Electroglottographic Analysis of Actresses and Nonactresses' Voices in Different Levels of Intensity

*Suely Master, †Marco Guzman, ‡Helder Carlos de Miranda, and §Adam Lloyd, *‡*São Paulo, Brazil,* †*Santiago, Chile, and* §*Orlando, Florida*

Summary: Background. Previous studies with long-term average spectrum (LTAS) showed the importance of the glottal source for understanding the projected voices of actresses. In this study, electroglottographic (EGG) analysis was used to investigate the contribution of the glottal source to the projected voice, comparing actresses and nonactresses' voices, in different levels of intensity.

Method. Thirty actresses and 30 nonactresses sustained vowels in habitual, moderate, and loud intensity levels. The EGG variables were contact quotient (CQ), closing quotient (QCQ), and opening quotient (QOQ). Other variables were sound pressure level (SPL) and fundamental frequency (F_0). A KayPENTAX EGG was used. Variables were inputted in a general linear model.

Results/Discussion. Actresses showed significantly higher values for SPL, in all levels, and both groups increased SPL significantly while changing from habitual to moderate and further to loud. There were no significant differences between groups for EGG quotients. There were significant differences between the levels only for F_0 and CQ for both groups.

Conclusion. SPL was significantly higher among actresses in all intensity levels, but in the EGG analysis, no differences were found. This apparently weak contribution of the glottal source in the supposedly projected voices of actresses, contrary to previous LTAS studies, might be because of a higher subglottal pressure or perhaps greater vocal tract contribution in SPL. Results from the present study suggest that trained subjects did not produce a significant higher SPL than untrained individuals by increasing the cost in terms of higher vocal fold collision and hence more impact stress. Future researches should explore the difference between trained and nontrained voices by aerodynamic measurements to evaluate the relationship between physiologic findings and the acoustic and EGG data. Moreover, further studies should consider both types of vocal tasks, sustained vowel and running speech, for both EGG and LTAS analysis.

Key Words: Actresses–Actors–EGG–Sound level–Contact quotient–Closing quotient–Opening quotient.

INTRODUCTION

Several perceptual and acoustics differences between the actor's voice and the regular speaking voice have been reported. Most of these vocal characteristics are related to the performance requirements that actors and actresses need to accomplish during acting. They are needed for effective vocal projection, having the ability to produce a voice that is loud enough to hear in various performance spaces while using minimum vocal effort.[1] Moreover, other vocal features such as the mean pitch, intonation, and timbre features are also changed during performance to express different emotions to play a specific character.[2–4]

Researchers have tried to objectively describe what a good voice quality in performers is. One of the most important attributes that characterizes a well trained and, hence, a good actor's voice quality, is the so-called "resonant voice." According to Titze,[5] resonant voice is defined as a voice production that is both easy to produce and vibrant in the facial tissues, particularly on the alveolar ridge and adjacent facial plates. The perception of "ease" and "vibrancy" belongs primarily to the person producing the sound, but listeners can have similar perceptions. Moreover, it has been described as a voice that projects well[6] and is characterized by large harmonic content in the high part of the spectrum.[5] Therefore, resonant voice should be considered a goal in voice training for performers, and in fact it has been an important component in vocal pedagogy for a long time.

Although this concept is commonly used among voice trainers and professional voice users, the biomechanics, aerodynamics, and acoustic nature of resonant voice are not completely understood. Resonant voice could be the result of three main factors: (1) vocal tract changes, (2) changes of laryngeal adduction, and (3) an interaction between the voice source and filter.

Vocal tract changes cause the formant frequencies to shift. These changes in the vocal tract formants might produce a voice that projects well and has good harmonic content. In this regard, the "actor's" or "speaker's formant" has been widely linked to the concept of resonant voice in performers. Leino,[7] using a long-term average spectrum, found a peak around 3.5 kHz as a differentiating feature of good voice quality and named this peak the "actor's formant." The author also reported that poor voice quality was different from good voice quality by the steepest spectral slope. Leino[7] suggested that the spectral slope declination has a perceptual relevance in the evaluation of voice quality. A gentle spectral slope and a prominent peak at 3 and 4 kHz seem to be some of the features often characterizing a good male speaking voice. Nolan[8] suggested that the

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From the *Department of Performing Arts, UNESP-Univ Estadual Paulista, Campus São Paulo, São Paulo, Brazil; †School of Communication Sciences, University of Chile, Santiago, Chile; ‡UNESP-Univ Estadual Paulista, Campus São Paulo, São Paulo, Brazil; and the §Voice Care Center, Ear, Nose, Throat, and Plastic Surgery Associates, Orlando, Florida.

Address correspondence and reprint requests to Suely Master, Department of Performing Arts, UNESP-Univ Estadual Paulista, Campus São Paulo, R. Dr. Bento Teobaldo Ferraz 271, CEP 01140-070, São Paulo, Brazil. E-mail: suely.master@gmail.com

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actor's formant is accomplished in the same way as the singer's formant according to Sundberg.[9] That is, when the cross-sectional area of the epilaryngeal tube opening is sufficiently different from the cross-sectional area of the low pharynx. In a study designed to investigate the origin of the "speaker's formant," it was found that after voice exercises were performed by a professional male actor, the strong peak at 3.5 kHz was present in all vowels and it was mainly formed by the clustering of F_4 and F_5. The results of modeling from the same study suggested that a speaker's formant could be obtained through a slight narrowing of the epilaryngeal region, widening of the back of the mouth cavity, and narrowing of the front part of it.[10]

This acoustic feature that characterizes a good voice has not only been observed in performers but also in ordinary speakers with good voice quality. Leino,[11] in a study conducted to seek the voice quality of normal vocally untrained male university students, reported that the good voices differed from the poor voices by having a more prominent peak at 3–4 kHz.

The actor's formant would help the production of effective vocal projection during acting. This is essential for performers, making it possible for their voices to be heard by the listeners with maximum intelligibility and minimum vocal effort. In this regard, Pinczower and Oates[1] pointed out that when comparing the intensity difference between the higher (2–4 kHz) and lower (0–2 kHz) regions of the spectrum in voice samples from the maximal projected condition, LTAS demonstrated increased acoustic energy in the higher region of the spectrum. This characteristic was not as evident in the comfortable projected condition. These outcomes offered some preliminary support for the existence of an actor's formant (prominent peak in the upper part of the spectrum) during maximal projection. Using acoustic and perceptual analyses, Master et al[12] compared male actors and nonactors. Outcomes showed that actor's voices were perceived as louder and better projected than nonactor's voices, even though sound pressure level (SPL) did not differ between the groups. This could suggest that not only SPL influence the perception of voice projection. In fact, they found a stronger peak at about 3.4 kHz (actor's formant) in actors, which might have affected the perception of projected voice. Furthermore, the alpha ratio was also greater in the actors (less step spectral tilt). Master et al,[13] in a similar study performed with actresses, did not find statistical significant differences in the spectral slope declination assessed with alpha ratio. Additionally, there was no evidence of an actor's formant cluster in the actresses' voices. Authors concluded that voice projection for this group of actresses seemed to be mainly a result of a laryngeal setting instead of vocal tract resonances.

A second factor that would contribute to the production and perception of resonant voice quality is the source-filter interaction. It has been proposed that by narrowing the laryngeal vestibule, producing a narrow anterior constriction or an artificial lengthening of the vocal tract induces an increase in vocal tract impedance, specifically resulting in changes in the inertive reactance.[14,15] This in turn would cause more skewing of the glottal airflow, increasing the energy of the higher frequency harmonics, and producing a richer voice quality. Furthermore, the oscillation threshold pressure is reduced by increased vocal tract inertance.[15] Vocal tract impedance appears to impact at least two components of voice source function: (1) glottal flow pulse and (2) vibrational characteristics of the vocal folds. The acoustic pressures propagating in the vocal tract affect the glottal flow pulse shape and hence the overall harmonic energy in the acoustic output signal. The second component is the mechano-acoustic interaction of the vocal tract pressures, which influences the vibrational characteristics of the vocal folds.[14] All these characteristics produce a more perceptually resonant voice quality.

In a study to test the hypothesis that resonant voice is produced by narrowing the laryngeal vestibule and is characterized by first formant tuning and more ample harmonics, Smith et al[16] reported that spectral analysis showed that first formant tuning was exhibited during resonant voice productions and that the degree of harmonic energy in the range of 2.0–3.5 kHz was related to voice quality: nonresonant voice had the least amount of energy in this range, a resonant-relaxed voice had more energy, and a resonant-bright voice had the greatest amount of energy. Videoendoscopic data indicated that laryngeal vestibule constriction was not consistently associated with resonant voice production.

Not only vocal tract changes and the source-filter interaction can contribute to a resonant voice quality but also a specific laryngeal configuration (glottal adduction) is an important factor by itself. A barely abducted, or a barely adducted, laryngeal configuration maybe favorable to produce a resonant voice.[17] Specifically, barely abducted vocal folds have been proposed to produce maximum "vocal economy" defined as the maximized ratio between voice output (dB) and intraglottal impact stress (kPa) under constant subglottic pressure and frequency conditions.[18] Previous studies indicated that vocally, healthy, trained subjects produced resonant voice with barely abducted, or barely adducted, vocal folds, and thus a configuration within the range of those producing maximum vocal economy.[19] Verdolini et al[17] conducted a study with vocally trained subjects to observe whether the electroglottographic (EGG) contact quotient (CQ) could be used to noninvasively distinguish resonant from other voice types. Results showed that the average contact quotient distinguished resonant from pressed voice but inconsistently distinguished resonant from breathy voice. Furthermore, no significant difference was found in CQ during resonant and normal productions. In a more recent study, Grillo and Verdolini[20] attempted to determine if pressed, normal, resonant, and breathy voice qualities can be distinguished from one another by laryngeal resistance and/or vocal efficiency in vocally trained subjects. Findings indicated that laryngeal resistance but not vocal efficiency reliably distinguished pressed, normal, and breathy voice. Neither of the measures, however, distinguished normal from resonant voice, which were distinguished perceptually.

Peterson et al[19] assessed several EGG and aerodynamic parameters during pressed, normal, resonant, and breathy vocal productions in vocally trained participants. The results indicate that for the vowel /a/ and /i/ (not for /u/), the contact quotient provides a sensitive tool for distinguishing the voice types in