MOTOR SPEECH DISORDERS Track Aug 2003

-COVER PAGE-

AEROWIN RT: CLINCAL APPLICATION for MOTOR SPEECH DISORDERS

Rajesh Vantipalli rajeshv@ku.edu 785-864-0650

Steven Barlow smbarlow@ku.edu 785-864-0632
785-864-4403 FAX

Communication Neuroscience Laboratories
1000 Sunnyside Avenue
DOLE 3001
University of Kansas
Lawrence, KANSAS 66045-7555

PRESENTATION FORMAT: Oral preferred ('live' data acquisition demo proposed), will accept either

Keywords: pressure, flow, digital signal processing

Audiovisual: LCD Projector, PC with Power Point, Audio Output for Sound Files.

<u>Abstract:</u> AEROWIN RT: CLINICAL APPLICATION for MOTOR SPEECH DISORDERS

Rajesh Vantipalli & Steven M. Barlow
Communication Neuroscience Laboratories
University of Kansas

A new clinical tool designated as AEROWIN *RT* has been developed to provide the clinician with a 6-minute automated aerodynamic measurement system to quantitatively assess vocal tract function during speech in a variety of patient populations, including children with orofacial clefts, and throughout the lifespan in patients with motor speech disorders. Real time display, stimulus control, and digital signal processing and automated report generation provide the speech pathologist with rapid, calibrated aerodynamic data on nasal cavity resistance, velopharyngeal resistance, and laryngeal airway resistance during speech and nonspeech activities. Moreover, the same technology can be used to develop customized treatment protocols using biofeedback. A wide range of time domain analyses completed on 16-bit resolution acoustic, air pressure, and air flow signals during patient evaluation provide the clinician with a new tool for exploring mechanisms of plasticity and sensorimotor reorganization of the vocal tract so evident in dysarthric patients. Several examples of the automated speech aerodynamic analyses will be shown from dysarthric patients with advanced forms of Parkinson's disease undergoing bilateral subthalamic deep brain stimulator implantation.

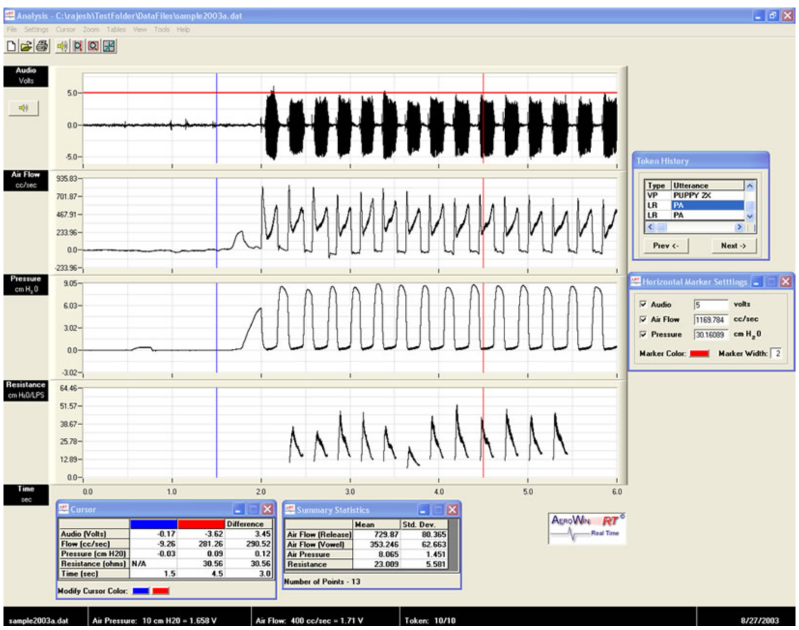
Introduction.

The human vocal tract is composed of several articulatory structures including the chest wall, larynx, velopharynx, and anterior vocal tract. These represent anatomically and neurophysiologically diverse muscle subsystems which exert their actions through precise adjustments in selection, sequencing and timing to effect regulatory control on breath stream dynamics, including air pressure and air flow during speech. An issue of special importance to speech pathologists concerns the relations between vocal tract aerodynamics, speech production, and speech intelligibility. Damage to brain structures important to the perception and action of speech motor control invariably alter the aerodynamics of voice and speech production through reorganization and plasticity, often with little noticeable affect on speech intelligibility (Barlow, Iacono, Paseman, Biswas, & D'Antonio, 1998; Barlow, Hammer, Seibel, Pahwa, 2003). A quantitative tool or method to rapidly provide standardized measures of laryngeal and velopharyngeal aerodynamics during speech and vocalization would be useful to the clinician in this regard.

In June of 2003, a special NIDCD Workshop on Motor Speech Disorders was held in Washington, DC to consider the current state of clinical practice for motor speech disorders. It was noted that clinical measurement of speech aerodynamics has been limited and primarily to research laboratory settings due in large part to the need for specialized analog and digital instrumentation, and time intensive off-line analysis tools. These factors have historically precluded such application in the clinical setting.

Workshop participants, representing major clinical and research centers world-wide acknowledged that speech intelligibility and auditory-perceptual measures have been the mainstay of clinical motor speech evaluations for several decades, but are clearly limited, especially in cases where vocal tract reorganization presents with near 100% intelligibility. It was further noted that the majority of patients with movement disorders affecting the limbs, trunk, and/or craniofacial muscle systems utilize mechanisms of neuroplasticity and reorganization over the course of brain disease progression or response to injury to achieve functional motor output. Auditory-perceptual and intelligibility measures of speech often result in the clinical assessment of '**within normal limits**,' in spite of the fact that physiological studies on the same patient reveal that vocal tract muscle systems are using compensatory mechanisms to offset one or more impairment vocal tract components which may be functioning well beyond an expected operating range. In addition to several other initiatives for future work, the NIDCD Workshop on Motor Speech Disorders concluded that speech intelligibility tests should be augmented with high-speed, standardized physiological assessment tools that can be used in the clinic, not only for diagnostics, but to serve a rehabilitative role. The charge to the profession is to identify salient measures that benefit those individuals with dysarthria. These tools should be real-time acquisition and display, use standard calibration methods, and offer real-time analysis and report generation.

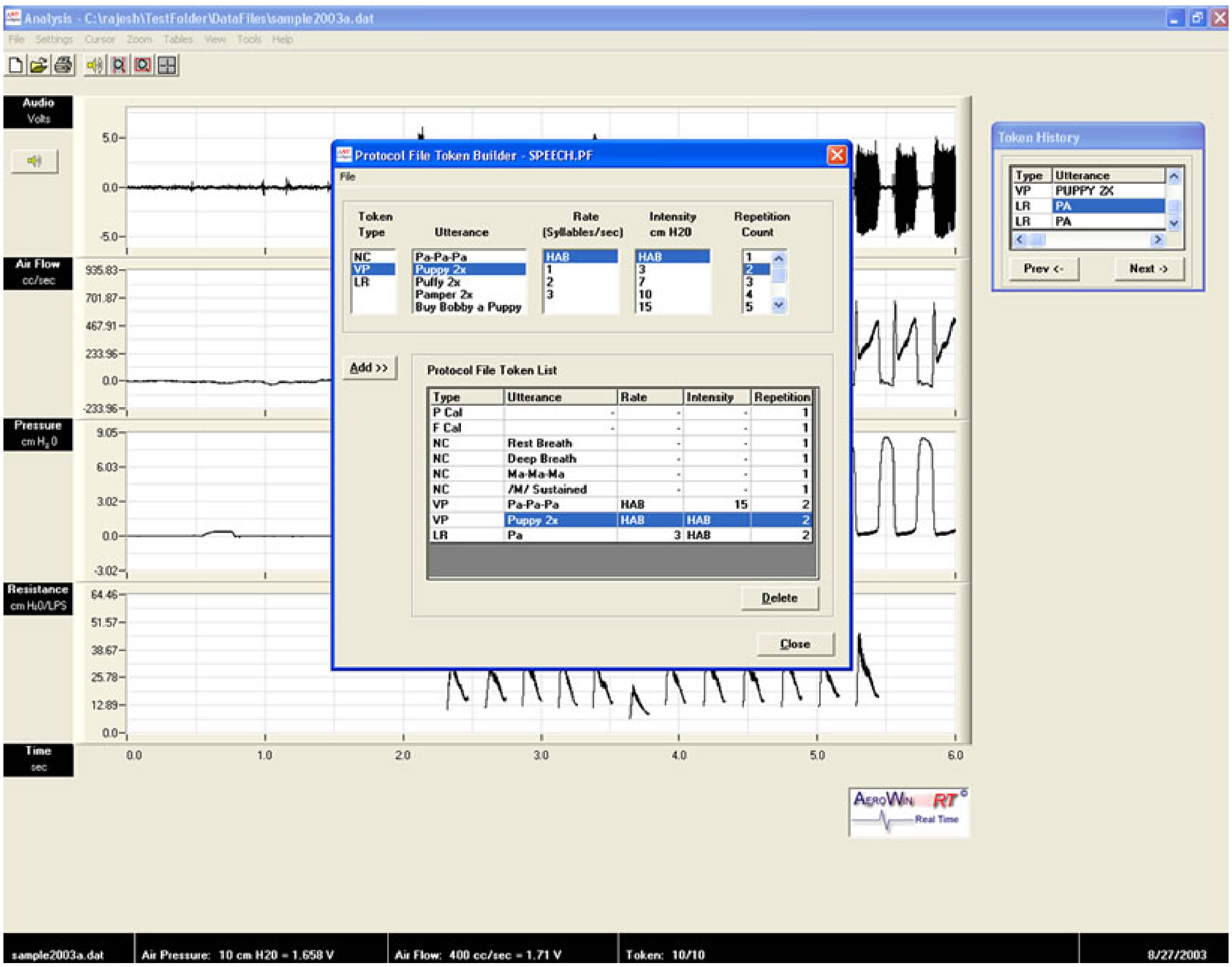
Thus, the objective of the current paper is to detail the implementation of a real-time speech aerodynamics recording and analysis system developed in the Communication Neuroscience Laboratories that provides automated measurements of air pressures, flow, and



voice, along with on-line calculations of nasal cavity, velopharyngeal, and laryngeal airway resistance (Smitheran & Hixon, 1981). Moreover, the real time display and digital signal processing provide the patient and clinician with tracking performance on either air flow and/or air pressure (intraoral air pressure) during speech for biofeedback applications.

Depending on the presentation format selected by the review committee, we would like to supplement the narrative of this paper with a '**live demonstration**' of a 4-minute speech aerodynamic session to reinforce the notion that it is now possible to conduct non-invasive aerodynamic assessments of the human vocal tract during speech in a manner conducive to the time and resource demands of a motor speech disorders clinic.

The new system, known as **AEROWIN *RT***, was designed to provide high fidelity multi-channel aerodynamic signal acquisition and stimulus control using the National Instruments E-series 16-bit I/O cards configured for the PCI, PC, or USB bus interface on Pentium microprocessors (MS WIN98, 2000, NT, XP). The graphical user interface provides real time display of patient-generated and target generated pressure and flow signals. Clinical speech aerodynamic test protocols can be designed by the clinician/user in a few minutes using the Protocol File Builder. This graphical utility allows the user to select channel assignments, calibration events, and speech tasks according to production rate and target pressure levels, and number of test trials or repetitions. After the initial configuration, an individual speech



aerodynamics test protocol file can be used repeatedly among many patients. A variety of test protocols can be created and stored for various types of aerodynamics tests customized for different patient populations, or age ranges, or by vocal tract system of interest. Transducer calibration information for each channel is retained in a single 6-second data block. A comprehensive set of time domain analyses are completed automatically on calibrated and scaled waveforms and available to the clinician and patient immediately after recording in tabular summary in report form. With this new technology, it is now possible to complete a detailed clinical assessment of speech aerodynamics in 4 to 6 minutes. System design is conducive to standardized calibration and DSP methods and accommodating for patients beginning around the age of 4 years and across the lifespan.

In summary, automated physiological studies of speech aerodynamics in individuals with dysarthria is expected to aid the clinician in the diagnosis and management of this complex and adaptive neurologically based speech disorder.

Cited Literature

Barlow, S.M., Iacono, R.P., Paseman, L.A., Biswas, A., & D'Antonio, L.D. (1998). The effects of experimental posteroventral pallidotomy on force and speech aerodynamics in Parkinson's disease. In M.P. Cannito, K.M. Yorkston, & D.R. Beukelman (Eds.). *Speech Motor Control* (pp. 117-156). Paul H. Brookes Publishing Company, Baltimore, MD.

Barlow, S.M., Hammer, M.J., Pahwa, R., & Seibel, L. (2003). The effects of subthalamic nucleus deep brain stimulation on vocal tract dynamics in Parkinson's disease. 55th *Abstracts of the Annual Meeting of the American Academy of Neurology*, Hawaii, 2146.

Smitheran JR, & Hixon TJ. (1981). A clinical method for estimating laryngeal airway resistance during vowel production. *Journal of Speech and Hearing Disorders*. 46(2):138-46.