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REAL-TIME BIOFEEDBACK and SPEECH AERODYNAMICS: A PRELIMINARY STUDY of LARYNGEAL MOTOR CONTROL

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Abstract: **REAL-TIME BIOFEEDBACK and SPEECH AERODYNAMICS: A PRELIMINARY STUDY of LARYNGEAL MOTOR CONTROL**

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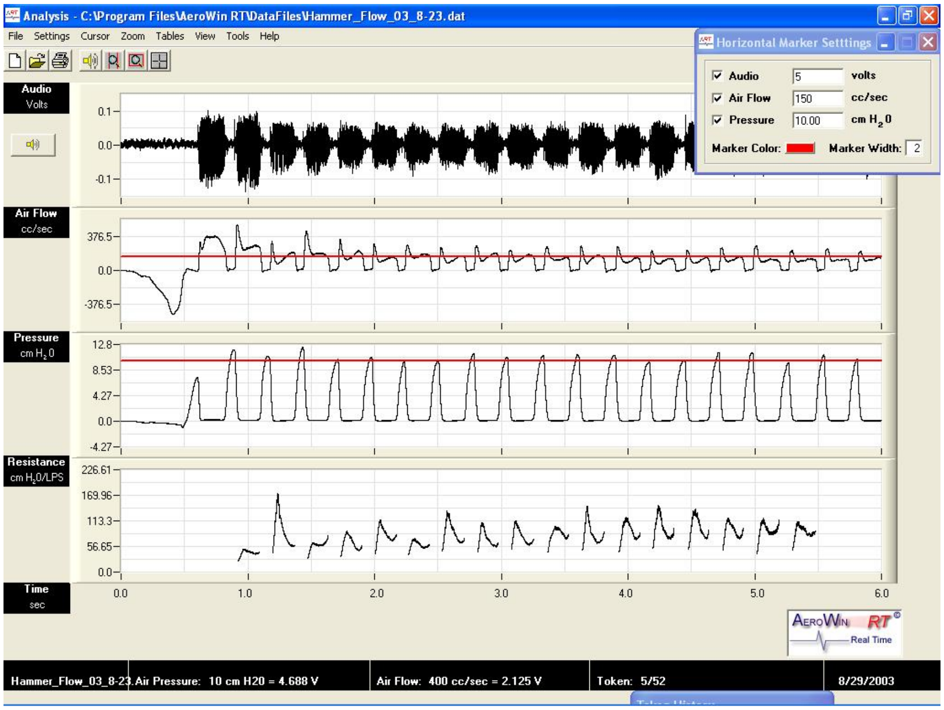
This study represents findings from a preliminary investigation of laryngeal motor control using speech aerodynamics with real-time graphic display of estimated subglottal air pressure (P_s) and translaryngeal airflow, and targeted values of these measures. Recent development of AEROWIN 2003 has made possible systematic study of these separate parameters of laryngeal motor control. This preliminary study examined resultant sound pressure level (SPL) under conditions of constant fundamental frequency (F_0) and P_s while systematically varying mean translaryngeal airflow (V-Flow). Initial findings indicate a curvilinear relationship between V-Flow and SPL. Relatively stable values of SPL were maintained over a considerable range of V-Flow values. While further experiments are to follow, these preliminary data support the role of P_s in control of SPL over a wide range of V-Flow values, and have implications for understanding normal laryngeal control and therapeutic approaches to voice rehabilitation.

Summary

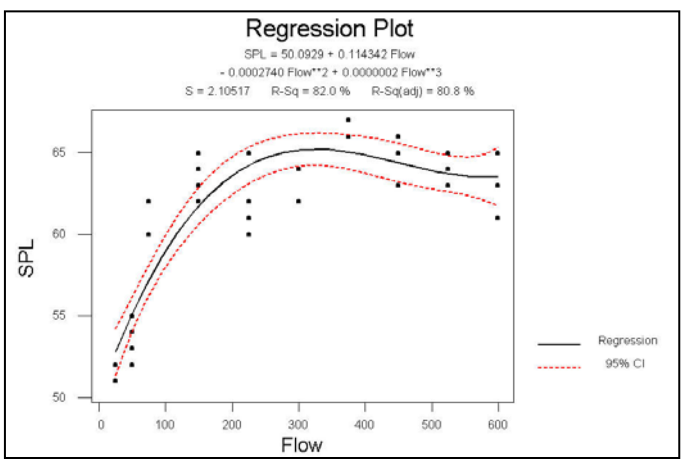
Laryngeal aerodynamics enables the examiner to assess critical features of vocal tract function including subglottal pressure (Ps), translaryngeal airflow, and laryngeal airway resistance (LR). Measures of laryngeal aerodynamics are known to vary systematically with vocal fundamental frequency (F_0) and sound pressure level (SPL). A few investigations have examined the relationship between transglottal airflow, P_s and F_0 with SPL (Holmberg, Hillman & Perkell, 1988; Holmberg, Hillman & Perkell, 1989; Netsell, Lotz, DuChane, & Barlow, 1991; Sundberg, 1995; Sundberg, Scherer & Titze, 1991). Very little research has examined the relationship between transglottal airflow and SPL while holding fundamental frequency and P_s constant. The goal of this preliminary study is to examine the relationship between changes in transglottal airflow and SPL while holding F_0 and P_s constant.

N = 1 subject (S1) served in this preliminary investigation. P_s and translaryngeal airflow were transduced and laryngeal airway resistance (LR) was calculated based on techniques described previously (Barlow, Suing & Andreatta, 1999; Smitheran & Hixon, 1981). This work was completed using the new application AEROWIN *RT* (Vantipalli & Barlow, 2003). AEROWIN *RT* provides 16-bit acquisition and real-time graphical display of acoustic, airflow, pressure signals and calculated resistance values. AEROWIN *RT* also includes a Horizontal Cursor to mark selected targets for acoustic, airflow, pressure or resistance. S1 was trained to repeat the consonant-vowel syllable /pa/ four times per second at a constant, target F_0 of 120 Hz at a constant P_s of 10 cmH_20 at seven mean trans-laryngeal airflow during phonation (V-Flow) rates (75, 150, 225, 300, 375, 450 & 525 cc/sec). S1 monitored P_s and the V-Flow using real-time graphic display of signals.

Horizontal cursors were placed at a P_s of 10 cm H_20 and at each of the target V-Flow levels. The signals with horizontal cursors were displayed on an LCD monitor as shown to the left. Resultant SPL (dB(A)) was hand recorded on-line from a sound level meter constantly positioned 22 mm from the subject's lips. S1 produced five sets of /pa/ at each of seven V-Flow rates for a total of thirty-five sets.



The relationship between V-Flow and SPL was plotted using a cubic regression modeled by the equation: SPL = 50.0929 + 0.114342 Flow - 0.0002740 $Flow^2$ + 0.0000002 $Flow^3$, S = 2.10517, R^2 = 82.0 %, R^2 (adj) = 80.8 %. Notable is the relative stability of SPL over a considerable range of V-Flow values. These preliminary findings support the role of P_s in control of SPL over a range of V-Flow rates. Clinical voice literature has implicated increased translaryngeal airflow as a potential treatment goal



indicating that adequate voice SPL can be produced under conditions of decreased laryngeal effort (Colton & Casper, 1996). These data also support this notion.

Further extension of this preliminary work will include refining the tasks and instructions to increase ease of target monitoring and reduce the cognitive load for participating subjects. Measures will also be made at additional P_s and F_0 levels to examine the relationship of V-Flow and SPL over a range of respiratory drive and laryngeal configurations. Once these tasks are refined, it is anticipated that additional imaging measures of laryngeal stroboscopy will be made at selected levels of P_s and V-Flow to examine assumptions made regarding laryngeal configuration under these conditions.

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