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Investigating feedback and feedforward control during vowel production by Dutch adult speakers: insights from auditory feedback perturbation tasks

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Introduction

In this study, we investigated how Dutch adult speakers respond to changes in their auditory feedback. Specifically, participants produced speech while their formants were shifted upwards or downwards in either an unexpected or a sustained manner: an unexpected perturbation taps into a speaker's reflexive responses and the functioning of their feedback system, while a sustained perturbation assesses a speaker's adaptive responses and the ability of their feedforward system to learn new motor commands.

Some studies have previously investigated adaptive responses in Dutch speakers (e.g., van Brenk & Terband, 2020) but to our knowledge none have tested Dutch speakers' reflexive responses nor used the target word combinations of this study. In line with prior studies on other languages (predominantly English), we expected participants to respond to the formant perturbation by shifting their own formant production in the opposite direction (e.g., Houde & Jordan, 2002).

Methods

In total 60 speakers (34 female; age range 22 to 59) completed a sustained perturbations task, an unexpected perturbations task, or both. Speakers were instructed to read several high-frequency monosyllabic Dutch words containing the vowel /ɛ/ while wearing headphones. During production, vowel formants were shifted using Audapter software (Cai et al., 2008).

During the sustained perturbations task, formants were gradually shifted with each successive production, until reaching the maximum perturbation of 20% decrease in F1 and 15% increase in F2 (resulting in a vowel closer to /ɪ/). There were altogether 114 trials, of which 48 were produced at the maximum perturbation (i.e., the STAY phase). During the unexpected perturbations task, the perturbation was smaller than in the sustained perturbations task, namely a 10% decrease in F1 and 5% increase in F2 for an upward trial (resulting in /ɪ/), and a 10% increase in F1 and 5% decrease in F2 for a downward trial (resulting in /ɑ/). There were altogether 120 trials: two thirds of the trials were randomly perturbed either upwards or downwards, the rest were control catch trials.

Most shifts in both experimental tasks resulted in a real Dutch word being produced. For example, the target word /bɛt/ ('bed') could be shifted towards /bit/ ('bridle bit') or /bat/ ('bath'). After completing the experiment, the participants filled out a questionnaire, asking them whether they had noticed the perturbation.

Results and discussion

We used generalized additive mixed models to analyse participants' reflexive and adaptive responses. For both tasks, participants showed expected responses: when vowels were perturbed upwards, the speakers shifted their productions downwards and vice versa (see Figure 1 for plotted response to the sustained perturbations task). This adaptation occurred even though, according to their questionnaire responses, few speakers consciously noticed the perturbation.

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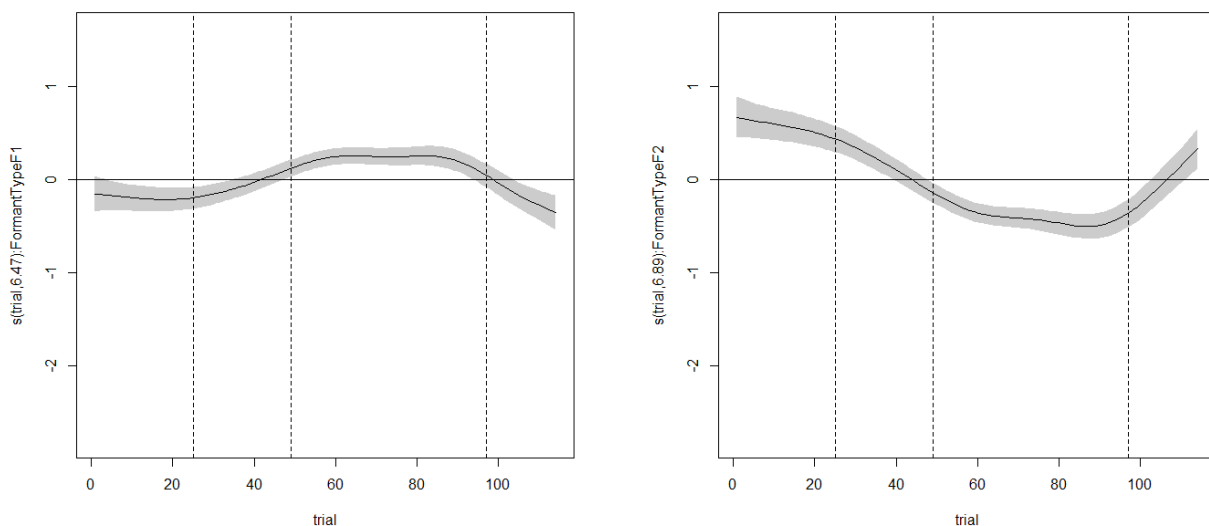


Figure 1: Change in F1 (left) and F2 (right) in response to a sustained perturbation. Dotted vertical lines denote the four phases of the experiment (START, RAMP, STAY, END).