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## THE 'ACUTE' PROBLEM OF TONOGENESIS

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This study was designed to determine whether there is a linguistically significant variation in the fundamental frequency ( $f_0$ ) of syllable nuclei when surrounded by grave versus acute consonants. Jakobson, Fant and Halle (1952) described the feature grave as being the predominance of energy at either half of the significant speech spectrum. Chomsky and Halle (1968) abandoned all acoustic features in establishing a strictly articulatory feature system. Although one must concede the possibility of acoustic correlates of articulatory features, there still have been attempts (Hyman 1973) to phonologically motivate a reinstatement of the feature grave.

The crucial datum given by Hyman is in high vowel reduplication in Petit Diboum villages of Fe?fe?-Bamileke, spoken in the Cameroons of Western Africa. Hyman claims there is an acoustic assimilation that cannot be handled by the Chomsky-Halle feature coronal. Remember that the feature +/-grave is not mutually substitutable for the feature +/-coronal. The reduplicated vowel in Fe?fe? patterns with the graveness of the preceding consonant. The feature coronal does not group together palatal stop [c] with palatal glide [y] which is necessary to handle the reduplication datum. On this basis Hyman argues for a reinstatement of the acoustic feature grave.

The brunt of any proof for a reinstatement of the feature grave will fall on whether there is phenomenological (here I mean acoustic and/or articulatory) evidence for acoustic assimilations. Evidence has been presented showing the effects of phonetic context on the pitch of syllable nuclei, and their significance in tonogenesis. Here I am talking about segmental effects.

The following are factors that have been demonstrated about phonetic context. The phonetic environment of voiceless obstruents has the effect of raising  $f_0$  of syllable nuclei, as compared to voiced obstruents (Peterson and Lehiste 1961 and Lea 1972). In general, voiceless environments have higher pitch. Lea (1973) also observed  $f_0$  contour dips after voiced obstruents, and monotonic  $f_0$  increases in  $f_0$  after sonorants. Excluding consonantal environments, every vowel has its intrinsic pitch: higher vowels tend to have higher  $f_0$  (Lea 1973, Lehiste 1970 and Peterson and Lehiste 1961). Voice-

less stops in English tend to increase  $f_0$  in following vowels (Lea 1972 and Peterson and Lehiste 1961), and there is diacronic evidence (Haudricourt 1972) that voiceless aspirated stops in Camuhi motivated the development of high tones: note that English stops are aspirated.

This has led to speculation that aspiration is the motivating phonetic parameter for the development of high tones. I have observed that the acoustic property of aspiration is high frequency energy between the closure of the stop and the onset of phonation. If such high frequency noise serves as one perceptual motivation for the occurrence of high tones, then this means that other segments which do have this acoustic property of high frequency noise might produce the same effects.

Segments classified acute (versus grave) also have this above described energy at higher frequencies, and these consonants were examined to see if there was a transferring of this high frequency energy from the consonantal environment to the  $f_0$  of the syllable nuclei. It was decided to examine fricatives in English to test the high frequency energy factor, and to get datum free of the aspiration factor. There is evidence (Stevens 1960) that this datum could be generalized to some voiceless stops, because the aspiration should be acoustically similar to a homorganic fricative.

Four vowels ([ɪ], [ε], [ɔ] and [ʊ]) were chosen to get a representative sampling of the vowel quadrilateral i.e., four corners. The vowels [ɪ] and [ʊ] were chosen because they have similar (relatively high) intrinsic pitches, and the vowels [ε] and [ɔ] were chosen because they have similar (relatively low) intrinsic pitches. The fricatives [s] and [f] and their voiced counterparts [z] and [v] were chosen because they, too, in syllable initial position have very close effects on  $f_0$  of syllable nuclei (Peterson and Lehiste 1961). Although the major effect was thought to be from the syllable initial consonant onto the vowel, it was decided to use a syllable of the type C.VC<sub>i</sub> in order to magnify the effects of the environment.<sup>i</sup> The fricatives used in this study will be crucial items of acoustic effects because there can be no articulatory explanation such as variations in larynx height for  $f_0$  fluctuations.

Except for one, the subjects were all native speakers of the Southern California dialect of Standard American English. There were eight subjects between the ages of twenty-three and forty years old. They were all

males and were not members of any minority group nor did they speak nonstandard dialects. They were not involved in linguistics, nor were familiar with any tone languages. The one exception to being a speaker of the Southern California dialect learned English as his native language in India from people with a British cultural heritage. This compensated for missing observations of the vowel [ɔ] which gave a relatively more balanced number of scores on each item, for each subject. The subjects were told they were in an experiment to demonstrate the difficulties of the English spelling system. They were told that it was their task to memorize a list of nonsense words. They were given a pronunciation key (in the form of sample English words) for each symbol that appeared in every nonsense word i.e., it was demonstrated to the subjects that every symbol was phonemic.

The sentence frame "Read the form      many times" was used for two major reasons: first, it puts sentence medial stress and intonation on the syllable; second, it surrounds the test item with the bilabial nasal [m]. This consonant was ideal because it was easy to articulate in the context of the fricatives (no tongue twist-ers), and it has a neutral pitch. Each item occurred twice in random order. With the four vowels and four consonants, this yielded a matrix of sixteen different items (therefore, thirty-two for each subject) and a matrix of forty-eight scores for each item. With the above-mentioned syllable structure, each item had three "phonemes." Broad and narrow band sonagrams were made. The syllables were segmented, and the syllable nucleus was separated out using Naesar's (1970) criteria for segmentation--minus glottal transitions. The nuclei were then halved and the midpoint located. Measurements of f were taken at three points: syllable onset, medial and final. All measurements were done in one-fortieth of an inch scale.

The experimental design was set up to be a four factorial Analysis of Variance, with the factor grave at two levels, and with the factor voice and two levels, the factor vowel quality at four levels, and finally the factor syllable point at three levels. This yields forty-eight combinations of levels. The factor grave was assigned the first major break while the factors voice, vowel quality, and syllable point were assigned the second, third and fourth, respectively. With eight subjects, this should yield a total of seven-hundred-sixty-eight observations; however, one-hundred-eighty-three were missing, leaving five-hundred-eighty-five scores. All of the missing observations, however, were statistically compensated for by the computer program.

The above described ANOVA was carried out by the UCLA Health Sciences computer program BMD X64. The program uses a general linear hypothesis, and computes regression coefficients, gives descriptive statistical data, predicted values for cells, and it generates variables for missing observations. Also it gives a complete ANOVA table. The factors grave and voice had one degree of freedom each, while the factor vowel quality had three degrees of freedom, and the factor syllable point had two degrees of freedom. This program does all of these analyses between cells to show interactions. With the dependent variable being held constant for each cell, this will leave an error score of five-hundred-thirty-seven.

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TABLE 1: Statistically significant factors and factor interactions in the analysis of Variance performed by the BMD X64 program and their significance levels.

<u>FACTOR</u>	<u>SIGNIFICANCE LEVEL</u>
voicing	.01
vowels	.01
syllable point	.01
interaction of grave and syllable point	.05

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Having examined how the experimental design was carried out, it should be time to examine the results. Statistically (see table 1) the ANOVA showed significant differences in levels of the factor voicing, the factor vowel quality, and the factor syllable point. They were significant at the .01 level. The only interaction that turned out to be significant (at the .05 level) was between the factor grave and syllable point. As can be seen from figure 1, there was a significant difference between grave versus acute consonantal environments at the point of syllable onset. This was the environment most crucial to my hypothesis. The variance at syllable medial and final points were also above the difference limen for  $f_0$  ( 0.7 per cent, Flanagan and

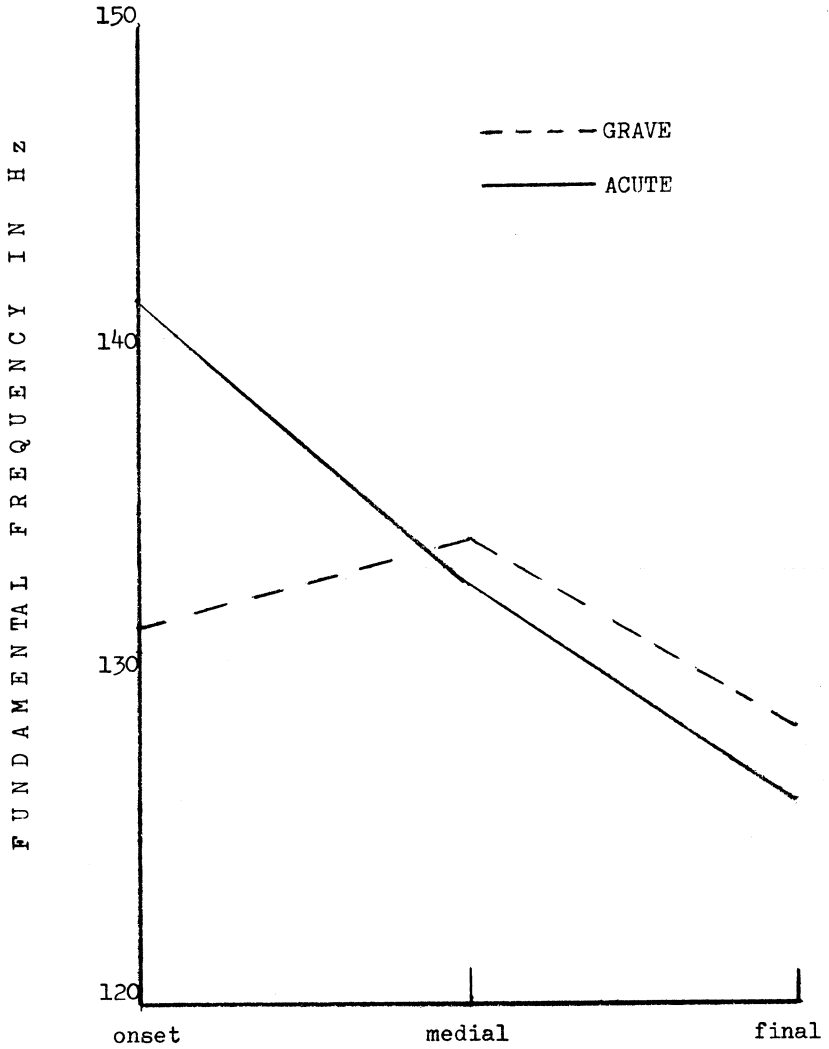


FIGURE 1: Mean fundamental frequency values for grave versus acute conconantal environments.

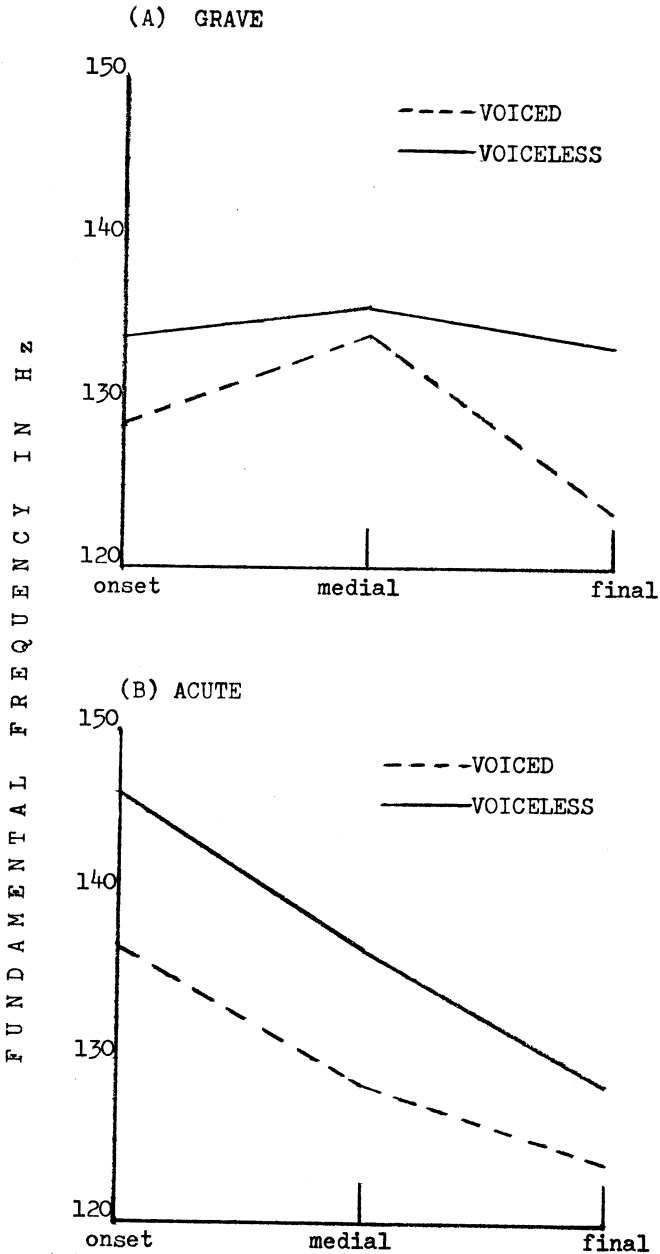


FIGURE 2: (A) Mean fundamental frequency values for grave voiced versus voiceless consonantal environments. (B) Mean fundamental frequency values for acute voiced versus voiceless consonantal environments.

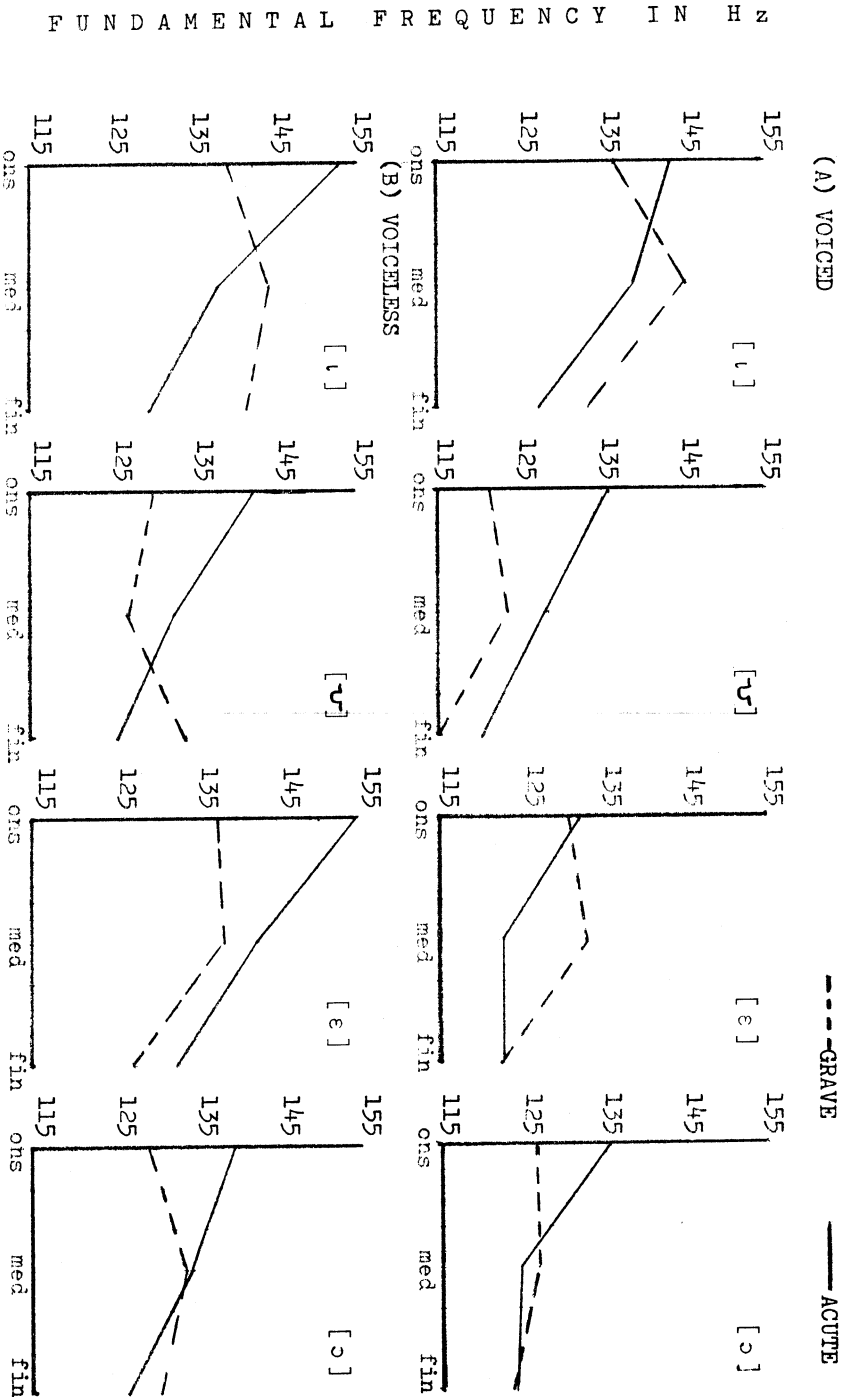


FIGURE 3: (A) Mean fundamental frequency for the four vowels in voiced grave versus acute consonantal environments. (B)...in voiceless grave versus acute consonantal environments.

Saslow 1958), but were relatively insignificant compared to the syllable initial point.

The following generally known facts about the effects of phonetic context on the  $f_0$  of syllable nuclei (mentioned above) were replicated by this study, and therefore, give some indication of this study's validity. As figure 2 shows there are significant differences between voiced and voiceless environments. Part A compared to part B show the grave versus  $f_0$  contours hold for both voiced and voiceless environments. This study did demonstrate the intrinsic pitch of vowels as shown on figure 3. [ɪ] had a higher pitch than [ɛ] for both voiced and voiceless environments (figure 3, parts A and B, respectively). However, the difference between [ʊ] and [ɔ] was insignificant: one hertz for the mean of combined voiced and voiceless environments. Notice on figure 3 that  $f_0$  contours for grave versus acute consonantal environments hold for all voiced environments. Here note that I am talking about the shape of the contour, not its pitch. It also held for the voiceless environments except for the vowel [ʊ] where the contour is concave rather than convex relative to higher  $f_0$ .

One very crucial point to my hypothesis was that at syllable onset point, every acute consonantal environment had higher pitch.

Although this datum might be considered in conflict with Lehiste (1970) relative to the effects of [s] and [f], it should be noted that Lehiste was not looking specifically at these segments, nor does she give datum on syllable onset position.

Even though this datum is new and perhaps surprising, it does match previously examined factors like voicing and vowel quality. As expected there were significant differences for all items, dependent upon the point the syllable was measured. However, this and/or similar experiments should be conducted to determine this study's reliability. The task of the phonologist now becomes to look for languages which do (or have) made use of these observed pitch differences, because this will be the ultimate test of this study's validity. I would expect to see one of two possibilities: first, after acute consonants, the development of a high tone; second, the development of a falling tone after acute consonants.

Finally, it becomes clear that here is a case of phenomenological--more phonetic than phonological--evidence for acoustic assimilations.

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