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Bibliography VI

A Critical Bibliography on the Tense/Lax Distinction in Vowels

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A. Introductory remarks

References to a vowel distinction known variously as tense/lax, open/close, or narrow/wide have appeared in the literature of phonetics and phonology for at least a hundred years. Phonologists point out that the sound patterns of many languages indicate the existence of such a distinction; but phoneticians, thus far, through a variety of experimental approaches, have been unable to discover a consistent and particularized articulatory correlate of the distinction, although there does seem to be a rough acoustic correlate (a kind of 'centralization vs. peripheralization' with respect to the acoustical vowel diagram).

The following annotated bibliography is intended to note the major references to and descriptions of this distinction, and thus to document the search for its phonetic correlates. A variety of approaches to the distinction have been taken, and I will group the references around these major themes. I will use the terms tense and lax to refer to the phonological distinction, but I intend them as labels, without assuming particular physical correlates.

B. The literature

The original distinction referred to the shape of the vocal tract and was further defined in terms of articulatory effort.

Melville Bell (1867) refers to the distinction primary vs. wide with tense vowels being primary, and lax ones wide. Wide refers to the greater width of the pharyngeal cross-section for lax as opposed to tense vowels.

Sweet (1906) bases his narrow vs. wide distinction on the shape of the tongue and the resulting passage: narrow (tense) vowels have "a feeling of tenseness in that part of the tongue where the sound is formed, the surface of the tongue being made more convex than in its natural 'wide' shape, in which it is relaxed and flattened. This convexity...narrows the passage--whence the name." Sweet distinguishes the narrow/wide opposition from vowel height, maintaining that one can raise [ɛ] to [ɪ] without producing an intermediate [e].

Sievers (1901) calls the distinction gespannt (tense) vs. ungespannt (lax), and ascribes it to the tension of the tongue musculature and vocal bands. Sievers preferred his terminology to Sweet's or Bell's because his direct reference to tenseness would avoid confusion of this distinction with the height distinction.

Stumpf (1926) describes vowels in terms of the vocalic triangle. Since [i] is lowered and retracted when laxed, and [u] is lowered and advanced when laxed, he described the distinction which we call tense/lax in terms of a shift toward the middle of the vowel triangle. This seems to parallel Bell's notion of the tense vowels as primary.

Daniel Jones (1964) expresses doubts that differences in muscular tension correspond to the real facts of the tense/lax distinction. He regards tense/lax as a distinction applicable only to high vowels, [e/ɛ] being a distinction of height. He notes that lax [ɪ] is lowered and retracted from the close position of [i], and that lax [ʊ] is lowered and advanced as compared with [u], and he is apparently unwilling to make any further declaration on tenseness vs. laxness. However, he does observe that the tense/lax difference may be felt by placing the fingers on the throat and noting the different muscular tensions for the tense/lax pairs.

Raphael (1971) describes an electromyographic experiment to test the tense/lax hypothesis vis a vis the traditional vowel triangle. When genioglossus activity was measured for front vowels, the order of decreasing activity was [i, e, ɪ, ɛ], with [ɪ] and [e] transposed from their usual triangle positions with respect to height. Tongue height, however, may be based on more than just genioglossus activity. Jaw opening for [e] and [ɛ] is greater than for [i] and [ɪ], so the tongue bunching activity may be counterbalanced; and tongue backing may be involved in the production of [ɪ] and [ɛ], although the data acquired on the superior constrictor (an indicator of tongue backing) were not wholly consistent in this experiment. Raphael concludes that although his data do not strongly affirm the picture presented by the vowel triangle, they do allow for the possibility of such a view.

Meyer (1910) and others have concerned themselves with the possibility that the distinction is related to degree of air flow: tense vowels are associated with lower air flow than lax ones.

When Meyer measured air flow for tense and lax vowels, he found that there is a stronger approximation of the vocal cords and a correspondingly smaller air flow for tense vowels than for the corresponding lax ones.

Heffner (1950) points out that an acoustic and perceptual distinction of the tense/lax variety does seem to exist, but notes that 'there is nothing in the acoustic data that permits us to class [ɪ] with [i], or [ɛ] with [e], or to group any of the rest together'. He also points out that the distinction 'is not due merely to a difference in the elevation of the tongue.' He prefers to attribute the distinction to a difference in 'laryngeal positions and air pressures', noting Meyer's findings as to the 'breath consumption' of the various vowels. (pp. 96-98).

An attempt to verify Meyer's (1910) conclusions about the stronger vocal cord approximation and consequently smaller air flow of tense vowels is reported by Schumacher (1966). Tubes passed through the nose to the pharynx and esophagus were connected to manometers which measured supra-glottal and sub-glottal air pressure respectively. Mean air flow was measured by means of a flow meter. Mean air flow

was 1 1/3 times higher for lax vowels than for tense ones (both in closed syllables); sub-glottal pressure was the same. Tense vowels were 'characterized by a higher supraglottal air pressure', Schuhmacher observes, but it is difficult to see what the manometer connected to the pharynx was actually measuring in his experiment. (pp. 85-86). The air flow results support Meyer (1910), however.

Stetson (1951) suggested that tense/lax was related to syllable articulation and the manner in which the vowel is arrested. A syllable, for Stetson, 'is constituted by a ballistic movement of the intercostal muscles' (p. 33). He maintains that the lax vowels are arrested by a consonantal movement alone, while tense vowels are arrested by both the consonantal movement and a contraction of the arresting chest muscles (external intercostals). This explanation is dependent on the chest pulse theory of the syllable, however, which phoneticians no longer consider tenable.

A number of phoneticians have associated the distinction with length and with acoustic distance from a neutral vowel; in addition some retain a definition in terms of articulatory effort.

Jakobson Fant and Halle (1952) maintain that tense phonemes, in contra-distinction to lax ones, display a longer sound interval. They do not cite measurements to support this notion, and their attempt to distinguish tenseness from length (on the basis that the former is an inherent, 'protensity' feature and the latter a prosodic feature defined with reference to the syllabic chain) is not particularly successful. They maintain that tenseness differs from diffuseness because diffuse vowels are intrinsically shorter than compact ones, but that 'tense vowels have a longer duration than the corresponding lax ones'. [But since lax vowels are less diffuse than their tense counterparts, one would expect a canceling effect.]

Jakobson, Fant and Halle also state that, associated with their longer duration, tense vowels are articulated 'with greater distinctness and pressure' and with greater deviation from the neutral position (an open [æ] (p. 18)); and they note that this parallels the acoustic fact that the sum of the deviations of the formants of a tense vowel (from the neutral vowel [æ]) is always greater than that of the corresponding lax vowel.

In their 1964 paper, 'Tenseness and Laxness', Jakobson and Halle remark on Stumpf's (1926) and Jones' (1964) observations that laxness involves a shift toward the middle of the vocalic triangle. They reiterate their position that tenseness involves a greater deviation from the neutral position of the tract (very open [æ]), and they again relate this to the longer duration of tense segments and to their heightened sub-glottal pressure. [Note, however, that Schuhmacher (1966) found no difference in sub-glottal pressure.] This article is a modest expansion of the material in Jakobson et al. (1952).

The 'shift toward the middle of the vocalic triangle' is tested by H. P. Jørgensen (1966) in terms of the acoustical vowel diagram. Jørgensen measured formants of German vowels in German words spoken

by four speakers. He notes that the lax vowels were all lower than the corresponding tense ones (for one speaker, even lax /a/ had a higher F_1), and that the lax vowels were more centralized, i.e.--F_2 was characteristically higher for lax back vowels than for their tense counterparts, and F_2 was characteristically lower for lax front vowels than for their tense counterparts. F_1 and F_2 values were very close for tense and lax /a/. Jørgensen maintains, however, that the apparent acoustic centralization of non-low vowels does not necessarily reflect an articulatory centralization.

Requiring that phonetic features represent physical scales describing independently characterizable aspects of the speech event, Chomsky and Halle (1968) describe tense/lax in articulatory terms rather than acoustic ones. They refer again to the greater muscular effort, greater duration of the 'appropriate configuration', and greater deviation from neutral or rest position (which is now assumed to be that of [ɛ]) which characterize tense vowels (pp. 324-5). In Chapter 9, they claim that the unmarked value for tenseness is [+tense].

A number of linguists have attempted to associate tense/lax with tongue root advancement/retraction.

Ladefoged (1964) points out that many West African languages have a kind of vowel harmony based on something like tense/lax, where the vowels in any given word are either all from the tense set of vowels or all from the lax set. The articulatory correlates of the distinction seem to be hard to pin down, but by cineradiology the author finds that, in Igbo, 'in each case the body of the tongue is more retracted for the vowels of set 2. So it appears that there is a physiological parameter that distinguishes between these two sets of vowels, despite the fact that it is difficult to specify a unique auditory property that characterizes one or the other set.' (pp. 39-40). He refers to Sweet's mention of convexity or 'bunching up' of the tongue for 'narrow' vowels, and he suggests a redefinition of tense-lax or a return to Sweet's 'narrow-wide'.

Stewart (1967) describes the vowel harmony systems of dialects of Twi and Fante. In attempting to characterize the 'raised/unraised' contrast of their harmony systems, he notes that the 'raised' vowels are produced with the upper surface of the tongue raised and the lower surface of the chin lowered, and he suggests that the important factor must be a pushing forward of the root of the tongue. He notes that Ladefoged's (1964) cineradiology data for Igbo support this hypothesis. He maintains that the wide pharynx associated with raised vowels would account for their 'breathy' quality, and that advancing would also account for their greater susceptibility to palatalization (as opposed to their unraised counterparts. Stewart claims that raised/unraised (i.e. advanced/unadvanced) must be distinguished from tense/lax (in the Jakobson-Halle sense) for several reasons:

1. Unadvanced African back vowels show no shift toward the middle of the vocalic triangle,

2. Advanced and unadvanced vowels do not appear to have the length difference that Jakobson and Halle claimed to exist between

tense and lax vowels, and

3. Phonological evidence from the harmony systems studied indicates that unadvanced may be the unmarked member of the opposition, while lax is the marked member of tense/lax, and unadvanced is supposed to correspond to lax.

He remarks that 'the implications for their lax/tense distinction are serious if its supposed role in vowel harmony in African languages is the only evidence of its autonomy.' (p. 202), and he suggests that (1) if the African and European distinctions are to be identified, tongue root position is vital and length and tension are not (although he presents no experimental evidence against these correlates), and (2) that if such identification is possible, there is a strong case for viewing unadvanced or lax as the unmarked member.

In light of Halle and Stevens' (1969) suggested revision of vowel features, this article takes on a good bit of importance. It shows the origins of their suggestion, but it also makes apparent the premature nature of their claims regarding the marked and unmarked members of the opposition.

Chomsky and Halle (1968) also introduce an extra feature to account for the African vowel harmony systems: this is the feature covered/non-covered. Based on Ladefoged's X-ray tracings, they determine that 'covered sounds are produced with a pharynx in which the walls are narrowed and tensed and the larynx raised; uncovered sounds are produced without a special narrowing and tensing of the pharynx.' They associate a dull or breathy quality with 'covered' vowels. Chomsky and Halle here make no attempt to identify this distinction with tense/lax.

In an attempt to integrate tense/lax and covered/non-covered (±advanced tongue root), Halle and Stevens (1969) re-examine Bell's decisive role in the tense-lax distinction. Noting that the two classes of Igbo vowels are distinguished by movements of the tongue root, they suggest that (based on cineradiographs) English tense/lax pairs are similarly distinguished--that tense vowels have a wider cavity in the vicinity of the hyoid bone and lower pharynx. They note that the acoustic consequences of such a distinction are theoretically predictable: a lowering of F_1 with advancing, a raising of F_2 for front vowels with advancing, and a lowering of F_2 for back vowels with advancing. For non-low vowels at least, these predictions fit the acoustic differences (between tense and lax vowels) that actually occur. They would fit Ladefoged's African data, except that his data show no downward F_2 shift for back vowels with advancing. Halle and Stevens suggest that unmarked high vowels are [+Advanced Root], and unmarked low vowels are [-Advanced Root]; for mid vowels, they don't know yet. They note that in many languages advancing is concomitant with height.

It is suggested that a flattened-out sound wave form is responsible for the dull or breathy character of vowels with advancing, and the authors speculate on the reasons for this effect, but they draw no firm conclusions.

Continuing the approach taken by Halle and Stevens, Perkell (1971) proposes two revisions, based on physiology, of the features specifying vowels. His 'suggested revisions' are the replacement of [±Tense] by [±Advanced Tongue Root] and the replacement of [±Low]

by [±Constricted Pharynx] (the latter an unpublished suggestion of Halle and Stevens). Using superimposed tracings of lateral cineradiographs of two speakers, Perkell attempts to provide 'a crude physiological framework corresponding to the features' (p. 128). That is, he attempts to associate each feature with the activity of a particular muscle group.

In [+High] vowels, the tongue body and mandible are higher (than for [-High]), and the posterior third of the genioglossus and the styloglossi are responsible. The sternohyoid and sternothyroid lower the hyoid bone and larynx during [+High] vowels. For [+Back] vowels, the styloglossi and hyoglossi pull the tongue body back. One speaker also used the pharyngeal constrictors for this. It is suggested that tongue root advancing is due to the contraction of a small segment of the genioglossus at the tongue root. The contour of the posterior half of the tongue dorsum, the epiglottis, and the hyoid bone are farther back for [+Constricted Pharynx] vowels, probably due to contraction of the middle and lower pharyngeal constrictors and the hyoglossi.

Perkell points out that considerable muscular interaction is involved in achieving 'the phonetic and acoustic goals'; and he suggests that the physiological configurations correlated with the new features support these two suggested revisions.

Lindau, Jacobson and Ladefoged (1972) observe that the suggestion of the feature [±Advanced Tongue Root] involves two claims: that it distinguishes vowels in some way other than the features high and low distinguish them; and that the tense/lax distinction in English and German is identifiable with the distinction which governs African vowel harmony sets. In order to determine whether advancing is independent of the tongue height mechanisms, Lindau et al. traced cineradiographs or X-rays of four African speakers, one German, and six English speakers. Their measurements showed that advancing was clearly used to separate the tense/lax sets of Twi and Dho-Luo, and that high vowels were partly differentiated by advancing in Igbo, but that in Ateso the vowel sets differed by height, not by a separate mechanism of advancing. In German, too, the difference in advancing between tense and lax vowels was non-significant; tongue height was attained by lifting and advancing, so advancing was not a separate mechanism for the German speaker. For English, it seems that 'there is a substantial variability in the mechanisms used to distinguish between vowels. Tongue height is attained by different combinations of jaw opening, lifting, and advanced tongue root for different speakers.' (p. 87). It is suggested that a vowel target may be a particular configuration in an acoustic space where the relations between formants play a crucial role.

The authors also note that the variation among English speakers (their use of different articulatory mechanisms to produce perceptually similar vowels) shows the need for caution in viewing the productions of a single speaker as characteristic of the language.

In 'An auditory motor theory of speech perception', which appeared simultaneously with Lindau et al. (1972), Ladefoged, Declerk, Lindau, and Papcun (1972) discuss the results of studies of

cinefluorograms of six speakers of American English; they note that various speakers use various combinations of mechanisms to produce what is perceptually the same sound. Regarding the tense/lax distinction, their speakers 2, 3, and 6 use advanced tongue root to produce tense vowels, but the other speakers vary considerably.

Ladefoged et al. suggest that speakers use acoustic rather than articulatory targets for vowels, noting Lindblom and Sundberg's (1971) observations that speakers can produce a given vowel with a variety of jaw openings--with no apparent need for modification governed by auditory feedback. F_1 could be correlated with vowel height, and F_2 may be correlated with the traditional front-back dimension, according to Ladefoged et al. Lip rounding, which is a fairly straightforward articulatory feature, has 'no uniform auditory or acoustic correlates', and may be organized by speakers in articulatory terms, even though vowel height and frontness are based on acoustic correlates.

The variety of approaches shown here is adequate testimony to the difficulty of finding precise phonetic correlates for this frequently-mentioned phonological distinction. In spite of the difficulty, however, the phonetician is not free to conclude that the distinction does not exist; such a conclusion would leave unexplained the phonological facts which argue for such a distinction.

C. Comments from a phonologist

A look at the phonological effects of tenseness and laxness may help clarify the sorts of phonetic correlates to be expected. In studying diachronic, synchronic, and developmental phonological substitutions, I have observed that vowels are distinguished from other vowels not only by height but also by color (Miller, forthcoming). Color includes principally palatality (tongue-fronting), and labiality (lip-rounding, lip-narrowing).

The distinction between chromatic vowels (those marked by one or more color) and achromatics (vowels without color, like [ɨ ɯ ʌ ɤ ɑ]) is revealed in context-free phonological processes such as raising, which applies to chromatic vowels and not to achromatic vowels, or lowering, which applies to achromatic vowels if it applies to chromatic ones. Presumably, raising is a phonological means of optimizing color--by providing a closer articulation which makes increased palatality or labiality possible. Achromatic vowels, which are free of the close articulations associated with palatality and labiality, are especially susceptible to lowering, which seems to be a phonological means of optimizing sonority (in the traditional sense). A similar hierarchy of susceptibility appears in bleaching, the loss of palatality and/or labiality: the susceptibility of a vowel to bleaching is an inverse function of its height, and thus apparently of its degree of palatality or labiality.

The way these substitutions respond to color or degree of color is exactly paralleled by the way they respond to tenseness. If lax vowels are raised, the corresponding tense vowels are raised. Conversely, if tense vowels are lowered or bleached, the corresponding

lax vowels are lowered or bleached. This strongly suggests that tenseness is a relatively greater degree of color--palatality or labiality or (in front rounded vowels) both.

These facts suggest that achromatic (nonpalatal, nonlabial) vowels could not participate in a tense/lax distinction. There is some phonological evidence for this conclusion: languages that give up a long/short distinction typically recode it, in the chromatic vowels, as a tense/lax distinction. But unless one or both of the pair [ɑ:/ɑ] is 'colored' (changed to [æ] or [ɔ]), these achromatic vowels merge. A well-known example is Romance (Labov et al., 1972).

In some languages, the length distinction is not lost, but tense/lax is superimposed on long/short. This appears to be the case in Modern German; here, as Jørgensen's (1966) study shows, the non-low, chromatic vowels show a quality distinction for tense/lax pairs, but the two achromatics display nearly identical formant values, suggesting that the so-called tense/lax distinction for this pair may really be long/short instead.

The phonological distinction 'intense/non-intense color' corresponds to and summarizes many of the various kinds of physical correlates associated with tense/lax.

A number of authors (Jakobson, Fant and Halle (1952), Jakobson and Halle (1964), Jørgensen (1966), Ladefoged et al. (1972)) point out the lower F_1 value and the more extreme F_2 values of tense vowels as opposed to the corresponding lax ones: this amounts to the acoustic centralization of lax vowels and peripherality of tense ones. Correspondingly, even though the articulatory correlates of tenseness remain rather ill-defined, there is general agreement that the articulatory gesture is somehow more extreme for the tense member of a tense-lax pair. Raphael determined that geniglossus activity is greater for the tense vowels [i, e] than for the lax [ɪ,ɛ]; and Meyer (1910) and Schuhmacher (1966) note a lower airflow in tense vowels which suggests a more constricted oral articulation.

Jakobson, Fant and Halle (1952) maintain that length is one of the physical correlates of tenseness, but none of the studies surveyed have pursued their claim. The above-mentioned tendency for length to be recoded as tenseness or for tenseness to be superimposed on length is evidence that tenseness is phonologically related to length, but this tendency could be accounted for by pointing out that the greater duration of long vowels apparently allows time for the more extreme articulations associated with tenseness. If Jakobson et al. are correct in claiming that tense vowels are inherently longer than the corresponding lax vowels, one might expect to find languages whose tense vowels become phonologically long, or are treated as long by a phonological process. That is, a process might class all tense vowels together with (tense and lax) long vowels--e.g. [i, i:, ɪ:] would undergo or condition the process but [ɪ] would not--but I do not know of any clear cases of such a situation.

The precise relationship of tenseness to tongue-root advancement is not clear, but judging from the work of Ladefoged et al. (1972) and Lindau et al. (1972), it does not look as if they can be regarded

as the same feature, on either articulatory or acoustic grounds. In any event I know of no phonological evidence that the two features are the same--e.g. there do not seem to be any languages where vowel harmony is based on a tense-lax distinction of the 'European' variety; and, as far as I know, there is no relation between the advanced-tongue-root distinction and length in African vowel harmony languages which display an advancing distinction. For speakers of languages like German or English who advance the tongue-root in producing a tense/lax distinction, advancing may serve as a color-amplifying gesture (for palatal vowels) which occurs in conjunction with tongue lifting. The relation of advancement to tenseness in back or round vowels is not well-established, although Perkell found that advancing bore some relation to the [u/ʊ] distinction for two speakers; in general, the articulatory correlates of tenseness have been less thoroughly studied for non-palatal vowels.

In suggesting that the phonological distinction tense/lax can be described as intensity/nonintensity of color, I do not mean to imply that no more precise physical description can be or ought to be found. On the contrary, the explanation of the phonological substitutions which are sensitive to this distinction depends on the discovery of its physical correlates. The investigation of these physical correlates, however, can be aided by attention to the kinds of substitutions which the distinction conditions.

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