MICRO-PHONETIC INFLUENCES ON SYLLABIFICATION

Manjari Ohala[a] *& John J. Ohala*[b]

[a]San José State University, USA;
[b]University of California, Berkeley, USA
manjari.ohala@sjsu.edu; ohala@berkeley.edu

ABSTRACT

How should one syllabify medial homorganic nasal plus stop (-VNCV-) clusters in Hindi such as those in [ləmba] 'tall' and [kəŋkəɽ] 'pebble'? A variety of principles have been proposed by phonologists, the three most common ones being the 'legality' principle, 'maximize onset' principle, and the 'sonority sequencing' principle. In this paper we will attempt to show that all -VNCV- clusters do not behave alike and that phonetic factors such as the voicing of the following stop and the duration of the nasal also have to be taken into account. Thus, along with phonological factors, micro-phonetic factors also play a role in syllabification.

Keywords: phonetics, syllabification, Hindi, nasal and stop duration

1. INTRODUCTION

Syllabification is said to serve various functions such as differentiating certain minimal pairs, such as the well-known English set, *nitrate* and *nightrate* and to determine certain allophonic variation such as the presence or absence of aspiration on the medial /t/ in the same example. Phonologists have proposed a variety of principles that are claimed to cover those and virtually all cases of syllabification. In this paper we provide experimental evidence from Hindi demonstrating that syllabification of medial homorganic nasal plus stop clusters, -NC-, is not only influenced by phonological factors such as the 'legality principle', 'maximize onsets', and the sonority hierarchy (Pulgram [7], Clements and Keyser [2], Clements [1]) but also by micro-phonetic details such as the duration of the nasal, its place of articulation, and the duration of the following stop which in turn depends on whether it is voiced or voiceless.

2. BACKGROUND

2.1. Hindi nasals

First some details about such nasals in Hindi need to be given: At the phonetic level Hindi has nasals at the bilabial, dental/alveolar, retroflex, palatal, and velar places of articulation, and all of these form clusters with homorganic stops, (or in the case of the palatal nasal, the following obstruent is the palatal affricate). However, based on the usual criteria for phonemic analysis, only the bilabial and dental/alveolar nasals are considered phonemes. A few linguists such as Kelkar [4] and Dixit [3] have posited the velar nasal to be a phoneme based on a few Sanskrit loans such as [vaŋməj] 'literature'. With regards to syllabification, Kelkar [4] posits VN.CV for all homorganic nasal plus stop clusters (where the period denotes the syllable boundary). Although such a break would obey the 'maximize onset' principle, it would violate the 'legality' principle in the case of the retroflex, palatal, and velar nasal in the -VNCV- clusters: it violates the phonotactic constraints of Hindi since these three nasals do not form legal codas.

2.2. A psycho-phonological study

In an attempt to access the mental reality of syllabification of medial -NC- (homorganic nasal plus stop) clusters for native speakers of Hindi, Ohala [5] reported on an experiment conducted using a word game.[1]

2.2.1. Method

Subjects were told that a new game for children was being devised in which the vowel [ɪ] would be inserted in the middle of a word. They were given two examples which involved inserting the vowel before a single intervocalic consonant, e.g., [ʧʰʊpa] 'hidden' → [ʧʰʊɪpa] and for intervocalic clusters, inserting the vowel between the CC, e.g., [bəsṯa] 'knapsack' → [bəsiṯa]. The training session then continued where they were to apply these processes to 45 word, which included 22 words with intervocalic single consonants (such as [bəḍam] 'almond') and 23 with a variety of intervocalic two-consonant clusters (e.g., [sɪski] 'sob', [ʧaplus] 'flatterer', [ʧəkla] 'round platter for rolling dough') but none of which contained -NC-

clusters, the ultimate focus of the experiment. For their responses to these 45 words they were given feedback of "correct" or "incorrect" and if incorrect, the correct answer was provided. Thirteen correct answers in a row was set as the criterion that they had learned the insertion rule but all 45 training words were presented even if the subjects had already reached this criterion (so that all subjects would have equal chance at hearing all the words and the correct answer to any incorrect responses.) At the end of the training session the test session started during which no feedback was given. Subjects were not told when the training session ended and the test session started. The test session contained 25 items, 15 with -NC- clusters and 10 control items (i.e., words similar to the training session): 4 with intervocalic single consonants and 6 with clusters not consisting of -NC-. These words also acted as a control to make sure the subjects had indeed learned the word game. The NC clusters included the bilabial, dental/alveolar, retroflex, palatal and velar, nasals followed by homorganic stops (both voiced and voiceless).

2.2.2. A summary of the results

In the case of the bilabial and dental/alveolar nasal plus homorganic stop clusters, the results showed that a VN-CV break is justified. The majority of the subjects did break the cluster after the nasal. As mentioned above the bilabial and the dental/alveolar are the only two nasals that occur freely, i.e., are unarguably phonemic. The responses to the other NC clusters were more complex. In the case of the velar nasal the overwhelming response was to keep the nasal plus stop cluster intact. Thus a VN-CV syllabification would not be justified. For the retroflex and palatal places of articulation, there was no clear preference between keeping the NC intact vs. breaking the cluster but in the latter case changing the place of the nasal to dental/alveolar, presumably due to pronunciation constraints since these nasals **only** occur before homorganic consonants. However, there was a clear preference **not** to break up the cluster while retaining the original place of articulation of the nasal. Interestingly, her results also showed that the voicing of the following stop seemed to play a role in subjects' responses. Subjects made a clear choice **not** to break up the cluster in the case of N plus voiced stop. Thus, we see that -NC- clusters do not all behave alike.

3. THE PRESENT STUDY

Given the results of Ohala [5], the present study addressed the following two questions: (a) why did the voicing of the following stop play a role in subjects' syllabification responses? Could this be because the duration of the nasal is different before voiceless stops than before voiced ones? If the duration of the nasal is long in comparison to that of the following voiced stop, it may account for the preference not to break the cluster (i.e., the percept of a 'cluster' might be very weak). (b) Why did the velar nasal not pattern similar to the retroflex and palatal nasals? In other words, why did subjects not syllabify between the -NC- and change the place of articulation of the velar nasal to dental/alveolar (in order to conform to the phonotactic constraints) as they did in the case of the retroflex and palatal nasal plus stop clusters? Could it be that the voiced velar nasal is rather long and the voiced velar stop after it too brief to give the percept of a cluster?

3.1. Duration of nasals and voiced and voiceless stops in homorganic nasal plus stop clusters

3.1.1. Method

To study this, a randomized list of 28 words were spoken by four native speakers of Hindi (one male and 3 female) and digitally recorded and analyzed using the software Praat. There were 3 words for each of the 5 nasal types except for the retroflex nasal, for which there were only two words. The words were said in the frame [vo___kəho] 'say that ___'.

3.1.2. Analysis

Amplitude changes in the wave form, amplitude changes in the spectrum (i.e., spectral discontinuities), pitch changes, were all used as landmarks for the onset and offset of the nasal. We also listened to the segments. The burst of the stops was not included in measuring the duration of the stop. A two-way ANOVA was conducted separately for the nasal duration and the stop duration, 5 places of articulation by two voicing conditions.

3.1.3. Results

There was considerable variation in the values measured, no doubt due to the different speaking styles of the four subjects, nevertheless, the ANOVA conducted on the nasal duration showed a significant effect due to the voicing of the following stop (F-ratio = 21.5, $p < .00001$). A boxplot of the distributions is given in Fig. 1.

Figure 1: Boxplot of the distributions of the duration of the nasal consonant before voiced stops (left) and voiceless stops (right). Vertical axis here and in the other figures gives fractions of a second.

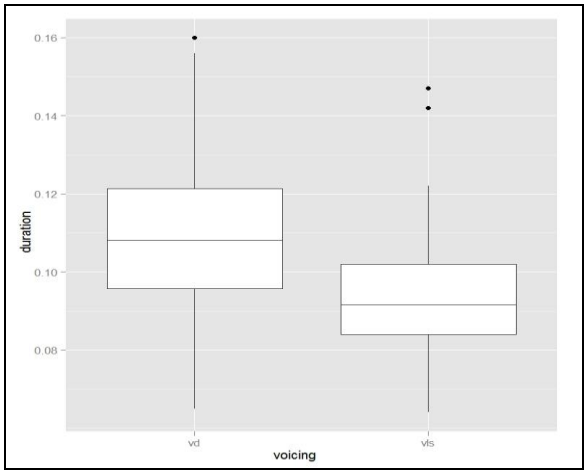
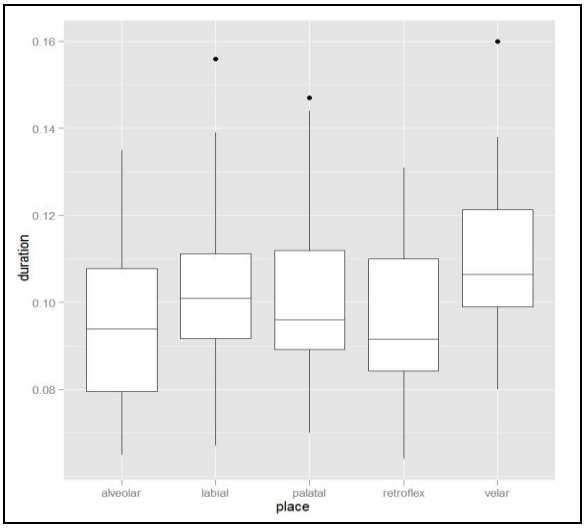


Figure 2: Boxplot of the distributions of the duration of the nasal consonant as a function of place.



For the distributions of the duration of the nasal as a function of its place the same ANOVA gave an F-ratio of 2.35, $p < .0597$. Although this value does not achieve the conventional level of statistical significance, we conclude that there may be an effect of place that needs further investigation. Interestingly, it was the velar nasal whose duration was markedly longer than that of the nasals at other places. A boxplot of the distributions is given in Fig. 2.

As for the duration of the stop, the ANOVA showed a highly significant effect due to voicing (F-ratio = 144.8135, $p < .000$) and a significant effect due to place (F-ratio =9.7551, $p < .000$). In the latter case it was the palatal stop (which is actually the closure part of the palatal/palato-alveolar affricate) that was markedly shorter than the stops at the other places. Boxplots of the relevant distributions are given in Figs. 3 and 4.

Figure 3: Boxplot of the distribution of the duration of the stops: voiced (left) and voiceless (right).

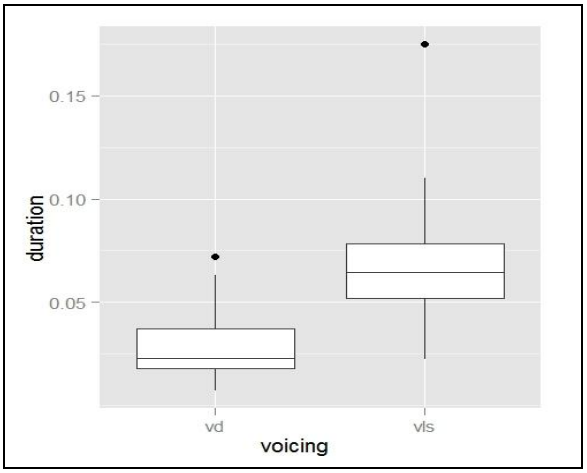
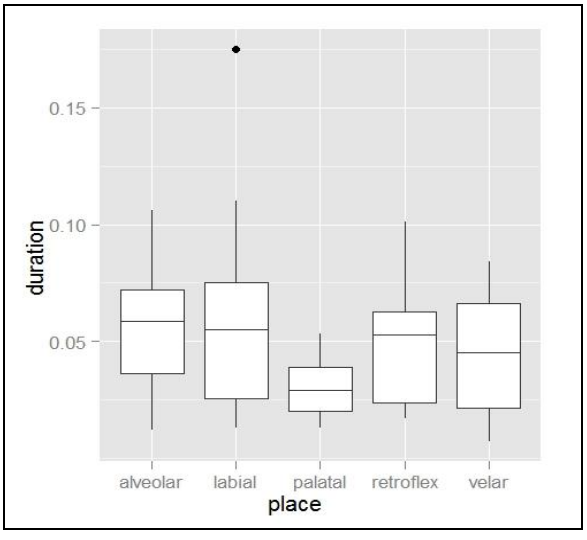


Figure 4: Boxplot of the distributions of the stops as a function of its place of articulation.



4. CONCLUSION

We see from the above that nasals are longer before voiced stops than before voiceless stops. We also see that after nasals voiceless stops are longer than voiced ones. The hypothesis that the

shortness of the voiced stops influenced subjects' responses in Ohala's [5] phonological experiment has support. As for the hypothesis that the velar nasal in particular might be longer than the nasals at other places, our results suggest that this may be case but requires further data to be conclusive and to clarify whether it is production or perception factors which predominate in determining speakers' responses.

In sum, there is enough evidence to support the hypothesis that at least some micro-phonetic effects influences syllabification.

5. ACKNOWLEDGEMENTS

We thank two anonymous reviewers for their helpful comments.

6. REFERENCES

[1] Clements, G.N. 1990. The role of the sonority cycle in core syllabification. In Kingston, J., Beckman, M.E. (eds.), *Papers in Laboratory Phonology I: between Grammar and Physics of Speech*. Cambridge: Cambridge University Press, 283-333.

[2] Clements, G.N., Keyser, S.J. 1983. *CV Phonology: A Generative Theory of the Syllable*. Cambridge Mass.: MIT Press.

[3] Dixit, R.P. 1963. *The Segmental Phonemes of Contemporary Hindi*. Master's Thesis, Austin: University of Texas.

[4] Kelkar, A.R. 1968. *Studies in Hindi-Urdu I: Introduction and Word Phonology*. Building Centenary and Silver Jubilee Series, 35. Poona: Deccan College.

[5] Ohala, M. 2006. Experiments on Hindi syllabification. In Wiebe, G.E., Libben, G., Priestly, T., Smyth, R., Wang, H.S. (eds.), *Phonology, Morphology, and the Empirical Imperative: Papers in Honour of Bruce L. Derwing*. Taipei: Crane Publishing Co., Ltd, 115-156.

[6] Pierrehumbert, J., Nair, R. 1995. Word games and syllable structure. *Language and Speech* 38, 77-114.

[7] Pulgram, E. 1970. *Syllable, Nexus, Cursus, Word*. The Hague: Mouton.

[1] For a review of the use of word games in phonological research, see Pierrehumbert and Nair [6].