Does the extent of acoustic variability prior to an auditory perturbation affect motor learning in speech production?

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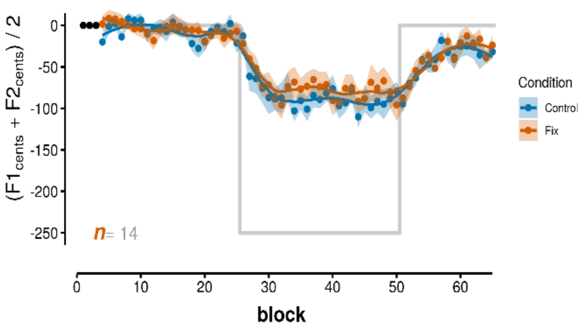
Background: Variability in the execution of both speech and nonspeech movements is ubiquitous. However, it is still unclear how motor variability influences motor learning. On the one hand, recent studies have suggested that variability, interpreted as action exploration, may facilitate motor learning in both reinforcement learning tasks and feedback-based sensorimotor learning (Wu et al. 2014). On the other hand, subsequent studies have disputed a general contribution of variability to motor learning, arguing for a differentiation of variability-related effects depending on the sources of this variability (He et al. 2016). In particular, Therrien et al. (2018) showed that artificially introduced motor variability decreased motor learning in a visuomotor rotation task. Here, we present initial results from a systematic program of research investigating how various types of variability affect auditory-motor learning in speech production. Specifically, in this first study of the series, we experimentally eliminated or exaggerated *sensory* variability (i.e., in the auditory feedback signal) – without accompanying manipulation of motor variability – during the baseline phase *prior to* the introduction of a formant-shift auditory perturbation.

Method: In a mixed-design experiment, subjects were randomly assigned into two groups ("Fixed" and "Extra"). All subjects first participated in a pretest during which they produced the three target words "tech," "tuck," and "talk" with unaltered auditory feedback. Offline, we calculated the subject's median formant frequencies (F1 and F2) for each target word. Subsequently, subjects completed two conditions of a speech auditory-motor adaptation task, one with and one without manipulated auditory feedback during the baseline. Each task included a baseline phase, a perturbation phase, and an after-effect phase, but the feedback manipulation during the baseline phase of the experimental condition differed between groups. Subjects in the Fixed group received auditory feedback with zero variability during the baseline phase of the experimental condition and unaltered feedback during the baseline phase of the control condition. The fixed feedback was created by shifting F1 and F2 for each trial to the subject's median formant values for that same target word calculated from the pretest. Subjects in the Extra group received auditory feedback with artificially exaggerated variability during the baseline phase of the experimental condition and unaltered feedback in the baseline phase of the control condition. The exaggerated variability was created by increasing to 250% the difference between the formant values of each trial and the subject's median formant values for the same target word as produced in the pretest. The order of the two conditions within each group was counterbalanced across subjects. During the perturbation phase of each condition for both groups, subjects heard altered feedback of their current production with both F1 and F2 shifted up by 250 cents. Online formant shifting was accomplished with a modified version of the Audapter software, and feedback was presented through insert earphones.

Results and Discussion: Formant values for each block of three test words, averaged across stimuli, formants, and subjects and converted to cents, are shown in Figure 1 for the Fixed group (left panel) and the Extra group (right panel). With the current sample sizes (*n*=14 for both groups), preliminary results suggest that neither fixing nor exaggerating sensory feedback alone (here manipulating auditory feedback without explicitly manipulating motor variability) affected the extent of auditory-motor learning during the subsequent perturbation exposure. The absence of an effect on learning of these particular manipulations of variability highlight the importance of dissociating, among other factors, motor vs. sensory variability and variability prior to vs. during the perturbation phase.



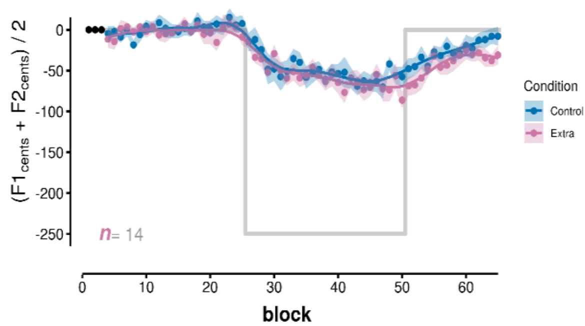


Figure 1: Adaptation during experimental and control conditions for the Fixed group (left) and the Extra group (right).

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