The relative vertical laryngeal position (VLP) in the neck appears to be one of the more obvious physiological differences between singers and nonsingers (Shipp and Izdebski, 1975; Shipp, 1977). These data show that singers kept their larynx positioned below a physiologic rest position regardless of phonation frequency; whereas the nonsingers had a strong tendency to elevate their larynx as vocal pitch increased. A study of nonsingers (Shipp, 1974) reported that the relationship between vocal frequency and VLP was strongly positive when frequency change was performed in a glissando maneuver, but was much more weakly related when the increased vocal frequency was produced individually with each step separated by a breath.

Disregarding possible linguistic issues, it seems apparent that VLP is not critical to nonsinger voice usage, but is important to that of the singer. It was the purpose of the study to examine VLP behavior in a group of professional male singers, to identify some of the possible factors that might influence larynx position during sustained vowel vocalization. The dependent variables where phonation frequency and intensity in discrete vocalization.

**METHOD**

Eight male singers participated in the study, each of whom met the following criteria: earned at least 50% of his income by singing, was classically trained, and had a prominent larynx. This latter factor was important since we measured VLP with motion pictures. Each subject stood in his comfortable singing stance, with a condenser microphone placed 6 inches from his lips lateral to the midline. A motion picture camera (Redlake Locam) filming at 25 frames/sec was positioned 20 feet from the subject, with the zoom lens at larynx resting height. Each film frame encompassed the singer's mandible, ear, neck region to the sternum and, just anterior to the neck, the display of an electronic counter being driven at 100 Hz by a custom pulse generator. The same 100 Hz timing signal and the subject's voice output were recorded on separate channels of an Ampex 351-2 tape recorder. The singer began each task by inhaling for phonation. The first task was filming the subject's laryngeal "rest position," after he was instructed to relax the muscles controlling jaw, tongue, neck and larynx movement. This laryngeal position results from a balance of gravitational forces and connective tissue restrictions. The vocal tasks involved sustaining the vowel /a/ at low, high, and most comfortable effort levels (MCE) at the following frequencies: 90, 100, 150, 200, 250, 300, 350, and 400 Hz. Several subjects were unable to produce one or the other frequency extreme. To assess reliability of VLP, each subject repeated six frequencies at the most comfortable effort level. The frequencies to be sustained were given vocally to the subjects by the experimenter, who matched the output of a signal generator (Hewlett-Packard, Model 3312A.)

**Data Analysis**

The film record of each subject's performance was projected on a glass tablet 14" square using a variable speed 16mm projector at 4 frames/sec. The glass tablet was a portion of a Graf-Pen GP-2 sonic digitizer. This instrument utilizes a pen-like device with a stylus that the experimenter places on the film image of the subject's anterior thyroid prominence, which is tracked manually throughout the task. As each film frame is projected, the computer (PDP-12) signals the digitizer to emit a
spark at the stylus tip, the sound of which is picked up by strip microphones positioned at right angles to each other. From the differential arrival of the sound at the two microphones, the unit calculated the stylus location and stored the value. Thus a series of VLP measures (approximately 160 points) were obtained for each task. VLP was expressed as the deviation in millimeters above or below the resting physiologic level. For each vocalization task, VLP was measured during a period of relative stability 400 ms after phonation onset.

RESULTS

Frequency

Figure 1 shows each subject's VLP plotted against phonation frequency. Values produced by one subject are connected with solid lines. Though the VLP behavior is quite variable across frequencies, it is clear that all but subject #1 lowered their larynx while performing the tasks. The mean lowering was 11.3 mm below the resting position, and the standard deviation was 4.8 mm, with a range of intersubject values (lowest-highest) of 14.5 mm.

Figure 1. VLP (in mm) measured on eight subjects during phonation at various frequencies. Data points connected by lines are from the same subject. The zero line corresponds to each subject's physiologic resting position.

No simple frequency dependence is evident from Figure 1, but its general appearance suggests that each subject might have a characteristic average "working" VLP; that is, a typical laryngeal position for phonation of whatever type, that might obscure a relationship between VLP and frequency. Therefore, each subject's average VLP was subtracted from his VLP data and displayed with respect to frequency in Figure 2. This plot indicates that even when the data scatter is reduced by "normalizing" VLP, there is still no significant VLP dependence on phonation frequency.

Effort

Figure 2. VLP plotted against frequency (discrete phonations at MCE). Each point denotes the average of eight subjects; the vertical bars denote the standard deviation. The zero line corresponds to each subject's average "working" VLP (see text).

Figure 3 shows the change in VLP when comparing high effort to low effort tasks at the same frequency. Lines between data points connect values from the same subject. Six of eight subjects exhibited a clear tendency to lower their

Figure 3. Change in VLP when comparing high effort to low effort phonation (discrete tasks). A point below the zero line means that the larynx was lower during high effort phonation. Data points connected by lines are from the same subject.
larynx with increased effort. The average decrease in VLP for all subjects for high effort phonation was 4.7 mm, while the six indicated subjects had a mean decrease in VLP of 6.2 mm. Comparison of either effort extreme with MCE showed a similar trend, but of lesser magnitude. VLP as a function of effort shows no dependence on vocal frequency.

Intrasubject Reliability

Most of the MCE frequency tasks were repeated by each subject. The difference between the first and second VLP for each frequency duplicated is shown in Figure 4. The small number of data points prevent a valid statistical analysis, but examination of Figure 4 reveals that only four duplications had the same precise (+/−0.5 mm) VLP level. The range of VLP difference values was from 0–17 mm with a mean difference of 4.5 mm. No order effect was apparent—there were as many instances of VLP elevation as lowering.

![Figure 4](image)

Figure 4. Differences in VLP upon repetition of frequency tasks.

**DISCUSSION**

The finding of no VLP dependence on vocal frequency duplicates the findings previously reported (Shipp and Iezdebski, 1975). Given that those data were derived from vocalizations by fewer subjects, most of whom were students, the similarity in findings emphasizes the basic laryngeal posturing for vocalization by male singers with classical training. Whether this low laryngeal position is taught directly or results from other pedagogical techniques is not known. Informal discussions with subjects in both studies indicated experiences of both types, but their VLP behaviors were essentially the same.

The strongest evidence for the lack of a direct relationship between VLP and voice frequency during discrete trials is the large intrasubject VLP variability for replicated trials. Only one subject at one frequency point duplicated the exact VLP for the same voice frequency repetition.

The finding of a close relationship between VLP and vocal effort in 2/3 of the subjects may be explained most readily as a mechanical consequence of other structural adjustments along the vocal tract that are intended to produce more effortful phonation. For example, it seems reasonable that a singer would inspire more air prior to a high effort production than for a low one. Since all respiratory structures from diaphragm to larynx are directly attached, a lowering of the diaphragm for air intake to high volume would tend to lower everything in the tracheobronchial tree, including the larynx. Further, effortful phonation is usually accompanied by greater mouth opening from a lowered mandible, which, through the mandible-hyoid bone-laryngeal interconnection would allow the larynx to lower somewhat. Hence it seems that laryngeal lowering for high vs. low effort phonation is a passive movement in response to other mechanical events closely tied to high effort phonation.

What, then, could be the explanation for singers’ low laryngeal position? No data have surfaced to contradict the assumption made previously (Shipp, 1977) that singers’ low laryngeal position for phonation regardless of phonation frequency is a voluntary effort to influence positively the quality of voice produced. As shown by Sundberg (1974), lowering the larynx not only unfolds supraglottal resonators (vibricle, eveygloglottic space), but also establishes a size ratio between the laryngeal vestibule and pharyngeal cavity that favors the development of the “singer’s formant,” or “ring” in the voice. Moreover, a lower larynx facilitates vertical phase shifting (rolling, undulating) vocal fold vibration by reducing the vertical softening of the vocal fold margins. This mode of vibration generates a vocal tone rich in partials.

Further studies factoring out the effects of such variables as continuous frequency and/or effort phonation, jaw position, and lung volume level must be conducted to complete our understanding of singers’ VLP behavior.

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Thomas Shipp
Speech Research Laboratory
VA Medical Center
San Francisco, CA 94121