

THE FEATURE [FLAT] IN CROSS-LANGUAGE PERCEPTION

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ABSTRACT

The legitimacy of [+/- flat] has been repeatedly discussed (Jakobson et al, 1969; McCawley, 1972; J. Ohala, 1985). One argument offered in justification consists of unified acoustic-perceptual correlates in spite of distinctive articulatory characteristics. Following an earlier suggestion and an empirical test, this paper examines the extent to which [+/- flat] of one language is heard as [+/- flat] in another language when the articulatory correlates in the two languages are different. Languages chosen were Arabic (pharyngealization) and Bengali (retroflexion); each language has a traditional orthography which indicates the [+/- flat] distinction. Speakers of the two languages listened to both Arabic and Bengali nonce words contrasting [+/- flat] consonants between vowels and transcribed these according to the orthography of their language. Subjects accurately perceived [+/- flat] in their own respective languages, but [+ flat] consonants of one language were rarely heard as [+ flat] in the other. Also, Bengali listeners often identified Arabic [-flat] as the corresponding Bengali [+flat] consonants. Thus, the unity of perceptual correlates for [+/- flat] appears to be questionable.

INTRODUCTION

Among the set of distinctive features proposed in Preliminaries [1], was the distinction flat versus plain: [+flat] segments manifested "a downward shift of a set of formants or even of all the formants in the spectrum," as compared to plain segments. The proposed feature [+flat] encompassed labialization, pharyngealization, and retroflexion, which were held to be similar in acoustic/auditory effect and never phonologically contrastive in the same language. The utility of the proposed feature has been challenged, both on formal [2], and substantive grounds [3]. McCawley argued against the feature as requiring as many descriptive and interpretive levels as taxonomic phonemics, while other authors noted that all three articulatory manifestations of [+ flat] are not in strict complementary distribution [4]. In Chomsky & Halle's feature set, [+/- flat] was discarded. J. Ohala [5], however, noted several reasons for the usefulness of the feature, including distributional similarities, effects on neighboring segments, and phenomena of borrowing and sound change.

Ferguson [6] proposed an empirical test of the perceptual unity of [+ flat] consonants, investigating the perceptual judgements of Arabic pharyngealized consonants and South Asian retroflex consonants, since speakers were readily available and the respective orthographies afforded representation for the hypothesized [+/- flat] distinction.

Feder [7] conducted a cross-linguistic perception test of [+/- flat] using Arabic and Hindi words and nine Arab listeners. Stimulus words were recorded by a number of native speakers of each language. In order to reduce the influence of Arabic vowels which co-vary with the [+/- flat] consonant distinction, all CV stimulus words were edited to include only a very short /i/ or /a/. Arab listeners usually responded correctly on Arabic words, but they rarely heard Hindi retroflex stops as [+ flat], although more such identifications occurred when the following vowel was /a/ (16%) than when the syllable contained a high vowel (2%). Feder concluded that a more refined cross-linguistic test of [+/- flat] was needed.

METHODS

The present experiment was designed to further test the perceptual unity of the feature [flat] with speakers and listeners from the same language areas tapped by Feder. However, there were several methodological differences.

First, rather than reducing influence of the vowels surrounding [+/- flat] consonants, we sought to include as much naturally-occurring information as possible. It has often been noted that the auditory effects of retroflexion are more striking on the vowel preceding [+ flat] consonants, while for pharyngealized consonants, although both preceding and following vowels may be affected, the more prominent auditory effects typically occur on the following vowel. In order to give listeners from both language groups equal opportunity to perceive these effects, the [+/- flat] contrast was placed in a medial position between two similar vowels in a CVV format. Duration of the adjacent vowels was not manipulated.

Second, we used only a single, male speaker of each language in recording the stimulus tape, but relied on a number of native speakers of each language as listeners (11 Bengalis and 13 Arabs), who transcribed recorded tokens in their entirety according to the conventions of their respective orthographies. By asking listeners to transcribe the whole "word", we hoped to obtain information about potential vowel effects of the [+/- flat] distinction, as well as data on consonant perception per se. Finally, in the present experiment, all stimulus items were nonce words in both languages. By excluding real words, we intended to avoid potential semantic effects and focus listeners' attention on the phonetic correlates of [+/- flat].

Items contrasting [+/- flat] consonants

consisted of three minimal pairs in each language (/kiṭi/-/kiti/, /niḍi/-/nidi/, and /ʃata/-/šata/) and one non-minimal pairing, because of real-world constraints, Arabic /naḍa/-/rada/ and Bengali /kada/-/rada/. The stimuli were created by digitizing and splicing the target "words" which were spoken in a frame sentence. Arabic tokens were recorded by a male speaker of the urban Palestinian dialect, while the Bengali speaker was a native of Calcutta, India. Each token was repeated tentimes, then randomized onto a stimulus tape containing items in both languages.

Spectrographic analysis of the stimuli showed that the acoustic correlates of [+ flat] were generally more pronounced in the Arabic than in the Bengali tokens. This was particularly true when Arabic [flat] consonants occurred between two high vowels. For example, Arabic /niḍi/ showed a steep rise in the second formant of both the first and second instances of /i/, a consequence of pharyngealization described by earlier acoustic analyses [8,9]. Bengali /niḍi/ differed from its plain counterpart less dramatically in the location of vowel formants, but manifested a rather salient difference in locus and amplitude of the release burst for /ḍ/ in comparison to /d/.

Listeners were not told that they would be hearing two languages, but were instructed to write as closely as possible, in their own language, the speech on tape. They were told that they would hear possible but non-occurring words in their own language, and that the recorded words had been processed by a computer.

#### RESULTS

Table 1 shows each group of listeners' responses to flat and plain (dental) stops in either language. In tallying responses, only the value of the feature [+/- flat] was considered, disregarding other misperceptions (e.g., of consonant voicing). For both [+ flat] and [- flat] consonants, listeners were much more accurate when judging their own language. Each group correctly perceived [+ flat] consonants in their own language over 90% of the time. Yet only rarely were [+ flat] stops of one language identified as the corresponding [+ flat] stops in the other. Arabs heard Bengali retroflex stops as pharyngealized Arabic /ṭ/ or /ḍ/ less than 8% of the time. As Table 1 shows, except for one subject's unscorable responses, Bengalis never heard the Arabic emphatic /ṭ/ or /ḍ/ as retroflex.

When listening to [- flat] stops in their own language, neither group of subjects erred more than 3% of the time. Arab listeners also had a relatively low error rate on Bengali plain stops, misidentifying them as [+ flat] only 10% of the time. On the other hand, Bengalis perceived nearly half of the Arabic [- flat] stops as retroflex. A t-test revealed that Bengali listeners had a significantly higher rate of false-positive responses (i.e., misidentification of [- flat] consonants as [+ flat]) in this cross-linguistic task ( $t=5.17(df=22)$ ,  $p<0.001$ , 2-tailed).

One possible source of the Bengali listeners' bias for hearing plain stops as retroflex might lie in the pronunciation of Arabic by the speaker we recorded. It may be that he sometimes

pronounced the Arabic plain stops with an alveolar place of articulation, since no distinction between dental and alveolar stops exists in Arabic, allowing for free-variation. If our speaker pronounced the Arabic plain stops as alveolar, then Bengali listeners' frequent misidentification of these stops as retroflex is not surprising, given that Hindi speakers perceive American English alveolars as retroflex 91% of the time [10].

We also examined the influence of vowel context on listeners' errors. Results are shown in Table 2, which lists percent errors for each set of stops and each group of listeners. As can be seen, for [+ flat] consonants, neither group's errors were much affected by the surrounding vowels. But, for [-flat] consonants, each group of listeners was affected by vowel context, but only when not perceiving their own language. As in Feder's earlier experiment, Arabs more often mistook Bengali [-flat] stops for their pharyngealized /ṭ/ or /ḍ/ when the Bengali plain stops were presented between low vowels ( $t=3.72(df=12)$ ,  $p<0.01$ , 2-tailed). Since in Arabic, /a/ is fronted to [æ] in the context of [- flat] stops, Arab listeners, hearing a [- flat] consonant surrounded by low back vowels, transcribed the consonant as [+ flat].

Bengali listeners, in contrast, made more errors in judging Arabic [- flat] stops when these were surrounded by high vowels ( $t=4.17(df=10)$ ,  $p<0.001$ , 2-tailed). Thus, Arabic plain stops were most often heard as retroflex when in the context of /i/. This pattern of errors is somewhat surprising, given the more pronounced acoustic effects of retroflexion on the high second formant of /i/ rather than on the already low formant structure of /a/. At present, we have no explanation for this paradoxical result.

#### DISCUSSION

Our findings have demonstrated that while both Arabic and Bengali speakers accurately perceive the phonological feature [+ flat] in their own languages, they rarely identify [+ flat] in the other language. This result argues against the proposed unitary acoustic/perceptual correlates of [+/- flat] as a phonological feature.

In particular, the large percentage of false-positive responses by Bengali listeners would seem to challenge the distinctiveness of the proposed acoustic correlates of [+ flat]. Since Bengali listeners most often heard Arabic plain stops as retroflex when in the context of a high vowel, one might infer that for a Bengali listener, the proposed acoustic correlate of lowered formant structure is not a necessary cue for judging a consonant as [+ flat] (Cf. [10]).

While our findings as a whole did not confirm the proposed cross-linguistic identification, we are not yet ready to discard the notion of [+ flat] as a class of perceptually similar sounds. Our reservation is based not only on the conflict of these experimental results with earlier explanations of sound change [5], but also on limitations in the scope of the present study. We tested only a small set of stimuli in two languages, which included other phonetic distinctions as well as the consonant contrasts. Perhaps a more thoroughly controlled test, including other [+ flat]

segments (such as labialized consonants) and minimizing co-varying phenomena would yield a more unified picture of flat perception, with greater cross-linguistic agreement.

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Table 1: Perceptual Confusions According to Native Language of Listeners

	STIMULUS			
	Arabic [+flat]	Bengali [+flat]	Arabic [-flat]	Bengali [-flat]
RESPONSE				
1. Arabic-speaking listeners (2076 responses)				
[+flat]	90.2%	7.9%	2.3%	9.5%
2. Bengali-speaking listeners (1756 responses)				
[+flat]	0.0% <sup>a</sup>	92.0%	47.3%	2.3%

<sup>a</sup>One Bengali subject consistently added an extra syllable for 3/4 of the Arabic [+ flat] stimuli. These unscorable responses are omitted from the table.

Table 2: Percent Listener Errors in Identification of [+/- flat] Consonants According to Vowel Context

	Arabic [+flat]		Bengali [+flat]		Arabic [-flat]		Bengali [-flat]	
	/i/	/a/	/i/	/a/	/i/	/a/	/i/	/a/
1. Arabic-speaking listeners	0.0	19.6	99.6	84.6	0.4	4.2	0.4	18.5
2. Bengali-speaking listeners	89.0	95.4	7.3	8.6	62.7	31.8	4.1	0.4