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A Study on Voiceless Nasals in Burmese

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1. Introduction

It is well known that Burmese has two nasal series in phonemic contrast. One is the ordinary nasal series /m-, n-, ny-, ŋ-/, and the other is a voiceless nasal series /hm-, hn-, hny-, hŋ-/. The voiced-voiceless contrast is found not only in nasals but also in laterals in Burmese. Voiceless nasals themselves are not limited to Burmese[1]). It is known that some languages cognate with Burmese, for example the Yi (Lolo) Language (mainly spoken in the Southwestern part of China), have this kind of phonemic contrast (Nishida, 1980). Many other languages in the Southeast Asian areas also have the opposition between voiced and voiceless nasals.

In this paper, we would like to describe the nature of voiceless nasals in Burmese. From the diachronic point of view, it might be inferred that there was a historical change from consonant clusters to single voiceless nasals. From the synchronic point of view, on the other hand, there are two different phonological interpretations, that is, some linguists (McDavid, 1945) regard them as consonant clusters, e.g. /h/+/m/, /h/+/n/, /h/+/ŋ/, etc, while others (Cornyn, 1944, Sprigg, 1965, Okell, 1969, Nishida, 1972, etc.) regard them as independent phonemes, e.g. /hm/, /hn/, /hŋ/, etc. However, the literature on the phonetic substances of the voiceless nasals in Burmese is quite limited. The present study is intended to explore the characteristics of voiceless nasals in Burmese and to examine their acoustic features, hoping to make a more concrete contribution to the phonological interpretations on them.

2. General Scope of the Present Study

In the first place, we would like to survey the previous works both on the diachronic studies including a letter-graphic study and on the synchronic studies including a grammatical function analysis. It seems plausible to extract some useful pieces of information from those studies.

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1) Icelandic also has the voiceless nasal [n̥], spelled "nn" (Schubiger, 1970), and some Bantu languages have the voiceless nasals [m̥Φ] or [ɱ̊f] (Heffner, 1950).

Diachronic view

From the diachronic point of view, it can be hypothesized that some consonant clusters containing nasals as second consonants changed into voiceless nasals (Nishida, 1970). Nishida (1975) discussed Burmese and one of the related languages, Tibetan in considerable details.

> "We may then assume the earlier *Cn- and *♯n- as the initials of the earlier Tibetan forms. Taking into consideration the corresponding WrT (Written Tibetan) forms, we may proceed to set up *lnga* and *rna* for the respective Tibetan forms in High tone and *♯nga-* and *♯na-ba* for those in Low tone. By analogy we can then assume **Cna* 'five', *♯*na* 'I', **Cna* 'ear' and *♯*na* 'sickness' for the Burmese cognate forms...
>
> There are several Burmese forms that retain a vestige of C.
>
> | | | | | | | |
> |---|---|---|---|---|---|---|
> | 'to give' | WrT | *gnang-ba* | : | WrB | *hnang*^{2}- | High |
> | 'to borrow' | | *brnya-ba* | : | | *hnga*^{2}- | High |
> | 'nose' | | *sna* | : | | *hna* | Low" |

He assumed that some consonant clusters like /gn-/, /brny-/ or /sn-/ in Written Tibetan have useful information to reconstruct the prototype forms of voiceless nasals in Burmese. It can be inferred that the voiceless noisy portion of the voiceless nasals in Burmese, which is represented by "h" at the present time, is a result of modification of some other phonemes like /g/, /s/, etc. Therefore, we would assume the voiceless nasals to have been consonant clusters from the interpretation of historical data of the related languages.

Letter-graphics

It is assumed that the letter-graphics of Burmese reflect the pronunciation of a certain period of bygone ages. Therefore, it is not meaningless to survey the graphical structure of voiceless nasals. From the graphical point of view, voiceless nasals are represented by adding a subscript called "ha. t'o:" (in the shape of " J ") under the basic nasal letters. e.g.:

မ	ma^{3}	မှ	hma^{3}
န	na^{3}	နှ	hna^{3}
င	nga^{3}	ငှ	hnga^{3}
ည	nya^{3}	ညှ	hnya^{3}

When "ha. t'o" is added to the ancient form of "r-", it generates the fricative /sh-/:

ရ	ya^{3} (*ra)	ရှ	sha^{3}

On the other hand, unaspirated and aspirated plosives have independent graphics, respectively:

ပ	pa^{3}	ဖ	pha^{3}

တ	ta³	ထ	tha³
က	ka³	ခ	kha³
စ	sa³	ဆ	sha³

It means that the aspirated plosives appeared to be different and to be independent units from the unaspirated ones. On the contrary, it can be inferred that the voiceless nasals seemed to be binary units, namely, ordinary nasals plus something. From this kind of view also, we would assume them to have been consonant clusters.

Grammatical Function

From the grammatical point of view, it is said that the opposition between voiceless nasals and voiced nasals stands in a parallel position with the one between aspirated consonants and unaspirated ones.

"ex.	phi	"press, compress"	pi	"be pressed"
	phe³	"break off (a piece)"	pe³	"break off, be chipped"
	pho	"reveal"	po	"appear"
	che?	"cook"	ce?	"be cooked"
	cha³	"drop, throw, put"	ca³	"fall, be situated"
	shou?	"tear"	sou?	"be torn, shabby"
	shu?	"moisten, make damp"	su?	"be damp"
	khwe²	"split, separate"	kwe²	"be split, separated"

While,

hmyou?	"bury, submerge"	myou?	"be buried, submerged"
hmyin³	"raise, make higher"	myin³	"be high, tall"
hni?	"submerge, sink"	ni?	"be submerged, sink"
hne³	"loosen" (in socket, etc.)	ne³	"be loose"
hna?	"complete cooking"	na?	"be completely cooked"

(From Okell, 1969)

"These pairs of verbs are called "h/non-h" pairs. The relationship between the verbs in each pair is that the verb with an aspirate (h) initial is the "transitive", "active", or "causative" correlate of the verb with a plain initial[2)] (Okell, 1969)."

From this point of view, it can be said that the contrast between voiced and voiceless nasals is functionally the same with the one between aspirated and unaspirated plosives. It seems that the voicelessness of the voiceless nasals is equivalent to the aspiration of the aspirated consonants. Therefore, as we regard the aspirated consonants as single phonemes, we could regard voiceless nasals as single phonemes.

2) Only limited verbs belong to h/non-h pairs. About fifty pairs have this relation (Okel, 1969). Other verbs have no such relation to each other.

Syllable structures

Syllables in Burmese consist of open and closed syllables. Syllable structures in Burmese can be shown as below[3)].

Open syllable	Closed syllable
V	VC
VV	VVC
CV	CVC
CVV	CVVC
CCV	CCVC
CCVV	CCVVC

There are some instances in which initial voiceless nasals are followed by semi-vowel consonants /w/ or /y/.

hmwei[3]	"to smell sweet"	*hmwan*[3]	"to decorate"
hmyo[3]	"set afloat"	*hmyin*[3]	"raise, make higher"

Therefore, if we assume voiceless nasals are consonant clusters, there would be formed other types of syllables, namely CCCV, CCCVC[4)], etc. However, examining the data in syllable structures of Burmese, it seems implausible to recognize such consonant clusters. Therefore, we would like to assume them as single phonemes.

3. Phonetic Analysis

In order to explore the phonetic nature of voiceless nasals in Burmese, we carried out four kinds of spectrographic analyses, namely, wide-band analysis, narrow-band analysis, amplitude display and contour display. From the wide-band analysis, the formant structure can be examined. The narrow-band analysis gives the harmonic structure. Amplitude display shows the overall intensity as a continuous function of time. The contour display analysis is useful for examining frequencies of the spectrum and for scanning relative intensity.

Materials

Informants are two female adult Burmese from Rangoon. They came to Japan as trainees. They were recorded reading word-lists containing relevant words in Burmese. Recordings of these materials were made by Prof. K. Shimizu at the soundproof room of Nagoya Gakuin University. All these materials are one syllable words which contain the voiceless nasals or ordinary nasals in the syllable initial position in principle.

3) There are several interpretations on the syllable structures in Burmese. For example, Ohno (1983) does not admit the diphthongs (VV) in the open syllables.

4) If we assume /w/ and /y/ to be vowels (/u/ and /i/), it is not essential to provide the CCC-types of syllables.

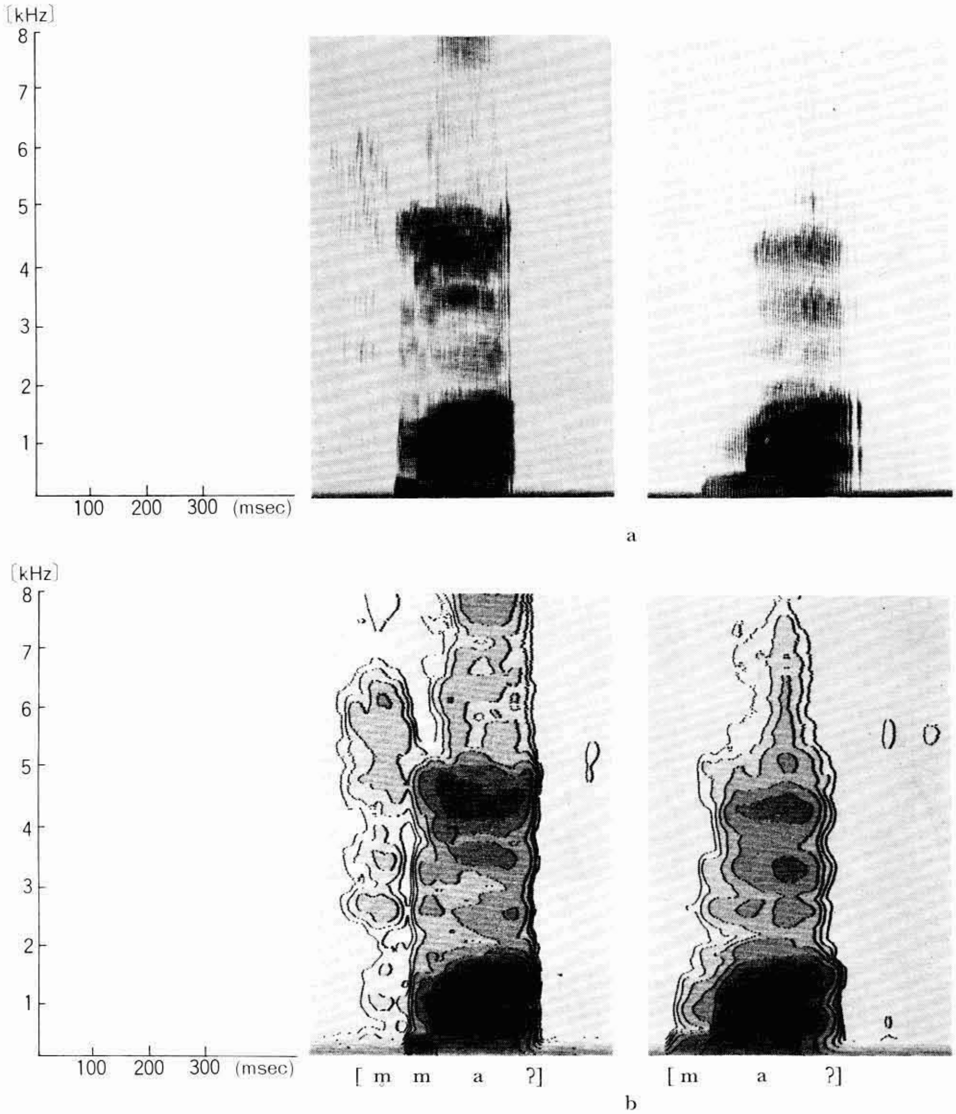


Fig. 1. The wide-band and contour display sound spectrograms of the voiceless nasal and ordinary nasal.

Constitution

From the wide band analysis, it can be clarified that voiceless nasals in Burmese consist of two portions. One portion is the noisy portion, namely, the nasal friction. As we can find neither voice bar nor striations, we assume the nasal friction portion to be voiceless. This is the portion that is represented by /h/ conventionally. It is said that this portion is produced with the articulator, viz. the lips or tongue, in position for the voiced nasal portion which follows (Armstrong and Pe, 1925). Therefore, according to the difference of the point of articulation, it can be rep-

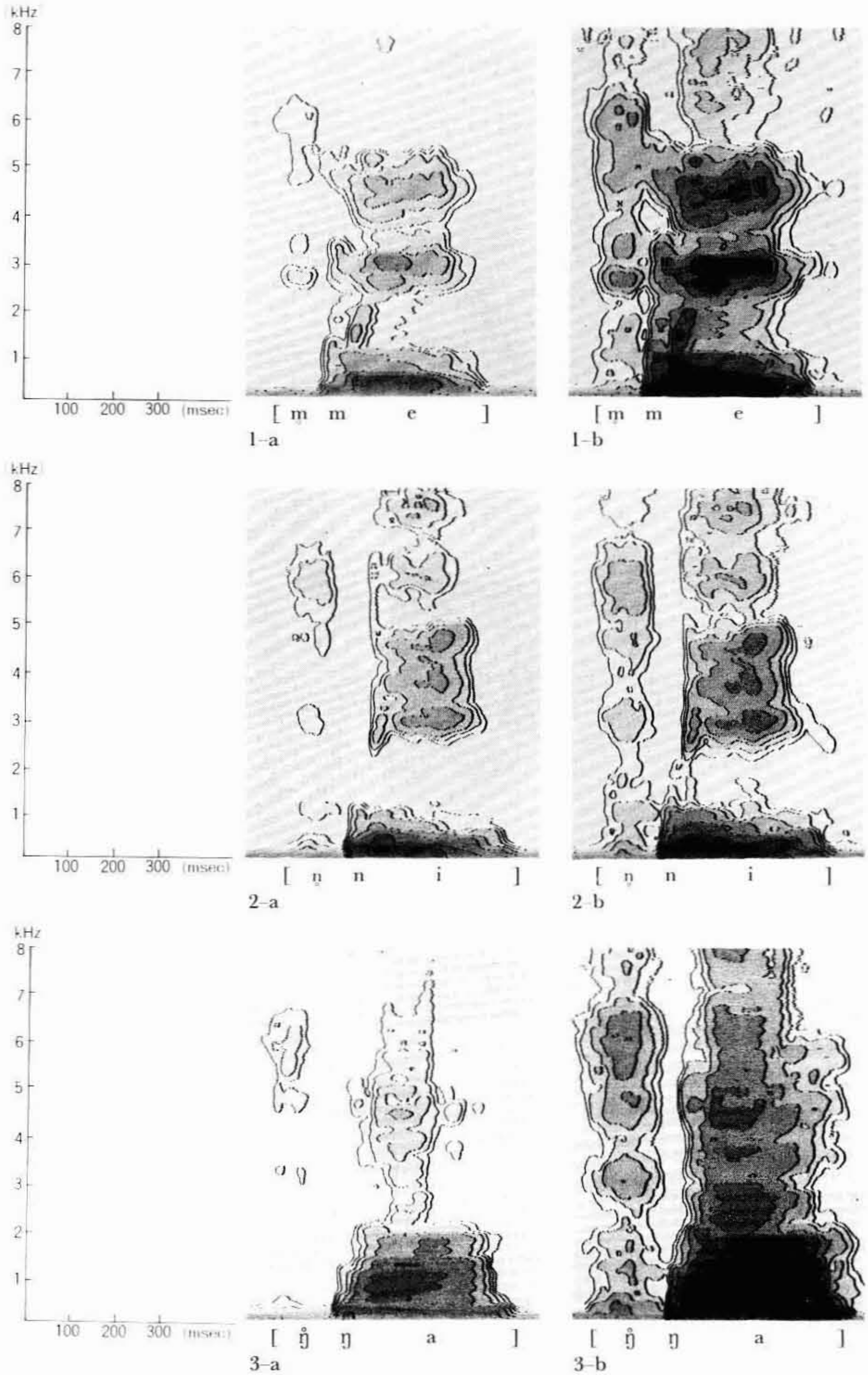


Fig. 2. Influence of adjustment of each level.

resented by [m̥], [n̥] or [ŋ̊]. The other portion is the voiced nasal portion (as inferred from striations). It can be represented by [m], [n] or [ŋ], for it seems to

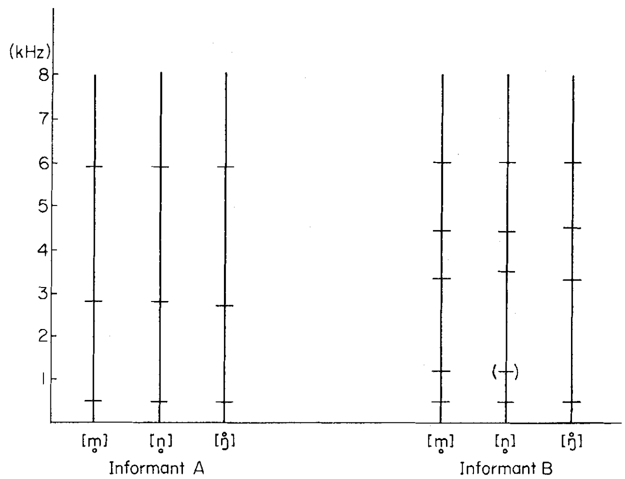


Fig. 3. The prominent peaks of the spectrum of the nasal friction portion of voiceless nasals.

be a variant of nasal stop. The intensity of the voiceless nasal friction portion is quite low in comparison with that of the voiced nasal portion. On the other hand, the duration of the voiceless nasal friction portion is quite longer than that of the voiced nasal portion. In these respects, we will refer to the detail afterwards. The wide-band and contour display spectrograms of voiceless nasals are presented in Figure 1.

Spectrum

At first sight, it seems that the distribution of spectrum of nasal friction portion is limited. However, if the recording, reproducing and mark levels are adjusted, we can find that the distribution of spectrum is expanded from the lowest frequency range to over 8KHz (Fig. 2). It also has been found that there are several prominent peaks of energy in the spectrum of the voiceless nasal friction portion. The prominent peaks of spectrum are about 0.5, 2.8 and 5.9 KHz for informant A and about 0.5, 3.3, 4.5 and 6.0 KHz for informant B. It seems that the spectrum of informant B has more prominent peaks than that of informant A. However, it depends on the fact that the whole spectrum energy of the nasal friction portion of informant B is weaker than that of informant A, so the standard value of prominent peaks for informant B that we adopted is lowered. Therefore, putting together informants A and B, it can be said that the prominent peaks of spectrum of voiceless nasal friction portion are about 0.5, 3 and 6 KHz. We can not find a significant difference depending on the difference of the point of articulation. Then, this would confirm Ohala's remark on the noise spectra of voiceless nasals (Ohala, 1975). We only found that the spectrum of the bilabial [m̥] of informant B has another prominent peak around 1.2 KHz. However, as there is a slight difference in distribution of prominent spectral peaks between informants A and B,

Table 1. Difference of intensity between nasal friction and voiced nasal portion of voiceless nasals in Burmese.

(dB)	Number of instances	
	Informant A	Informant B
0~	1	0
−6~	6	0
−12~	6	0
−18~	20	8
−24~	16	28
−30~	6	15
−36~	1	3
	56	54

we feel it necessary to further collect additional materials.

Intensity

So as to measure the intensity, we made use of both amplitude display and contour display. We can see a difference of 24dB at most by amplitude display, 42dB maximum by contour display. Armstrong and Pe (1925) pointed out that intensity of nasal friction of voiceless nasals is very weak. In order to evaluate the intensity of nasal friction, we measured the difference of amplitude between the nasal friction and the voiced nasal portion. Results are shown in Table 1. Table 1 shows that almost all instances are negative quantities. This means that the intensity of nasal friction is weaker than that of the voiced nasal portion. The average is −21dB in case of informant A and −27dB in case of informant B. It means that the intensity of the nasal friction portion is much lower than that of the voiced nasal portion. Therefore, we can confirm their indication.

From Table 1, we can also notice that the intensity of nasal friction of informant A is a bit stronger than that of informant B. It was observed that there is a peak of power of nasal friction in the low frequency range below 500 Hz in many cases of informant A (Fig. 4). This seems to be due to a hard blow of breathing through the nose. It seems that this is a personal characteristic of informant A.

From the view point of the difference of the points of articulation, we can not find any significant difference in intensity among /hm/, /hn/ and /hŋ/. For example, in the case of informant A, the intensity of velar [ŋ̊] is slightly weaker than that of bilabial [m̥] and alveolar [n̥]. On the other hand, in the case of informant B, the intensity of alveolar [n̥] is slightly weaker than that of the other sounds. However, these are not statistically significant.

Duration

In order to measure the duration of the voiceless nasals, we made use of contour

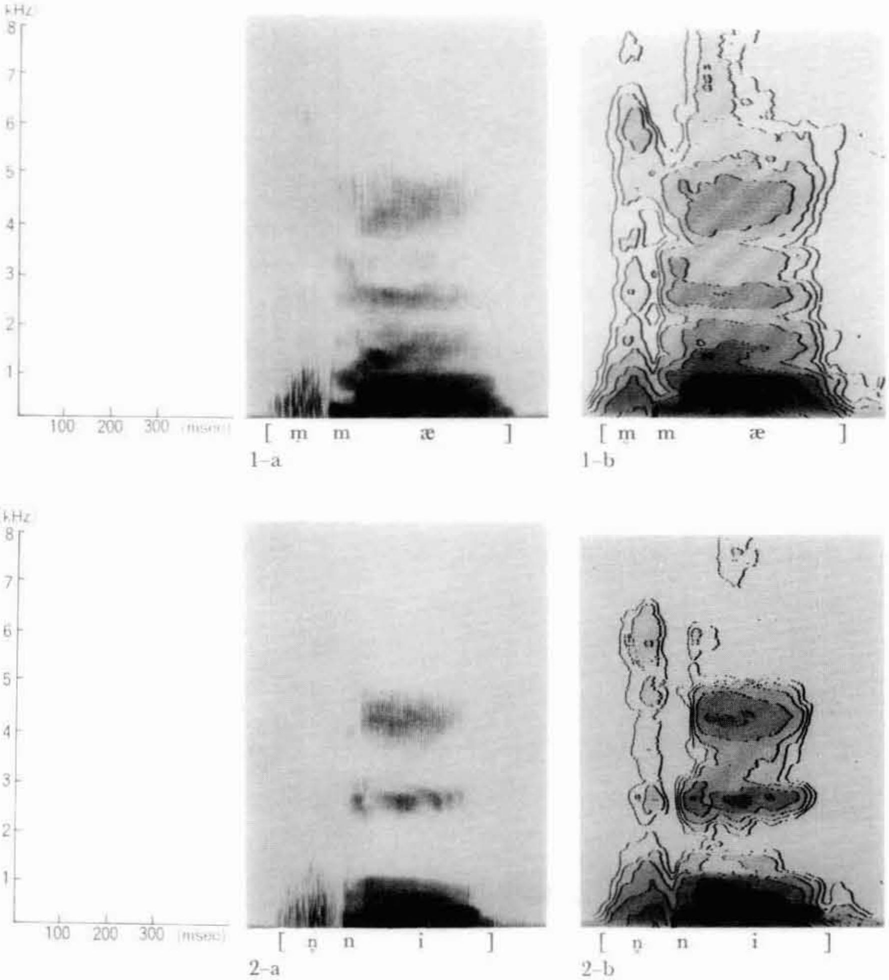
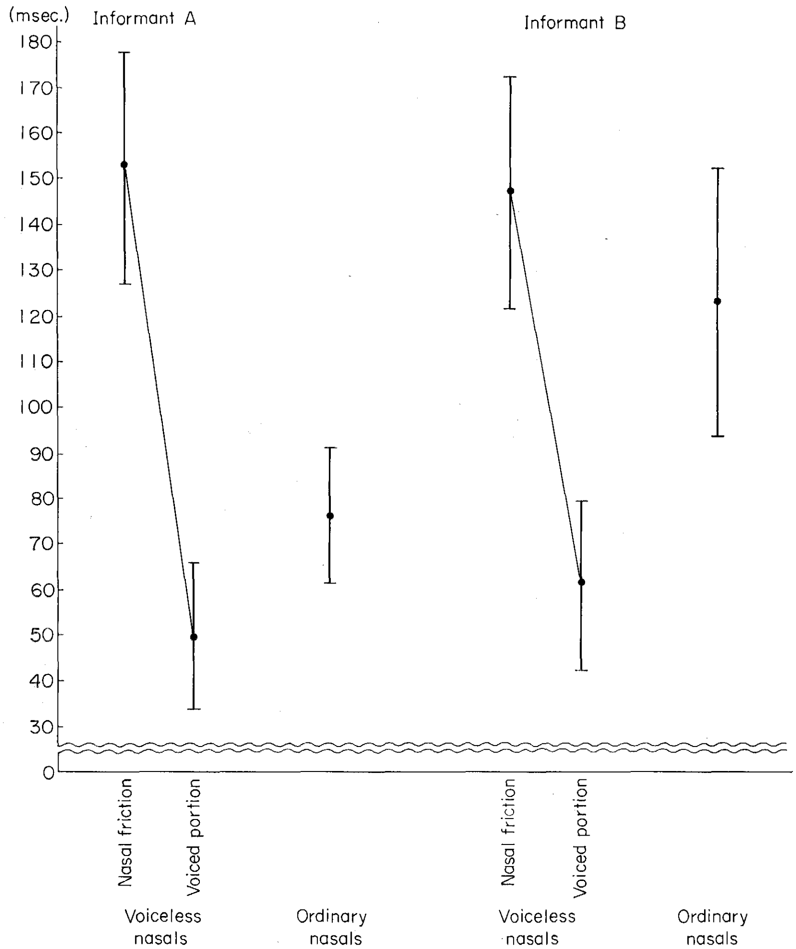


Fig. 4. A peak of power of nasal friction in the low frequency range of informant A.

Table 2. Durations of the voiceless nasals and ordinary nasals.

		nasal friction (msec.)	voiced portion (msec.)	ordinary nasal (msec.)
A	mean	152	50	76
	max	239	75	114
	min	99	12	67
	S.D.	25	16	15
B	mean	146	60	122
	max	198	123	211
	min	43	23	67
	S.D.	25	19	29

a.



b.

Informant A		Informant B	
	[♯N] 76		[♯N] 122
[N̥] 152	[N] 50	[N̥] 146	[N] 60
[m̥] 154	[m] 52	[m̥] 155	[m] 61
[n̥] 140	[n] 57	[n̥] 130	[n] 62
[ŋ̊] 167	[ŋ] 21	[ŋ̊] 150	[ŋ] 39

([♯N] = ordinary nasal [N̥] = nasal friction portion [N] = voiced portion The numbers represent the durations (msec.).)

Fig. 5. Durations of the voiceless nasals and ordinary nasals.

display. As the nasal friction portion is very weak, it is difficult to identify the beginning of the nasal friction from the wide-band spectrogram. We measured not only the duration of the nasal friction portion and voiced nasal portion of the voiceless nasals, but also the duration of the ordinary nasals. The results are shown in Table 2 and Fig. 5. The values of the durations of the voiceless noisy portion and the voiced portion of the voiceless nasals are very similar to those of the voiceless lateral approximant reported by Maddieson and Emmorey (1984). In this respect, the durations of the voiceless noisy portion (nasal friction) are 152 msec. (informant A), and 146 msec. (informant B), and those of the voiced portion are 50 msec. and 60 msec., respectively. In comparison, the durations of the voiceless noisy portion and voiced portion of the voiceless lateral approximant are 136 msec. and 55 msec, respectively (Maddieson et al., 1984). The proportions of the duration of the voiced portion to the total duration of voiceless nasals are 25% in the case of informant A and 29% for informant B. Therefore, it can be said that the duration of the voiced portion is quite shorter than that of the nasal friction.

On the other hand, Table 2 shows that the duration of the voiced portion of voiceless nasals is also quite shorter than that of ordinary nasals. The proportions of the voiced nasal portion of voiceless nasals in comparison with ordinary nasals are 66% in case of informant A and 49% in case of informant B. The mean durations of the voiced portion of the voiceless nasals are 50 msec. (informant A) and 60 msec. (informant B). On the other hand, the minimum values of the durations of the the ordinary nasals are 67 msec. for both informants A and B. It means that the mean durations of the voiced portion of the voiceless nasals are less than the minimum duration of the ordinary nasals. It therefore can be said that a reduction takes place in case of the voiced nasal portion of the voiceless nasals in Burmese. It is reported that such a reduction can also be observed in the case of nasals in consonant clusters of English (Haggard, 1973a). However, the proportions of reduction are 99% for /#m/ vs. /sm/ and 81% for /#n/ vs. /sn/. As the reduction rate of voiced portion of voiceless nasals in Burmese is extremely high compared with consonant clusters in English, we would not assume them to be independent phonemes, namely, /m/, /n/, /ŋ/, etc. We should rather assume them to be transition portions to the following vowels. There exist some instances which have almost no voiced portion (below 20 msec.). This tendency is especially noticeable in the case of the velar voiceless nasal /hŋ/. From this point too, we can support the interpretation which regards the voiced portion to be only a transition portion.

There is a tendency that the duration of the voiceless nasal friction portion of the alveolar voiceless nasal /hn/ is slightly shorter than that of the bilabial /hm/ and the velar /hŋ/. In this respect, however, we cannot find a statistically significant difference according to the point of articulation in the strict sense. On the other hand, the duration of the voiced portion of the velar voiceless nasal /hŋ/ tends to be quite short in comparison with others. This is statistically significant ($p<0.05$).

Table 3. Correlations of durations between the nasal frictions and the voiced portions of voiceless nasals.

	Informant A	Informant B
	r=−0.49	r=−0.47
/hm/	r=−0.48	r=−0.42
/hh/	r=−0.31	r=−0.56
/hŋ/	r=−0.55	r=−0.57

(r=coefficient of correlation)

Correlations and Regressions

In connection with the durational study, we examined correlations[5] between durations of the nasal frictions and durations of the voiced nasal portions. The value of the coefficient of correlation varies from −1 to 1. When it is −1, there is a perfect negative linear correlation between the durations of the nasal friction portion and the voiced portion. On the contrary, when it is 1, there is a perfect positive linear correlation between them. Of course, as we cannot expect such a perfect correlation, we should pay attention to whether the value of the coefficient of correlation is negative or positive. Results are shown in Table 3. Table 3 shows that the nasal frictions and voiced portions have negative correlations. Coefficients of correlations in the aggregate are −0.49 (informant A) and −0.47 (informant B). We also examined linear regression coefficients. Regression coefficients of the duration of the nasal friction portion on the duration of the voiced nasal portion are -0.77 (informant A) and -0.62 (informant B). Regression coefficients of the duration of the voiced nasal portion on the duration of the nasal friction portion are -0.31 (informant A) and -0.36 (informant B). They are statistically significant ($p<0.01$). The negative correlation and regression mean that the longer the duration of the nasal friction is, the shorter the duration of the voiced portion is. These values suggest that there is a tendency of compensation of duration between nasal friction portion and voiced nasal portion. It indicates that the whole duration of voiceless nasals in Burmese has a tendency to keep constant. This confirms that we can regard the whole two portions (the nasal friction portions and voiced portions) as single units, namely, single phonemes.

In this respect, there are some reports that the durations of two segments in consonant clusters also have sometimes negative correlations (Haggard, 1973b). It has also been pointed out that measurement error is one of the possible sources of negative correlation between adjacent intervals (Ohala and Lyberg, 1976). However, we would like to take the position that such strong negative correlations between the nasal frictions and voiced portions of voiceless nasals indicate that they are not consonant clusters but single phonemes.

The coefficient of the voiceless alveolar nasal /hn/ of informant A is weak in

5) Pearson's coefficient of correlation.

comparison with others. It can be inferred that this phenomenon may be due to both the slightly shorter duration of the nasal friction portion and the longer duration of the voiced portion of the alveolar /hn/. A factor which disturbs the correlation between the duration of the nasal friction portion and voiced portion is the duration and quality of the following vowels. The negative correlation of voiceless velar nasal /hŋ/ was not statistically significant because of the small number of instances. Therefore, we are now collecting additional materials.

4. Problems

Burmese is a tone language. In the present study, we did not take into consideration the influence of tones on the nature of voiced-voiceless nasal contrast. We feel it necessary to examine how tones and vowel quality affect the phonetic characteristics of the contrast. In connection with voiceless nasals, Burmese has other types of voiceless sonorants, namely, the voiceless lateral approximant /hl/ and voiceless approximant (semivowel) /hw/. By further collecting and analyzing the data of these contrasts, we will have a better understanding on the phonetic nature of voiced-voiceless series in Burmese.

5. Summary and Conclusions

Through the present study, some properties of voiceless nasals in Burmese can be clarified as follows. From the diachronic point of view and a graphic study, it can be assumed that the voiceless nasals in Burmese have characteristics of consonant clusters. However, from the synchronic point of view based on a grammatical function analysis and an acoustic phonetic study, there can be another interpretation. From the grammatical point of view, some functions of voiceless nasals are similar to those of aspirated stops. The examination of the spectrographic analyses has demonstrated that voiceless nasals consist of a voiceless nasal friction and a voiced nasal portion. It has been shown that the energy of the voiceless nasal friction is much weaker than that of the voiced nasal portion by means of the intensity study. The durational pattern analysis has clarified that the duration of the voiced nasal portion of voiceless nasals are quite shorter than that of ordinary nasal stops. From the examination of correlation of duration between the nasal frictions and voiced nasal portions, it appears that they show negative correlation. Putting together these properties mentioned above, we would like to support the phonological interpretation that the voiceless nasals are single phonemes.

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