URDU NASAL CONSONANTS AND THEIR PHONOLOGICAL BEHAVIOUR

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1. INTRODUCTION

This paper presents the list of ***nasal consonantal sounds*** in Urdu language. Furthermore, the observed phonological behavior of these sounds is also reported.

Lack of research in linguistic aspects of Urdu has resulted in lack of authentic published reference for the Urdu sounds system. No authentic publication records the consonantal or vocalic sounds of Urdu, making Urdu a bad candidate, at the very least, to be used with computers.

Study of linguistic aspects of Urdu is severely needed, and the first step should be the agreement over of list of distinctive sounds. This study is a small contribution in this regard. Standard linguistic information about Urdu will help non-native speakers and foreigners in learning Urdu. Furthermore, it will be useful in development of computational models of Urdu.

2. LITERATURE REVIEW

There are no standardized documents on the sounds of Urdu language. Different studies at different levels have been published but none has been accepted as a standard.

Bokhari (Bokhari, 1985; Bokhari, 1991) and Alam (Khan, 1997) list ten nasalized vowels including five short and five long nasalized vowels. Kachru (Kachru, 1990), on the other hand, has not listed any nasalized vowel, but mentions in the text that oral and nasal vowels contrast, and that nasalization is distinctive (Kachru 55, 1991).

Kachru (Kachru, 1990) lists 37 consonants and has not mentioned any nasal aspirated consonant. Hussain (Hussain, 1997) lists 36 consonants and has missed the nasal consonants. Bokhari (Bokhari, 1985; Bokhari, 1991) lists 36 consonants and he has mentioned five nasal sounds i.e. [n, ŋ, m, m^h, n^h]. Bokhari misses interestingly many basic sounds, which are listed by Kachru and Hussain. Alam (Khan, 1997) lists, most of all, 42 consonants and has missed only one consonantal sound [ŋ]. Overall, the controversial nasal consonantal sounds are [n^h, m^h, ŋ].

The next challenge was the study of phonological behavior of nasal consonants. For this purpose the phonological rules of other languages were studied to get the starting point. The famous place assimilation rule for nasal consonants is an example. The rule states that a nasal has the same place of articulation as the following consonant. This rule can be found in many languages like English, Spanish, and Urdu with a little variation. Another rule of nasality assimilation is also very common in languages. Then some rules were found for deletion of nasal sounds, and devoicing of nasal sounds as in English.

English Speakers, usually know how to utter a voiceless version of /m/ [m̥] to begin exclamations like "hmmm" [m̥mmm], expressing thoughtfulness or dubiousness, and an intervocalic version in Uhumm [mm̥mmm] signaling agreement without opening one's mouth (Pickett, 1998 Pg. 25).

All such phonological rules for other language were tested for Urdu, plus many other tests were conducted to test the statements provided in the books of Urdu phonetics about the Urdu nasal sounds.

3. PROBLEM STATEMENT

The paper formally documents the nasal consonants of Urdu language and explains the phonological behavior of these phonemes.

As discussed in the previous section that there are some phonological rules regarding nasal phonemes that are quite common in most of the languages, due to the common articulation mechanism of speakers. These rules have been identified by formally studying the languages. Unfortunately such efforts have not been made for Urdu.

Do these rules apply to Urdu? Are there some phonological rules specific to Urdu? First of all how many nasal sounds exist in Urdu? Which of these sounds are phonemes and allophones? These questions have been answered in different publication of different levels but there are many controversies. A serious research effort is needed to standardize all these answers.

Is this topic worth a paper? Yes, because studying and identifying the nasal consonantal sounds of a language is not a big deal. But it needs a lot of efforts rather smart effort to identify the phonological rules of a language though for a small subset of phonemes, yet it takes a lot of time to analyze the speech formally and selecting the data to analyze at the first place.

4. METHODOLOGY

4.1. Subjects

The investigation hinges on the existence of minimal pairs for nasal consonants in Urdu.

To study the phonological behavior of nasal sounds, speech of five native Urdu speakers was analyzed. Furthermore, to find minimal pairs and confirm correctness of data, some established and respected dictionaries of Urdu language were consulted (See section 7 below).

Many published texts were consulted which are listed in the references section.

4.2. Data Recording and Processing

Acoustic analysis of the speech was carried out using two different software. **1)** Entropic Signal Processing System (ESPS) v.5.3, a collection of digital Speech-processing tools designed for Linux users. **2)** Speech Analyzer v.1.5 by Summer Institute of linguistics.

The equipment consisted of a high fidelity 600 ohms moving coil microphone, a Teac integrated stereo amplifier (power output 195 Watts per channel) and two high quality speakers with 8-ohm impedance.

4.3. Experimental Conditions

All subject speakers were provided with sentences of Urdu language having the words of interest. The speakers were unaware of the goals of the experiment so that they may remain unbiased.

The speech signals were passed through 70Hz high pass filter to remove the noise produced by the DC signal.

4.4. Experiments

Various experiments were performed to test different rules. The experiments were conducted to test the following

4.4.1. Minimal pairs for nasal sounds

Identifying a minimal pair for nasal consonants was not difficult for the sounds /m/, /n/. But since there is no orthographic character in Urdu for /ŋ/, so things were not as simple in this case, because minimal pair for the sounds /n/ and /ŋ/ had difference of two characters in orthographic representation. Acoustic analysis was

necessary to prove the validity of the minimal pairs for this case. There were no minimal pairs found for the proposed aspirated nasal sounds of the Urdu.

The orthographic character *"Do-Chasmi hay"* represents aspiration in characters preceding it. Many dictionaries listed different words with proposed aspirated nasal consonants, but minimal pairs are not available.

Then the question arises, if these aspirated nasals are allophones of other nasals. This was answered in a recent study of Urdu consonantal and vocalic sounds by language processing research group at center for research in Urdu language processing.

While our study of finding Urdu consonants continued, it became evident that the aspirated versions of the nasal stops are not present in Urdu language (Saleem et al., this volume).

1) The minimal pairs for /n/ and /ŋ/ is [sən , səŋ]. These words were recorded and analyzed acoustically.

4.4.2. Assimilation rules for Place and nasality

To identify the assimilation rules for the nasal consonants, two types of experiments were designed that were

A. To test the place assimilation rules for nasal consonants.

B. To test the nasality assimilation from the nasal consonants to vowels.

For the experiments of type A, five phonetically trained speakers were provided with the sentences containing words with the consonants clusters. These clusters were of the kind nC, where C was non-nasal consonant and n represents nasal consonants.

A sub-set of data is provided in the table 4.1.

TABLE 4.1. Data to be tested for place

Place of Non-Nasal consonant	Plosive and Affricate	Continuants
Bilabial	sanp, ənbar, əmbər	χ
Labio-Dental	χ	ənvər, ɪnfradi
Dental	ənd̪ər, mənt̪ər, ɪmt̪eɑz, ɪmd̪ɑd	
Alveolar	χ	əmsɑl, ɪnsɑn, mənzər
Palatal	χ	mənʃa, mənsur
Palato-alveolar	bʰɑndʒa, sɑntʃa, əmdʒəd̪	
Retroflex	kɑntɑ, kənɖɑ	
Velar	əngrɑi, bɑnkɑ, ɪmkɑn	

assimilation rule.

The data has different contexts due to different adjacent consonants. All possible contexts were tried in the experiments.

The (phonetically trained) speakers were consulted to identify the place of articulation of nasal consonants in various contexts. Spectrograms of some words were analyzed in which the combination nC has plosive consonants.

For the experiments of type B, the speakers were provided with the words containing the combination of VC, where V stands for vowel (both short and long) and C for nasal consonants. A sub-set of data is provided in the table 4.2 below

TABLE 4.2. Data to be tested for nasalization of vowels

Vowel	Words with possible nasalization	Words without nasalization
ɑ	ɑ̃na	ɑʈɑ
i	sĩŋ	sĩd^{h}
e	kəhẽ	kəhe
u	muñ	rɑhu
œ	bœ̃ŋən	bœt
o	dõŋa	dori
ɔ	kɔ̃nœn	pɔɖa
ə	bəndʒər	χəbər
ʊ	ũngəli	kʊrsi
ɪ	dʒɪn	tʃɪrja

In table 4.2 pair of words are selected in a way that one word had possibility of nasalization due to Vn combination and the other word has the same vowel but without the possibility of nasalization. This helped in comparing the intensity of formants of the vowels to identify nasalization.

4.4.3. Deletion rules for nasal consonants

The experiment was conducted with the same data as of the experiment of vowel nasalization. The speech was analyzed to test if the nasal consonant gets deleted after vowel nasalization or not.

It was detected by analyzing the spectrogram.

4.4.4. Devoicing in nasal sounds

This experiment was designed to test if Urdu speakers can utter voiceless nasal consonants or not. For the purpose of testing, speakers were provided with the sentences having the exclamation words. The data has been listed in the table 4.3 below.

The speech was recorded and analyzed to find the absence of voicing in nasal sounds. The data selected was close to the data presented for the English language.

TABLE 4.3. Data to test the voiceless nasal consonants

Sound	Comment
Hmmm	Sound showing a pause while thinking
Uhumm	Sound while negating or disagreeing
Ahannn	Sound to show that you are listening

5. RESULTS

5.1. Phonemes and allophones

The results of experiments, described in section 4.4.1 are shown in the figure 5.1.

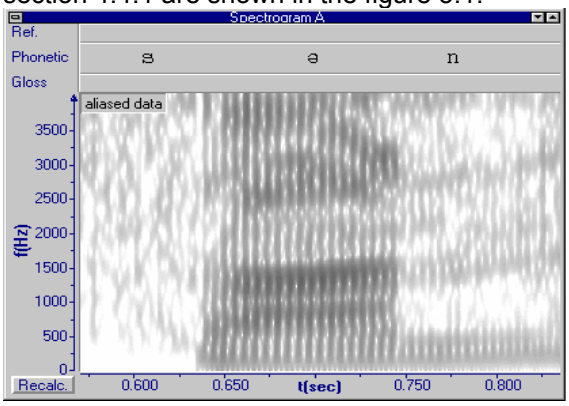


FIGURE 5.1.A. Spectrogram of "Sang" [sən]

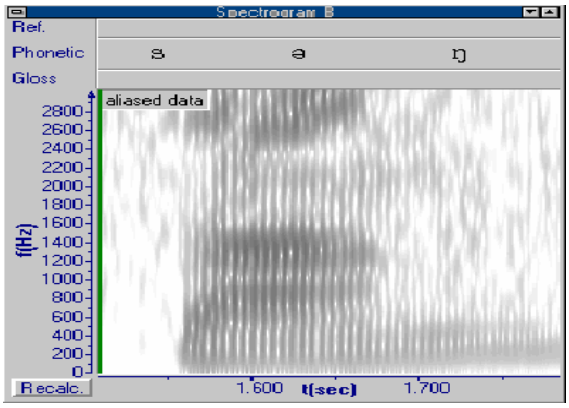


FIGURE 5.1.B. Spectrogram of [sən]

5.2. Nasal place assimilation

The test for the nasal place assimilation was conducted with phonetically trained speakers. The speakers reported these results.

1. /n/ followed by the bilabial stops,

gets labialised
2. /n/ followed by the dental stops, becomes dental
3. /n/ followed by the alveolar affricates [dʒ, tʃ], becomes alveolar
4. /n/ followed by the retroflex stops, becomes retroflex
5. /n/ followed by the velar stops, becomes velar
6. /n/ do not change place for following continuants
7. /n/ becomes the bilabial nasal /m/, when it gets labialised
8. /n/ becomes velar nasal /ŋ/, when it is followed by /g/. This can be seen in figure 5.1.a.

The spectrogram of the word [sanp] is shown in figure 5.2.a.

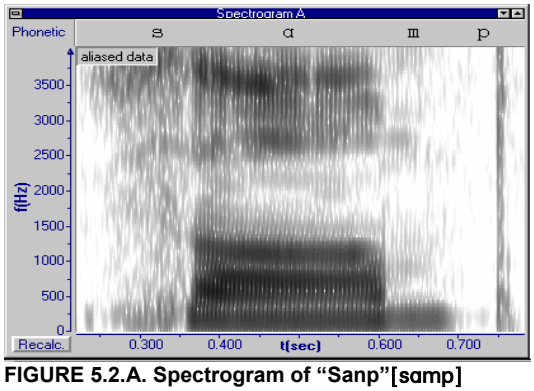


FIGURE 5.2.A. Spectrogram of "Sanp"[sɑmp]

The spectrogram is showing the fall of first and second formant of vowel /ɑ/ proving the next consonant as bilabial.

5.3. Vowel nasalization (Manner Assimilation)

Words listed in the table 4.2. were recorded and analyzed. The power of formants was calculated and compared. Results are listed in the table 5.4.

TABLE 5.5. The average power of formants of vowels

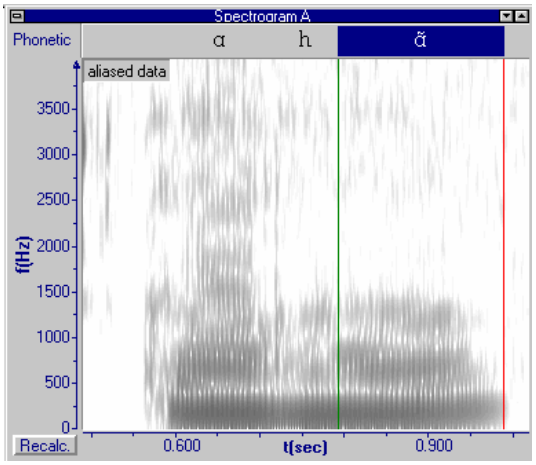
Vowel	Average Power in db (all are negative)					
	Nasalized			Non-nasalized		
	F1	F2	F3	F1	F2	F3
ɑ	30.7	38.1	27.5	20.0	26.0	16.8
u	40	45.3	67.5	27.0	35.8	50.7
o	33.4	29.7	44.5	29.8	8.5	36.2
œ	42.5	45.8	37.0	39.0	36.6	18.1
i	52.2	42.2	50.0	48.8	69.5	67.2
ə	38.1	49	50.4	10.9	27.6	34.3
ɪ	53.0	65.4	54.5	49.6	56.6	X
ʊ	52.9	34.3	X	23.3	34.0	27.0

The table shows that the power in decibels of all the formants is lesser than the power of non-nasal vowels. The "X" shows that the respective formant was diminished or merged with the closest formant.

5.4. Voiceless nasals

The spectrograms of the data analyzed are shown in figure 5.4.

FIGURE 5.4.A. The spectrogram of "ahann"



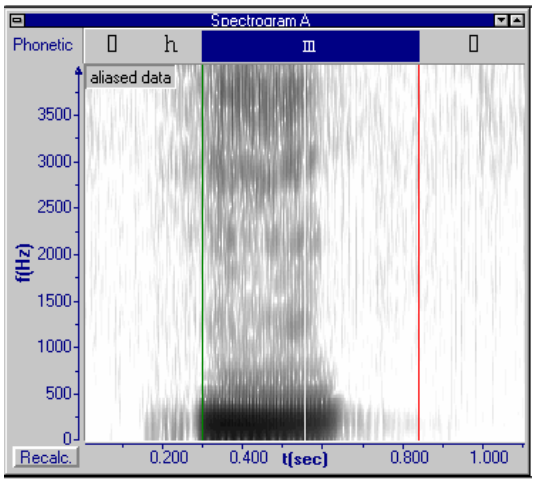


FIGURE 5.4.B. spectrogram of the sound [hmmm]

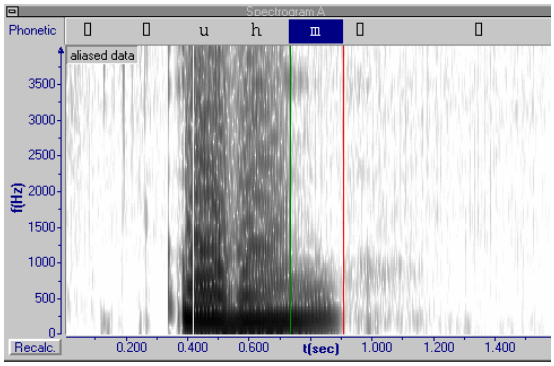


FIGURE 5.4.C. The spectrogram of the sound "Uhummm"

5.5. Nasal sound deletion

The spectrograms of the experiment are shown in figure 5.5. The words are "Ankhain" [ãnkʰen] and "Antain" [ãnten].

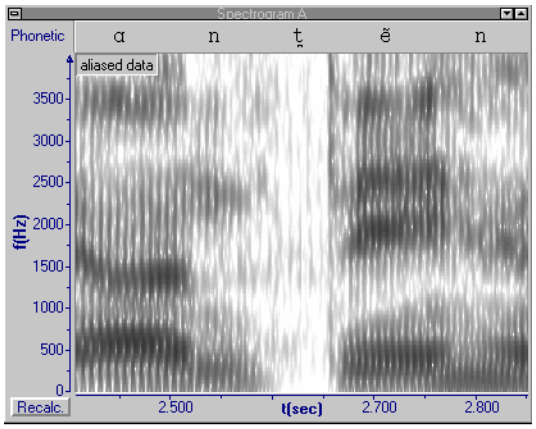


FIGURE 5.5.A. Spectrogram of "Anten"

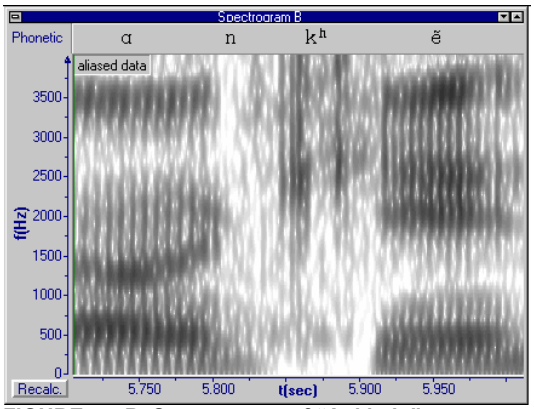


FIGURE 5.5.B. Spectrogram of "Ankhain"

6. DISCUSSION

6.1. Phonemes and allophones

Three nasal consonants of Urdu were identified which are

/m / [bilabial, voiced, plosive]
/n / [alveolar, voiced, plosive]
/ŋ / [velar, voiced, plosive]

The existence of minimal pairs is the best proof for existence of phonemes. The minimal pairs for these phonemes are

1. "Nan" [nɑn] and "Man" [mɑn] for the phonemes /n/ and /m/
2. "Sun" [sən], and "Sung" [səŋ] for the phonemes /n/ and /ŋ/.

The spectrograms of figure 5.1 shows, that both words have same number of phonemes with a difference of just one phoneme.

The acoustic analysis of [səŋ] showed that when /n/ proceeds /g/ [velar, voiced, plosive] then /n/ becomes /ŋ/ and /g/ is deleted. There is no burst of /g/, proving the deletion. Hence we get the word [səŋ] as a minimal pair for the word "Sun" [sən].

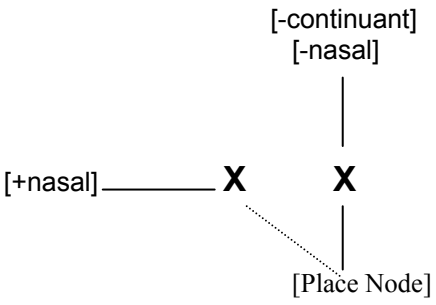
6.2. Nasal place assimilation

The experiments to find the assimilation of place for nasal phonemes showed the results listed in section 5.2. These results can be summarized as

1. The nasal sounds /m/, and /ŋ/ do not change place according the consonants preceding or following them.

2. The nasal consonant /n/ changes its place according to the consonant following it. This behavior can be completely defined with the help of Rule 6.1.

The Rule 6.1 shows that /n/ takes the place of articulation as that of the preceding plosive consonant.



Rule 6.1. Place assimilation rule for the nasal sound /n/

The spectrogram in figure 5.2 shows that when /n/ has a preceding bilabial consonants, then /n/ was labialised (becomes /m/) and this can be seen by the transition of formant from /ɑ/ to labialised /n/. Both formant one and two are falling to prove the labial consonant following the vowel.

6.3. Vowel nasalization (Manner Assimilation)

During the study of the nasalization of vowels, it became evident that both long and short vowels are nasalized in Urdu speech before the nasal consonants /n/ and /ŋ/.

The nasal consonant /m/ do not nasalize the vowels preceding it.

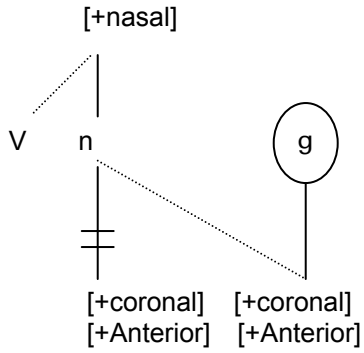
The vowels are not nasalized for every Vn or Vŋ combination. Vowels do get nasalized if this VC combination occurs in a syllable except the last syllable of the morpheme. If the combination occurs in the last syllable of the morpheme then the vowel may or may not get nasalized.

Interestingly this can be identified by the orthographic representation. If the orthographic representation of the morpheme has *'Nun-Ghuna'* to represent the /n/ or /ŋ/ in the last syllable then it represents nasalization on the other hand if *'Nun'* occurs in the last syllable then vowels are not nasalized.

During the analysis of Urdu vocabulary, minimal pairs were found to show that nasal vowels exist in Urdu language as separate phonemes not as allophones of normal vowels. Since the paper is about the nasal consonants, therefore the phonological behavior of such nasalized vowels was not studies in detail.

In case where the /n/ is followed by /g/ and preceded by a vowel like "Angara" [əŋɑra], two rules are applied to define the whole process of nasalization of vowel and change of /n/ to /ŋ/.

First /n/ gets the place of following consonant /g/ and becomes /ŋ/. Then the /ŋ/ nasalize the vowels. This process can be described as Rule 6.2.



Rule 6.2. Nasalization of vowels with /ŋ/

6.4. Voiceless nasals

Experiments show that Urdu speakers are not trained to utter voiceless nasal sounds. During the utterance of sounds like hmmm, or ahann the voicing never disappears. It can be seen in the spectrogram in the figure 5.4.

6.5. Nasal sound deletion

The study of the phenomena of vowel nasalization, it was also proposed that the nasal sound /n/ gets deleted in the cases when preceding vowels are nasalized.

The acoustic analysis of data proved it wrong. The spectrograms of figure 5.5 are supporting the argument. A nasal consonant can be seen in both words.

The nasal consonant /ŋ/, also do not get deleted even after the nasalization of vowels. The nasal consonant /m/ does not nasalize vowels and also it does not get deleted.

7. REFERENCES

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