SPEECH AND HEARING BIOSCIENCE AND TECHNOLOGY

END OF SUMMER TALKS

DAY 2

WEDNESDAY SEPTEMBER 16, 2009

ABSTRACTS

Simple Inverted Pendulum Feedback Control Model for Posture

Lara Thompson
Advisor: Conrad Wall *III*

The purpose of this research was to construct a simple feedback control model pertaining to quiet-stance postural control. From this model, optimal parameters were determined while minimizing the error between simulated model and experimental quiet-stance center-of-pressure (COP) traces used to describe spontaneous sway. These parameters could be used as a method of forming basis of comparison when characterizing normal and vestibulopathic, patients, for example.

A simple model of human postural control was constructed using Simulink and MATLAB. In this model, the body was treated as a single inverted pendulum of which the appropriate dynamics were determined. Stabilization of a human modeled as an inverted pendulum has been shown to require a component of corrective torque proportional to angular deviation (K_p), a component proportional to the time derivative to angular deviation (K_d), as well as a third component proportional to the integral of the deviation signal (K_i) (Johansson et al., 1988) Thus, the neural controller consisted of three components: a proportional, integrative and derivative (PID) control. Model parameters, such as K_p , K_d , K_i, as well noise gain (K_n), and time delay (t_d) were determined by utilizing a multidimensional optimization procedure which minimized the error between the model-simulated and experimental COP data sets.

The control model could be used for characterizing differences between normal and vestibulopathic human patients, as well as patients using sensory substitution such as the vibrotactile feedback device. However, the main purpose of the model is to be modified, then used in conjunction with my thesis work in the hopes to characterize spontaneous sway of normal rhesus monkeys, monkeys with bilateral vestibular hypofunction (BVH), and BVH-implanted to monkeys to determine the changes for each study group.

An investigation into phonological awareness in children with reading disorders : An fMRI, ERP and MEG study

Sofia Vallila
Advisor: John Gabrieli

The ability to recognize the phonological units of language is critical to the processing of both orthographically and auditorily presented linguistic stimuli and is an integral part of children's early reading development. Atypicality in the development of phonological awareness has been shown to correlate with poor reading skills in children, deficiencies surfacing in beginning readers and children with dyslexia in the form of poor rhyme production, rhyme matching and syllable segmentation [2,3] as well as through reduced temporoparietal activation in functional magnetic resonance imaging (fMRI) studies of phonological processing [1].

The current research project aims to further characterize the phonological deficits that surface in children with dyslexia using three non-invasive imaging techniques: fMRI, electroencephalography (EEG) and magnetoencephalography (MEG). In timed trials, children were instructed to make a button response to indicate whether prime-target pairs rhymed or did not, matched or did not match. These tasks were selected because they highlight the different on-line processing involved in whole word discrimination (matching) compared to complex phonological awareness (rhyming); the rhyming task depending on the segmentation and recognition of phonemic units that is problematic for dyslexics. Lower accuracy is expected from the dyslexic group on the rhyming task with an ERP rhyming effect of different localization,

latency and amplitude. The work carried out this summer consisted largely of study design and programming, piloting and collecting control subjects. Preliminary data show that the tasks elicit the expected ERP wave components with differences arising between the rhyming and matching task as well as between groups. Children have been able to successfully perform the fMRI task, making way for the identification of components related to the neural regions underlying each task.

The role of auditory feedback in the online control of articulatory trajectory and timing in a multi-syllabic utterance

Shanqing Cai
Advisors: Frank H. Guenther, Ph.D., and Joseph S. Perkell, Ph.D, D.M.D.

Previous studies have shown that the speakers compensate for unexpectedly imposed perturbations to auditory feedback of speech by altering their productions (e.g., Purcell and Munhall, 2006, J. Acoust. Soc. Am., 119: 2288-97; Tourville et al., 2008, NeuroImage, 39:1429-43), indicating a role of auditory feedback in the online control of articulation. However, because those studies used prolonged quasi-steady-state vowels in isolated monosyllabic words (e.g., /ɛ/ in "pet"), it is still unclear whether and how auditory feedback is involved in the online control of articulation of multi-syllabic, time-varying utterances under natural speaking rates.

In this study, we aim to address this question through examining the production changes induced by time-varying perturbations to the 2nd formant frequency (F2) trajectory when subjects produce the utterance "I owe you a yo-yo". The perturbations either accelerated or decelerated the F2 transition between /i/ in the 1st word ("I") and /u/ in the 2nd word ("owe"), called acceleration-perturbation (AP) and deceleration-perturbation (DP), respectively. The perturbations occurred in only 1/3 of the trials (50%AP and 50% DP).

Compared to the unperturbed trials, the AP trials showed a shortening in the durations of the word "owe" and earlier initiations of the word "you" following the perturbation, whereas in the DP trials, the durations of the word "owe" was lengthened and the initiations of the word "you" became later. The differences between AP and DP reached statistical significance ($F(1,11)=5.06$, $p<0.05$). In addition to the timing changes, the perturbed trials also showed significant changes in the path of F2 compared to the unperturbed baseline. These F2 path changes were in directions opposite to the perturbations. These observations indicate that both the timing and trajectory of articulation can be altered by utilizing information from auditory feedback with a short latency (~100 ms) during multisyllabic utterances.

(Supported by NIH grant R01DC01925).

Relative Fundamental Frequency in Patients with Vocal Hyperfunction

Gabrielle R. Merchant
Advisor: Robert E. Hillman

Vocal hyperfunction has been defined as "conditions of abuse and/or misuse of the vocal mechanism due to excessive and/or imbalanced muscular forces characterized by excessive laryngeal and paralaryngeal muscular forces" (Hillman et al., 1989) and is associated with a high percentage of voice disorders. Current diagnosis of vocal hyperfunction is dependent upon subjective interpretation of patient history and a battery of various physical assessments, as no current objective measure for detection of vocal hyperfunction has been identified. This work aims to explore one acoustic measurement technique that could potentially be sensitive to phonatory hyperfunction, and could therefore be used to improve clinical assessment and treatment of hyperfunctional voice disorders.

Previous work has shown that there are systematic changes in relative fundamental frequency (RFF) surrounding phonetically governed devoicing (House and Fairbanks, 1953; Stevens, 1977; Ohde, 1984), and that excessive muscle tension can impact these changes (Watson, 1998; Goberman and Blomgren, 2008; Stepp, 2009). As one of the goals of voice therapy is to reduce vocal hyperfunction (and thus the excessive muscle tension), a clear next step in exploring this measure was to compare RFF data from patients with vocal hyperfunction prior to a course of voice therapy and upon completion of voice therapy. Our hypothesis was that after a full course of successful voice therapy, RFF of hyperfunctional patients will migrate toward normal patterns and away from those that reflect hyperfunction.

Pre- and post-therapy measurements of RFF were analyzed and compared in 18 subjects from the Massachusetts General Hospital Center for Laryngeal Surgery and Voice Rehabilitation. Additionally, three of these subjects were tracked over the course of their therapy to provide measurements at time hpoints between the pre and post measure. Results from the statistical analyses of these data will be presented and discussed.