HINDI SYLLABIFICATION

Manjari Ohala
San José State University
San José, California

ABSTRACT

Results are presented from an experiment conducted to see how native speakers of Hindi syllabify various intervocalic consonant clusters. Twenty-one native speakers of Hindi were asked to repeat the "first part" or the "last part" of a word twice for 19 selected test words. The results showed a preference for VC-CV syllabification for two-consonant clusters and a VC-CCV preference for three-consonant clusters. The sonority value of segments did not play a role and the 'onset-first' principle was only partially supported. The VC-CCV syllabification preference for three-consonant clusters for all cases would not have been predicted by recent proposals of Optimality Theory. The results also lend support to the notion that mental grammars of adults are partially shaped by literacy.

1. INTRODUCTION.

I report on how native speakers syllabify various intervocalic two- and three-consonant clusters in Hindi. (Results for intervocalic single consonants are reported in [6].) The results shed light not only the (psychological) sound pattern of Hindi but also on aspects of recent "universal" theories of syllabification. Is syllabification sensitive to the sonority value of segments and does it follow the 'onset first' principle which states that other things being equal, choose onsets of following syllables over codas of preceding ones [2]? Is it in accord with the syllabification proposals of Optimality Theory [1, 10]? Finally, the results have relevance to the issue of the influence of literacy on phonological awareness [3, 5].

1.1 The Hindi Syllable

As documented by Ohala [6] native Hindi monosyllabic words permit up to two consonants initially with C1 consisting of a stop, nasal, or fricative and C2 a glide. In final position they permit two-consonant clusters of either a fricative followed by a stop or a nasal followed by a homorganic stop or fricative. Loan words (many of them in common use) also permit initial and final three-consonant clusters and permit many more consonant types to participate in such clusters.

2. METHODOLOGY.

The experimental method was that of Fallows [4] where subjects were asked to repeat a word given by the experimenter, saying the first (or last) part of the word twice (see below).

Subjects: Twenty-one 30-60 year-old literate native speakers of Standard Hindi residing in Delhi, India, were interviewed individually. Although earlier experiments [8] showed the desirability of using illiterate or preliterate subjects in order to control for orthographic influence on subjects' responses, this proved to be impractical since the majority of them could not grasp the concept of "last part of the word". The concept of segmenting monomorphemic but polysyllabic words into parts appears to be a literacy-induced skill [3, 5].

Stimuli: Twenty test words were used (see Appendix), all of which are common existing words exhibiting intervocalic consonant clusters. (The appendix only lists 19 words because one of the intervocalic three-consonant cluster words was mispronounced by a number of subjects and thus was excluded from further analysis.) Of the words with two-consonant clusters, 4 contained geminates, 4 homorganic nasal + stop clusters and the remaining 8 involved different consonant types (stop + fricative, fricative + stop, stop/fricative + sonorant) representing different sonority contours. Four words with intervocalic three-consonant clusters were also included (but, as just mentioned, only three analyzed). Unless otherwise noted, the words were all monomorphemic. Stress is not a variable in syllabification in Hindi. Also, the existence of word stress in Hindi is disputed [7].

Procedure: The experiment was divided into two parts. First the subjects were asked to repeat the first part of the given word twice. "Part" was not defined for the subjects but exemplified by using a compound word such as [ɡaj ɡʱər] 'cow+house, cowshed' (from [ɡaj] 'cow' + [ɡʱər] 'house'. They were instructed to transform this to [ɡaj ɡaj ɡʱər]. Then they were asked to perform another task not related to the present study. Subsequently they were asked to repeat the last part of the word twice, e.g., [ɡaj ɡʱər ɡʱər]. Of course in the actual test the stimuli were not compounds but rather monomorphemic words (with a few exceptions to be discussed below). The term 'syllable' was never used.

3. RESULTS AND DISCUSSION.

If some segment was not included either in repeating the first part of the word or in repeating the last part of the word, i.e., it was not parsed with either syllable, it was counted as a deletion and not included in computing the results. The responses were tabulated then as to whether the intervocalic consonants were assigned to the first or the second syllable. If a consonant was included with the first part of the word and also with the second, it was considered to be ambisyllabic. Responses that did not fall into any of these types were disregarded. In general the sonority value of segments did not play a role in subjects' responses and will therefore only be mentioned where it was relevant.

3.1. Intervocalic two-consonant clusters.

For all but one of the two-consonant words the candidate syllabifications, VC-CV, V-CCV, and VCC-V, all obeyed the phonotactic constraints. The exception was [t͡ʃaplus] where the VCC-V (i.e., -pl) does not occur in existing words (although -bl does). All the words were monomorphemic with the exception of [sɪski] 'sob' which is /sɪsək + i/ 'sob v. + nominalizing suffix'. The results indicate that the morphemic constituency of this word did not play a role in subjects' responses. Table 1 gives the results and the statistical analysis.

Table 1. Syllabification of [t͡ʃaplus]-type words.

VC-CV	V-CCV	VCC-V	Ambisyllabic
77	10	0	10

$\chi2 = 151.4$, df = 3, $p<<.001$

For the majority of such words (which I will refer to as [t͡ʃaplus]-type words) the overwhelming response was the VC-CV syllabification with a probability of .78. The VC-CV preference was exhibited regardless of whether the cluster exists as a possible onset and regardless of the onset first principle. For example [t͡ʃaplus] could have been syllabified [t͡ʃa - plus] since [pl-] occurs as an onset in existing words and would also have been dictated by the onset first principle. However only two out of 21 subjects chose this response.

There were some two-consonant cluster words where C2 was the glide [j] that did not follow the above VC-CV response pattern. I refer to these as [ʋidja]-type words. Unlike the [t͡ʃaplus]-type words they had a rather low ratio of VC-CV responses: .08, as shown in Table 2.

The results given in Table 2 are based on two words with the [j] glide (#7 and 8 of the Appendix).

Table 2. Syllabification of the [ʋɪdja]-type words.

VC-CV	V-CCV	VCC-V	Ambisyllabic
23	3	1	7

$\chi2 = 31.9$, df = 3, $p <<.001$

What might explain this behavior? One possibility is that there is something special about [j] in C2 position. At the present time I have no insights to offer on this. The results from some earlier experiments [8] rule out the possibility that glides in general are special. That experiment involved both [ʋ] and [j] and the glide [ʋ] followed the same VC-CV preference as the words in Table 2. Thus it is only clusters with [j] that show the V-CCV preference.

The second possibility for the low number of VC-CV responses to the [ʋɪdja]-type words could be orthographic influence. In the Devanagari writing system the sequences pronounced as medial clusters in the [t͡ʃaplus]-type words can be represented in two ways. In the first way, the first consonant in such clusters can be represented with a full symbol which stands for a consonant followed by a schwa (i.e. Cə) since Devanagari is a quasi-syllabary. This schwa would not be pronounced because the spelling-to-sound rules would delete it (thus yielding medial CC). In the second way the first consonant can be written with a half symbol attached to the next consonant thus overtly marking a cluster. Dictionaries list which of these two alternatives is prescribed. One does, however, find some variation in native speakers' writings since the average Hindi speaker has the same type of insecurities regarding spelling as the average English speaker. Of the 6 such words used in the experiment (#1-6 in the Appendix) [səsta] is written using the second alternative, i.e., with the first consonant of the medial cluster written with a half symbol; [kɪsmət] can be written either way [11]; and the remaining 4 use the first alternative. For the words written using the first alternative, if orthography was an influencing factor, it would dictate against the V-CCV syllabification because the above mentioned schwa-deletion rule only applies morpheme medially, not initially. (Although the -CC is not really morpheme initial, making it syllable initial gives it initial status.) Thus it is possible to attribute to orthographic influence the paucity of V-CCV syllabification for these words (only 10 out of a possible 99; see Table 1). Similarly the total lack of VCC-V responses can also be attributed to orthographic influence. Orthographically the '-V' would have to be treated as if it were morpheme initial and thus meriting a full vowel symbol rather than the vowel-diacritics with which these words are written. Perhaps the strongest case for orthographic influence can be made on the basis of subjects' responses to [ʋɪdja] 'knowledge' and [aɡja] 'permission' which involve a very special symbol for the -dj- and -gj- clusters, i.e., one unique to these clusters. This could explain the rather few VC-CV syllabifications and the preponderance of V-CCV ones. However, the situation is not so simple. Subjects' responses for [səsta] go against orthography which would predict V-CCV syllabification since the word is written using the second alternative and st- is a legal onset; only 4 subjects chose this whereas the near unanimous response was VC-CV. Of course one could control for orthographic influence by using illiterate subjects but, as mentioned earlier, this did not prove feasible.

3.2 Intervocalic homorganic nasal plus stop clusters.

Is the syllabification for such cluster VC-CV, V-CCV, or VCC-V?

At the phonetic level Hindi has the following nasals [m], [n], [ɳ], [ɲ], [ŋ]. Based on the usual procedures of contrast and complementary distribution /m/ and /n/ would be judged to be phonemes and, in fact, occur quite freely. The other nasals for the most part only occur before homorganic consonants. (The status of [ŋ] is somewhat controversial, see [6] for details.) The only time [ɳ], [ɲ], or [ŋ] occur independently is in reciting Devanagari, a quasi-syllabary, which, following the Sanskrit orthography, has separate symbols for all five nasals. Thus in recitation one would say [kə], [k^{h}ə], [ɡə], [ɡ^{ɦ}ə], [ŋə] and similarly for the other places of articulation. Four words with the dental, bilabial, velar, and retroflex homorganic nasal plus stop clusters were included in the experiment (#9-12 in the Appendix). These words could be analyzed as monomorphemic or bimorphemic with a morpheme boundary before the final vowel. However even if they were treated as bimorphemic, it did not influence the responses; only 7 responses (out of 60) were VCC-V (syllabification predicted by a VCC + V morphemic analysis). Table 3 presents the results.

Table 3. Syllabification of N + stop words

VC-CV	V-CCV	VCC-V	Ambisyllabic
42	4	7	7

$\chi2 = 61.67$, df = 3, $p< .001$

Thus the majority of responses again favor the VC-CV syllabification with a probability of .70. Phonotactic and/or pronunciation constraints of Hindi would rule out the V-CCV alternative since homorganic nasal plus stop clusters do not occur (and are difficult for subjects to pronounce) morpheme/syllable initially. Therefore the VC-CV syllabification is in accord with the onset first principle. In pronouncing the homorganic nasals as syllable final and thus separated from the following stop, [ɳ] was pronounced as [n] (and thus this syllabification does not violate phonotactic constraints) but [ŋ] was retained as [ŋ]. Perhaps [ŋ] should be treated as a special type of segment as proposed in [6] . On the other hand, the fact that in giving a VC-CV response subjects had to modify the pronunciation of part of a word, e.g. [ɳ] to [n], is a weakness of the experimental paradigm. None of the syllabifications would be in accord with the orthographic conventions. VC-CV, and V-CCV are bad for the representation of the homorganic nasal and VCC-V is bad for the representation of the '-V'. Thus here orthographic influence is not an issue.

3.3. Intervocalic geminates.

Is the syllabification VC-CV, V-C:V, or VC:-V?

As mentioned earlier, four monomorphemic words with intervocalic long consonants, usually called "geminates" were included in the experiment (#13-16 in the Appendix). Phonetically, geminates involve the closure held for a longer period vis-à-vis their non-geminate counterparts, the ratio of the geminate duration to non-geminate being 1.96:1 [9]. Thus phonetically they are not really two separate consonants as the term "geminate" would imply. The Devanagari orthography does however represent them as two consonants (using a half symbol for the first consonant and thus overtly marking a cluster). Subjects' treatment of these words is presented in Table 4. Of the 32 responses that could have been classified as deletion only one was a clear case (since there was no intervocalic consonant) with the rest being ambiguous as to deletion or treating the geminate as a single unit. In other words, the V-CV responses could either be interpreted as deletion of the first consonant of the geminate (if it is conceived of as two, as implied by the orthography) or as an indication that the subjects were treating geminates as single consonants (i.e., as V-C:V) but were having to make them conform to pronunciation constraints by using their singleton counterparts since geminates cannot be pronounced in initial position. For example, responses such as [gə-da] or [gəd-a] 'mattress' could be considered deletion or as intended/psychological //gə-d:a// or //gəd:-a// with the medial stop modified to a non-geminate to conform to pronunciation constraints. Given this ambiguity no statistical test was applied.

Table 5. Syllabification of geminates.

VC-CV	V-CCV	VCC-V	Del	Ambiguous
46	3	0	1	31

Since geminates neither start nor end morphemes, the V-C:V syllabification as well as VC:-V would violate the phonotactic constraints of Hindi. None of the subjects chose the latter and only three chose the former.

For words involving geminates orthography has to be ruled out as an influencing factor since it would have favored the VC:-V response which none of the subjects chose. Thus the jury is still out on whether geminates are represented in the native speaker's mental grammar as two consonants or singletons.

Current phonological theory treats geminates as occupying two units on the timing tier similar to consonant clusters but on the melodic tier they are represented as singletons similar to single consonants. Thus presumably either representation is possible in a mental grammar. If it were the case that some subjects consistently treated them as clusters and others as units, one could say that this represents different mental grammars. However, if the same subject varied giving cluster responses to some words and singleton to others, as was the case for many subjects in the present experiment, the above mentioned two-tiered approach to geminates is not supported as being psychologically real for native speakers of Hindi. Also, if indeed the mental representation of geminates has these two faces one might have predicted that subjects would give ambisyllabic responses. However, as mentioned above, this is not what the subjects chose.

3.4. Intervocalic three-consonant clusters.

Are intervocalic three-consonant clusters syllabified as VC-CCV, VCC-CV, V-CCCV, or VCCC-V?

Table 5 presents the results for three such words (items #17-19 in the Appendix). With the exception of [bɪstra] 'bedding' (which could be analyzed as bimorphemic) all the words were monomorphemic.

Table 5. Syllabification of 3-cons clusters

VC-CCV	VCC-CV	V-CCCV	VCCC-V	Ambisyllabic
33	4	4	0	8

$\chi 2$ = 14.06, df = 4, p<< .001.

The majority of subjects chose the VC-CCV syllabification (.67) This syllabification is in conformity with the sonority hierarchy, phonotactic constraints (the -CC in all these words is a permissible onset), and for all the words except [bɪstra] 'bedding' it also conforms to the onset first principle. In the case of [bɪstra], str- is a possible onset (at least in loan words) and thus V-CCCV would have been predicted by the onset first principle, although it would not be a desirable onset according to Clements [2] since st- does not progressively increase in sonority. This preference for VC-CCV syllabification is similar to the VC-CV syllabification preference shown for two consonant clusters given above in section 3.1 in that it yields a closed first syllable.

As for the other syllabification possibilities, the VCCC-V syllabification would be ruled out by the phonotactic constraints as would V-CCCV for all the words except [bɪstra] since, as mentioned above, [str-] is a possible onset. None of the subjects chose the former and there were only 4 responses to the latter type, and none of these were for [bɪstra]. Finally, although the VCC-CV syllabification does not violate any phonotactic constraints and conforms to the sonority contour, it does not obey onset first principle since [tr-, dr-, sn-] are all possible onsets. This syllabification received only 4 responses. However, one cannot invoke the onset first principle to account for the lack of such responses here because as was mentioned earlier in 3.1 this principle did not play any role in subjects' responses to two-consonant clusters. Orthographic influence was not at play here. For [d͡ʒjotsna] 'moonlight') none of the syllabifications would be in accord with the orthographic conventions. For the other two words orthographic convention would have dictated the VCC-CV alternative which only four subjects chose.

Finally, it might be of interest to see how subjects' responses obtained in this experimental study would be accounted for by current formulations of Optimality Theory [1, 10]. For the VC-CV syllabification preference demonstrated by the subjects one could say that in Hindi *COMPLEX, (consonant clusters are not preferred at syllable edges) is ranked higher than NO CODA, (syllables should end with vowels), thus leading to the preference of VC-CV over V-CCV. But the V-CCV preference for the word [ʋɪdja] discussed in section 3.1 would remain problematic. In the case of three-consonant clusters, regardless of what syllabification one posits, the *COMPLEX constraint would be violated since there would have to be a cluster at the edge of the syllable. For a word such as [bɪstra] one might have predicted the preferred syllabification to be [bɪ-stra] since at least the NO CODA constraint would not be violated, since [str-] is a legal onset. Instead the subjects preferred [bɪs-tra]. However, if three-consonant clusters are considered to violate the *COMPLEX constraint more drastically (i.e. if they merit two **) then of course the form [bɪ-stra] would not be favored. That still leaves [bɪst-ra] and [bɪs-tra] as contenders. Both violate the NO CODA constraint and both would equally violate the *COMPLEX constraint. Nor can the sonority hierarchy help since [tr-] exhibits the appropriate increasing sonority for an onset and [-st] the appropriate decreasing sonority. Venneman's [12] syllable "contact law" holds that syllable breaks favor decreasing sonority and thus would select the desired [bɪs-tra] over [bɪst-ra] but it would incorrectly select V-CCV syllabifications for a number of the words with two-consonant clusters discussed in section 3.1. Thus it too cannot be invoked here.

4. CONCLUSION.

The results show a VC-CV preference for intervocalic two-consonant clusters including homorganic nasal + stop clusters. Thus the onset first principle is only partially supported (since for two-consonant clusters the subjects did not choose V-CCV). The results do not provide definitive answers for the syllabification of geminates or homorganic-nasal-plus-stop clusters (in spite of the higher VC-CV responses for the latter) because the experimental paradigm used runs into the problem of pronounceability of syllable-initial NCV and C:V. Thus the lower incidence of such syllabification could be an indication of pronunciation constraints rather than representation in the mental grammar. Although in examining subjects' responses, orthographic influence could be ruled out in some of the cases, in others it is still a factor to contend with. Perhaps one needs to accept the possibility that the mental grammar of a literate adult is partly shaped by literacy. Moreover, if indeed word segmentation is a literacy dependent skill, then syllabification could not be universal, i.e. innate. Finally, additional experimental paradigms more suitable for preliterate or illiterate subjects need to be developed.

ACKNOWLEDGMENTS

Research supported by the San José State University College of Humanities and the Arts Dean's Small Grant. Thanks to John Ohala, Maria-Josep Solé, William Cowan, Laura Downing, and Thomas Berg for their comments, to my subjects in India for their cooperation, and Promila Puri of Lady Sri Ram College for her help in obtaining subjects.

APPENDIX: Test Words

1. [t͡ʃəkla] 'dough-rolling platter'	11. [pəŋkʰa] 'fan (n.)'
2. [t͡ʃaplus] 'flatterer	12. [ɖəɳɖa] 'stick (n.)'
3. [səsta] 'cheap'	13. [gəd:a] 'mattress'
4. [kɪsmət] 'fate'	14. [rəs:i] 'rope'
5. [sɪski] 'sob (n.)'	15. [pət:a] 'leaf'
6. [ʈokri] 'basket'	16. [gən:a] 'sugarcane'
7. [ʋɪdja] 'knowledge'	17. [bɪstra] 'bedding'
8. [agja] 'permission'	18. [səntra] 'orange'
9. [gənda] 'dirty'	19. [d͡ʒjotsna] 'moonlight, proper name'
10. [ləmba] 'tall'	

REFERENCES

[1] Archangeli D. & Langendoen T. (Eds.). 1997. *Optimality Theory: an overview.* Oxford: Blackwell.

[2] Clements, G. N. 1990. The role of the sonority cycle in core syllabification. In J. Kingston & M. E. Beckman (Eds.), *Papers in laboratory phonology I: between grammar and physics of speech* (283-333). Cambridge: Cambridge University Press.

[3] Derwing, B. L. 1992. Orthographic aspects of linguistic competence. In P. Downing, S. D. Lima, & M. Noonan (Eds.), *The linguistics of literacy* (pp. 193-210). Amsterdam: John Benjamins.

[4] Fallows, D. 1981. Experimental evidence for English syllabification and syllable structure. *Linguistics*, 17, 179-392.

[5] Goswami U. & Bryant, P. 1990. *Phonological skills and learning to read.* Hillsdale: Lawrence Erlbaum Associates.

[6] Ohala, M. 1983. *Aspects of Hindi Phonology*. Delhi: Motilal Banarsidass.

[7] Ohala, M. 1991. Phonological areal features of some Indo-Aryan languages. *Language Sciences,* 13, 107-124.

[8] Ohala, M. In press. The syllable in Hindi. In H. Van der Hulst & N. Ritter (Eds.), *The syllable.* Mouton-De-Gruyter.

[9] Ohala, M. & Ohala, J. J. 1992. Phonetic universals and Hindi segment duration. *2nd ICSLP, Banff.* 831-834..

[10] Prince, A. S. & Smolensky, P. 1993. *Optimality Theory: constraint interaction in generative grammar.* RUCCS Tech. Rep. #2..

[11] Varma, R. C. (Ed.) 1958. *Sankshipt Hindi Shabdasagar.* Varanasi: Nagaripracarini Sabha.

[12] Venneman, T. 1988. *Preference laws for syllable structure and the explanation of sound change.* Berlin: Mouton de Gruyter.