MOTOR SPEECH DISORDERS Track Aug 2003

-COVER PAGE-

FORCEWIN RT: CLINICAL APPLICATION for MOTOR SPEECH DISORDERS

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

Keywords: force, orofacial, digital signal processing

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

<u>Abstract:</u> FORCEWIN RT: CLINCAL APPLICATION for MOTOR SPEECH DISORDERS

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A new clinical tool designated as FORCEWIN *RT* was designed to routinely perform automated biomechanical measures of active force dynamics among orofacial muscle subsystems pertinent to the clinical evaluation of patients with motor speech disorders. Real time display, stimulus control, linked sequencing of stimulus events, and digital signal processing provide the patient and clinician with tracking performance on force recruitment, hold phase, decruitment, and tetanic output for the upper lip, lower lip, jaw, tongue, and upper limb. A wide range of time and frequency domain analyses completed on 16-bit resolution force signals during patient evaluation provide the clinician with a new tool for exploring mechanisms of plasticity and sensorimotor reorganization presumed to occur in dysarthric patients. Several examples of the orofacial force dynamics analysis will be shown from dysarthric patients with Parkinson's disease.

Introduction.

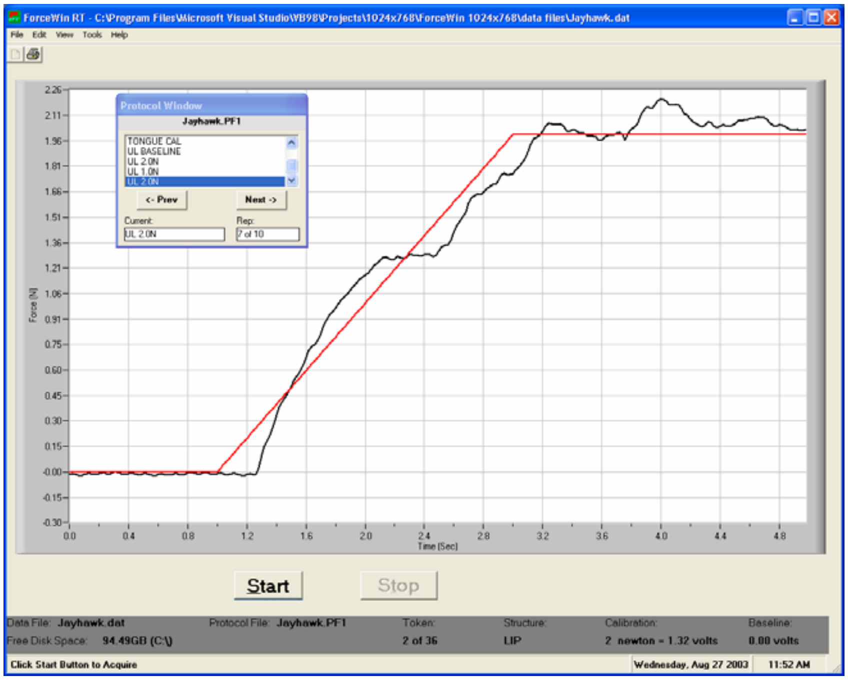
The orofacial mechanism, composed of the lips, tongue, and jaw, represents an anatomically and neurophysiologically diverse collection of muscle subsystems. These structures manifest functional interdependence during motor actions such as swallowing, facial gesturing, and speech. An issue of special importance concerns the relations between the underlying dynamics of orofacial motor control and speech production. Damage to brain structures important to the selection, sequencing, and activation of orofacial muscles may degrade the motor control of speech and reduce intelligibility (Barlow & Abbs, 1986; Barlow, Iacono, Paseman, Biswas, & D'Antonio, 1998). Moreover, the need to assess individual muscle systems of the orofacial complex is motivated by the fact that these structures frequently manifest differential degrees of motor impairment in individuals with lesions of the central nervous system (Hunker, Abbs, & Barlow, 1982; Barlow & Netsell, 1989; Barlow & Burton, 1990; Barlow et al., 1998; Barlow, 1984; Barlow & Abbs, 1984; 1986; Barlow, Hammer, Seibel, Pahwa, 2003).

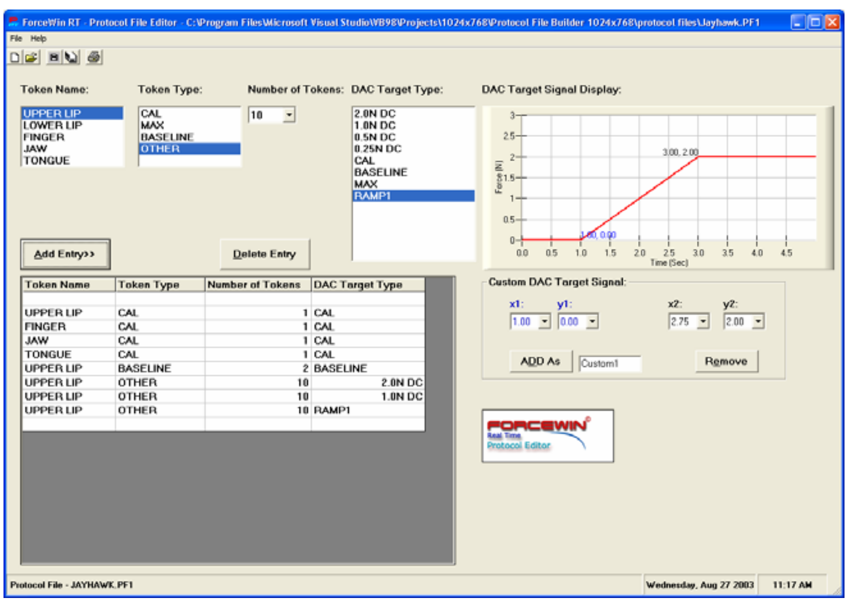
In June of 2003, a special NIDCD Workshop on Motor Speech Disorders was held in Washington, DC to consider the current state of clinical practice for motor speech disorders. It was noted that clinical measurement of muscle performance variables in muscle subsystems of the vocal tract, including the orofacial complex , has been limited 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.

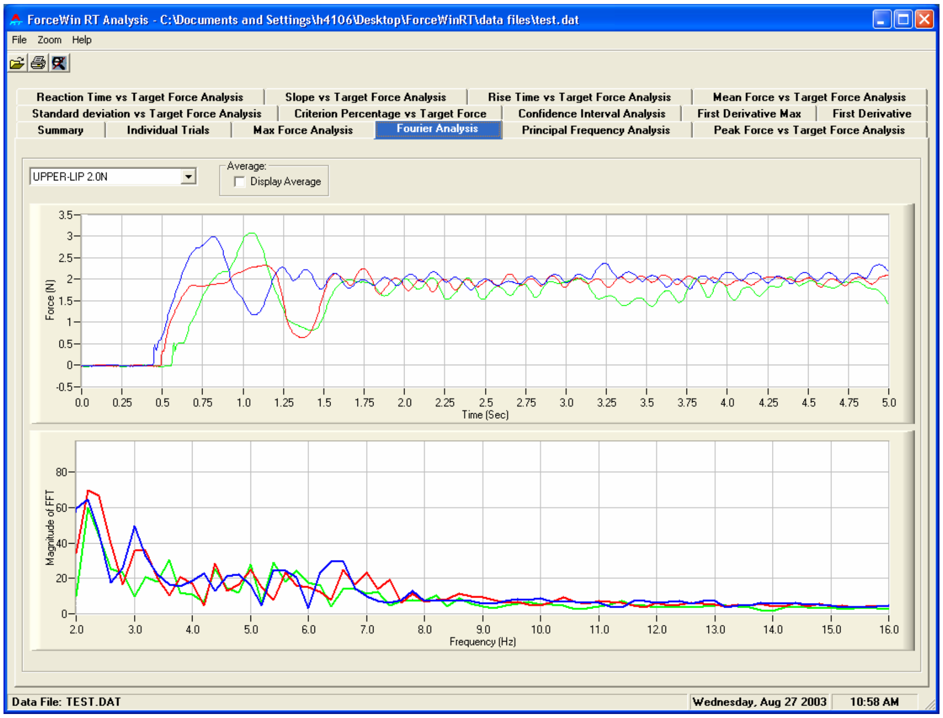
Thus, the objective of the current paper is to detail the implementation of a real-time orofacial biomechanics recording and analysis system developed in the Communication Neuroscience Laboratories that provides automated measurements of active force dynamics throughout the operating range for the upper lip, lower lip, mandible, and tongue. Real time display and digital signal processing provide the patient and clinician with tracking performance on force recruitment, hold phase, decruitment, and tetanic output. 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 an orofacial force recording/analysis to reinforce the notion that it is now possible to conduct physiological assessments of muscle subsystems in a manner conducive to the time and resource demands of a motor speech disorders clinic.

The new system, known as **FORCEWIN *RT***, was designed to provide multi-channel force data 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 force signals. Clinical force test protocols can be setup by the clinician/user in a few minutes using the Protocol File Builder. This utility allows the user to select channel assignments, calibration events, and force target levels and type (static versus dynamic targets including recruitment ramps, decruitment ramps, and arbitrary target waveforms), and number of repetitions within a trial block. Once configured, an individual force test protocol file can be used repeatedly among many patients. A variety of force test protocols can be created and stored for various types of force dynamics tests, including assessments of fine force control, maximum voluntary force, single or multiple muscle systems. Transducer calibration information is retained in a single 5-second data block. The new





FORCEWIN *RT* system also features a randomized test presentation sequencing routine that is initiated by the clinician with a single mouse click. The computer then uses an interstimulus interval randomization table to control the timing and presentation of test stimuli to the patient,



and cycles through the protocol file until the final 5-second test token is completed. A comprehensive set of time and frequency domain analyses (reaction time, 10-90% force rise time, first derivative of force dF/dt, peak force, hold phase standard deviation, mean force during hold phase, criterion percentages within target range, discrete Fourier Transform and tremor analysis) are completed automatically 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 active force dynamics on a single muscle system (i.e., Lower Lip) in less than 10 minutes. System design is conducive to standardized calibration and DSP methods and accommodating for the dysarthric patient.

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

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