An Acoustic Study of Vowel Nasalization in Punjabi

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Abstract

Nasalization is a very prominent but less understood feature of many languages spoken in Pakistan. This paper compares the contextual and contrastive nasalization phenomenon in Punjabi vowels. The degree and direction of nasalization is determined using acoustic measures. The results depict that contrastively nasal and contextually nasal vowels show almost the same degree of nasality except /ɪ/ vowel. For the latter, both the anticipatory and preservatory nasalization are observed in Punjabi.

1. Introduction

Punjabi language is a member of the Indo-Aryan family. Primarily, Punjabi is spoken in India and Pakistan but there are speakers of Punjabi in East Africa, United Kingdom and Canada as well. Nearly forty five million people use this language either as their first or second language. [1]

Many regional dialects of Punjabi are used y its speakers. The major dialects of Punjabi are Majhi, Malwi, Doabi and Powadi. Furthermore, Rathi, Ludhianwi, Patialwi, Bhattani are also some traditionally recognized Punjabi dialects whose independent status as dialect is in question [2]. These dialects of Punjabi differ from each other on the basis of distinct variation in their phonemic inventories [1].

Punjabi is written in three scripts which are Gurmukhi, Perso-Arabic and Devanagari scripts. Hindus in India write Punjabi in Devanagri script; Sikhs in India write in gurmukhi script while in Pakistan, Punjabi is written in shahmukhi (Perso-Arabic) script. [2]

The present paper aims to report the trend of vowel nasality in the speech of Majhi speakers of Punjabi living in Lahore.

2. Review of Literature

The oral sounds are produced with the complete closure of nasal tract, whereas the nasal sounds are produced with open velopharyngeal port. The phenomenon of vowel nasalization exists in almost all the languages of the world [3]. But the level of velopharengeal port's opening varies from language to language and from speaker to speaker.

All the languages of the world have oral vowels, but there are some languages which have nasal vowels as well. French, Taiwanese, Urdu, Punjabi, etc. are the examples of languages which have oral-nasal contrast in their vowel system. The nasal vowels are never observed to be greater in number than the oral vowels in any language [17]. Other than contrastive nasalization, there are also some languages which have contextual nasalization e.g. English, where the presence or the absence of nasality feature in the vowel does not change the meaning of the word [8].

During the production of vowels with neighboring nasal consonants, the languages with contrastive vowels restrict the level of velum lowering and make vowels less nasalized than the languages which lack this oral-nasal contrast. The velum lowering is restricted to maintain oral- nasal contrast and to avoid the contextual nasalization. Herbert [18] reports that only the languages which have oral- nasal contrast for vowels have this pattern of velum lowering restriction for oral vowel production in context of nasal sounds. Furthermore, Manuel [5] illustrates that the contrast of nasality in vowels and the degree of coarticulation are correlated inversely.

Cohn [4] reports a higher degree of contextual vowel nasalization before a nasal consonant in English, a language which does not contain nasality contrast in its vowels. It may be compared with French, which has nasal-oral contrast for vowels.

Ladefoged et al. [8] describe that the vowel nasalization phenomenon exists in all the dialects of

English language. In English, vowels tend to assimilate with the nasal consonants whenever they occur in nasal context. They illustrate the example of the English word "man". In such circumstances where a vowel is followed or proceeded by the nasal sound, all the vowels become completely nasalized. So in English vowels are nasalized because of the phonetic context. Vowels in oral context never adopt nasality feature except in the disordered speech.

Languages having contextual nasalization or contrastive nasalization or even containing both types of nasalization differ from each other because of different nasality patterns. There is evidence that the languages which lack oral/nasal contrast for vowels show extensive degree of nasalization. English language is a good example of heavy nasalization of vowels in nasal context.

Furthermore, Delvaux et al. [14] describe that the languages which have oral/nasal contrast for their vowels may limit the degree of contextual vowel nasalization in both high and low vowels, in order to maintain the oral/nasal contrast between vowels. French allows an extensive degree of contextual nasalization for the high oral vowels as all the nasal vowels are mid-low and low in French. So the vowels which have oral and nasal contrast show lesser degree of nasal coarticulation than the vowels which have no nasal counterpart.

Moreover, Kawasaki [16] studies the degree of nasalization between Taiwanese contrastively and contextually nasalized vowels. He states a greater degree of nasalization in contrastive environment (nasal vowel) in comparison with non contrastive environment (contextually nasalized vowels).

On the other hand, Al-Bamerni discusses the extensive degree of velopharyngeal opening for the high back vowels in Gujarati and Hindi, the languages which have contrastive nasality in their vowel systems (as cited in [14]). This asymmetry between the degrees of nasalization among various languages suggests that the extent of nasal coarticulation is not dependent on the phonemic inventory of languages. Different languages have different patterns of nasalization for vowels regardless of the presence and absence of oral/nasal contrast for vowels.

The study of vowel nasalization is very complex because of the variation in the exact acoustic characteristics of nasalization among speakers. The acoustic characteristics of nasalization are difficult to examine due to the changes in the anatomical structure of the nasal cavity, vowel quality, and also because of the degree of oral and nasal tract's coupling. [9]

The vowels are nasalized because of the nasal and oral tract's configuration. The more the velum lowers; the heavier the degree of vowel nasalization. So, this variation in configuration between oral and nasal tract introduces change in spectrum at transition between the vowel and the nasal consonantal sounds [12]. These acoustic effects are transformed in spectra through introducing nasal poles and zeroes in the region of first formant (F1) and also the shift of vowel formants (especially F1).

Various acoustic effects of vowel nasalization are explored through multidimensional ways. Ladefoged et al. [8] report that the vowels which have extra nasality feature are distinguished with reduction in intensity of the first formant (F1) and increase in third formant (F3). This reduction in the intensity is because of the diversion of acoustic energy from the oral cavity to the nasal cavity. There is evidence from the perception based experiments that the reduction in F1 amplitude by 6-8 db is necessary to get a significant level of nasalization perception [10]. But later studies do not support this assumption providing the view that the degree of F1 amplitude's lowering is somehow language and speaker specific. As Chen [7] reports the results of her study on nasalization, the degree of F1 amplitude varies among English speakers and the French speakers. So there is lack of any fixed measure of the lowering of F1 amplitude.

Furthermore, the flattening of spectral region is also studied as an indicator of nasality. Maeda [11] has studied spectral variations analyzing 11 French vowels. He reports that the diversion of energy from oral to nasal tract flattens the spectral region between 300 Hz and 2500 Hz. Similarly, Stevens [15] reports that the widened first formant (F1) and the overall reduced vowel amplitude is the indicator of the presence of nasality feature in a vowel.

Fant [13] also illustrates that the nasalized vowel has "a distortion superimposed on the vowel spectrum" which is significant by the nasal effect on harmonics in the region of low frequencies (below F1) (p. 156). Similarly, Beddor et al. [6] describe that the vowels with nasality feature have broader and flatter spectral prominence in the region of low frequency (below F1).

Chen [7] has introduced an acoustic approach for the measurement of nasality in her study of nasalized vowels of French and English. She finds the reduction of first formant as the primary cue of nasalization in vowels. She has distinguished nasalized vowels of French and English successfully, employing the two parameters which are A1-P0 and A1-P1. Here A1 is the amplitude of the first formant (F1), P0 is the amplitude of first nasal peak below the first formant (F1) and P1 is the measure of the amplitude of nasal peak between first formant (F1) and the second formant (F2) of the vowel. So, the

results of her study confirm that the amplitude of F1 in nasalized vowel reduces relative to its amplitude in oral vowel, and the extra nasality peaks are also noticed. These measured acoustic parameters of nasalization in nasal and oral vowel are given below.

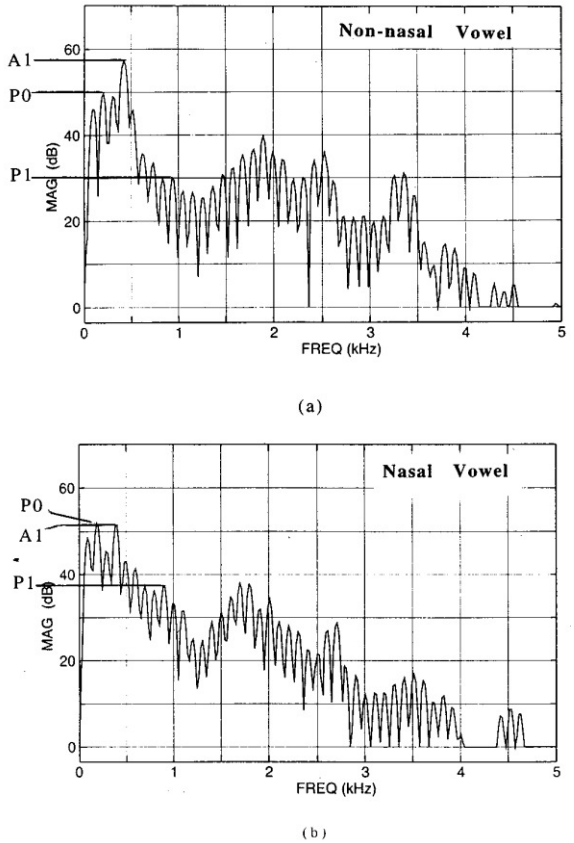

Figure 1: The measurements of A1, P1 and P0
Adapted from Chen [7]

Chen [7] has measured vowels at initial, medial and final positions. But she has not observed any differences among the measures taken at these three points in vowels. So she has averaged these measures across three points and has got results.

Punjabi is one of those languages which have oral-nasal contrast in their vowel system. There are ten oral vowels in Punjabi. It has three short /ɪ, ə, ʊ/ and seven long /ɪ, e, æ, a, ɔ, o, u/ vowels. All these oral vowels have their nasal counterparts as well [19]. This study is an attempt to explore nasalization phenomenon in Punjabi. This aims to determine the degree and direction of nasalization in both contrastive and non-contrastive environments.

3. Methodology

For this study, the participants with low fundamental frequency have been selected, so that the harmonics can be traced in spectrum accurately. Three male speakers of Majhi dialect from Lahore, with Punjabi L1 are selected for the present study.

The data consists of four syllable types; CVC, CṼC, CVN, NVC. The first two syllable types are chosen to measure the degree of nasality in contrastive environment while the other two are used to study the degree of nasality in non-contrastive anticipatory and preservatory environments respectively.

In the CVN and NVC contexts the N is /n, m, ŋ/. The vowels in CVC, CVN and NVC syllable types are /ɪ/, /æ/, /a/ and /ʌ/. While in CṼC context, the vowels are /ĩ/, /æ̃/, /ɑ̃/ and /ʌ̃/. All the words are embedded in a carrier phrase for recording:

میں ------- کیا

/mæn _____ kea/

“I said _____”

The detailed list of tokens is given in appendix A. Three repetitions of each word have been recorded. The acoustic measures A1-P1 and A1-P0 introduced by Chen [7] are used to study the degree of nasality. A1-P1 is measured for high vowels and A1-P0 for low and mid vowels. These measurements are taken at the initial, medial and final points of the vowels and are compared to study the degree of nasality in different contexts. The measurements are taken at different points of vowels so that the difference in vowel portions can be observed.

4. Results

A total of 144 utterances have been recorded and analyzed (3 speakers * 3 repetitions * 4 templates * 4 vowels). The measurements of A1-P1 and A1-P0 are made at three locations (initial, medial, final) within each vowel and are compared for oral vowels (O), nasal vowels (N) and contextually nasalized (CVN and NVC) vowels.

4.1. /æ/ vowel

The analysis of the vowel /æ/ clearly shows difference in the degree of nasalization among four syllable types. The measure A1-P0 has lower value for nasal vowels and the vowels in nasal context (VN, NV) than the oral vowels. There is no consistent trend of assigning nasality across contrastively nasal vowel and the contextually nasal vowel. Therefore, both these categories of nasality are significantly different from the oral vowel. The

difference among these three can be seen clearly in Figure 2.

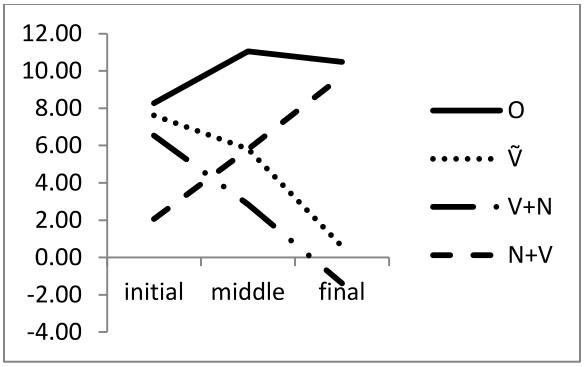

Figure 2: A1-P0 (db) values averaged across three speakers and three repetitions. V+N presents the values averaged across the contexts (v+n, v+m, v+ŋ) and N+V presents the values averaged across the contexts (n+v, m+v)

The average standard deviation (s.d.) for the vowel /æ/ across four syllable types and the measures at three points (initial, middle and final) within vowel is 3.55. The minimum standard deviation is 2.23 and the maximum is 5.18.

4.2. /ʌ/ vowel

The measures taken in the different locations of /ʌ/ vowel in different contexts show greater A1-P0 value in oral context than the other (CVN, NVC and Ṽ) contexts (see Figure.3). The vowel is nasalized greatly at its onset in N+V context and at its offset in V+N context. The nasal vowel /ʌ̃/ reflects greater degree of nasality at its offset.

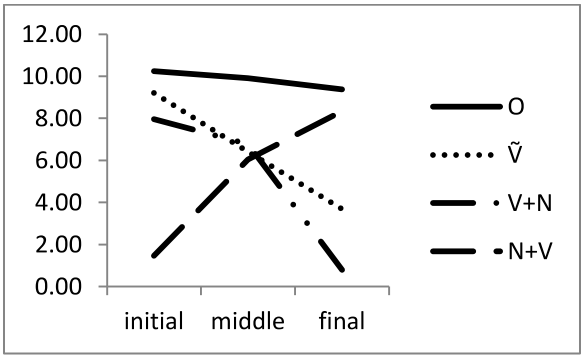

Figure 3: Average A1-P0 (db) across three speakers and three repetitions

The average standard deviation for the vowel /ʌ/ for A1-P0 measure is 3.38, ranging from 2.59 minimum and 5.36 maximum.

4.3. /ɑ/ vowel

The measured A1-P0 values for /ɑ/ in different syllable types provide a clear distinction of nasality in oral vowel and the nasal vowels. We can see the difference among oral and nasal vowels in the Figure 4. The values are lowest for the vowel in CVN and NVC contexts at offset and onset respectively, which depict the effect of neighboring nasal consonant on the preceding and following vowel. The measures at the mid points of contrastively and contextually nasalized vowel are less than the oral one.

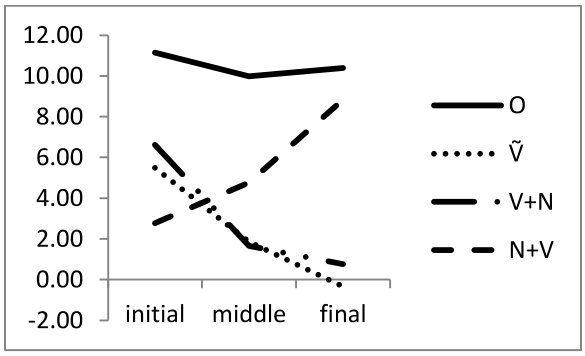

Figure 4: Average A1-P0 (db) across three speakers and three repetitions

The standard deviation for /a/ vowel is 2.75. The minimum s.d. is 2.12 and the maximum is 4.15.

4.4. /ɪ/ vowel

The A1-P1 values measured for /ɪ/ vowel show a greater difference between the oral and nasal vowel. The nasal vowel /ĩ/ depicts strong nasalization as compared to the contextually nasalized vowel /ɪ/. The measures of A1-P1 are given in Figure 5.

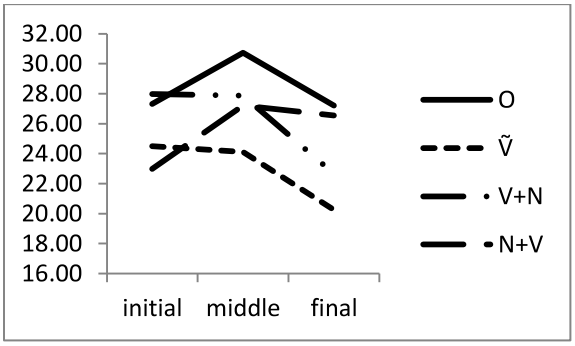

Figure 5: Average A1-P1 (db) across three speakers and three repetitions

The average standard deviation for the measures of the vowel /ɪ/ is 6.94 with 3.75 minimum and 10.14 maximum.

The direction of nasality is shown in the figure 6 clearly. The nasal vowels show greater degree of nasalization than the contextually nasalized vowels. The vowels in CVN context show greater degree of nasality in their offsets. On the other hand the vowels in NVC contexts have greater degree of nasality in their onsets. But the values measured at the middle of the vowels show a greater degree of nasalization in VN context than in NV context. So the Punjabi vowels tend to be nasalized in anticipatory direction

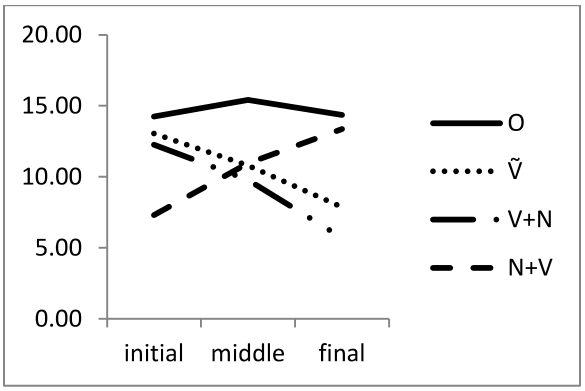

Figure.6. Average (A1-P1, A1-P0) in CVC, CṼC, CVN and NVC contexts across vowels

5. Discussion

The results obtained from the data show very consistent trend of nasalization for both the contrastively and contextually nasalized vowels.

There is significant difference between the A1-P0 and A1-P1 values for oral and nasal vowels. The three nasal vowels /ʌ/, /æ/ and /a/ show tendency to be less nasal at initial point of the vowel but it gradually shows higher degree of nasality towards the middle and final locations within the vowel. Therefore, the A1-P0 and A1-P1 measures show greater difference at middle and final portions of nasal vowels from the oral vowels. Only /ɪ/ shows the opposite trend. For this vowel, the measures of A1-P1 and A1-P0 are lesser at initial and middle locations than the final portion of nasal vowel. The overall averages of the four vowels show the nasal vowel to be nasalized heavily at final point and lesser at initial point (see fig.6).

There is no difference in the degree of nasalization for the contrastively nasal /æ̃/, /ɑ̃/ and /ʌ̃/ and contextually nasalized vowels /æ/, /ɑ/ and /ʌ/ in Punjabi. Only the nasal vowel /ĩ/ shows a greater degree of nasalization than the contextually nasalized vowel /ɪ/. So this study presents a different perspective from the previously cited work on the other languages which have oral/nasal contrast for vowels like French, Taiwanese etc. These languages confirm greater degree of nasalization in contrastively nasal vowels as compared to the contextually nasalized vowels. But Punjabi provides a different account. Punjabi contrastively nasal and contextually nasalized vowels have almost similar degree of nasalization, except /ɪ/ vowel. It contributes to the notion that languages differ on the basis of nasalization patterns.

The vowels in CVN context show greater degree of nasalization in their offsets (following nasal consonant). This tendency marks the influence of neighboring nasal consonants on the following and preceding vowels. The vowels following a nasal consonant, show minimal influence of nasality on their onsets.

On the other hand the vowels in NVC context adopt nasality from their preceding nasal consonant, which is more dominant in the onset of vowels than the other portions. The results of this study observe the Punjabi vowels' tendency to be nasalized in anticipatory direction.

6. Conclusion

This paper has acoustically studied the degree and direction of nasalization in Punjabi vowels. The findings indicate the patterns of nasalization in the contextually nasalized vowels and the contrastively nasal vowels. The contrastively nasal and contextually nasalized vowels are clearly different from the oral vowels. There is no clear difference in the degree of nasality between the vowels in contrastive environment and the vowels in non-contrastive environment, except /ɪ/.

The results also show a clear tendency of Punjabi vowels to adopt contextual nasality in anticipatory direction.

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Appendix A: Data set used for the study

vowels	V	Ṽ	v+n	v+m	v+ŋ	n+v	m+v
æ	ɣæb	pæ̃da	bʰæn	qæm	bʰæŋə	nær	mæl
a	pak	bã̃g	pan	ʃam	Taŋ	nap	map
ʌ	kʌt	kʌ̃b	kʌn	kʌm	dʒʌŋ	nʌg	mʌt
ɪ	pɪt	pĩ̃d	dɪn	nɪm	dɪŋ	nɪb	mɪt̪