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Using acoustic and kinematic measures to test a neural model of over-reliance on auditory feedback in stuttering

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This line of research uses a computational model of speech production to pose specific hypotheses regarding the neuromotor mechanisms that underlie stuttering. Specifically, we have developed a "neurally impaired" version of the DIVA model, a neural network model of speech acquisition and production [1], which generates articulatory kinematic and acoustic outputs that can then be compared with similar data collected from persons who stutter (PWS). Recently, we used this model to evaluate the hypothesis that stuttering may result in part from impaired readout of feedforward control of speech, which forces PWS to produce speech with a motor strategy that is weighted too much toward auditory feedback control [2]. Such an over-reliance on feedback control could lead to production errors which if large enough, can cause the motor system to "reset" and repeat the current syllable, leading to a sound/syllable repetition. Model simulations were found to show similar patterns to published acoustic data from PWS' fluent speech, and from combined acoustic and articulatory movement data collected from the dysfluent speech of one PWS. Together these results support the hypothesis that sound/syllable repetitions may be due to a bias away from feedforward control and toward feedback control.

More rigorous testing of this hypothesis using a larger PWS subject pool is needed (we would like to consult with the panel on the necessary dataset size). Our research plans include testing at least two specific predictions of the simulations: 1) that PWS are most likely to produce deviant formant frequencies in phonetic events with rapid second formant (F2) transitions (since the rate of acoustic change will exceed the feedback controller's ability to make timely adjustments, see Fig. 1), and 2) that repairs of these production errors constitute sound/syllable repetitions. To this goal, we intend to measure error size and frequency of sound/syllable repetitions on different phonetic events produced by PWS. If our predictions are correct, these measures should be higher on events with rapid F2 transitions. We also plan conducting kinematic analysis. Since PWS are expected to perform too slow on transitions such as /bi/ (Fig. 1(a)), they might also have reduced tongue velocities in these instances (in bilabial contexts, the tongue is the articulator whose position correlates with F2 the most). Moreover, feedback mediated process is likely to exhibit greater number of velocity peaks.

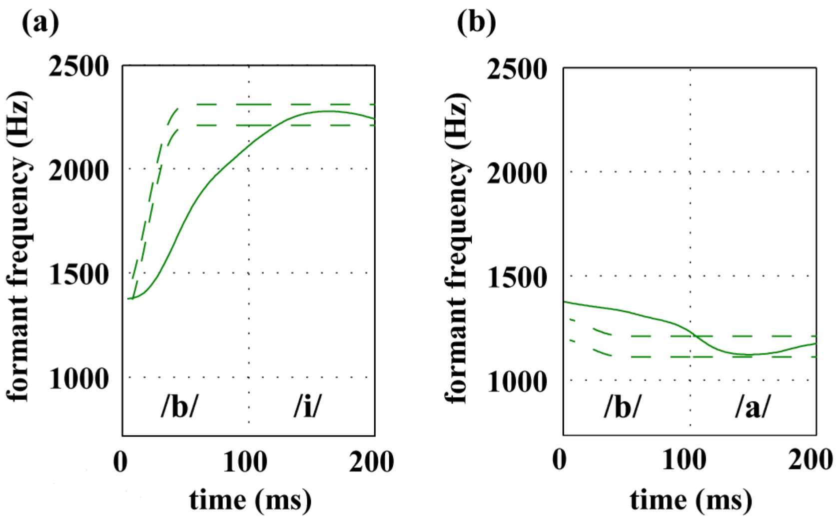

Figure 1. F2 frequencies (solid lines) during productions of (a) /bi/, and (b) /ba/ by a "neurally impaired" version of the DIVA model. Errors, which occur when the F2 frequency falls outside the target region (limited by dashed lines), are greater on /bi/ (the difference between the low F2 locus of the bilabial /b/ and the high F2 frequency of the front vowel /i/ necessitates a larger, faster F2 transition, which challenges the feedback controller).

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[1] Guenther, F.H., Ghosh, S.S. & Tourville, J.A. *Brain Lang.* **96**, 280-301 (2006).

[2] Civier, O., Tasko, S.M. & Guenther, F.H. *J. Fluency Disord.* **35**, 246-279 (2010).

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