**Boston University** Office of the Provost
Undergraduate Research Opportunities Program

UROP symposium 2024

# Formant perturbations to understand feedback control in speech learning pilot experiment

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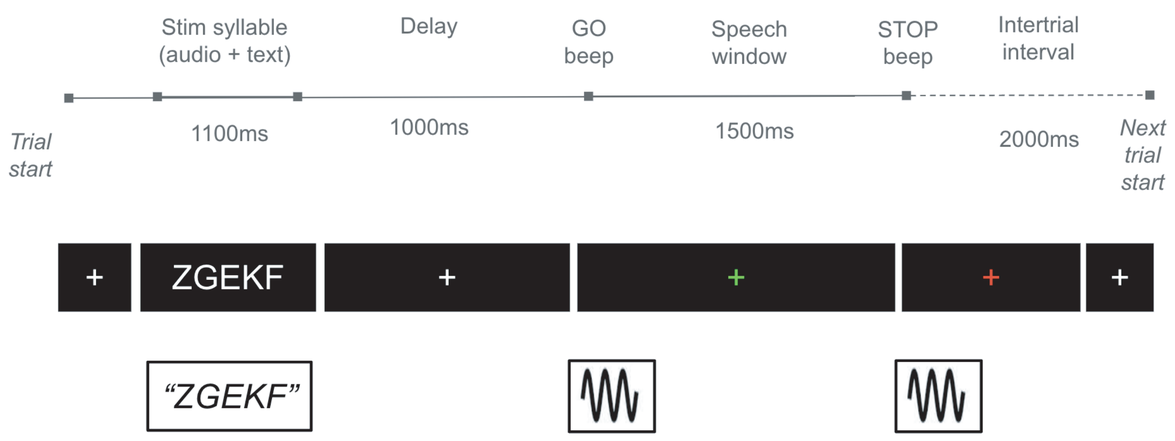
## Abstract

As humans speak, we receive both auditory and somatosensory feedback from our speech. How the relationship between both forms of feedback change as an individual learns to speak is not understood, and is an unresolved question in models of speech production. The hypothesis we are examining is that the early stages of speech motor learning relies on auditory feedback more than somatosensory feedback, relative to the later stages of speech learning. In order to investigate this, adult human subjects were instructed to repeat a series of syllables prompted to them in two sessions. The purpose of the first session (training session), was for the subject to become familiar with the learned syllables. During the second session, the frequency of formant 1 was perturbed either up or down in the subject's ear to change how the syllable sounded. For example, "bed" changed to a higher frequency "b[a]d" or a lower frequency "b[i]d". This is in order to test the subject's response when the auditory and somatosensory feedback no longer match. A perturbation response was observed from the subjects, meaning when presented with the perturbation the subjects adjusted their speech up for down perturbations and adjusted their speech down for up perturbations. This result indicates the subject is adjusting to the perceived audio disconnect. This experiment will be continued with more subjects and analysis to explore if the subjects are responding to the perceived disconnect in feedback systems.

## Methods

- Two sessions on back-to-back days
  - First session (training): nonnative learned and native syllables
    - No perturbation
  - Second session (testing): nonnative (learned and unlearned) and native syllables.
    - perturbation

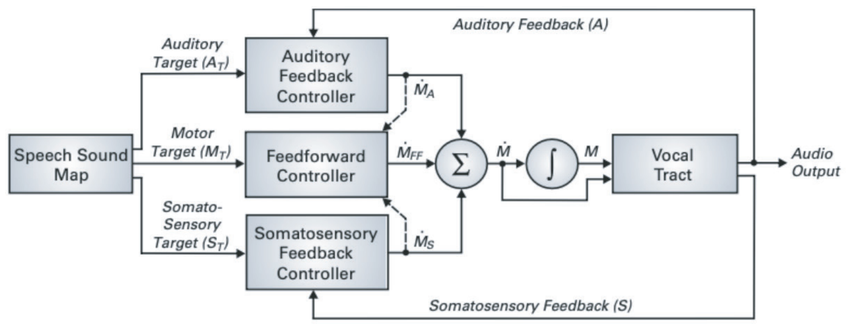



Experiment timecourse

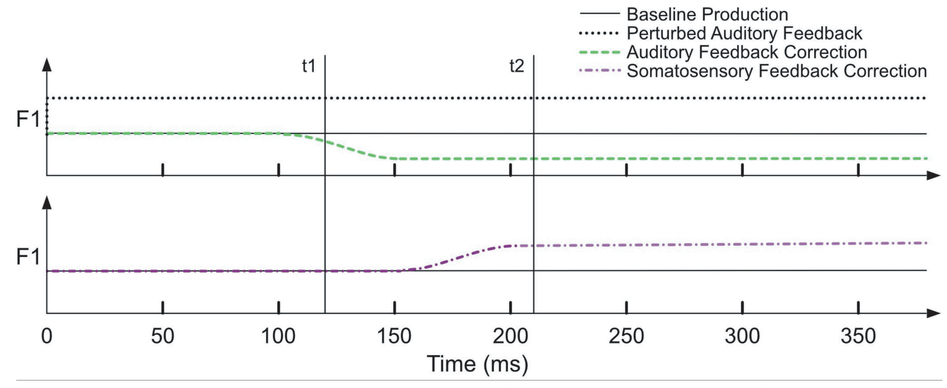

Experimental setup

## Research Goals

The goal of this experiment is to test the hypothesis that the subjects use more auditory feedback while learning new speech motor patterns, and as they learn more they start to use more somatosensory feedback. If this phenomenon is demonstrated, it would look like the subject correcting more to the perturbation when speaking syllables they are unfamiliar with, whereas when they are speaking syllables they are more familiar with, they would correct less to the perturbation.




DIVA control scheme from Guenther, 2016

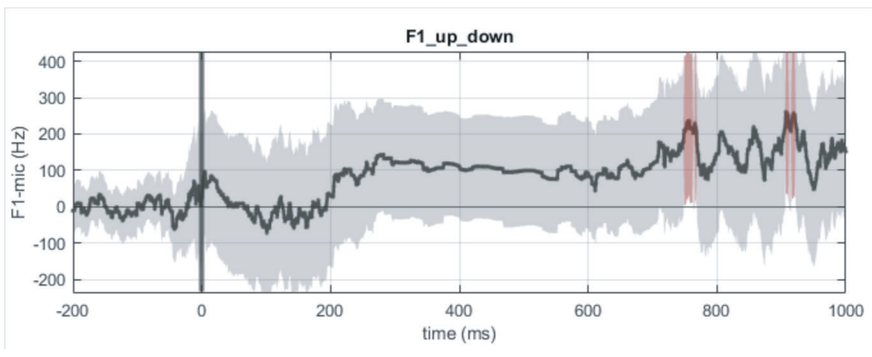



Timecourse of a perturbed trial from Kearny et al., 2019

## Results and Next Steps

We were able to demonstrate that the subjects do respond to the perturbation in the expected manner. For example, for a downshift the subject will respond by shifting their voice up. We were able to demonstrate this by using the lab's custom auditory perturbation analysis software.

The experiment is continuing as my honors thesis. We expect to collect 15 subjects and use the data collected from those subjects to demonstrate whether or not the degree of learnedness of a word affects how the subject responds to the perturbations.




Preliminary analysis output

## Acknoledgements

1. Guenther F H (2016) Neural control of speech. Cambridge, MA: The MIT Press
2. Kearny, E. et al. (2019) A simple 3-parameter model for examining adaptation in speech and voice production. Fronteirs in Psychology 10. https://doi.org/10.3389/fpsyg.2019.02995