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The Glottal Fricative and Schwa Deletion in Hindi : Implications for Speech Synthesis

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ABSTRACT

Hindi is known to have a general process of schwa deletion, whereby unstressed schwas in open syllables are dropped when preceded by stressed syllables, as in /ʧa:həte:/ >[ʧa:hte:] 'like- OBL', /kəhəna:/ >[kɛɦna:] 'say- INF', but not in /ʃəhər/ [ˈʃəhər] 'city' (closed syllable), and /bəhəttər/ > [bəˈhəttər] 'seventy-two' (stressed). It has been found by the present authors that although the schwa following a /h/ may be 'heard' to be deleted, in speech synthesis based on trained data, the deletion of the schwa leads to problems. Along with the schwa, /h/ too gets dropped. The acoustic features of /h/ in relation to the presence of flanking vowels and a following consonant after the deletion of the following schwa need examining. In the present study a total number of 22 words including content words (nouns, verbs, adjectives) and grammatical words (pronouns, auxiliary verbs) were recorded in the speech of 8 speakers- four female and 4 male. Thus, the total number of tokens analyzed for the data were 22x8 =176. An attempt is made in the paper to account for the merger of /h/ with schwa in intervocalic unstressed contexts. It is shown that speech synthesis programmes must treat these contexts of schwa deletion as exceptions.

Keywords : Schwa Deletion, Fricative, Approximant, Stress, Merger

I. INTRODUCTION

Although /h/ in Hindi has been treated as a 'voiceless glottal fricative' [1], in the present investigation, it has been found to have two variants- a voiceless aspirated fricative [h] and a voiced approximant [ɦ]. The data taken for analysis include both the western and the eastern varieties of Hindi. The method of data collection and analysis are discussed below.

II. DATA COLLECTION

The data were collected through digital recording in a sound proof recording studio using Edirole-07 high quality digital recorder with a sampling frequency of 44 KHz 16 bit wave form. In all 8 subjects were selected, 4 from the western and 4 from the eastern varieties. Of the 4 from each variety, 2 were male and 2 female. They all belonged to the age group 22-25 and were students at Jawaharlal Nehru University, New Delhi.

A. The Data

The data consisted of a total of 22 words, selected on the basis of the occurrence of /h/ in the following contexts: (i) word-initial position, (ii) word-medial onset position in a stressed syllable, (iii) word-medial onset position in unstressed syllables, (iv) before schwa deletion in unstressed syllables, and (v) word-final position. In all, 22 words were selected for recording from 8 speakers. The total number of tokens for analysis was thus 176.

III. DATA ANALYSIS

/h/ has two different realizations in the data- as a voiceless glottal fricative [h] and as a voiced glottal approximant [ɦ], as pointed out above. Whereas all the fricative realizations yield a segmentable /h/, the approximant realizations are two- one segmentable in relation to the flanking vowels, and the other merged with the flanking vowel and thus non-segmentable.

There is one context in which we get a variable result- an intervocalic stressed /h/, as shown in (3) below.
The contexts in which the fricative [h] always occurs is the following:
(1) (i) Word-initially, e.g. /ha:thi:/ ‘elephant’.

The contexts in which the approximant [ɦ] occurs are the following:
(2)

(i) Intervocalic unstressed,
(a) before a vowel other than the schwa /ə/, e.g. /bəhut/ [bəɦöt] ‘a lot, very’, /məhila:/ [ˈməɦïla:] ‘lady’
(b) before /ə/, e.g. /ʃəhər/ [ˈʃəɦər] ~ [ˈʃɛ̈ɦɛ̈r] ‘city’
(ii) before a consonant following deleted schwa, e.g. /pəhəle:/ [pɛ̈ɦle:]‘before, earlier’
(iii) Word-finally, e.g. /kəh/ [kəɦ] or [kɛ̈ɦ] ‘say-IMP’
In one context, in the present data, we get both the fricative [h] and the approximant [ɦ]. It is the following:

(3)
(i) Stressed /h/ intervocalic position, e.g. /suha:na:/ [suˈha:na] ~ [süˈɦä:na] ‘pleasant’. These variable realizations are speaker-specific, although more commonly found in the eastern varieties.

Of the various contexts listed in (2) for the realization of an approximant [ɦ], in (2i) alone the approximant is segmentable. In all other contexts it is merged with the following vowel. As a consequence, when an attempt is made to delete the following vowel, [ɦ] is also deleted along with it. The process that we assume to be at work here is that the vowel features in the form of the formants of the following vowel are merged with the aspiration feature of [ɦ]. The rationale for this assumption is the view taken by [2] and supported by [3], who argue that [h] and [ɦ] are not voiceless and voiced fricatives but voiceless and voiced approximants, respectively. They are without place features and take the formants of the neighbouring vowels as features of their approximant quality. Reference [4] goes so far as to say that /h/ and [ɦ] should be labeled as glottal approximants in the International Phonetic Alphabet. Reference [5] insists that the term fricative should continue to be used for the sounds in the IPA for phonological and practical reasons rather than strictly phonetic, as in many languages these consonants function as syllable margins.

It is quite reasonable to assume that the auditory perception of deleted schwa following unstressed /h/ in Hindi is because of the vowel features being merged with the voiced [ɦ]. The latter is indeed an approximant. And not a fricative as is evident from Fig. 2, Fig. 3 and Fig. 4 below. In fact the schwa is not really deleted in this context, as assumed, following a general rule of schwa deletion (e.g. [6], [7), but merged with the approximant. The approximant [ɦ] and the schwa [ə] are thus indivisible. A speech synthesis programme based on the rule of schwa deletion fails on these grounds.

As Fig. 1 and Fig. 2 show, /h/ in Hindi has both manifestations- as a fricative and as an approximant.

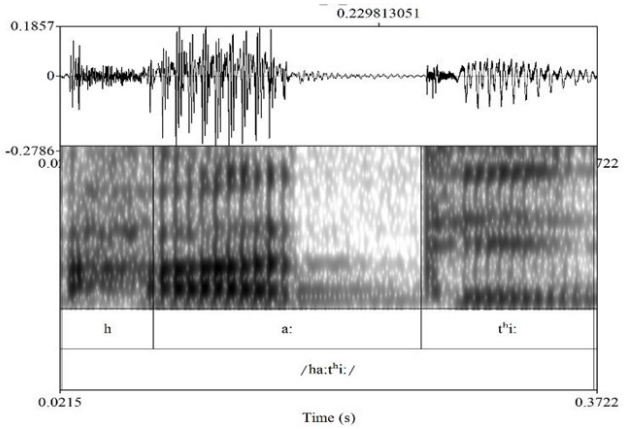

Figure 1: Oscillogram and spectrogram of word-initial /h/ in /ha:thi/

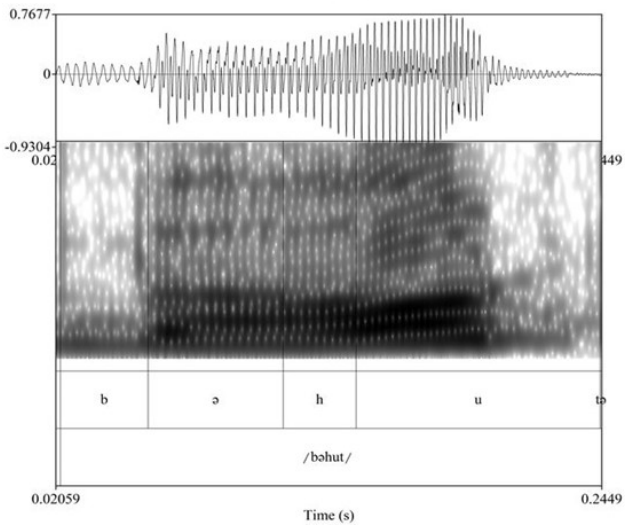

Figure 2: /bəhut/

We assume along with [5] that the notion of fricative cannot be entirely dropped from the description of /h/. With regard to the approximant realization, a crucial question that arises at this point is, if the glottal approximant takes the formant features of the flanking

consonants, is there preference for directionality in the assimilation? That is, is it the preceding or the following vowel or both whose features are copied onto the approximant? Alternatively, is the assimilation between /h/ to the flanking vowels is progressive or regressive or bidirectional? This issue is not addressed in [2] and [3].

On a close investigation of the data from Hindi in the present study, the generalization that emerges is that formant features of either of the vowels are assimilated by the glottal approximant. In order to find an answer to the question, the VhV sequence was sliced into three equal parts. For objective results, the medial 75% portion was selected, with the beginning and ending 12.5% of the sequence kept out for measurement. It was possible to do so in PRAAT, following the slicing devices available.

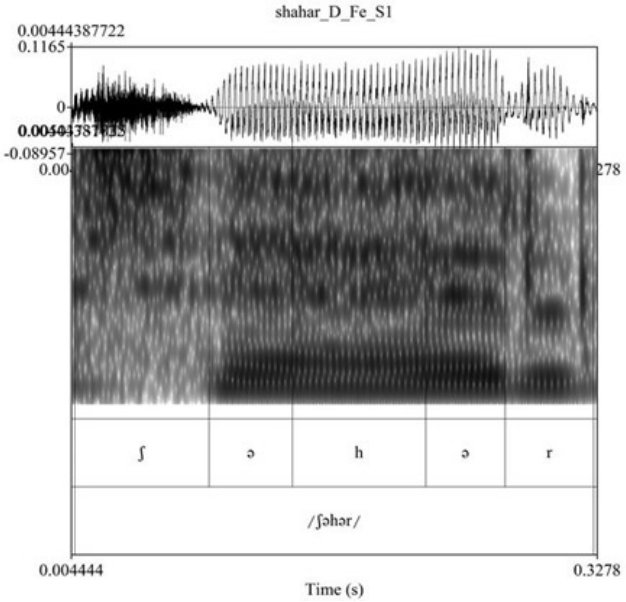

Figure 3: /ʃəhər

Fig. 2 and Fig. 3 present the formant values of the VhV sequence in two two types of words- one, in which the flanking vowels are non-identical, like [ə] and [u], as in /bəhut/ ‘a lot, very’ and other, in which the flanking vowels are identical, as in /ʃəhər/ ‘city’. In the present data the identical vowels are [ə].

It is interesting to note that in the case of words with schwa deletion, as in and /pəhəle:/ or [pɛ̈ɦɛ̈le:] or [pɛ̈ɦle:] ‘before, earlier’, the pattern is the same. In the case of these words, too, as in the case of words with clearly two vowels, the method of extracting the formants was the same. That is, the medial 75% portion was selected, with the beginning and ending 12.5% of the sequence kept out for measurement. The result can be seen in Fig. 4.

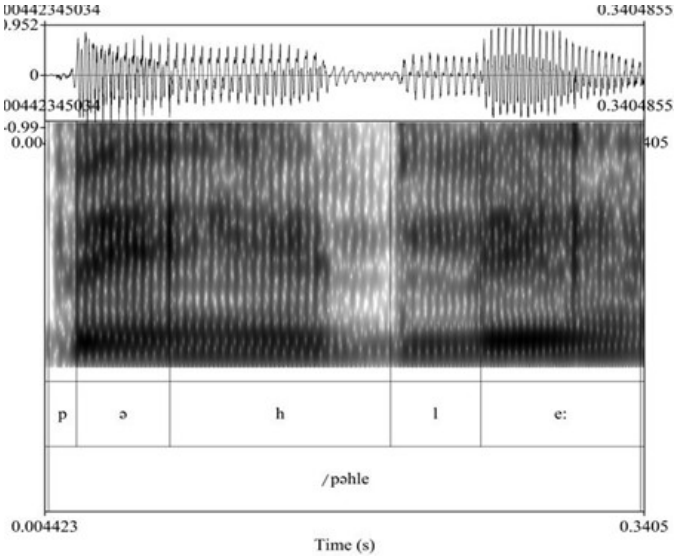

Figure 4 : Formants of VhV sequence in /pəhəle:/ [pɛ̈ɦle:]

Another interesting fact we observe is that we get a voiced glottal approximant [ɦ] irrespective of whether the following consonant (after schwa deletion) is voiced, as in /pəhəle:/ [pɛ̈ɦle:] ‘before, earlier’ or voiceless, as in /ʧa:həte:/ [ʧə̈:ɦte:/ ‘like- OBL’ and

Fig. 5 shows the approximant character of /h/ before a voiceless consonant following schwa deletion, that is in words of the type /ʧa:həte:/ [ʧə̈:ɦte:] ‘like- OBL’.

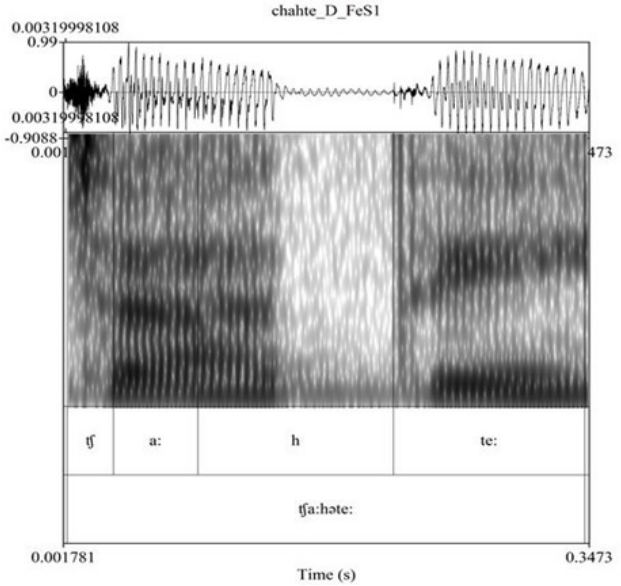

Figure 5 : formants of VhV sequence in /ʧa:həte:/ [ʧə̈:ɦte:]

IV. CONCLUSIONS

The main conclusions drawn from the present investigation affirm the realizations of 'h' in Hindi both as a glottal fricative and as a glottal approximant. The latter shows merger of the aspiration feature of /h/ with the flanking vowels, with /h/ being murmur vowel. The following schwa in this context is not deleted contrary to a general assumption. This finding has implications for speech synthesis in Hindi. Schwa deletion does not apply in this context.

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