glottis closing before the initial sound is made. The initial glottal closure is not immediately evident in the spectrograms, and it is difficult to distinguish the glottalized sonorants from their plain counterparts[2].

However, glottalized sonorants occur frequently in word-initial position. About 62 words beginning with glottalized sonorants appear in *A Short Dictionary of the Gitksan Language* by Hindle and Rigsby (1973). The question to be asked is: what are their acoustic properties? That is, what are the cues to distinguish them from their plain counterparts? In order to address this question, the following minimal or near-minimal pairs are examined (one female speaker, two repetitions):

[2] Nicola Bessell reports that while she found word-initial glottalized sonorants in Gitksan hard to recognize, the speaker did not seem to have any trouble telling them from plain sonorants.

(2) Minimal or near-minimal pairs showing word-initial contrasts of glottalized sonorants and plain sonorants

		Hindle and Rigsby (1973)
m'itx^{w}	'dust storm'	m'itxw
mitx^{w}	'to be full'	mitxw
m'al	'canoe'	m'al
ma:y'	'berries, fruit'	
n'aX	'bait'	n'a<u>x</u>
naX	'snowshoe'	na<u>x</u>
w'in	'tooth'	w'in
wis	'rain'	wis
w'a	'to find, arrive'	w'a
wa:x	'to paddle'	waax
y'imq	'whiskers, beard'	
yip	'land'	yip
y'ans	'leaf'	y'ans
yat^{s}	'hit, beat something'	yats

3.1 Sonorant duration

The oral constriction duration of initial nasals, i.e., the interval from the onset of voicing to the release of the oral closure, is measured. This would exclude any possible initial glottal closure.

(3) The duration of the glottalized and plain nasals

glottalized	m'al	44[3]		
	m'itx^w	31	45	
	n'aX	33	15	
	n'it	30	37	Mean: 33.57 ms (S.D.: 10.13)
plain	ma:y'	82	70	
	mitx^w	69	56	
	naX	120	74	Mean: 78.50 ms (S.D.: 22.02)

The nasal portion of the glottalized nasals is considerably shorter than that of the plain ones[4]. The same tendency was observed in glottalized sonorants in Montana Salish (Ladefoged et al. 1994).

3.2 Abrupt onset in glottalized sonorants

A word-initial glottal stop is typically followed by an abrupt increase in amplitude (Bessell 1996). If the glottal closure occurs in word-initial position as part of glottalized sonorants, the same phenomenon is expected for the glottalized sonorant. As expected, the abrupt onset of glottalized sonorants can be visually seen in the envelope of the sound wave. The envelope created by the program 'Sound Scope' represents the outer bounds of its amplitude (in volts) plotted as a function of time. In the case of the glottalized sonorant the increase in amplitude is relatively abrupt, as can be seen by the steep slope in (4), compared to the rather gradual increase in amplitude of the plain sonorant in (5):

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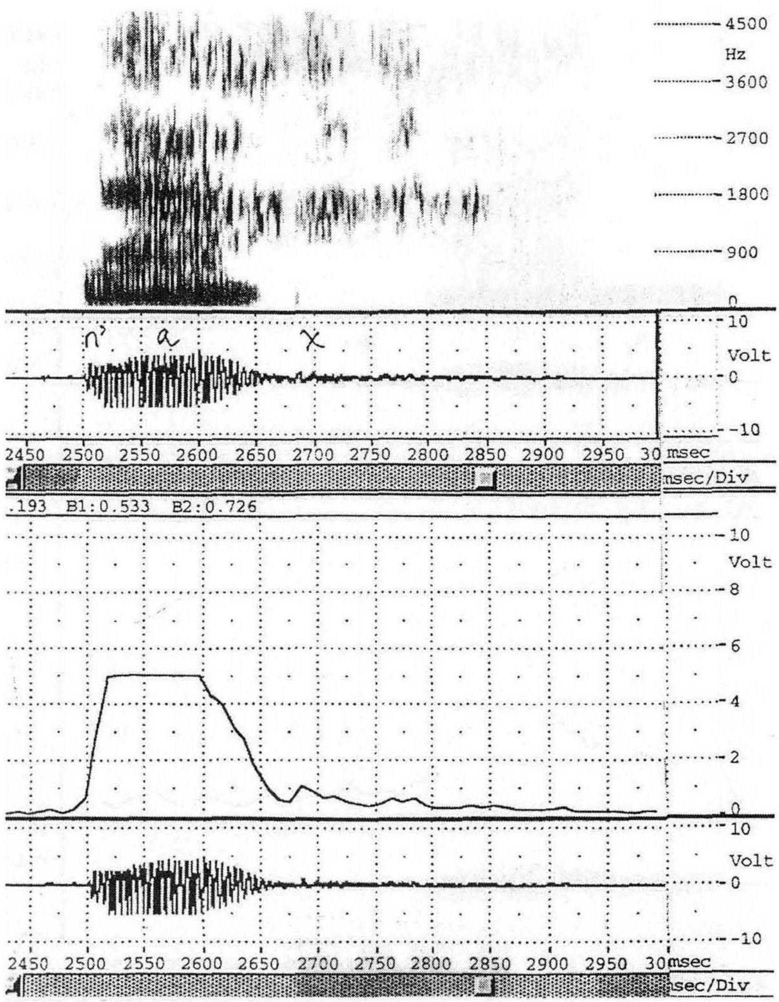
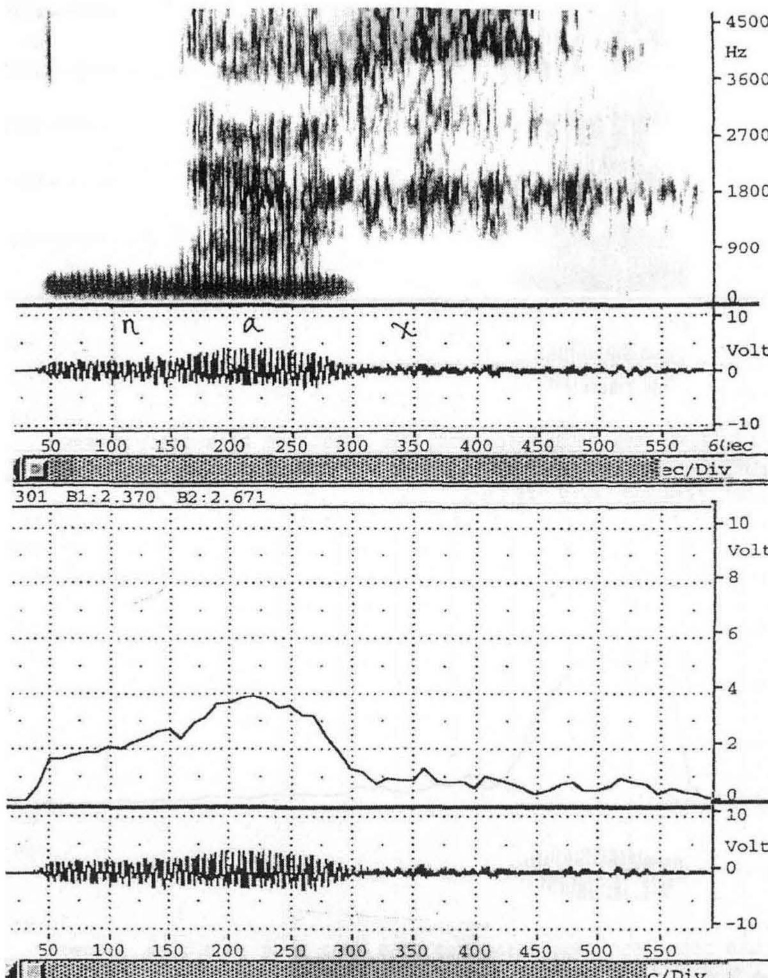
[3] Only one token is measured for this word. In the other token, the nasal duration is very short -- much shorter than that of the first token -- and it is hard to delimit the nasal and the following vowel.

[4] The duration of glides is not measured, since the delimitation between the glide and the following vowel is not always easy. However, the same observation is made for the glide. That is, the duration of the glottalized glide is shorter than that of its plain counterparts.

(4) Spectrogram and energy envelope of n'aX 'bait'



(5) Spectrogram and energy envelope of naX 'snowshoe'



In order to quantify the difference, the ratio of the time to reach the peak of amplitude to the whole amount of time for the whole length of the sound wave (%) is calculated[5].

(6) Time to reach the peak of amplitude/ whole amount of time (the length of the sound wave) (%) calculated for two tokens of each word

		%	%
Glottalized	m'itx^{w}	30.77	28.57
	m'al	13.79	9.52
	n'aX	21.26	11.84
	w'in	17.65	21.73
	w'a	9.08	23.08
	y'imq	33.92	36.61
	y'ans	16.67	5.83

Mean: 20.02%
(S.D.: 9.71)

		%	%
Plain	mitx^{w}	45.63	46.42
	ma:y'	35.20	36.37
	naX	69.37	56.20
	wis	43.90	53.71
	wa:x	70.37	42.33
	yip	81.06	35.72
	yat^{s}	40.24	18.75

Mean: 48.23%
(S.D.: 16.58)

In the sound wave that includes the word-initial glottalized sonorant, the time to reach the peak in amplitude takes on average 20.02% of the

[5] The point of the peak in amplitude is used as a reference point, since it is not meaningful to compare the absolute steepness of the slope, the amplitude level of each recorded word being different.

total amount of time (the whole length of the wave), which is much shorter than the 48.23% rise-time in the case of the plain sonorant. This tendency of rise-time of amplitude seems to be partly related to the length of the segments. That is, the abrupt and rapid rise-time of amplitude in the glottalized nasals can be due to the shorter duration of the glottalized nasals[6].

3.3 Absence of creaky-voicedness in word-initial glottalized sonorants

As mentioned above there is no sign of creaky voice in the spectrograms of word-initial glottalized sonorants. According to Kingston (1985), in association with sonorant articulations, glottalization modifies the voice quality and fundamental frequency of the sonorant and the neighboring vowels. As far as the fundamental frequency is concerned, the Gitksan glottalized sonorants themselves and the following vowels do not show any distinctive F0 pattern.

According to Ladefoged, Maddieson, and Jackson (1988), when producing creaky voice, the vocal tract is excited by a sharper pulse that has more energy in the higher harmonics, and as a result the energy in the higher frequencies can be increased. They suggest that one measure of the sharpness of the glottal pulse is the difference in dB between the intensity of the fundamental frequency and the intensity of the largest harmonic in the first formant. If the energy in the higher frequencies is increased, the dB difference between the amplitude of the fundamental frequency (L0) and that of the first fromant (L1) is predicted to be small in creaky voice[7]. Gobl and Ni Chasaide (1992) report that creaky voice has a noticeably lower L0 than other voice qualities. Also, according to Lindblom, the low amplitude of the fundamental frequency directly reflects a phonation type which is characterized by a great adduction force (cited from Ahn (1997)). In Gitksan glottalized sonorants, however, L0 is not lower than that of the

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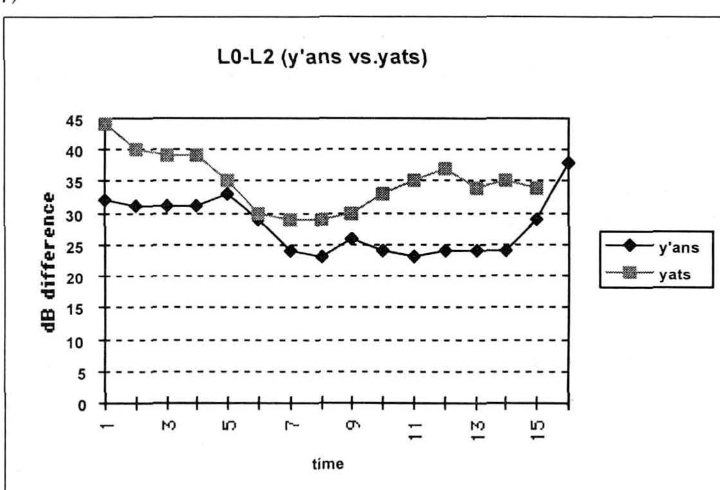
[6] It does not seem to be possible to quantify and compare the absolute values of the rise-time of the amplitude (steepness of the slope), since the maximum amplitude of each word is different.

[7] This is so only when the amplitude of F0 (L0) is higher than that of the other formants. In Gitksan, L0 is always higher than L1 and L2.

plain sonorants. The following experiment was done on the basis of the assumption that if glottal closure is made before the sonorant, some distinct amplitude pattern should be expected, at least in the very first part of the sonorant. The prediction is that the dB difference in the first part of the glottalized sonorant is lower than that in the plain sonorant.

In the Average Spectrum, which shows the frequency distribution for the entire wave or segment, with intensity (in dB) on the vertical axis and frequency on the horizontal axis, a 45 Hz (narrow band) filter was used to make the amplitude of each of the component harmonics clearly visible. Average spectra (window size: 20 ms) were calculated at 10 ms intervals from the beginning of the first glottal pulse of the sonorant to the end of the vowel. Measurements of the intensity of the first harmonic, i.e., fundamental frequency (L0), and the intensities of the largest harmonic in the first and second formant frequency regions (L1 and L2) were made. The results are plotted in graphs like (7):

(7)



Since there are some problems in performing this experiment with glottalized sonorants, only a limited set of data was used for this measurement. First of all, because of the spectral properties of nasals, namely spectral zero or anti-resonance, it is not possible to measure the amplitudes of the formants in nasals. Consequently, nasals are omitted from consideration. Second, due to the formant transition and the attenuation of the amplitude of higher frequency regions, accurate values of L1 and L2 in glides are hard to obtain. Third, the data is not controllable and the difference in syllable length makes the comparison difficult. Finally, for high vowels and the first part of the glide, L1 is hard to decide, since F1 coincides with F0. Therefore, L1 cannot be used for the glide y. The following are the results:

(8) Results:

(a) Supporting data

w'a vs. wa:x : dB differences between L0 and L1, and L0 and L2 in w' are distinctly lower in the first part of w'; L1 and L2 are relatively high in w'.

y'imq vs. yip : dB differences between L0 and L2 are relatively low in y'; L2 is relatively high in y'.

y'ans vs. yat^s : In the beginning part, dB differences between L0 and L1, and L0 and L2 are low in y'; L1 and L2 are relatively high in y'.

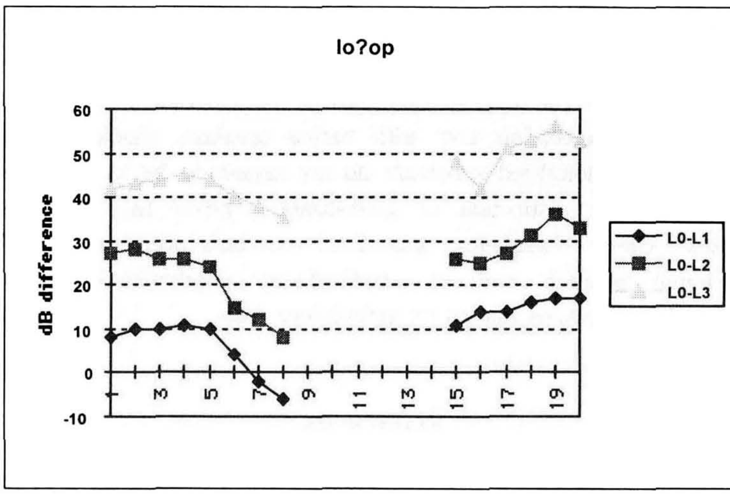
(b) Non-supporting data

w'in vs. wit : dB differences between L0 and L1 are almost the same. Those between L0 and L2 are slightly higher in w'; L2 is slightly lower in w'.

It is true that in the above three pairs of words (8a) the smaller dB difference we expected for glottalized sonorants was found at least in the first part of the sonorants. That is, the amplitude in the higher frequency regions in glottalized sonorants is higher than that of plain sonorants. However, it is not clear if the differences in dB they show are significant. In addition, in the pair w'in/wit (8b) the dB difference pattern we expected was not found.

The same measurements were made for words containing intervocalic glottal stops and final glottalized sonorants. For both cases, an amplitude drop is evident in the preceding vowel. This suggests that some cues for the glottalized sonorants are in the preceding vowel and that the initial glottalized sonorant may be difficult to hear due to the lack of accompanying context that can contain cues for identification (i.e., a preceding vowel).

(9) Pattern of amplitude difference in lo?op and hat'al'



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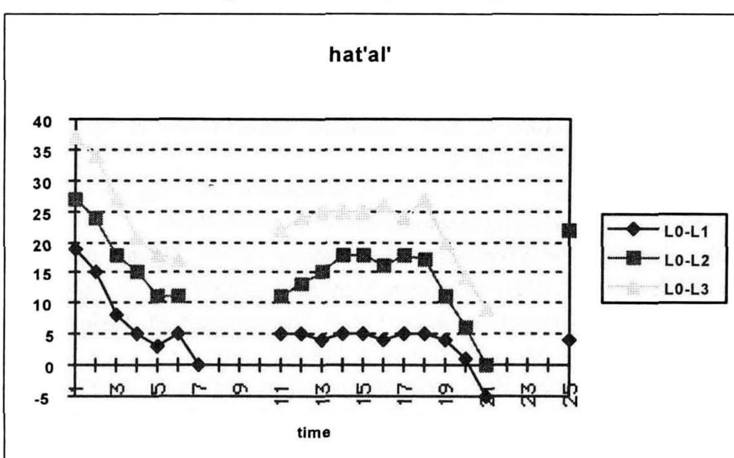

a t' a l'

4. Summary and conclusion

To summarize, the main properties of Gitksan word-initial glottalized sonorants are a short duration and an abrupt onset. Without the evident presence of creaky voice, the duration and quality of the onset seem to be the cues for the glottalization of the sonorant in word-initial position. Therefore, it may be harder to perceive the glottalization of sonorants in word-initial position than in medial or final position where the complete glottal closure or creakiness is evident, and the preceding vowel also carries the glottalization cues of the sonorant.

Although a perception test with native speakers should be done, word-initial preglottalized sonorants do not appear to be in a favorable position for the distinction of glottalization, given the absence of contextual cues. Nonetheless, glottalized sonorants occur frequently in word-initial position and are realized as preglottalized, not as postglottalized, perhaps due to its articulatory ease.

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