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The Nasal Vowels in Maithili: An Acoustic Study

Sunil Kumar Jha
Tribhuvan University

Introduction

At one point or another, every theory of speech production has to contend with the transition from discrete phonological units or categories to "continuously varying phonetic dimension", as Benguerel and Lafargue (1981: 309) put it. Similarly, every theory of speech perception has to contend with the inverse transition - i.e. from the phonetic continuum to the discreteness of the phonological level. The use of a certain phonetic dimension in a given language may or may not reflect a corresponding contrast in the phonology of that language. Vowel nasalization, for example, is a phonetic phenomenon which does not reflect a phonological contrast in, say, English, although this phonetic phenomenon is often present to some extent whenever a derived level non-nasal vowel occurs between nasal consonants. But there are other languages, e.g. French, Portuguese, Gujarati, Urdu, Hindi and Maithili, in which vowel nasalization does mark a phonological contrast.

Various studies on vowel nasalization (e.g. Lightner, 1970; Ruhlen, 1973; Ferguson, 1974; Cagliari, 1977) point out that many languages show long phonetic vowels in place of underlying VN sequences. Like Hindi and Urdu (e.g. Narang and Becker, 1971; Bhatia and Kenstowicz, 1972), or like Gujarati (e.g. Dave, 1977), Maithili has phonologically distinctive nasal vowels. The present paper analyses the main acoustic realisations of these nasal vowels.

Procedures

For the purpose of the present study, a list of test utterances containing the Maithili nasal vowels was prepared, keeping the vowels both in isolation[2] and in word contexts. All the test utterances used in this study are listed in Table 1. Each test utterance was put in a sentence context (the frame of the sentence being ['pʰero . . . kəhi'yəu] 'please say . . . again') and it was spoken at a normal conversational speed.

Nine tokens of each test utterance were recorded in a soundproof studio at Essex University. All these recordings were made on a Revox B 77 tape-recorder. Of the nine tokens of each test utterance, the first two as well as the last two tokens were ignored, and all the remaining five tokens from the middle were used to obtain visual records in the

Table 1

Test utterances containing the Maithili nasal vowels spoken in isolation and in words.

Vowels in isolation	Vowels in words	Oral and nasal vowels contrasted in words
/ĩ/	/ʧʰĩʈ̣/ 'garment dyed with spots'	/ʧʰiʈ̣/ 'scatter' /ʧʰĩʈ̣/ 'garment dyed with spots'
/ẽ/	/ʧʰẽʈ̣/ 'surplus (e.g. of grain)'	/bʰeʈ̣/ 'see'; 'get in touch' /bʰẽʈ̣/ 'a kind of flower-seed'
/æ̃/	/sæ̃/ 'husband; lover'	/bʰæt/ 'will become' /bʰæ̃t/ 'kind'; 'type'
/ã/	/hãs/ 'goose'	/bas/ 'shelter' /bãs/ 'bamboo'
/ə̃/	/hə̃s/ 'laugh (imp.)'	/'kəʈ̣gər/ 'commendable' /'kə̃ʈ̣gər/ 'thorny'
/ɔ̃/	/sɔ̃/ 'from'	/gɔt/ 'will sing' /gɔ̃t/ '(cattle) urine'
/õ/	/ɖʰõɽʰ/ 'a kind of snake'	/gʰoʈ̣/ 'mix (imp.)' /gʰõʈ̣/ 'swallow (imp.)'
/ũ/	/ɖʰũɽʰ/ 'search (imp.)'	/kə'hu/ '(please) say' /kə'hũ/ 'somewhere'; 'in case'

form of spectrograms. Wideband spectrograms and wideband 'sections' (i.e. short-term spectrum) of each of the five tokens were made on a Sona-Graph 6061-B Sound Spectrograph, Kay Electronic Co., Pine Brook, N.J.

The formant frequency of each token was measured from wideband spectrograms, since these were found to offer the most convenient way of locating the centre frequency of each formant. Duration measurements were made from all the five tokens of each test utterance as recorded in various contexts. Formant frequency and duration measurements were made to the nearest 20 Hz and 5 ms, respectively.

Formant Frequency Measurement Results and Discussions

The phonetic evidence gathered from the spectrograms of the record-

ings done for this study strengthens the fact that all the nasal vowels in Maithili are unit sounds, and not sequences of an oral vowel plus a nasal consonant. The acoustic analysis presented in this piece of work is based on this fact. Table 2 presents the average frequencies of the first three formants as well as of the nasal formant (Fn) for the nasal vowels spoken in isolation[3]:

Table 2

The average frequency values of F_1, F_2, F_3 and Fn for the Maithili nasal vowels spoken in isolation (in Hz).

Vowel	F_1	F_2	F_3	Fn
/ĩ/	288	2636	3236	962
/ẽ/	448	2354	3104	1274
/æ̃/	708	1752	2682	1084
/ã/	718	1256	2682	1534
/ə̃/	514	1068	2778	1178
/ɔ̃/	580	856	2536	1336
/õ/	432	726	2792	1140
/ũ/	322	614	2786	1070

Table 3

The average frequency values of F_1, F_2, F_3 and Fn for the Maithili nasal vowels spoken in words (in Hz).

Vowel	Word	F_1	F_2	F_3	Fn
/ĩ/	/ʧʰĩṭ/	330	2638	3490	952
/ẽ/	/ʧʰẽṭ/	436	1944	2608	1068
/æ̃/	/sæ̃/	750	1728	2598	1126
/ã/	/hãs/	736	1294	2480	974
/ə̃/	/hə̃s/	534	1246	2542	1722
/ɔ̃/	/sɔ̃/	610	894	2576	1486
/õ/	/ḍʰõṛʰ/	442	770	2764	1484
/ũ/	/ḍʰũṛʰ/	338	634	2566	1092

Table 3, on the other hand, lists the average frequencies of F_1, F_2, F_3 and Fn for these nasal vowels spoken in words[4]. In Figure 1 a comparison is made between the average F_1, F_2 and F_3 frequency values of these nasal vowels (connected lines) and those of their oral counterparts (broken lines)[5] as spoen in isolation. As Tables 2 and 3 as well as Figure 1 show, each nasal vowel in Maithili is sufficiently distinguished by the first two formants. Whether spoken in isolation or in words, the F_2 for all nasal vowels goes downwards throughout the series: /ĩ ẽ æ̃ ã ɔ̃ ɔ̃ õ ũ/. The F_1 goes up for the front vowels /ĩ ẽ æ̃/, and then down for the back vowels /ɔ̃ õ ũ/ in that order. The F_1 for /ã/, whether spoken in isolation or in words, always remains higher than what it is for /ə̃/.

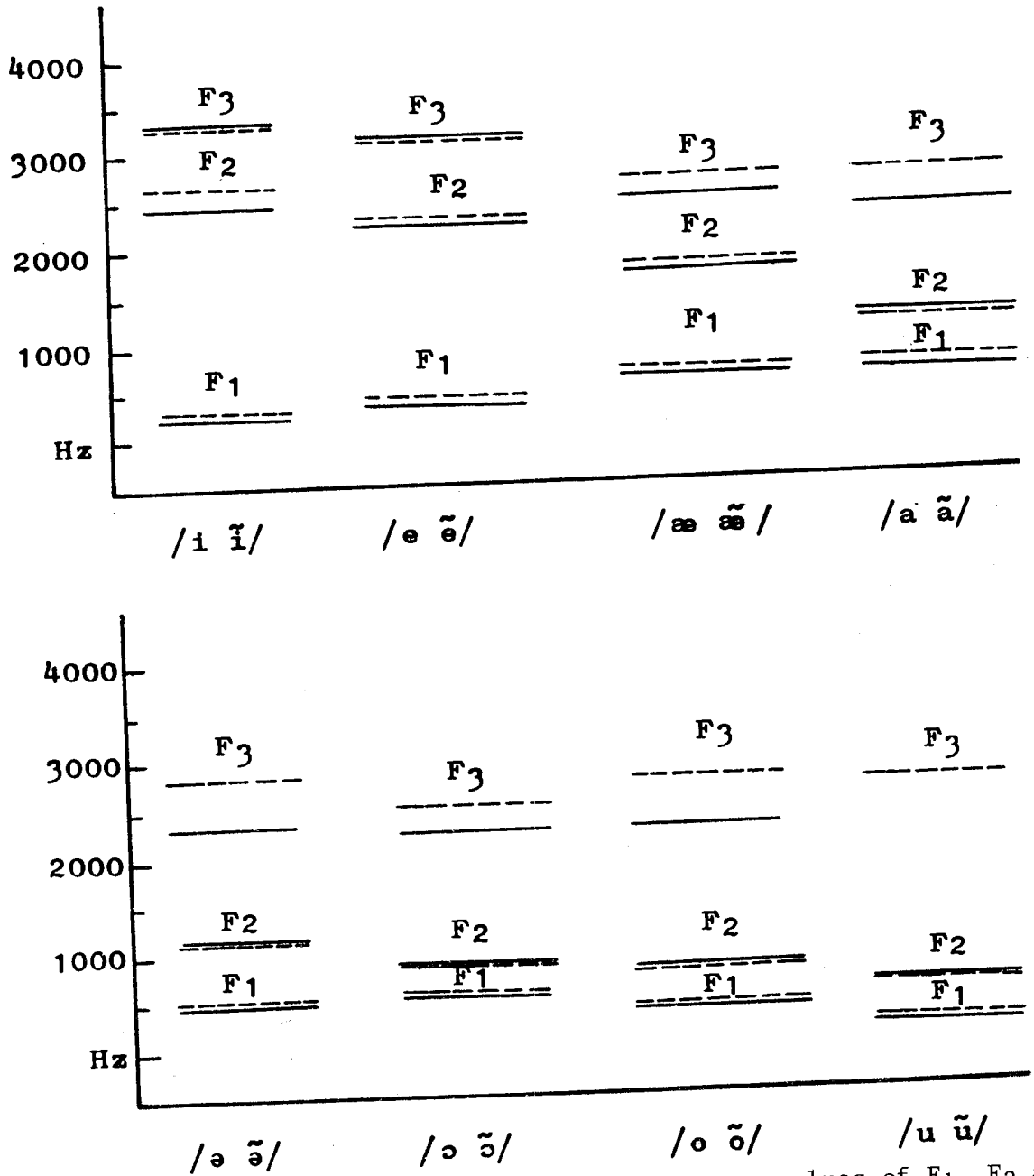

Figure 1: A comparison between the average frequency values of F_1, F_2 and F_3 for the Maithili oral vowels (connected lines) and for their nasal counterparts (broken lines) spoken in isolation.

The average F_1 and F_2 frequencies for these nasal vowels as given in Tables 2 and 3 are also plotted on a formant chart in Figure 2 for a comparison between these vowels spoken both in isolation and in words. In Figure 2 the actual frequency values shown by broken lines differ from those shown by connected lines in that the former display the effects of the consonantal environments in which the nasal vowels were spoken. Figure 2 clearly shows that, except /ẽ/, the remaining nasal vowels /ĩ æ̃ ã ə̃ ɔ̃ õ ũ/ maintain relatively lower vowel heights when spoken in words than when spoken in isolation. In addition, when spoken in words:

(i) the front nasal vowels /ẽ æ̃/ become less fronted;

(ii) the central nasal vowels /ã ə̃/ become more central - i.e. more fronted and less back; and

(iii) the back nasal vowels /ɔ̃ õ ũ/ become less back.

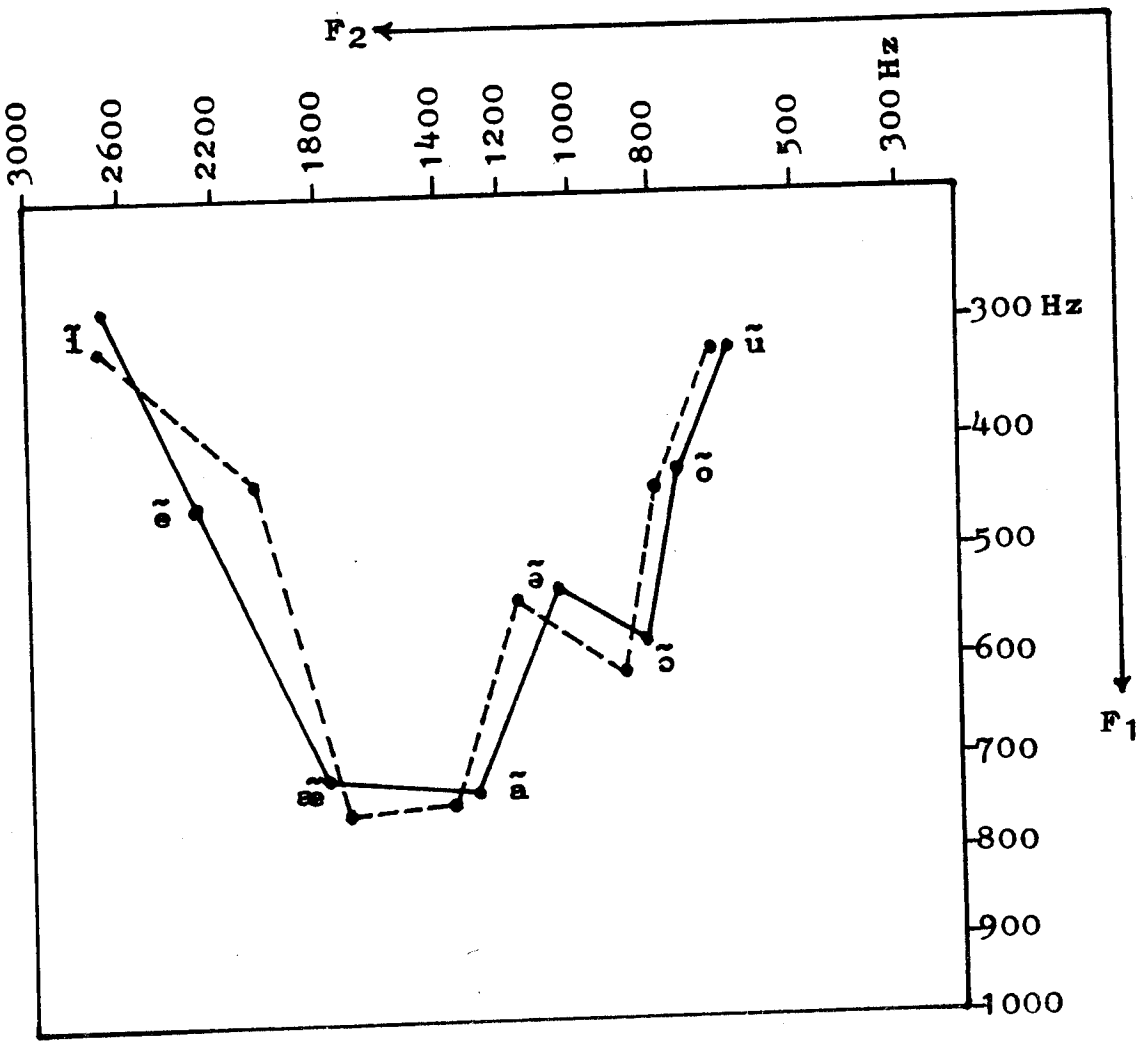

Figure 2: Average frequency values of F_1 and F_2 for the Maithili nasal vowels spoken both in isolation (connected lines) and in words (broken lines).

Figure 3 makes a graphic representation of both the oral (connected

lines) and the nasal (broken lines) vowels in Maithili as spoken in isolation. The figure shows a good deal of similarity between the overall frequency patterns of these oral and nasal vowels. It also shows that the nasal vowels maintain relatively lower vowel heights than their oral counterparts. In addition, Figure 3 also shows that, when compared with their oral counterparts:

(i) the front nasal vowels /ĩ ẽ æ̃/ are more fronted;

(ii) the central nasal vowels /ã ə̃/ become less central - i.e. less fronted and more back; and

(iii) the back nasal vowels /õ ɔ̃ ũ/ become more back.

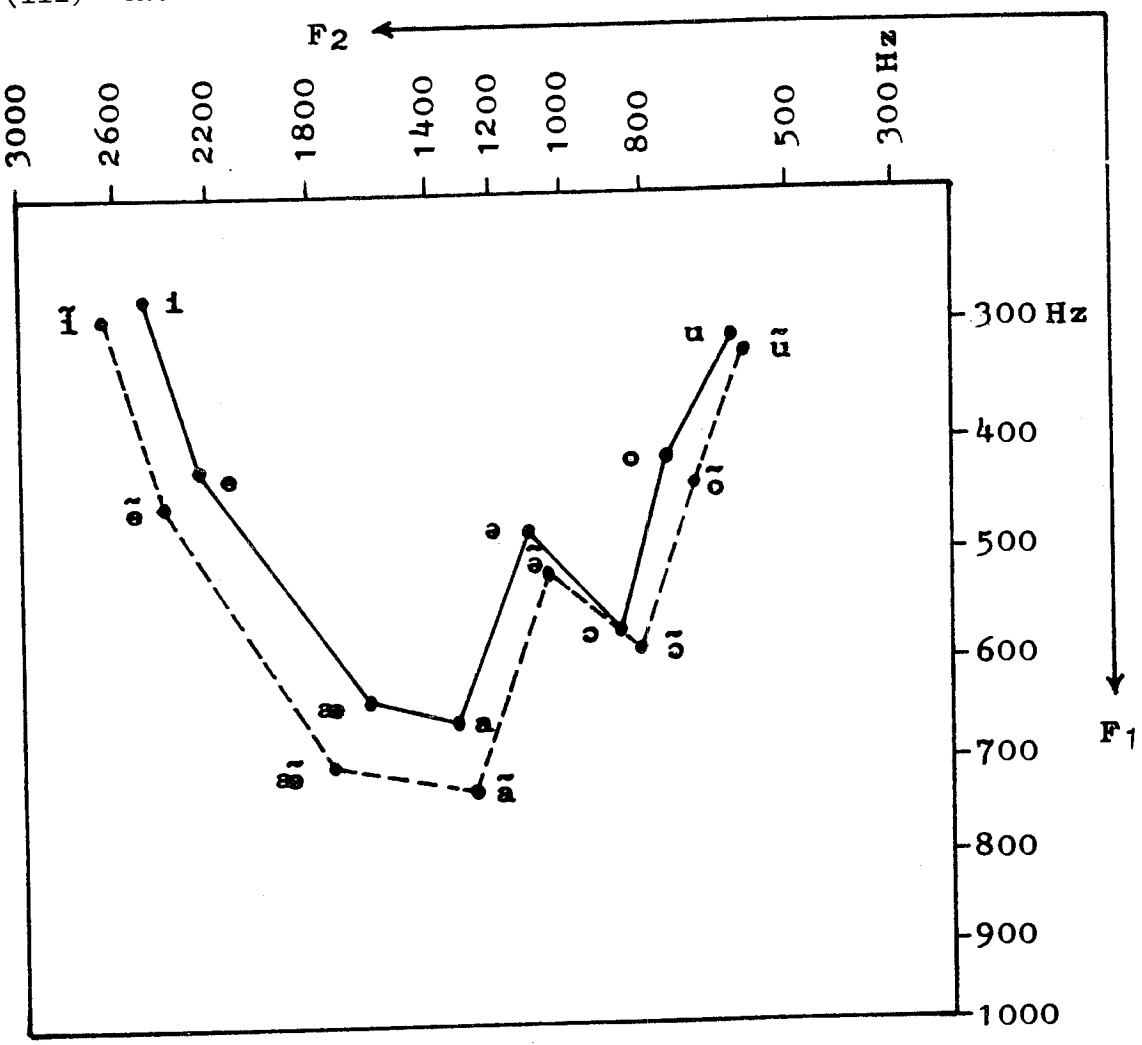

Figure 3: Average frequency values of F_1 and F_2 for the Maithili oral vowels (connected lines) and nasal vowels (broken lines) spoken in isolation.

In order to make a further comparison between these oral and nasal vowels, each one of them was also recorded in words of the same stress and consonantal environments. Table 4 gives the average frequency values of the first three formants for these oral and nasal vowels[6]. The F_1 and

Table 4

Average frequency values of F_1, F_2 and F_3 for the Maithili oral and nasal vowels spoken in words of the same stress and consonantal environments.

Vowel	Word	F1	F2	F3
/i/	/čʰiṭ/	310 Hz	2430 Hz	3408 Hz
/ĩ/	/čʰĩṭ/	330	2638	3490
/e/	/bʰeṭ/	424	1935	2578
/ẽ/	/bʰẽṭ/	450	1962	2626
/æ/	/bʰæt/	680	1679	2460
/æ̃/	/bʰæ̃t/	751	1724	2572
/a/	/bas/	683	1366	2450
/ã/	/bãs/	753	1232	2402
/ə/	/'kəṭgər/	523	1314	2636
/ə̃/	/'kə̃ṭgər/	543	1218	2522
/ɔ/	/gɔt/	631	907	2552
/ɔ̃/	/gɔ̃t/	648	857	2570
/o/	/gʰoṭ/	429	812	2450
/õ/	/gʰõṭ/	443	740	2764
/u/	/kə'hu/	318	776	2352
/ũ/	/kə'hũ/	324	613	2448

F_2 frequency values for these oral and nasal vowels are also graphically plotted on a formant chart in Figure 4.

Thus, to summarize, the acoustical measurements displayed in all the tables and figures of this study, and close inspections of formant amplitudes as well as of the relative intensity of the first three formants of all the oral and nasal vowels in Maithili strengthen the following main remarks:

First, our results support the observation of most previous investigators of nasal vowels (e.g. House and Stevens, 1956: 225; Fant, 1960: 148-149; Kongsdal, 1967: 59-66; Dave, 1977: 62-68; R. Yadav, 1979a: 173-174) that the major attributes for these vowels lie in the region of F_1. Our study reveals that there are three major attributes for nasal vowels in the F_1 region: i.e. F_1 frequency, F_1 intensity and F_1 amplitude. The results of our F_1 frequency-measurements show that on average all the nasal vowels in Maithili maintain relatively higher frequency values, and

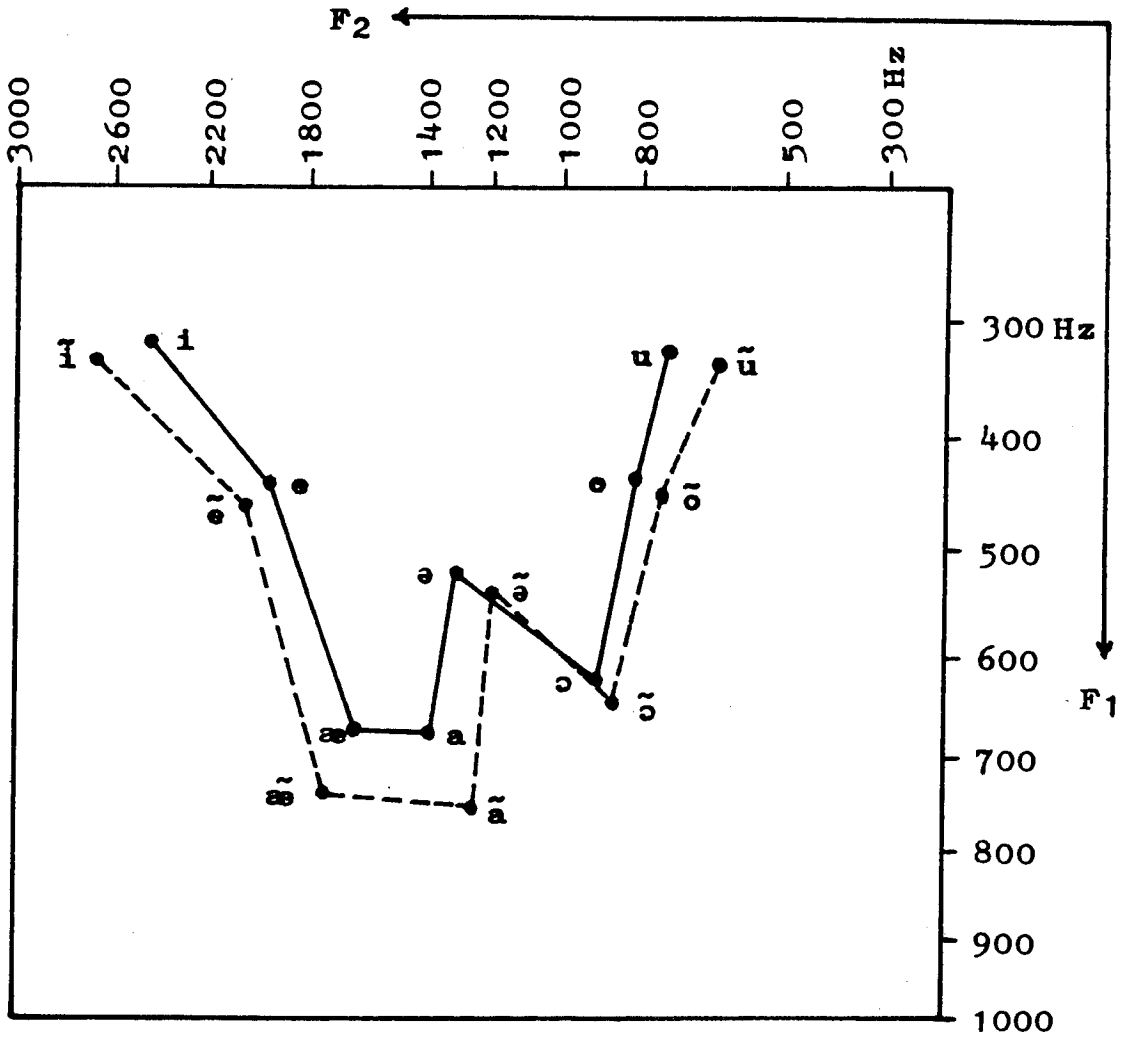

Figure 4: Average frequency values of F_1 and F_2 for the Maithili oral vowels (connected lines) and nasal vowels (broken lines) spoken in words of the same stress and consonantal environments.

therefore relatively lower 'vowel height', than their oral counterparts. A close study of all spectrograms investigated in this study indicates that in the nasal vowels, when compared with their oral counterparts, the F_1 loses much of its intensity in favour of the F_2. In addition, our results also show that the F_1 amplitude for the nasal vowels remains relatively lower than that of their oral counterparts.

Secondly, our results also show a good deal of similarity between the overall frequency-patterns of the Maithili oral and nasal vowels. But, on the whole, when compared with their oral counterparts:

(i) the front nasal vowels /ĩ ẽ æ̃/ are more fronted;

(ii) the central nasal vowels /ã ə̃/ are less central - i.e. they

tend to be positioned more toward the back than the front; and

(iii) the back nasal vowels /ɔ̃ õ ũ/ are more back.

As a result, the Maithili nasal vowels occupy relatively more extreme positions in the formant charts than their oral counterparts. Dave (1977: 63) also reports a similar finding for the Gujarati oral and nasal vowels.

Thirdly, almost all spectrograms investigated in this study show that the relative intensity of F_3 remains much weaker in the Maithili nasal vowels than in their oral counterparts.

Finally, the appearance of nasal formants has also been said (e.g. Joos, 1948; Fant, 1960; Delattre, 1969; Ladefoged, 1975/1982; Cagliari, 1977; Dave, 1977) to be an important attribute of nasal vowels. According to Smith (1951), nasal formants usually occur in nasal vowels at around 1000 Hz. Our Fn measurement-results support Smith's claim, but only partly. Although it does not always seem easy to state the exact Fn frequency of nasal vowels, our results show that the average Fn frequency region for the Maithili nasal vowels has a range between 952 Hz and 1722 Hz. This (952 Hz-1722 Hz) range should not be taken as surprising because Ladefoged (1975: 173), too, reports the presence of 'pseudoformants' for some American English vowels at around 1700 Hz "due to a slight degree of nasalization", and Dave (1977: 67) also reports the presence of 'extra formants' for some Gujarati nasal vowels "in the region of 1000 to 2500 cps".

Duration Measurement Results and Discussions

To determine the relative duration of the Maithili nasal vowels, duration measurements of all these vowels were made from spectrograms. Following the experimental method outlined earlier in this paper, the duration of these vowels was measured in ms. Table 5 lists the average duration of these nasal vowels spoken in isolation[7]:

Table 5

Average duration of the Maithili nasal vowels spoken in isolation (in ms).

Vowel	ĩ	ẽ	æ̃	ã	ə̃	ɔ̃	õ	ũ
Duration	241	253	270	280	150	275	256	235

Table 6 lists the average duration of these vowels as spoken in words[8]. The average duration values of these tables are also plotted on a chart as displayed in Figure 5 in which the dots linked by connected lines represent the nasal vowels spoken in isolation, while those linked by broken lines represent the same vowels spoken in words. The figure clearly shows that the nasal vowels spoken in isolation have longer durations than when spoken in words. It also shows that open nasal

Table 6

Average duration of the Maithili nasal vowels spoken in words (in ms).

Vowel	ĩ	ẽ	æ̃	ã	ə̃	ɔ̃	õ	ũ
Duration	160	196	255	227	102	231	211	196

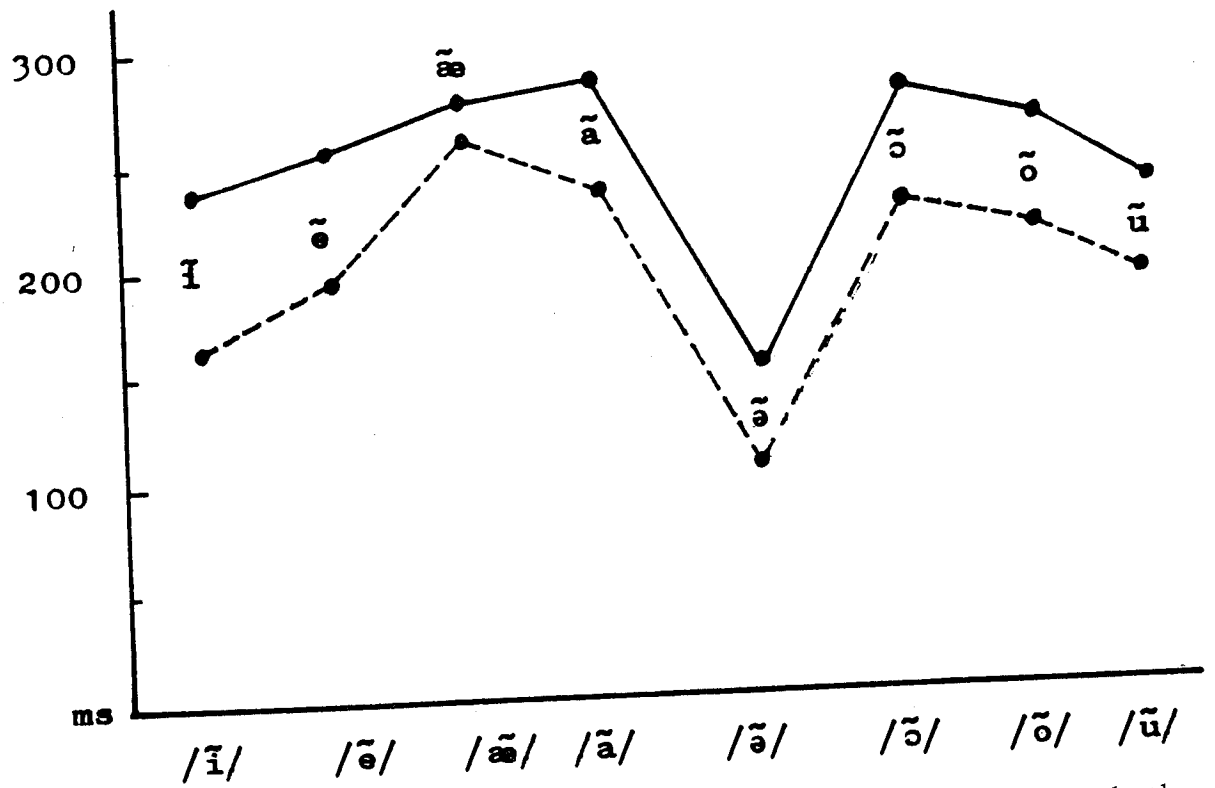

Figure 5: Average duration of the Maithili nasal vowels as spoken both in isolation (connected lines) and in words (broken lines).

vowels tend to maintain longer durations than less open and closed ones.

The relative durations of these oral and nasal vowels as spoken in isolation are compared in Figure 6. The figure clearly shows that all the nasal vowels maintain longer durations than their oral counterparts. Table 7 presents the average durations of all these vowels spoken in words of the same stress and consonantal environments.[9] The average duration values for these vowels as given in Table 7 are also graphically plotted in Figure 7.

As Figure 7 shows, there is a good deal of similarity between the overall duration-patterns of these oral and nasal vowels. In general, even when spoken in words of the same stress and consonantal environments,

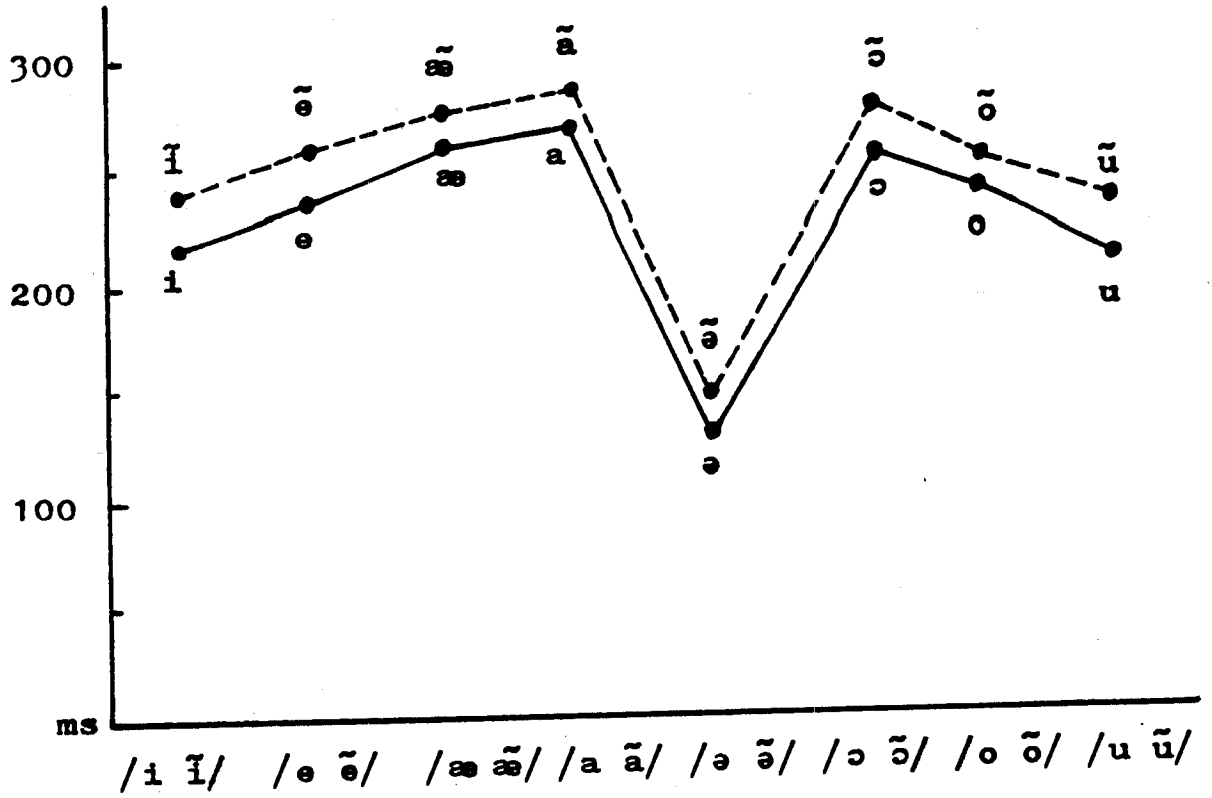

Figure 6: Average duration of the Maithili oral vowels (connected lines) and nasal vowels (broken lines) spoken in isolation.

Table 7

Average duration (in ms) of the Maithili oral and nasal vowels spoken in words of the same stress and consonantal environments, together with the average duration of overall utterance and the average percentage of vowel duration within the overall utterance.

Vowel	Word	Vowel duration	Duration of overall utterance	% of vowel duration within the overall utterance
/i/	/cʰiṭ/	132	278	47
/ĩ/	/cʰĩṭ/	160	310	51
/e/	/bʰeṭ/	159	306	52
/ẽ/	/bʰẽṭ/	202	342	59
/æ/	/bʰæt/	197	419	47
/æ̃/	/bʰæ̃t/	231	455	51
/a/	/bas/	218	424	51
/ã/	/bãs/	247	448	55
/ə/	/'kəṭgər/	59	436	14
/ə̃/	/'kə̃ṭgər/	80	449	18
/ɔ/	/gɔt/	221	411	54
/ɔ̃/	/gɔ̃t/	260	428	61
/o/	/gʰoṭ/	207	404	51
/õ/	/gʰõṭ/	242	438	55
/u/	/kə'hu/	326	440	74
/ũ/	/kə'hũ/	352	456	77

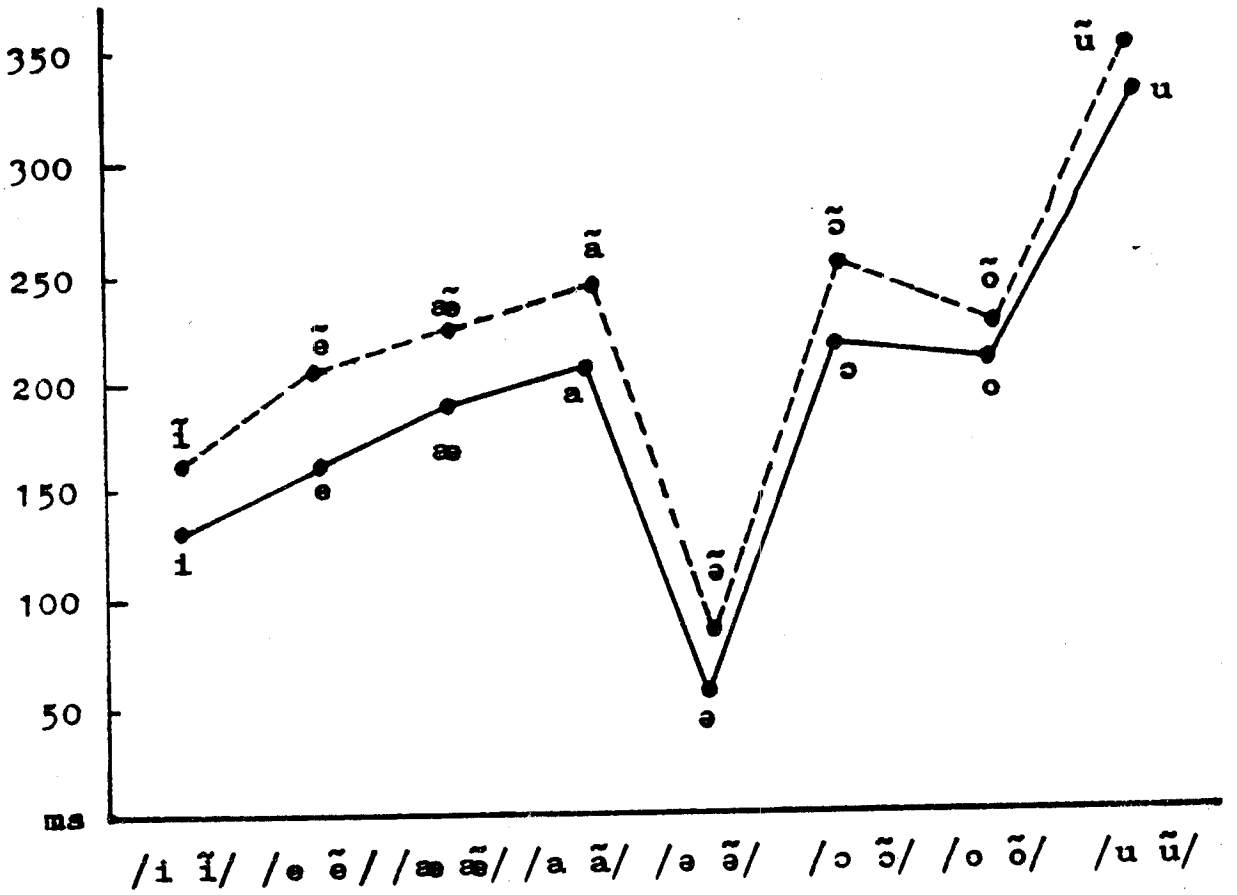

Figure 7: Average duration of the Maithili oral vowels (connected lines) and nasal vowels (broken lines) spoken in words of the same stress and consonantal environments.

the nasal vowels remain longer in duration than their oral counterparts - the length of this duration-difference ranging between 3 and 7 percent within the overall utterance. Pathak (1976: 314) carried out an electrokymographic study of phonetic nasalization in Bagheli - a dialect of Hindi spoken in eastern India - and he also came to a similar conclusion: i.e. "the nasalized vowels in Bagheli have a little longer duration than their oral counterparts". Our results shown in Table 7 and graphically displayed in Figure 7 indicate quite clearly that the presence of the nasal vowel lengthens the overall utterance. That is to say, in almost each test utterance of Table 7 there is no compensation (for the increased length of the nasal vowel) taking place elsewhere in the utterance. And, in general, these data also confirm that, other things being equal, in Maithili open vowels remain longer in duration than close vowels.

NOTES

1. This paper forms part of the fourth chapter of Jha's (1984) doctoral dissertation. The author is grateful to both Professor Marcel A. A. Tatham and Dr. Jacques Durand of the Department of Language and Linguistics at Essex University (England) for their detailed criti-

cisms, comments and suggestions on various versions of this study which have led to its improvements both in style and in content.

2. It should be mentioned here that most of the Maithili vowels in isolation are used as morphemes, and in principle each one of them can be used as a 'free' or 'bound' morpheme in this language.

3. See Jha (1984: 318-319) for the detailed frequency values for each of the total recorded tokens, from which only the average is given in the present table.

4. For the detailed frequency values for each of the total recorded tokens - from which only the average is given in Table 3 - see Jha (1984: 320-321).

5. For the average frequency values of the first three formants for the Maithili oral vowels, see Jha (1984: 92).

6. See Jha (1984: 322-324) for the detailed frequency values for each of the total tokens, together with the average and range of all five tokens of each test utterance.

7. For the detailed duration measurement values for each token of the total utterances as well as for the average and range of those values, see Jha (1984: 325).

8. See Jha (1984: 326) for the detailed duration measurement values, together with the average and range of those values.

9. For the detailed duration measurement values and the percentage values of these measurements, see Jha (1984: 327-329). In the present table values less than 0.50% are ignored, while those between 0.50% and 0.99% are regarded as 1% - i.e. the values are rounded.

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