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Breathy Nasals and /Nh/ Clusters in Bengali, Hindi, and Marathi

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Abstract

Previous work on breathiness in Indic languages has focused primarily on the acoustic properties of breathy (also known as aspirated) oral stops in languages like Hindi ([**b**aːl] 'hair' vs. [**bʱ**aːl] 'forehead') or Bengali ([**b**ati] 'bowl' vs. [**bʱ**ati] 'kiln'). However, breathiness in some Indic languages also extends to nasals, as in Marathi ([**m**aːr] 'beat' vs. [m̤aːr] 'a caste'). It is not clear if languages such as Hindi and Bengali have breathy nasals in addition to breathy oral stops. This study addresses the following question: in Bengali and Hindi, are /N/ + /h/ sequences single breathy nasals ([N̤]), or are they clusters ([Nh])? To answer this question, simultaneous audio, aerodynamic, and electroglottographic recordings were made of Hindi, Bengali, and Marathi speakers. Within- and cross-language comparisons were made, and phonological evidence was examined. While some within-language comparisons gave inconclusive results for Hindi and Bengali, other comparisons with Marathi and within-language phonological evidence pointed to the lack of breathy nasals in Hindi and an uncertain status for breathy nasals in Bengali.

1   Introduction[1]

The Indic languages are typologically unusual, possessing a four-way oral stop

contrast that includes both voiceless and voiced aspirates.[2] This is exemplified in Table

1, with data from two Indic languages, Bengali and Hindi.

	Bengali	**Hindi**
Voiceless unaspirated	**p**ati 'mat'	**p**aːl 'take care of'
Voiceless aspirated	**pʰ**ati 'I burst'	**pʰ**aːl 'knife blade'
Voiced unaspirated	**b**ati 'bowl'	**b**aːl 'hair'
Voiced aspirated	**bʱ**ati 'kiln'	**bʱ**aːl 'forehead'

Table 1: Examples of the four-way oral stop contrast in Bengali and Hindi.

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[1] We would like to thank our speakers for their assistance with this project, as well as the members of the UCLA Phonetics Lab for their helpful comments. An earlier version of this paper was presented at the 149th meeting of the Acoustical Society of America, Vancouver, BC, May 2005.

[2] Throughout this paper, we will be using the term "aspirate" to refer to both aspirated voiceless stops (Tʰ) and breathy voiced oral stops (Dʱ). We will use the term "breathy" to refer to breathy nasals ([N̤]). This terminology is not meant to imply any particular phonetic differences between breathiness and aspiration. It simply reflects the traditional terminology used for with the Indic languages.

In a few languages of South Asia, such as Marathi, Konkani, and Newari, the aspiration contrast extends to nasal stops as well, producing breathy nasals. An example from Marathi is presented in Table 2.[3]

	Marathi	
	Oral	**Nasal**
Voiceless unaspirated	pal 'cloth or large blanket'	▨▨▨▨▨▨
Voiceless aspirated	pʰal 'fruit'	▨▨▨▨▨▨
Voiced unaspirated/modal	bal 'strength'	maːɾ 'beat'
Voiced aspirated/breathy	bʱal 'the head of a spear or arrow'	m̤aːɾ 'a caste'

Table 2: Example of the aspiration/breathy contrast in both the oral and nasal stops in Marathi.

However, in languages like the standard versions of Bengali and Hindi (that is, ones where the aspiration contrast is only in the oral stops) there are sequences of phonemic nasal consonants (/N/) followed by /h/ (that is, /Nh/). On the surface, it is not clear if these sequences are breathy nasals ([N̤]) or simply [Nh] clusters. For Hindi, different researchers present conflicting views; for Bengali, there has never been any phonetically-oriented research on this topic. Thus, the goal of this paper is to answer the following question:

- In Bengali and Hindi, are /N/ + /h/ sequences single breathy nasals ([N̤]), or are they [Nh] clusters?

Before addressing this question, we will first present some background information on the languages being studied, as well as previous literature on the issue of breathiness and aspiration in Indic languages. After this, we will present the methodology, followed by the results and discussion of the data.

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[3] Often, the historical source of these breathy nasals in Indic languages is the merger of a voiced C with a fricative [h]. For example, Marathi [n̤aːn] `bath' corresponds to Hindi [nahaːn].

2   Language Background
2.1   Bengali

Bengali (Bangla) is an Indo-European language spoken by approximately 171 million people in the People's Republic of Bangladesh and in the eastern Indian states of West Bengal, Assam, and Tripura. Bengali is also used as a second language by over 40 million Bangladeshis and Indians (Gordon 2005). Speakers of Bengali are typically fluent in more than one dialect; most Bengalis speak both the regional variety alongside the Standard Kolkata dialect (often called *Choltibhasha*), which is used in all media and formal education. All data in this study is pronounced in *Choltibhasha* by speakers born in the Dhaka Division of Bangladesh. Bengali, along with many other eastern Indic languages, is written with the Bengali script, a syllabic alphabet derived from the ancient Brahmi script.

2.2   Hindi

Hindi is an Indo-European language spoken primarily in a large belt across north-central India, including the states of Uttar Pradesh, Bihar, Madhya Pradesh, Rajasthan, Haryana, Himachal Pradesh, and the Union Territory of Delhi. Roughly 180 million people use it as a first language, with 120 million second-language speakers (Gordon 2005). While a number of different regional varieties of Hindi exist (such as Braj and Bhojpuri), the form examined here is Modern Standard Hindi, the language of literature, the press, and standard education. While this form of Hindi originally existed mainly as a lingua franca for speakers of the regional varieties, it is now spoken natively by many people, especially those from urban areas (Masica 1991). Hindi is written with the Devanagari script.

2.3   Marathi

Marathi is an Indo-European language spoken in the state of Maharashtra, located in the northwestern part of the Deccan plateau in south-central India. Major cities found in this region include Pune (Poona), Mumbai (Bombay), and Nagpur. Marathi has roughly 68 million native speakers, with 300,000 second-language speakers (Gordon 2005). Marathi is written with the Devanagari script.

3   Previous Research

Most previous work on breathiness in Indic languages has focused on oral stops (Ohala 1983 and Dixit 1987, to name a few). However, there has been one phonetic study on breathy nasals in Urdu, a language mutually intelligible with Hindi. Aziz (2000) studied word-initial, word-medial, and word-final /N/ + /h/ sequences in Urdu. In word-initial position, spectrographic evidence revealed that speakers consistently inserted a schwa between the nasal ([N]) and the [h]. Thus, there was no breathiness during the nasal. In word-medial position, speakers were inconsistent in the pronunciation of [h]. When speakers did produce the [h], there was some aspiration, but only in cases of /mh/, and not other places of articulation. In word-final position, speakers nasalized the preceding vowel, deleted the nasal consonant, and were inconsistent in their production of [h], creating [ṽ(h)] sequences. In sum, in all three positions, there was little evidence for phonetically breathy nasals in Urdu.

In general, there appears to be disagreement in the literature over the status of breathy nasals in Hindi. Some authors treat the /Nh/ sequence in Hindi as a cluster (Ohala 1983; Botma 2004) while others regard it as a single breathy nasal (Maddieson

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1984; Hinskens and van de Weijer 2003). No previous research has been conducted on Bengali /Nh/.

4   Current Study

The goal of the current study is to determine if /Nh/ sequences in Bengali and Hindi are breathy nasals, like Marathi [N̪], or if they are [Nh] clusters instead. To answer this question, simultaneous audio, aerodynamic, and electroglottographic (EGG) recordings were made for Bengali, Hindi, and (to provide a point for comparison) Marathi. Both within- and cross-language comparisons were made. In addition, we examined some phonological evidence to see if /Nh/ in Bengali and Hindi behave like clusters or single segments (expanded on in Part 7). We will begin by discussing the within-language comparisons.

5   Within-language comparisons

For the within-language comparisons, voiced aspirated oral stops ([Dʱ]) were compared to potentially breathy nasal ones (/Nh/) in Bengali and Hindi. If breathy nasals do exist in Bengali and Hindi, they might share some features with voiced aspirated oral stops (except, of course, for nasality).

5.1   Methods
5.1.1   Speakers

For Bengali, three adult male and two adult female speakers were recorded for this study. For Hindi, one adult female speaker was recorded. All speakers spoke English in addition to the language in question.

5.1.2 Speech Materials

The Bengali and Hindi speakers produced words that included the sounds given in Table 3:

1. Nasals	[N]
2. Potentially Breathy Nasals (nasals followed by [h])	/Nh/
3. Voiced Unaspirated Stops	[D]
4. Voiced Stops Followed by [h][4]	[Dh]
5. Voiced Aspirated Stops	[D⁶]
6. Glottal Fricative[5]	[h]

Table 3: A list of the consonants (and clusters) recorded for both Bengali and Hindi.

These consonants and consonant clusters were produced intervocalically. Six words per consonant/cluster were produced. Each word contained one and only one of the consonants/clusters in question. A word never contained more than one type of consonant/cluster being studied.

5.2 Procedure

Each word was repeated three times in the carrier sentence [ʃe ____ bollo] "S/he said ____" for Bengali, and [ab ____ kahie] "Please say ____ now" for Hindi. Simultaneous electroglottographic and audio recordings were made for each speaker. Tokens were digitized and analyzed at a sampling rate of 22 kHz using AcQuirer software (Scicon RD). Figure 1 shows the audio, oral flow, nasal flow, and EGG signals, respectively, for Hindi [paka:na:] "to cook (transitive)" as displayed in AcQuirer (Scicon RD). (The oral and nasal flow data are relevant to the cross-language comparison, Section 6.)

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[4] Recorded as an example of a consonant followed by an [h]. If /Nh/ is a sequence of [N] + [h], it should be similar to [Dh], which is a sequence of [D] + [h].
[5] Recorded as an example of a segment that contains only breathiness.
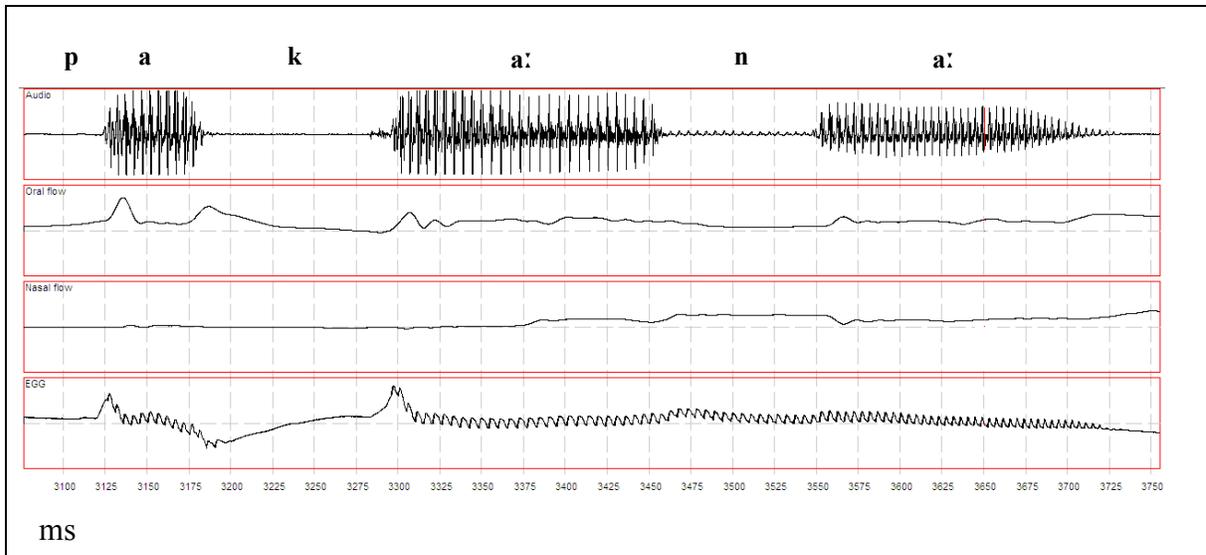
Figure 1: Audio, oral flow, nasal flow, and EGG of Hindi [paka:na:] "to cook (transitive)"

Duration and closed quotient were measured for each token. In the next section, we detail how and where each measurement was taken.

5.2.1 Description of measures
5.2.1.1 Duration

For each segment, the duration of the modal/unaspirated portion and the duration of the breathy/aspirated portion were measured in milliseconds (ms) using spectrograms created from the audio signal. For the unaspirated voiced stops ([D]) and the modal nasals ([N]), the duration of the entire segment was measured.

5.2.1.2 Closed Quotient

Closed quotient (CQ) was measured automatically with AcQuirer by dividing the amount of vocal fold closure (Tc) by the sum of the amount of vocal fold closure plus the amount of vocal fold opening (To) for each glottal pulse. Figure 2 shows this equation and how it was derived from a glottal pulse from the EGG signal.

Closed quotient = Total closure / (Total closure + Total open)
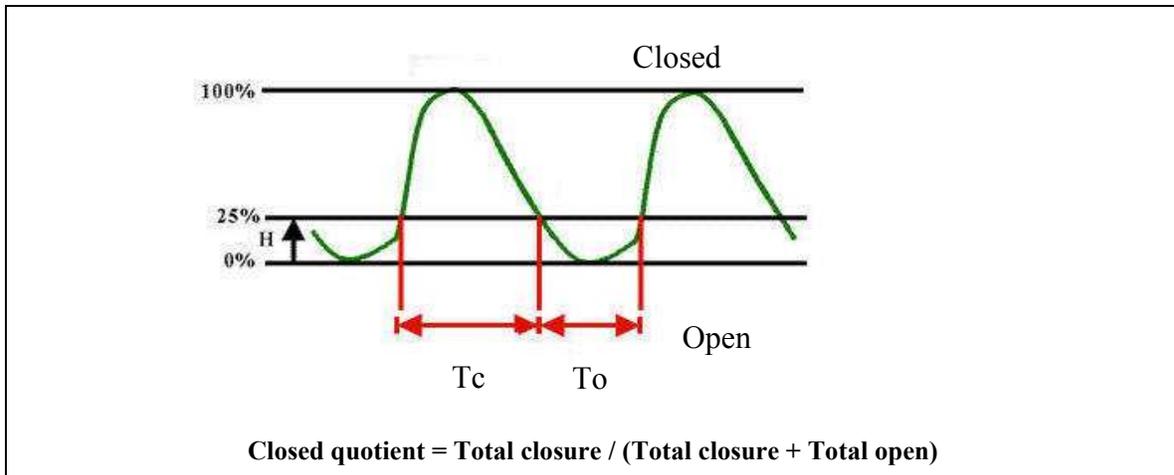
Figure 2: Closed quotient and how it was calculated from the EGG signal. *H* represents a default 25% threshold. Tc = total closure. To = total open

CQ was measured at two points: 1) the middle of the modal/unaspirated portion 2)

the middle of the breathy/aspirated portion. Again, spectrograms were used to determine

the modal/unaspirated and breathy/aspirated portions of the segment.

5.3   Results and Discussion

We begin by presenting the results and discussion of the within-language comparison

for Bengali, and then move on to Hindi.

5.3.1   Bengali
5.3.1.1   Duration

Figure 3 is a graph of the average duration of the breathy/aspirated and

modal/unaspirated portion of the segments [N], /Nh/, [D], [Dh], [D⁶], and [h]. Duration is

graphed on the y-axis in ms.   Due to typographical limitations, breathiness/aspiration is

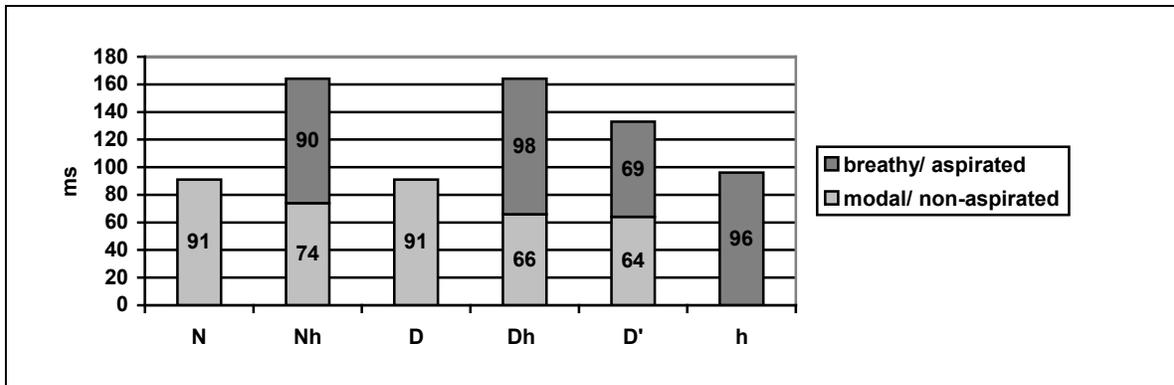represented by an apostrophe (') in all graphs in this paper.

Figure 3: Graph of the average duration of the breathy/aspirated and modal/unaspirated portion of [N], /Nh/, [D], [Dh], [Dᶠ], and [h] for Bengali.

The data presented here suggest that the duration of /Nh/ is similar to [Dh]. Like

[Dh], the duration of /Nh/ is longer than the single segment [Dᶠ]. The data indicate that

the /Nh/ is more like a sequence than a single segment.

5.3.1.2 Closed Quotient

Figure 4 is a graph of the average CQ value for [N], /Nh/, [D], [Dh], [Dᶠ], and [h].
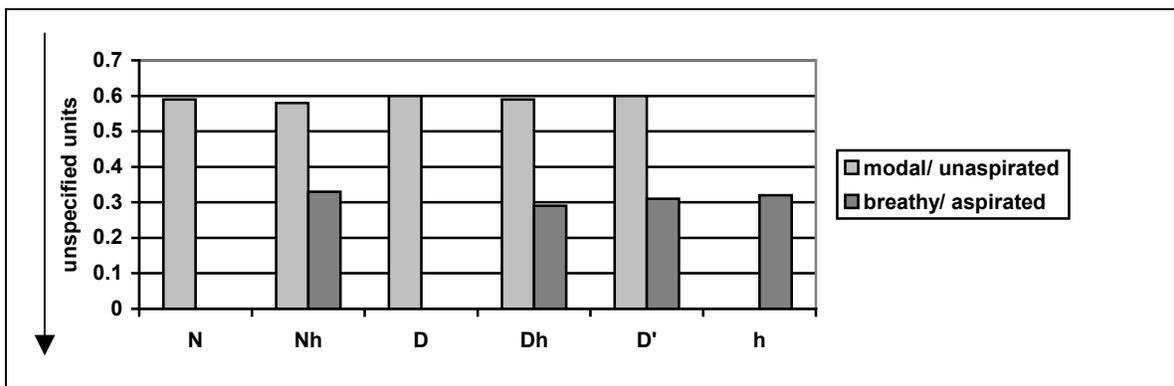
Lower values indicate increased breathiness.

Figure 4: Graph of the average closed quotient of [N], /Nh/, [D], [Dh], [Dᶠ], and [h] for Bengali. The arrow indicates the direction of increased breathiness.

Figure 4 tells us little about the status of breathiness in general. The CQ data fails

to distinguish even the phonemic distinction between [Dᶠ] and [Dh]; the value of both the

unaspirated and aspirated portions of these segments is very similar. As for the question

of breathy nasals in particular, the CQ values of /Nh/ pattern with both [Dʰ] and [Dh], making the data inconclusive for Bengali.

5.3.1.3   Summary of results for Bengali

The within-language comparison of the Bengali data, in general, is inconclusive. While duration indicates that /Nh/ is more like the cluster [Dh] than like [Dʰ], other evidence, such as CQ, is ambiguous, at best. The CQ data indicates that /Nh/ behaves like both the cluster [Dh], and the single segment [Dʰ]. Thus, it is not clear from the data whether /Nh/ is a cluster or a single segment.

We will now move on the results and discussion of data for Hindi.

5.3.2   Hindi
5.3.2.1   Duration

In Hindi, underlying sequences of /D/+/h/ were consistently split up by schwa epenthesis, yielding [Dəh]. A few of the /N/+/h/ tokens were also split up in this same way, yielding some productions of [Nəh]. All tokens with schwa epenthesis were excluded from the analysis, including all the graphs below. Figure 5 is a graph of the average duration of the breathy/aspirated and modal/unaspirated portion of the segments [N], /Nh/, [D], [Dʰ], and [h]. Duration is graphed on the y-axis in ms.
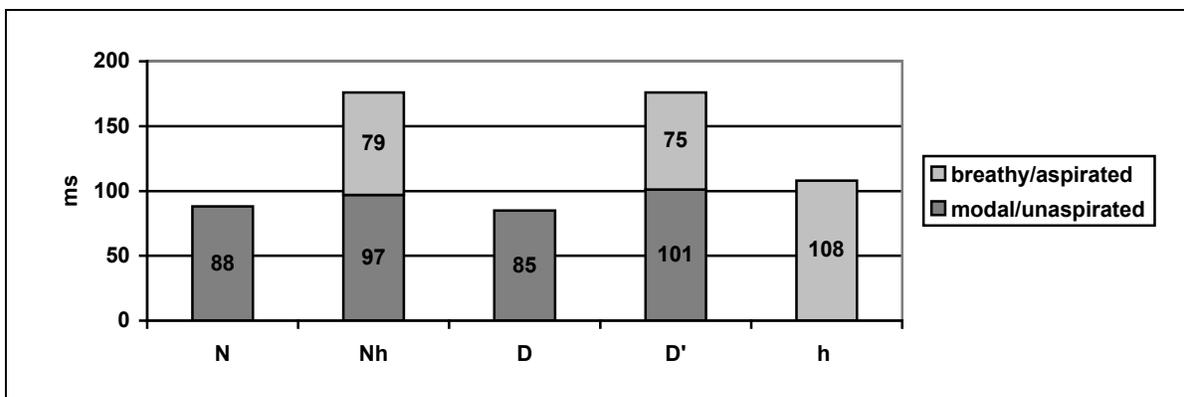

Figure 5: Graph of the average duration of the breathy/aspirated and modal/unaspirated portion of [N], /Nh/, [D], [Dʰ], and [h] for Hindi.

While the duration of /Nh/ is similar to [Dʱ], suggesting the former might be a single consonant, the fact that schwas occasionally break up /Nh/ make it look more like a cluster (a single segment like [Dʱ] cannot be split up in a similar manner). It is hard to draw a firm conclusion from the duration data, however, as true [Dh] clusters were not produced without schwa epenthesis.

5.3.2.2 Closed quotient

Figure 6 is a graph of the average CQ value for Hindi [N], /Nh/, [D], [Dʱ], and [h]. Lower values indicate increased breathiness.
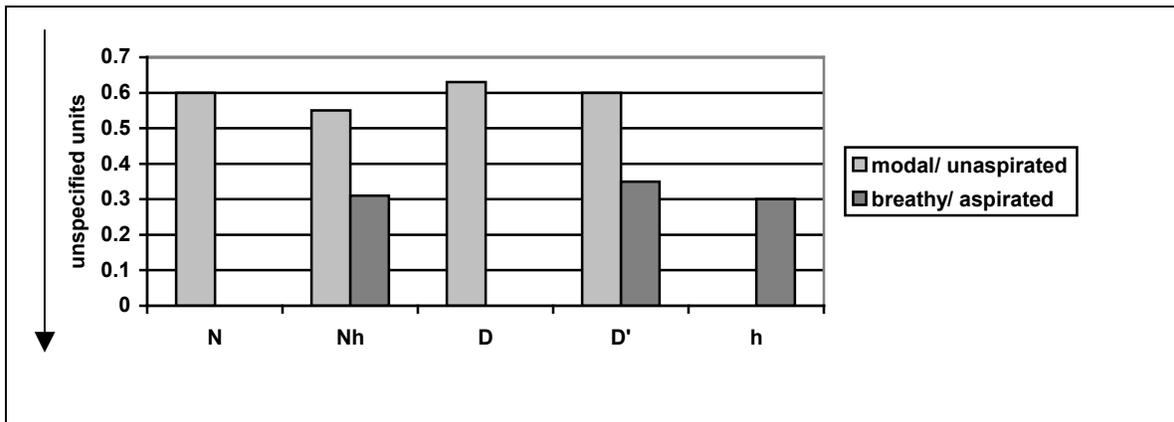
Figure 6: Graph of the average closed quotient of the breathy/aspirated and modal/unaspirated portion of [N], /Nh/, [D], [Dʱ], and [h] for Hindi. The arrow is pointing in the direction of increased breathiness.

As with the Bengali data, the CQ data for the Hindi is inconclusive. The CQ value of /Nh/ does not pattern like [N] + [h] in that the modal portion of the /Nh/ is actually breathier (i.e., has a lower CQ value) than modal [N]. This would suggest that the /Nh/ is more like [Dʱ], where the unaspirated (modal) part of [Dʱ] is also more aspirated (breathier) than that of the individual segment [D]. However, the /Nh/ also differs from the [Dʱ]; the [h] of /Nh/ is breathier than the aspirated part of [Dʱ]. Thus, the Hindi data is ambiguous.

5.3.2.3 Summary of results for Hindi

To summarize, the within-language comparison of the Hindi data is inconclusive. While duration indicates that Hindi /Nh/ is more like the single segment [D$^\text{ɦ}$], the schwa epenthesis suggests it is more like a cluster. However, the CQ data is ambiguous, indicating that /Nh/ behaves like both a cluster and a single segment.

We will now present the cross-language comparison.

6 Cross-language comparison

For the cross-language comparison, the potentially breathy nasals in Bengali and Hindi were compared to the phonemically breathy nasals in Marathi.

6.1 Methods
6.1.1 Speakers

The same Bengali and Hindi speakers used in Part 5 of the study were also recorded here. In addition, one adult female speaker of Marathi was recorded.

6.1.2 Speech Materials
6.1.2.1 Marathi

The Marathi speaker produced the sounds given in Table 4:

1. Nasals	[N]
2. Breathy nasals	[Ṇ]
3. Voiced Aspirated Stops	[D$^\text{ɦ}$]
4. Glottal Fricative	[h]

Table 4: A list of the consonant types recorded for Marathi.

These consonants were produced intervocalically. Six words per consonant type were produced. Each word contained one and only one of the consonant types in question and a word never contained more than one consonant type being studied.

6.1.2.2 Bengali and Hindi

The [N] and /Nh/ words from part 5 of this study were used again in this part of the study.

6.2 Procedure

For Marathi, each word was repeated three times in the carrier sentence [to ____ ʃəbda wats] "He said the word _____". For Bengali and Hindi, the same carrier sentences that were used in Part 5 of the study were used here. Simultaneous aerodynamic, EGG, and audio recordings were made for each speaker. (For Bengali, aerodynamic data could only be collected for one male and one female speaker.) Tokens were digitized and analyzed at a sampling rate of 22 kHz using AcQuirer software (Scicon RD). CQ was taken following the same procedure used in Part 5. In additional, peak airflow and duration of peak airflow were measured following the procedures described below.

6.2.1 Airflow

The peak airflow (that is, the greatest amount of oral or nasal airflow, depending on the consonant being measured) was taken at two points[6], 1) the middle of the modal/unaspirated portion and 2) the middle of the breathy/aspirated portion. (Spectrograms were used to determine where the modal/unaspirated and breathy/aspirated portions of each segment were.) For [D] and [N], there would naturally only be one measurement, within the non-aspirated portion, and for the [h] only within the aspirated portion.

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[6] Non-modal phonation is often confined to a portion of the segment, and is rarely produced on the entire segment. Thus, it is the case that [N̪] in Marathi has both a modal and a breathy portion. For more information on the localization of non-modal phonation see Silverman 1997 and Blankenship 1997.

6.2.2   Duration of peak airflow

Duration of peak airflow (that is, the amount of time the airflow was greater than 50 ml/s) was measured in ms. An example is presented in Figure 7.
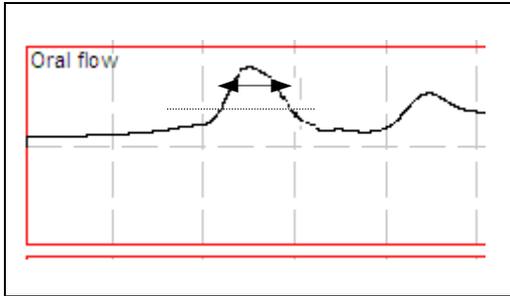
Figure 7: An example of how the duration of peak airflow was measured from the oral flow signal. The same procedure was applied to nasal flow, as well. The dashed line represents the 50 ml/s threshold. The arrows indicate the amount of time the flow exceeded 50 ml/s (measured in ms.)

6.3   Results and Discussion
6.3.1   Airflow

Figures 8, 9, and 10 are graphs of the average peak oral and nasal airflow of [N] and [N̪] for Marathi, and [N] and /Nh/ for Bengali and Hindi, respectively. Airflow is represented in ml/s on the y-axis. The /Nh/ in Bengali and Hindi and the [N̪] in Marathi have mostly nasal flow, but do have some oral flow towards the end of the breathy portion. Thus, both oral and nasal flow (in ml/s) are graphed in the figures below.
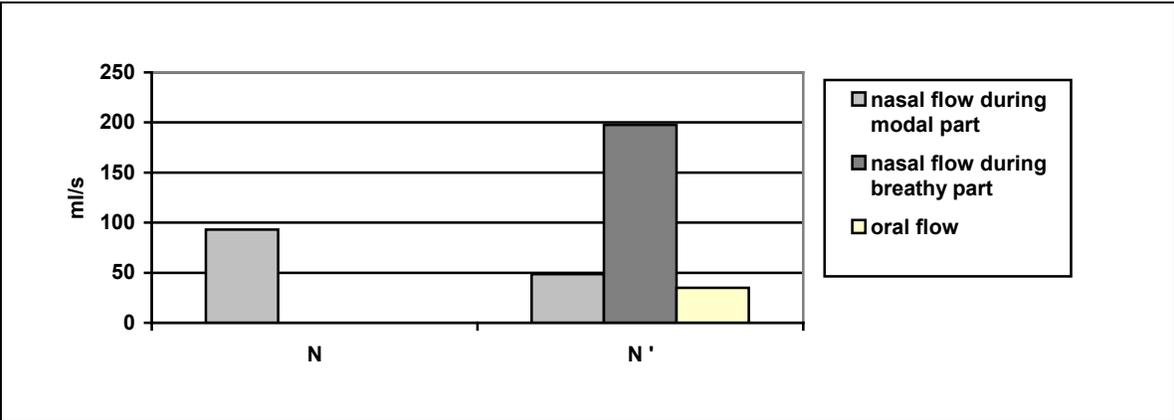
Figure 8: Graph of the average peak oral and nasal flow of [N] and [N̪] for Marathi.
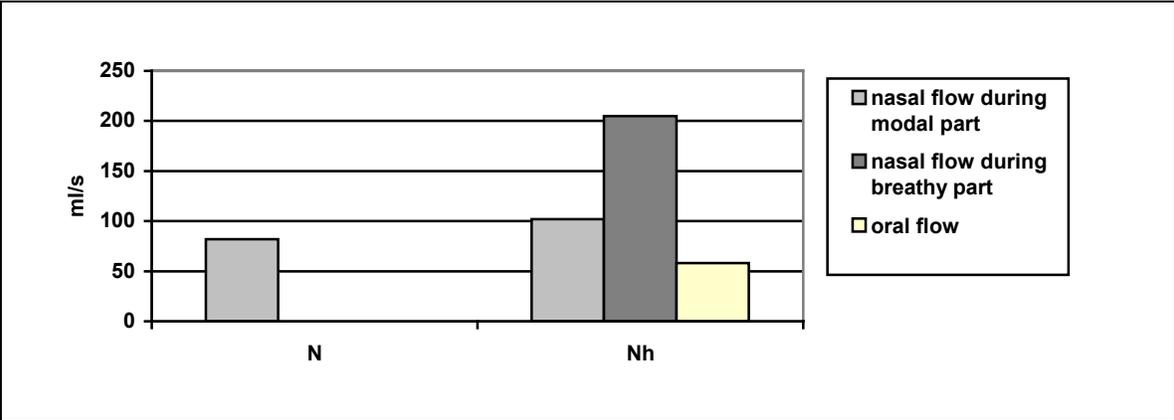

Figure 9: Graph of the average peak oral and nasal flow of [N] and /Nh/ for Bengali.
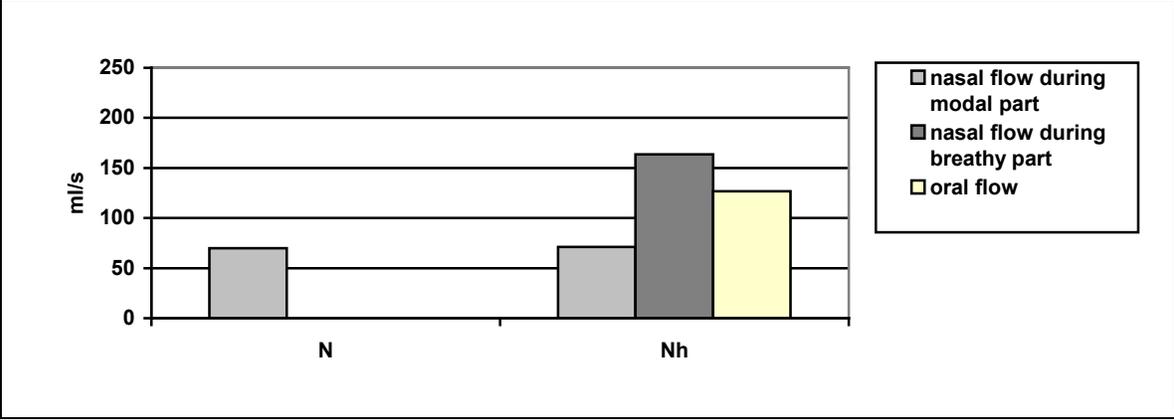

Figure 10: Graph of the average peak oral and nasal flow of [N] and /Nh/ for Hindi.

The [Ṇ] of Marathi and the /Nh/ of the Bengali have mostly nasal flow, with only a small amount of oral flow, suggesting that the /Nh/ of Bengali is more similar to [Ṇ]. On the other hand, Hindi /Nh/, in addition to the nasal flow, has a great deal of oral flow. This additional oral flow suggests the presence of two distinct segments, [N] and [h], in Hindi.

6.3.2 Closed Quotient

Figures 11, 12, and 13 are graphs of the average CQ value of the [N] and [Ṇ] for Marathi, and [N] and /Nh/ for Bengali and Hindi.
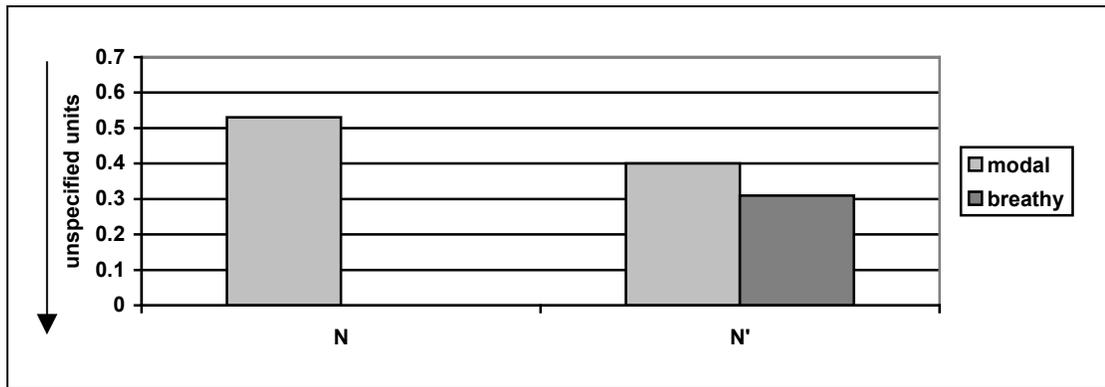
Figure 11: Graph of the average closed quotient value of [N] and [Ṇ] in Marathi. The arrow is pointing in the direction of increased breathiness.
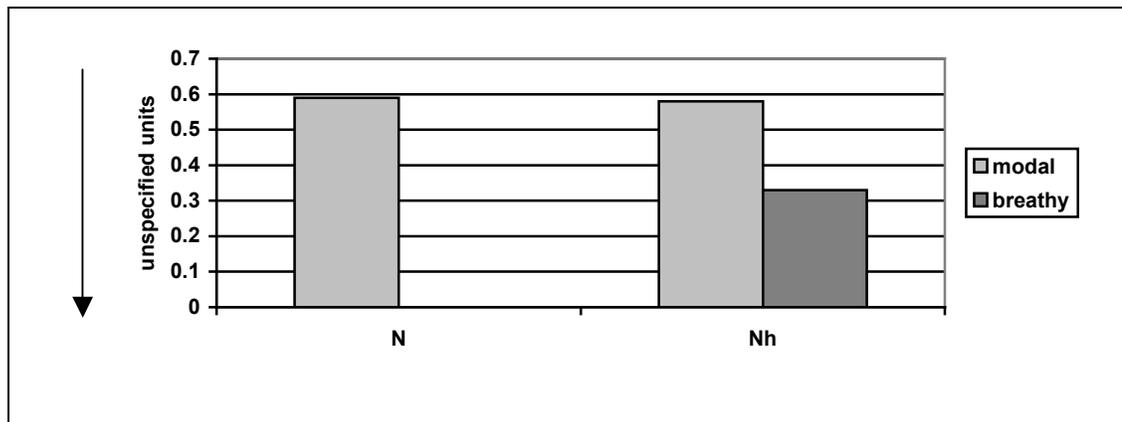
Figure 12: Graph of the average closed quotient value of [N] and /Nh/ in Bengali. The arrow is pointing in the direction of increased breathiness.
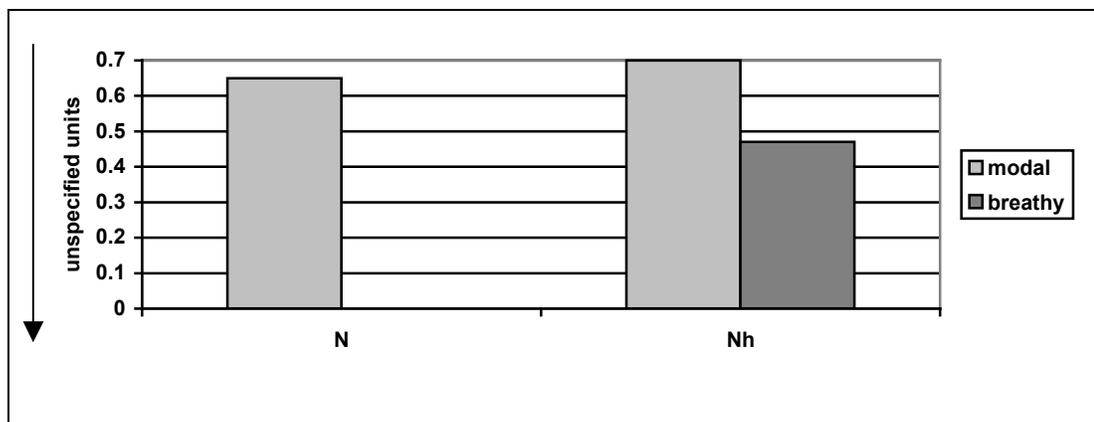
Figure 13: Graph of the average closed quotient value of [N] and /Nh/ in Hindi. The arrow is pointing in the direction of increased breathiness.

In Marathi, [N̪] has an overall lower CQ (i.e., is breathier) than modal [N]. This is not true of Bengali or Hindi, where the /Nh/ has a lower CQ only during the [h] portion; the modal portion of the /Nh/ has a similar CQ value to the modal [N]. In fact, the Hindi /Nh/ begins with a somewhat higher CQ (i.e., is less breathy) than the phonemically modal [N].

6.3.3 Duration of Peak airflow

Figures 14, 15, and 16 represent the average duration of peak airflow for [N̪] in Marathi, and /Nh/ in Bengali and Hindi. Duration is graphed on the x-axis in ms.
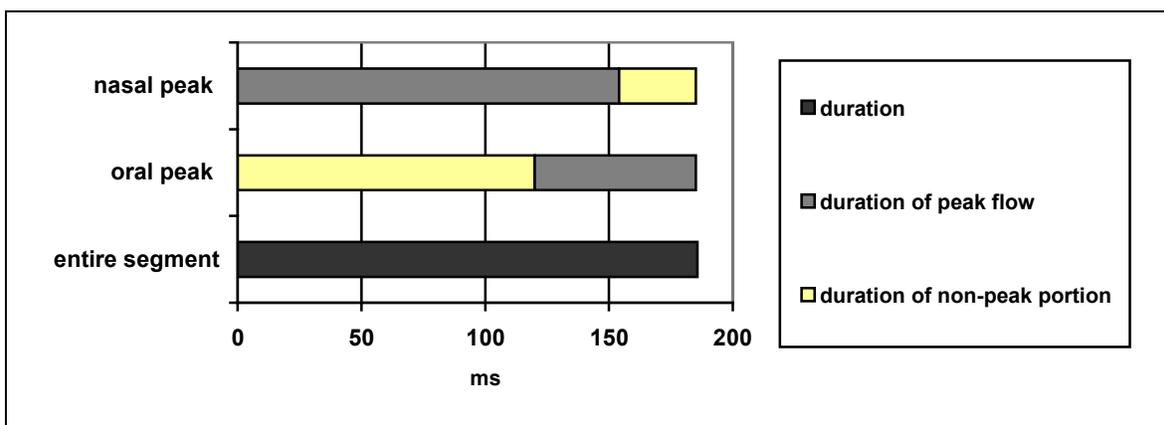

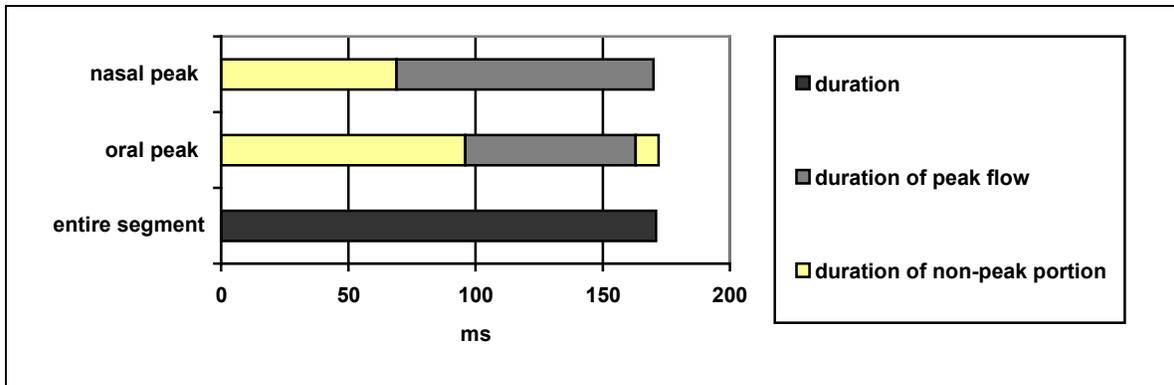**Figure 14: Graph of the average duration of peak airflow in Marathi [N̪].**

Figure 15: Graph of the average duration of peak airflow in Bengali /Nh/.
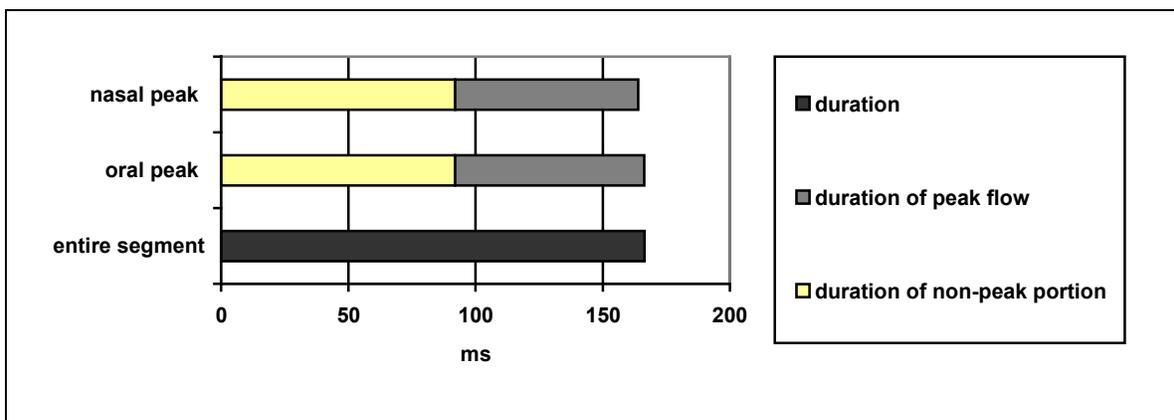

Figure 16: Graph of the average duration of peak airflow in Hindi /Nh/.

In Marathi, the [N̪] is composed mostly of nasal flow, with a small amount of oral flow near the end of the segment. This is not the case for Bengali and Hindi. In these languages, the /Nh/ is composed of similar parts nasal and oral flow, both taking place near the end of the segment, suggesting that these languages lack the type of breathy nasal found in Marathi.

6.3.4   Summary of Cross-language comparison

In sum, the Bengali and Hindi data do not pattern like that of Marathi, suggesting that the /Nh/ sequences in these languages are not breathy nasals. For example, when looking at duration of peak airflow, the Bengali and Hindi /Nh/ is composed of similar parts nasal and oral flow at the end of the segment, as opposed to Marathi, where the [N̪]

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has peak nasal flow throughout most of the consonant. In addition, according to the CQ value, the Bengali and Hindi /Nh/ is breathy only during the [h] portion, unlike Marathi, where the [Ṇ] is breathier than its modal counterpart [N] for most of the segment. The only evidence that the Bengali /Nh/ might be a single segment comes from peak airflow, where /Nh/ has mostly nasal flow, just like Marathi. However, in Hindi, the /Nh/ has considerable oral (in additional to nasal) flow, suggesting the Hindi /Nh/ is behaving more like a cluster.

7   Vowel Length

In addition to the comparisons made above, we also examined phonological evidence to determine the status of the /Nh/ sequences in Bengali and Hindi. In these two languages, vowels are phonetically longer in certain environments:

- **Bengali**: vowels are longer in open syllables

- **Hindi**: vowels are longer before a breathy/aspirated consonant (Maddieson & Gandour 1977)

These facts can be used as a simple diagnostic to help resolve the question about /Nh/ sequences. In Bengali, if vowels are longer before an /Nh/ sequence, they are likely in an open syllable, suggesting that /Nh/ is behaving as a single segment ([…Vː.ṆV…]). Two segments would likely create a closed syllable ([…VN.hV…]), removing the environment where the longer vowel appears. In Hindi, if vowels are longer before an /Nh/ sequence than before modal [N], then /Nh/ is presumably a single breathy segment, rather than a modal [N] followed by [h].

7.1   Methods
7.1.1   Speakers

The same Bengali and Hindi speakers used in the first part of the study were used

in this section.

7.1.2   Speech Materials

The speakers were asked to produce words with VC_0V sequences, where each

sequence was one of the following:

1) voiced aspirated oral stop ([V.DʱV])
2) voiced unaspirated oral stop ([V.DV])
3) potentially breathy nasal stop ([V.NhV])
4) modal nasal stop ([V.NV])
5) any of the sequences [VD.CV], [VN.CV], or [VD.hV].

In Bengali, the vowels being measured were stressed [a]'s. In Hindi, the vowels in

question were unstressed [ʊ]'s.

7.2   Procedure

Each word was recorded in the carrier sentences used in part 5 of the study. The

duration (in ms) of the vowel before each consonant (or consonant sequence) was

measured. Tokens were controlled for vowel quality, word position, and stress.

7.3   Results and Discussion
7.3.1   Bengali

Figure 17 graphs the average duration of [a] in seven different environments. The

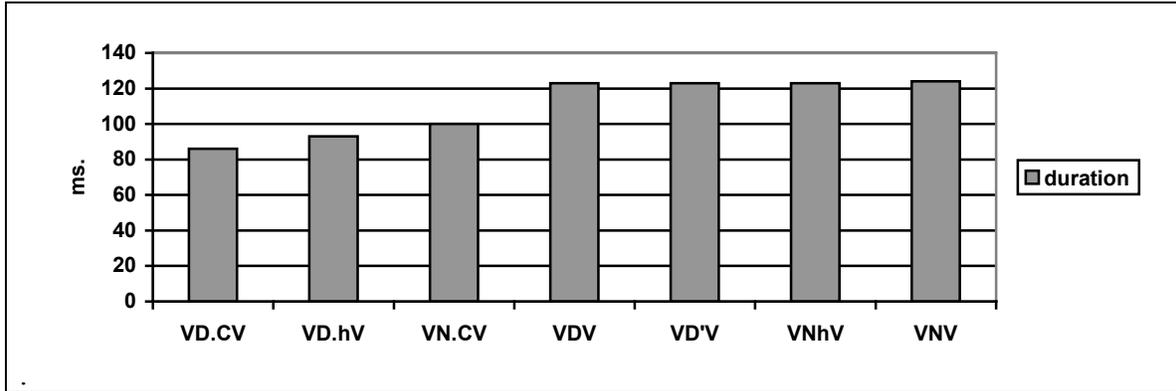length of the vowel in each environment type is plotted in ms along the y-axis.

Figure 17: Graph of the vowel duration in the sequences [VD.CV], [V.DhV], [VN.CV], [VDV], [VDɦV], /VNhV/, and [VNV].

As stated previously, Bengali vowels followed by a single segment ([D], [Dɦ], [N]) are longer than those followed by clusters ([D.C], [D.h], and [N.C]). The duration of the vowel is longer than 120 ms in each of the environments where a single segment followed the vowel, while the duration of the vowel is consistently shorter than 100 ms in all of the closed-syllable environments (i.e., where the vowel is followed by a sequence of two consonants). It turns out that vowels followed by /Nh/ are in fact longer than 120 ms, thus suggesting that /Nh/ is behaving more like a single segment than like a cluster of [N.C], [D.C], or [D.h].

7.3.2   Hindi

Figure 18 is a graph of the average duration of [ʊ] in [VDhV], [VDCV], [VNCV], [VDV], [VNV], /VNhV/, and [VDɦV]. Duration is graphed on the y-axis in ms.
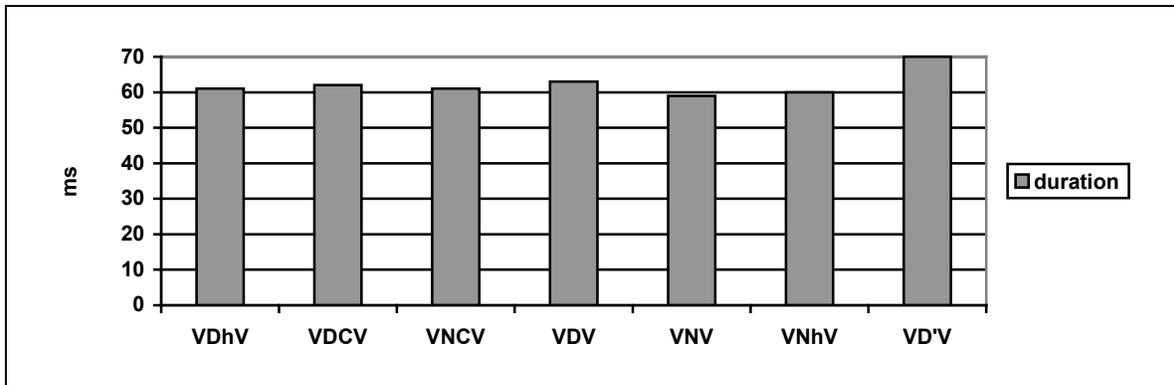
Figure 18: Graph of the vowel duration in the sequences [VDhV], [VDCV], [VNCV], [VDV], [VNV], /VNhV/, and [VDʱV].

Vowels are longer before the oral aspirated stops ([Dʱ]) than before their unaspirated counterparts ([D]). However, the vowels are not any longer before /Nh/ than before modal segments, suggesting the /Nh/ is a cluster beginning with a modal, rather than a single breathy nasal.

7.3.3 Summary

In Bengali, vowels preceding an /Nh/ sequence were found to be longer than those preceding [NC] and other clusters, and more similar in length to vowels preceding single segments ([D], [Dʱ], [N]). In Hindi, the opposite is true; vowels preceding /Nh/ were found to be shorter than ones preceding aspirated stops ([Dʱ]). The evidence here indicates that /Nh/ sequences in Bengali are behaving like single (breathy) segments, but that these sequences in Hindi behave as if they were clusters beginning with a modal segment.

8   Conclusion

To summarize, the Bengali data is inconclusive. For example, some data in the within-language comparison, (such as duration) point to cluster status for the /Nh/, while other data (such as vowel length), suggest the /Nh/ is a single segment. The results of the

measures of duration, CQ, duration of peak airflow, airflow, and vowel lengthening in Bengali are presented in Table 5.

	Within-language comparison	Cross-language comparison
Duration	Cluster	
CQ	Inconclusive	Cluster
Duration of peak airflow		Cluster
Airflow		Single C
Vowel lengthening	Single C	

Table 5: Summary of results for Bengali.

However, for Hindi, the majority of data suggest that the /Nh/ behaves more like a cluster than like a single breathy nasal. The results of duration, schwa epenthesis, closed quotient, duration of peak airflow, airflow, and vowel lengthening in Hindi are presented in Table 6.

	Within-language comparison	Cross-language comparison
Duration	Single C	
Schwa epenthesis	Cluster	
CQ	Cluster	Cluster
Duration of peak airflow		Cluster
Airflow		Cluster
Vowel lengthening	Cluster	

Table 6: Summary of results for Hindi.

In determining the phonetic status of underlying /Nh/ in Bengali and Hindi, within-language comparisons did not allow us to draw any clear conclusions. However, the data for Hindi leaned strongly towards a cluster analysis. Cross-language comparisons with Marathi, however, indicated that Bengali and Hindi /Nh/ sequences clearly do not behave like the Marathi [Ṇ]. Phonological evidence in Bengali and Hindi illustrated that, in terms of preceding vowel length, Bengali /Nh/ is being treated as a single segment, while Hindi /Nh/ is patterning with modal/unaspirated sounds.

From the results found here, it appears that there is little reason to posit breathy nasals for standard Hindi; neither phonetic nor phonological evidence points to their existence. Bengali, on the other hand, may have a phonological breathy nasal that simply lacks some of the phonetic attributes of its Marathi counterpart.

The results obtained in this study raise an interesting issue about the typology of breathy nasals in South Asia. Based on the evidence examined here, it appears that there might be three different treatments of /Nh/'s in Indic languages: phonemic breathy nasals (as in Marathi [N̤]), [Nh] clusters (as in Hindi), and a possible transitional state between the two (as in Bengali). It is necessary to examine /Nh/ data from a variety of other Indic languages (e.g., Nepali, Gujarati, or Punjabi) to see if this predicted three-way classification holds true for the rest of the family.

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