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A CINEFLUOROGRAPHIC-PHONOLOGIC INVESTIGATION OF EMPHATIC SOUND ASSIMILATION IN ARABIC

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1. INTRODUCTION

The purpose of this investigation was to examine empirically certain phonological treatments of emphatic sounds and their assimilation in context. This study critically examines the treatment of 'emphaticness' by Jakobson, Chomsky and Halle and the prosodic approach.

2. PROCEDURE

Cinefluorographic films were made of three native speakers of Arabic at 100 frames/sec. while they uttered sequences containing the consonants [b, s, t, k] and emphatic counterparts [b̤, s̤, t̤, k̤]. Consonants were combined with the vowels [i, u, a] and their short counterparts [ɪ, ʊ, ə] in CVCV sequences in nonsense and the real words [kæʃ]-[kəs], [kælb]-[kəlb̤], [kæʃɪr]-[kəsɪr], and [tæbaʃɪr] [tæbaʃɪr̤]. The position and movement of the tongue dorsum and tongue root, velum, hyoid bone, and posterior pharyngeal wall, etc. were measured from life-size tracings of the films using a tracing grid, Figure 1.

3. RESULTS

In all cases when emphatic consonants are articulated, the tongue exhibits a simultaneous slight depression of the palatine dorsum and a rearward movement of the pharyngeal dorsum toward the posterior pharyngeal wall, as seen in Figure 2. This resulted in a slight expansion of the oral cavity simultaneous with a marked constriction of the pharyngeal cavity. There was no differential movement of the posterior pharyngeal wall, nor hyoid bone, or any other major articulator observed between cognate pairs of emphatic-nonemphatic consonants. There was little difference in articulation timing and speed between cognate pairs. The sole exception was [k̤] for which the velum lowered until it often seemed to touch a rising tongue dorsum.

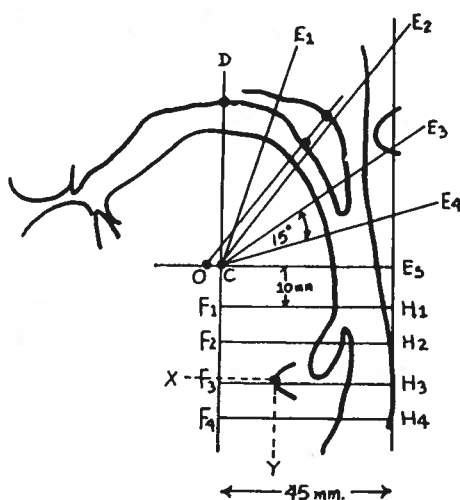


Fig. 1. Tracing grid for measurement of tongue, velum, hyoid bone, and posterior pharyngeal wall positions.

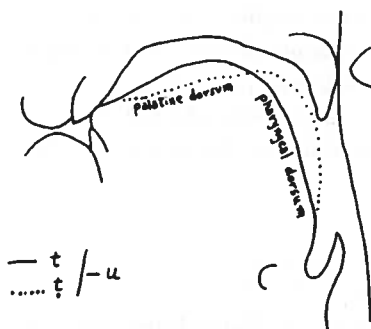


Fig. 2. A sample cine frame showing differences (in mm.) in tongue position for a contrasting emphatic-nonemphatic consonant cognate pair.

Vowels adjacent to emphatic consonants were emphaticized in that they showed pharyngeal constriction via tongue backing, about half as much as observed for the emphatic consonants. Figures 3 and 4 show the overall mean change in tongue position and cavity width for emphatic consonants and adjacent vowels in nonsense units. In real words emphatic consonants induce a tongue backing gesture over a distance of one to three neighboring segments, as shown in the words [kælb], [kæʃ] and [təbaʃir], Figures 5, 6, and 7. The *LR* spread of tongue backing is more extensive than the observed *RL* effects, especially in the case of [təbaʃir]. Apparently, tongue shape and position are the major factors differentiating emphatic from nonemphatic sounds.

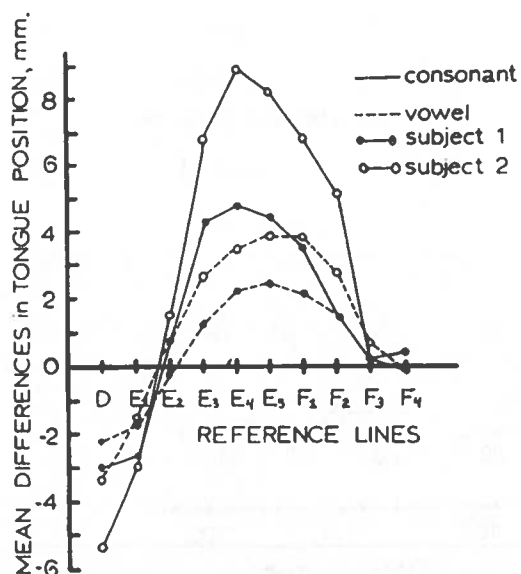


Fig. 3. Mean differences in tongue position (in mm.) between emphatic-nonemphatic cognate consonants and their associated vowels in nonsense words. Data represent mean values over all consonants and all vowels for Subjects 1 and 3.

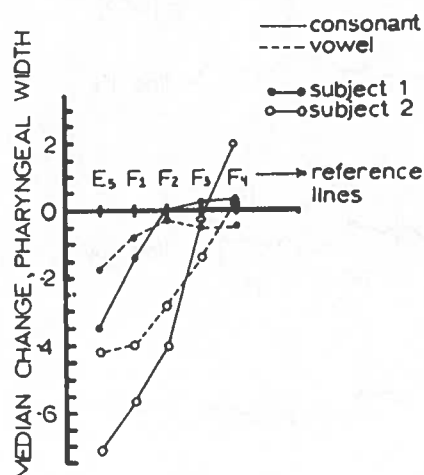


Fig. 4. Median change in pharyngeal cavity width (in mm.) between emphatic-nonemphatic consonants and their associated vowels in nonsense words. Data represent median values over all consonants and all vowels for Subjects 1 and 3.

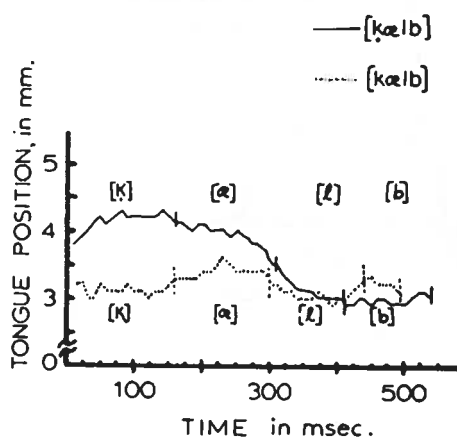


Fig. 5. Tongue position as measured along reference line E₄ (in mm.) during articulation of the words [kælb] vs. [kælb] for Subject 2.

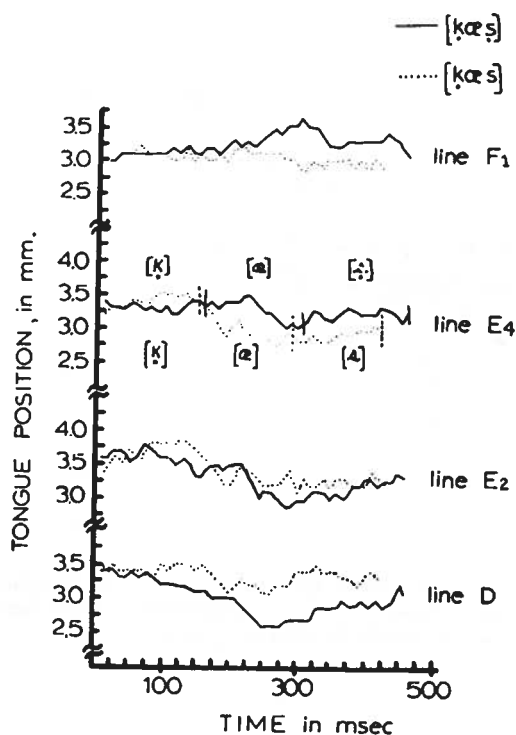


Fig. 6. Differences in tongue position along various reference measure lines (in mm.) during production of the words [kæʃ] vs. [kæʃ] for Subject 2.

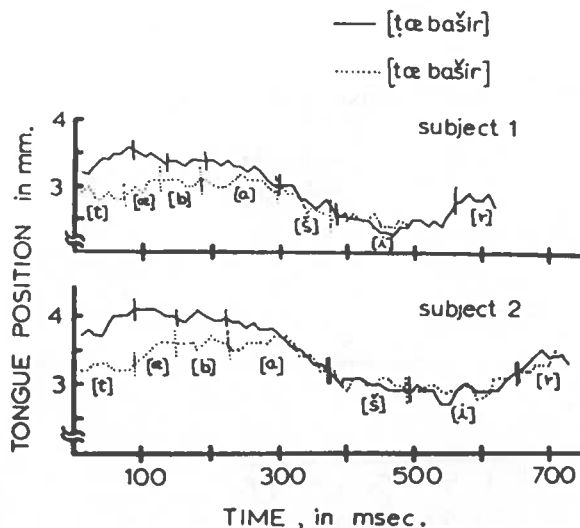


Fig. 7. Tongue position as measured along reference line E₄ during articulation of the words [tæbaʃir] vs. [tæbaʃir] for Subjects 1 and 2.

4. DISCUSSION

Jakobson (1962) argues that the features "flat" and "plain" adequately describe emphatic sounds. A narrowing of either end of the oral cavity induces "flatness". The distinguishing articulatory features of emphatic sounds are a contraction of the upper pharynx and/or a rounding constriction of the lip orifice. If one assumes that the feature 'flat' accounts for emphatic sounds, then the resulting phonetic representation (of certain phonological rules) is inadequate. According to Jakobson's procedure, the sound [ʃ] in [kæʃir] is specified [+ flat]; but our data show *LR* coarticulation from [ʃ] to [i] as shown in Figure 8. Thus, the vowel [i] carries the feature 'flat' from [ʃ], and should be specified [+ flat] instead of [- flat]. Accordingly, [i] would be realized as [u] or [ü]; [u-ü] is excluded since it doesn't exist in the language. This inadmissible result affects both [i] and [æ] in [kæʃir]; [æ] is changed to [ω], the lax counterpart of [ə]. Chomsky and Halle (1968) used tongue features such as low, high, back, and front to avoid such descriptive inadequacy. The features $\begin{bmatrix} + \text{back} \\ + \text{low} \end{bmatrix}$ were observed to occur simultaneously in this study, i.e., the pharyngeal dorsum of the tongue moved toward the posterior pharyngeal wall concurrently with the palatine dorsum movement downward as illustrated in Figure 8. A significant exception to Chomsky and Halle's specification of emphatic sounds as $\begin{bmatrix} + \text{back} \\ + \text{low} \end{bmatrix}$ was the emphatic [k]. All subjects displayed a simultaneous velum lowering, backward

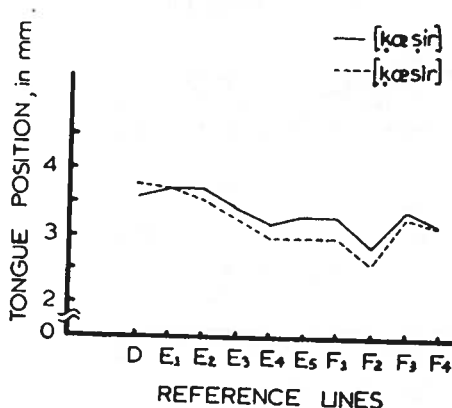


Fig. 8. Tongue position as measured along various reference measure lines (in mm.) for one frame from the center of the vowel [ɪ] in two different words, [kæʃɪr], and [kæʃɪr] for Subject 1.

movement of the tongue root, and a slight rise of the tongue dorsum resulting in most cases in what looked like actual contact between velum and tongue. Such tongue movement was also observed for the high, back, rounded vowel [u]. Accordingly, the emphatic [k] must not be specified [+ low]. It should be specified [+ high], or at least [— low], contra Chomsky and Halle. The inadequacy of their specification becomes clear if we keep in mind that the vowel [æ] of the word [kæʃɪr] undergoes assimilation (is emphaticized). Applying Chomsky and Halle's formulations, [æ] is specified as [ω], (the lax counterpart of [ɔ]). But [ω] does not exist in the language, therefore, Chomsky and Halle's approach and Jakobson's feature, 'flat', are rejected.

Perhaps the term 'emphatic' may be used as a single $\begin{pmatrix} + \\ - \end{pmatrix}$ feature. This term causes no confusion of feature specification when consonant-vowel harmony is involved in the process of assimilation noted above.

Next, a brief comment on the Arabists of the prosodic approach who believe that 'emphasis' is a prosodic feature. Prof. Mitchell of Leeds University states, "Emphasis has no predetermined domain — it may be referable to one, two, or three syllables, and it may or may not correlate with word divisions". (Personal Communication, April 1971.) Prof. Mitchell should have specified the type of syllable; we observed no emphatic backing in the final — CC# of the monosyllabic structures of [kælb], which is a closed syllable. In the word [kæʃɪr] the backing gesture was observed in the final C# of the second syllable which is also a closed syllable. Thus, we believe that the feature 'emphatic' is prosodic on a syllable basis. The syllable type(s) can be determined according to constraints imposed by intra-word context and can be specified by rules.

A final comment on 'place of articulation' and emphatic sounds may clarify our position. Emphatic-nonemphatic cognates differ mainly in terms of tongue shape. The change of tongue shape is probably the distinguishing factor involved in the

emphatic-nonemphatic differences. If tongue shape is ignored, there are no obvious physiological correlates to differentiate emphatic and nonemphatic cognates. Öhman's (1966) analysis indicates that consonants classified by place of articulation have characteristic acoustic transitions; transitions might differentiate the cognate pairs. But, Kent (1970) noted that movement patterns for consonants with similar places of constriction and manners of production are nondistinctive. The moderate, generalized pharyngeal constriction differentiates emphatic sounds. Thus, the traditional classification of sounds according to place and manner may be inadequate when vocal tract shape is alterable without marked, localized constriction or shift of place.

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DISCUSSION

CHATTERJI (Calcutta)

I would like to observe that the exact nature of the form 'emphatics' of Arabic, ع, ع, b, ḅ. (= ṣ or ṣ̣; ḍ or ḍ̣; ṭ or ṭ̣; and z, ẓ or ḏ̣) was not at all understood until rather late. Before Gairdner published his *Sounds of Arabic* (Egyptian Arabic), in the thirties of this century, the exact nature of these sounds, that they were VELARISED consonants, was not understood. (Also the nature of the pharyngeal spirants, the unvoiced ʕ [= ḥ, ḥ̣] and the voiced ʕ̣ or ʕ̣̣ [= ʕ, ʕ̣]). In Arabic Phonetics, the term used is عبق (= *itbaq*) = 'lidding', and the emphatic sounds are called عبق (= *mutbaq*) = 'lidded sounds'. This 'lidding' evidently meaning the simultaneous raising of the back of the tongue towards the velar or (soft palate) region. It is curious that these sounds would now be dropped or changed in most forms of spoken Arabic at the present day. That shows all the greater reason for a close scientific study of sounds, with all modern scientific aids. What were the values of the corresponding "emphatics" in other Semitic languages, ancient and modern, dead and living, e.g., Hebrew, Assyrio-Babylonian, Ethiopian, Ge'ez, Syriac, etc.? In revived Modern Hebrew, these are all dropped, including the 'ayn.

DANILOFF

As Dr. Chatterji suggests, the distribution of and mechanisms for 'emphatic' sound production may vary widely from one Semitic language to another, or between major dialects within such languages. Empirical observations of the articulatory mechanisms involved in 'emphatic' sound production would be quite straightforward, and would furnish interesting data for contrastive studies of the phonetics and phonology of these languages. In the future we shall attempt to extend our observations to speakers of other Semitic Languages, and thus perhaps provide answers to the question raised by Dr. Chatterji.

CATFORD (Ann Arbor, Mich.)

A propos accommodation in emphatic and vowel sequences. It is said that in Arabic the vowel /iy/, 'or instance, is modified by a preceding 'emphatic' (uvular) /q/. The Georgian phonetician Zhghent'i (in his *Kartuli enis ponet'ik'a*) has published X-ray tracings showing that the somewhat analogous Georgian uvular /q'/ has its place of articulation somewhat shifted forward before /i/. Does this not happen at all in Arabic?

DANILOFF

I have observed marked shifts of places of articulation for English /g/ in such a high vowel context. However, we did not unambiguously observe a shift in place for /k/. However, this is not as definite as we would wish, extensive palatal contact with tongue dorsum made observation of 'place' of contact quite difficult at times.

HALLE (Cambridge, Mass.)

I believe that you are correct in your criticism of the treatment of emphatics in *Sound Pattern of English*. I should now favor a solution quite like to the one you proposed here — i.e., with pharyngeal constriction in place of low, and back. I should like to ask whether you can provide information on the articulatory peculiarities of vowels in emphatic environment. I know that Gairdner remarks on the special character of the front vowel [i] in this environment. What are the facts about [u] and other back vowels in this environment?

DANILOFF

Yes, thank you for your comment. The vowels were not studied as closely as consonants in this study. Professor Ali is at present analysing the films for possible differences in articulation of various vowels in emphatic/non-emphatic contexts. It is my impression of the data that there are vowel associated differences in the front/back and high/low dimensions.

HAUDRICOURT (Paris)

Il y a une vingtaine d'années, Jean Cantineau avait montré que le [q] n'était pas une 'vélarisée' comme les autres emphatiques, mais une 'vélaire'.

DANILOFF

We observed both a tongue backing movement of the pharyngeal dorsum, lowering of the velum, and a slight rise of tongue dorsum during /k/ production. As I indicated to Professor Catford, we cannot absolutely say that place of articulation for /k/ was not altered because the lowered velum often produced extensive tongue-velum contact, preventing us from determining whether the point of primary occlusion (tightest constriction) for /k/ had changed.

GAGE (Washington)

In all the papers I have previously heard that were related to this problem, the scope, and even also the mechanism of emphasis, the question of dialect has been important. It must be emphasized that you are considering specifically Iraqi Arabic.

DANILOFF

Yes, Professor Ali has stated that both the distribution of emphatic sounds and its physiologic mechanism probably differs between various dialects of Arabic.

NASR (Beirut)

You assume that Iraqi Arabic does not have an emphatic /r/ phoneme, which I challenge. If there is an emphatic /r/ phoneme, then some of your conclusions would not hold.

DANILOFF

Yes, indeed. But, observe in Figure 7 that there is no difference in tongue position for /r/ in /tæbaʃir/ vs /tæbaʃir/. It was my impression that the /r/ segment was not emphatic in the Baghdad dialect of Iraqi Arabic; certainly we observed no differential articulatory behavior between /r/ in the two words.

PADDOCK (Wolfville, N.S.)

Perhaps I could add something about the acoustic and perceptual correlates of 'emphasis' in Arabic. My information is derived from four years of work at University College London where I carried out analysis and synthesis of this feature for ECA (Egyptian Colloquial Arabic). My results indicate that it is the pitch difference between the two sensations attributable to F_1 and $F_2 +$ which is the main cue for the perception of 'emphasis'. Experiments with synthetic CV syllables showed that this difference must be reduced to about 400 mels at some point in the duration of the CV syllable before 'emphasis' is heard by ECA subjects. Note that no absolute frequencies or pitches correlate with the feature of 'emphasis'. One may compare my comments on Dr. Lindbloms' paper at this Congress.

My work also throws light on some articulatory aspects of 'emphasis' in E.C.A.. We can assume that in E.C.A. the articulatory gestures required for the three ECA palatal vowel phonemes are incompatible with the gesture for 'emphasis' in the sense

that palatal vowel quality depends on wider separation of $F1$ and $F2$ whereas the quality of 'emphasis' is cued by a narrow separation of these formants. Therefore, whenever (natural or synthetic) syllables contain palatal vowels, the acoustic cues (and presumably the corresponding articulatory gestures) occur in temporal sequence; whereas they are simultaneous in ECA syllables which have non-palatal vowels.

Jakobson's proposal that rounding and 'emphasis' should be both included in his distinctive feature of Flat is NOT supported by my results. Any lowering of $F1$ (in addition to $F2$) in the synthetic ECA syllables was immediately rejected by ECA subjects as rounding rather than 'emphasis'. One must raise (or at least sustain) the level of $F2$ in order to produce perceptual 'emphasis'.

DANILOFF

Your remarks are most interesting. In addition to the alteration of CV transitions during emphatic sound production, our data showed that entire vowel segments are 'emphaticized'. In fact, we ran a tape-splicing study using the same utterances and speakers as in the cine-film study. We observed that subjects could detect the 'emphaticized' word even when the emphatic consonant was spliced away. However, we are re-running the study with ALL Iraqui-Baghdad listeners since our initial study utilized listeners of at least five or six dialects of Arabic, confounding our results as speakers of certain dialects were inconsistent.