THREE MAJOR VOCAL REGISTERS: A PROPOSAL

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A number of definitions of vocal registers have been postulated but no single one is very well accepted. Further, the precise number of vocal registers producible by humans has not been established. Most postulations indicate that there are between three and five — although various authors have suggested that there are as many as seven or as few as one. In any case, controversy exists in this regard. It does so to the extent that Morner, Fransesson and Fant (1964) published a paper in which they listed 107 different names which have been used to identify one register or another. In an attempt to meet such confusions, I define a vocal register as a series or range of consecutive vocal frequencies of nearly identical voice quality and that there should be little or no overlap in F_0 between adjacent registers. Furthermore, I maintain that before the existence of a particular vocal register can be postulated, it must be operationally defined (1) perceptually, (2) acoustically, (3) physiologically and (4) aerodynamically.

Accordingly, on the basis of my own research and the research of others, I propose that three major vocal registers already have been defined and experimentally described. They are the modal register, vocal fry and falsetto.[1] Along the continuum of fundamental frequency — from the lowest possible phonation — vocal fry is the lowest register. Next is the modal register, which is so named because it includes the range of fundamental frequencies that are normally used in speaking and singing. Finally, the falsetto register occupies the higher fundamental frequencies on the voice continuum. Considerable information about these registers is available and it would appear that they can be defined and described. If this is true, then it should be possible to apply the above cited approach in their determination.

Before proceeding, however, it must be conceded that it is quite possible there are more than three voice registers. For example, many workers in vocal music indicate that the modal register actually is comprised of two separate and distinct sub-registers

[1] Since giving this paper, a number of my collegues have suggested that, since I have assigned a new name to one of the registers (modal), I should have done so for all of them — in order to avoid confusion. This I have done (pulse instead of vocal fry and loft instead of falsetto) but with respect to this paper, I will retain the terminology used in the oral presentation.

(often referred to as 'head' and 'chest') or that it may contain three sub-registers ('low,' 'mid' and 'high'). Moreover, observation has been made of a very high frequency (and relatively rare) 'register' which is exhibited by a few women and children; it is usually referred to as the 'flute', 'whistle' or 'pipe' register. However, since this register seems to be an unusual one and since little or no empirical information is available about it, it obviously has not been established as part of the expected vocal physiology of normal human beings. Finally, it should be noted that, although there is practically never any F_0 overlap between the vocal fry and modal registers, many individuals can produce a curious sounding phonation at frequencies which seem to lie between them. These vocalizations appear to be a blend of voice qualities suggesting a mix of both vocal fry and modal register phonation produced simultaneously. However, even in the light of these various subjective observations, I maintain that only three major registers meet the test criteria cited above.

In a paper of limited length such as this one, it is impossible to review all of the evidence that could be utilized to support the three-register proposal. Accordingly, only summary statements will be made concerning the acoustic and aerodynamic correlates of these registers and, even with regard to perception and physiology only selected evidence will be provided.

A number of workers can provide data with respect to the acoustical parameters of the three registers. Notable among these publications are: (1) Hollien and Michel (1968), Colton (1969) and Hollien, Dew and Beatty (1971) relative to range of F_0; (2) Ruth (1963), Vennard (1967), Colton (1969) and Murry and Brown (1971) relative to intensity relationships, and (3) Large (1968) and Colton (1969) with respect to spectural information. Figure 1 provides information on the frequency ranges of

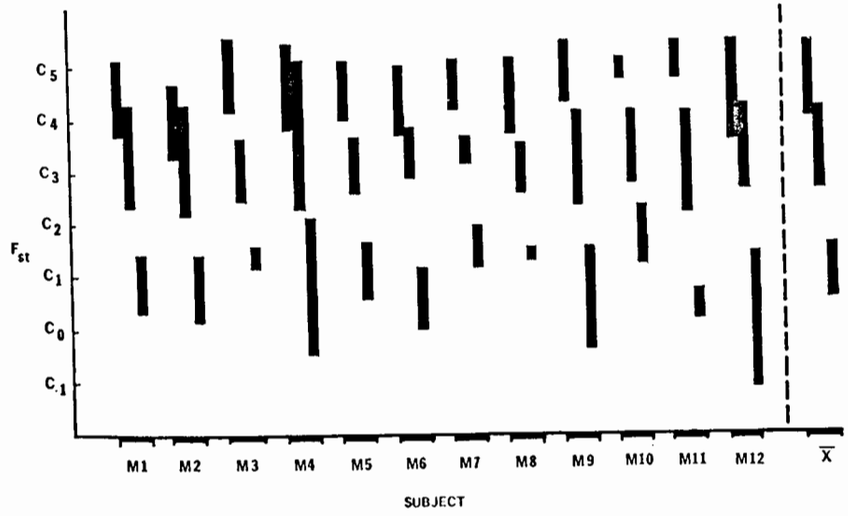

Fig. 1. Phonation ranges of 12 male subjects. For each subject, the lower bar is vocal fry, the middle bar the modal register and the upper bar is falsetto.

12 male subjects for the three registers; from the figure it can be noted, that the three registers are easily produced. In any case, it may be said that the vocal fry, modal and falsetto registers (1) occupy different F_0 ranges, (2) exhibit different magnitudes of vocal intensity and (3) possibly show different classes of wave composition.

With respect to the perceptual correlates of vocal registers, it is contended that all three registers can be reliably differentiated (and/or identified) perceptually on the basis of voice quality alone. However, only a small number of studies have been completed in this area and the position stated above is based primarily on the work of Luchsinger and Arnold (1965), Michel and Hollien (1968), Hollien and Wendahl (1968) and Colton and Hollien (1970). For example, Colton and Hollien (1970) report a series of experiments in which they attempted to make direct comparisons between the falsetto and modal registers. First they selected a group of individuals who could produce both registers at the same frequencies. These individuals were then asked to produce phonations first in falsetto and then in the modal register at three separate frequencies within this F_0 overlap; finally, the phonations were adjusted so that vocal intensity was reasonably well controlled. In one of the several experiments, the stimuli (grouped by frequency) were presented to both trained and untrained listeners; the observers made correct identifications about two-thirds of the time. In another experiment, all of the phonations from the two registers were evaluated by a paired comparison technique and in this case, a large group of judges differentiated between the two registers nearly 100 per cent of the time. These studies provide evidence that phonations in modal and falsetto registers are sufficiently different with respect to voice quality that they can be differentiated by that characteristic alone — at least under controlled conditions.

Since the modal and vocal fry registers do not overlap, studies of the nature described above cannot be carried out on these two registers. However, to test the perceptual uniqueness of vocal fry, Hollien and Wendahl 1968 asked eight males to match the pitch of a signal from an intergrated square-wave oscillator (pulse-train) to the pitch of pre-recorded vocal fry samples. The judges could do so within a small tolerance. These data provide some evidence that the vocal fry register has a quality that is readily identifiable. Moreover, in 1968, Michel and Hollien demonstrated both perceptually and acoustically that (clinically) harsh phonation was distinctly different from vocal fry. They did so by psychophysical experiments that were very similar to those cited above. In summary, all of the evidence to date suggests that the three proposed registers can be contrasted perceptually.

The physiological correlates of the modal register have been reasonably well established; considerable data is available also for the other two registers. Quite obviously, to review all of the appropriate information in this area would involve too lengthy a discussion. Accordingly, only data on vocal fold length and thickness (per-unit mass) will be used to establish that physiological differentiation of the three registers is possible. While data from electromyography studies, on vocal fold

vibratory patterns and so forth are not included, they also show different relationships among the different registers.

Vocal fold length measures may be obtained by means of a photography system (such as the one seen in Figure 2) which provides prints as seen in Figure 3; measurements then can be made as per Figure 4. By means of such indirect laryngoscopic

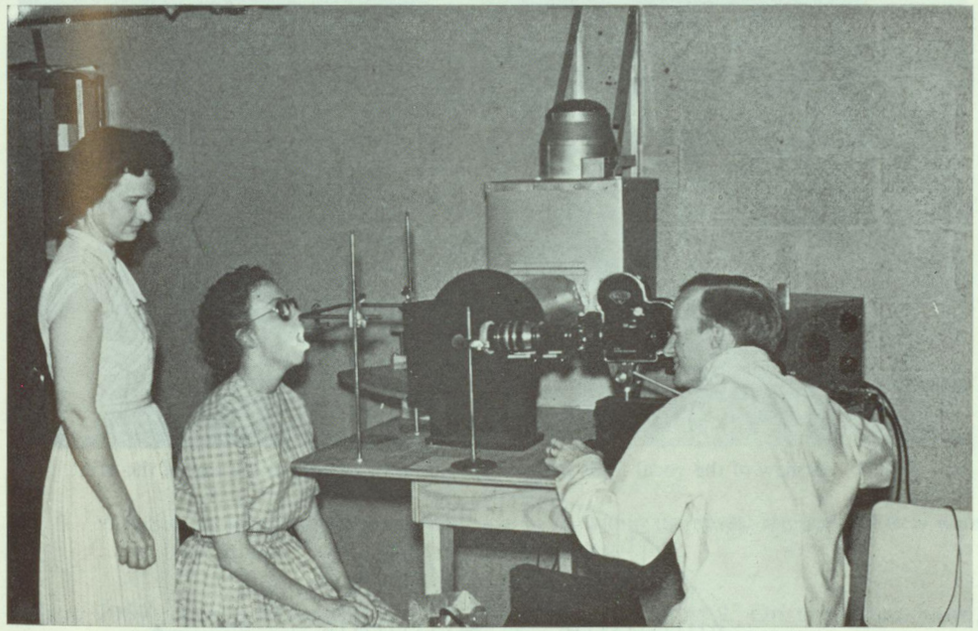

Fig. 2. A typical cinelaryngoscopy system.

techniques, as well as x-ray approaches, it has been demonstrated that the length of the vocal folds increases systematically with an increase in fundamental frequency of phonations for the modal register (Hollien and Moore, 1960, Sonninen, 1956; Damste, Hollien, Murry and Moore, 1968). Figure 5 provides an example of such data; note the systematic increase in vocal fold length with rising F_0. With respect to vocal fry, Hollien, Damste and Murry (1969) report no observable length changes; nor are systematic patterns related to falsetto (Hollien and Moore, 1960; Hollien, Brown and Hollien 1971). In fact, in falsetto, both lengthening and shortening patterns are observable. In any case, the lengthening patterns of the three registers are readily discernible one from the other.

Data on vocal fold thickness serve to differentiate among the registers also. Systems such as seen in Figure 6 (see Hollien, Curtis and Coleman 1968) provide x-ray plates as seen in Figure 7; measurements then can be made according to the protocols exhibited by Figure 8. Generally, for the modal register, the thickness of the vocal folds is systematically decreased as fundamental frequency of phonation is increased (Hollien and Curtis 1960, Hollien 1962, Hollien and Coleman 1970, Hollien and

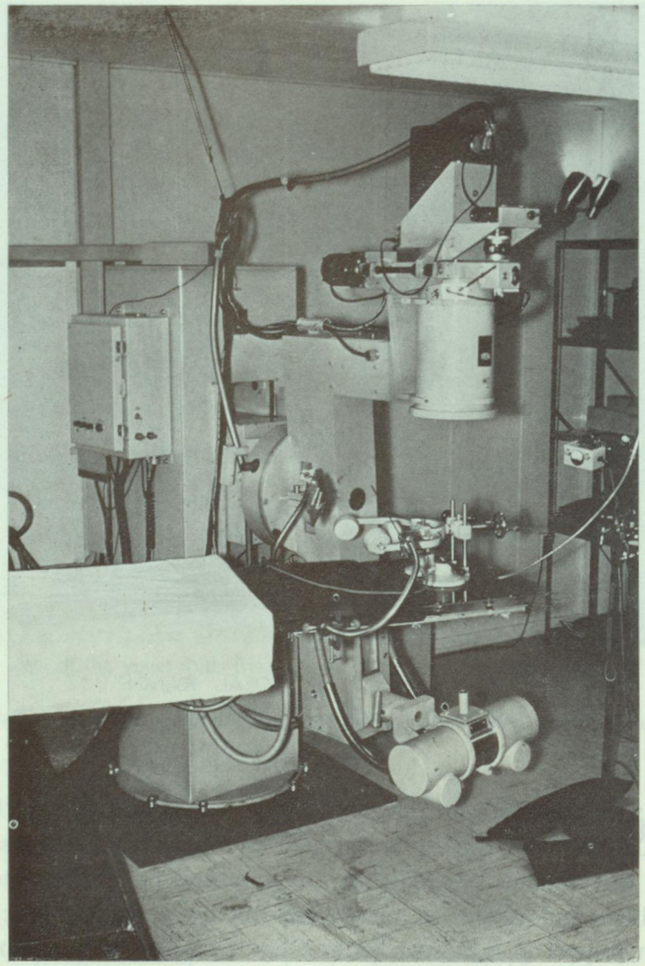

Fig. 6. Stroboscopic laminagraphic (STROL) system. It allows multiple, stop-action laminagrams of the vocal folds to be made.

in the modal register reveal that it increases as fundamental frequency is increased (Kunze 1964, Ladefoged 1962, van den Berg, 1956). For the vocal fry register, Hollien, *et al.* (1966) predicted lower overall magnitudes of P_s than for the other registers but Murry (1969) tested this notion and found the magnitudes of intratracheal air pressure associated with vocal fry to be larger than those observed in lower modal register phonations. Finally, Kunze (1964) reported that the subglottic pressure accompanying modal register phonations was greater than pressures accompanying phonation produced in falsetto even when both phonations were produced at the same F_0. Hence, it appears that P_s is lower for falsetto than for the other registers.

In summary, it seems apparent, even from this brief review, the vocal fry, modal

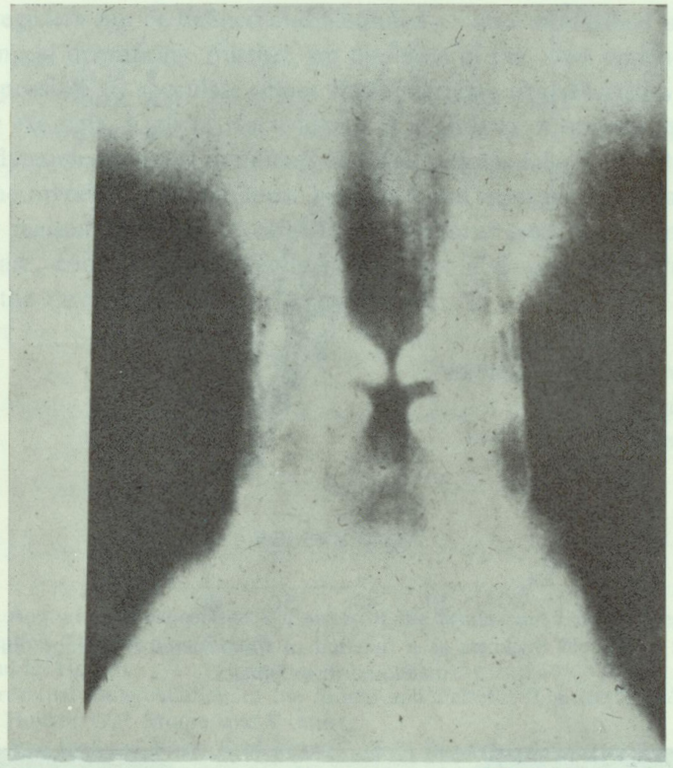

Fig. 7. A coronal cross-section laminagram of the vocal folds.

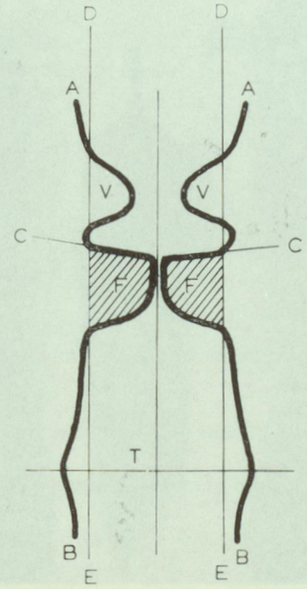

Fig. 8. A tracing of a laminagram of the vocal folds showing the reference lines used in making area and thickness measurements.

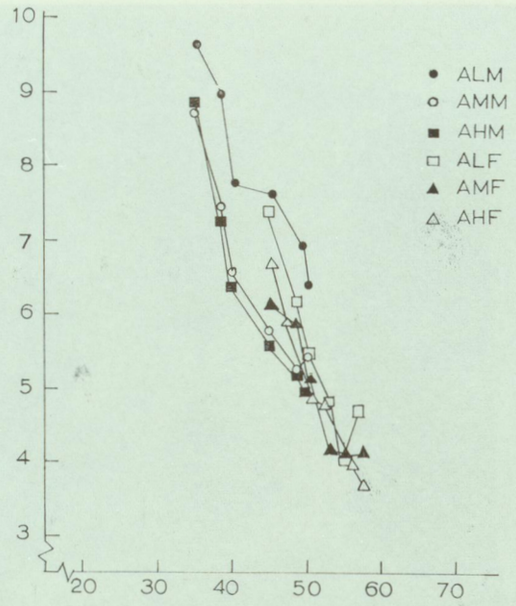

Fig. 9. Mean vocal fold thickness as a function of fundamental frequency. Subjects are three males and three females.

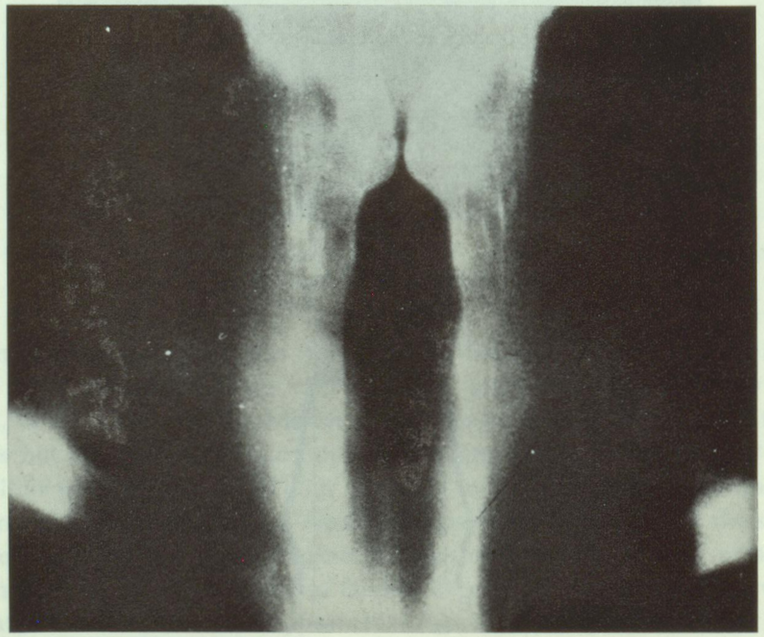

Fig. 10. Laminagram of the vocal folds during vocal fry (the folds are near the top of the print). Note that the ventricular folds are in contact with the true folds.

and falsetto registers can be defined and identified — and established as completely different laryngeal operations. Further, on the basis of the cited evidence plus other studies, it is possible to speculate about the underlying characteristics of the three registers. For example, if all of the evidence is evaluated, it appears quite possible that the aerodynamic theory is dominant in explaining the falsetto register; both that theory and the myoelastic theory must be considered in order to explain operation of the modal register and that myoelastic relationships seem best to explain vocal fry. In any case, considerable research is necessary if a reasonable theoretical explanation of the three registers is to be generated.

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DISCUSSION

SHIPP (San Francisco)
Your X-ray pictures of massive vocal folds in vocal fry or pulse register are consistent with our EMG data during this register production indicating extremely slack vocal folds — yet when speaking in this register, voiceless consonants appear to be produced easily. This observation seems to be in conflict with the Stevens and Halle notion that voiceless consonants are produced with stiff vocal folds. Do you have any speculations on this?

HOLLIEN
Your point is an excellent one — in fact the EMG work you are doing is fundamental to differentiation among registers. With respect to your question, I believe that we must base our conclusions on empirical data rather than theoretical speculation when the obtained information is as clear cut as it is in this regard.

PILCH (Freiburg-im-Breisgau)
Does the notion of 'vocal register' comprise such phenomena as the 'hoavy voice' of old men and the different voice qualities we use for a private chat vs. public speaking? I often wonder whether certain voice qualities may be language-specific, witness the 'soft voice' of many British speakers vs. the 'harsh voice' of many Americans or the 'mellow voice' of many speakers of French. I have been told to speak with different voice qualities in different languages.

HOLLIEN
If I understand your question correctly, my response would be as follows: REGISTER QUALITY is the basic voice quality and any adjustments for projecting the voice, producing vowels, or for any other purpose, are simply overlays on the basic register quality.