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# Effects of simultaneous lip-tube and auditory feedback perturbations

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## BACKGROUND

-Speech production involves feedback and feedforward control mechanisms (Perkell, 2012).

-Somatosensory (SS) and auditory (AUD) aspects of speech can be perturbed to study speech production (Savariaux *et al.*, 1995, 1999; Ménard *et al.* 2016).

-Previous experiments with adult French speakers producing the vowel /u/ with a perturbation of the lips using a lip-tube showed that they were able to compensate in part by moving the tongue towards the velo-pharyngeal region, using auditory feedback (Savariaux *et al.*, 1995,1999; Ménard *et al.*, 2016).

- The relative importance of auditory and somatosensory feedback on compensatory strategies to a lip-tube perturbation is not clear.

## OBJECTIVE

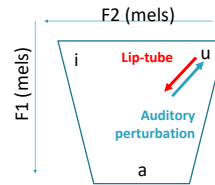
- This study aimed to evaluate the compensatory strategies of adult speakers of Quebec French in producing the vowel /u/ with a perturbation of the lips using a lip-tube, with and without natural or perturbed auditory feedback.

## Participants

- 10 males and 10 females
- 18 to 35 years old (mean age = 25.3)
- Native speakers of Quebec French
- No known pathology related to audition, language, or attention

## Task

- To produce 6 blocks of 20 /u/ tokens.
- 60 tokens were produced while the speaker had a plastic lip-tube between the lips that was designed to increase lip area, thus F1 and F2 values.
- 20 of the 60 tokens were also produced with simultaneous real-time modified auditory feedback designed to decrease F1 and F2 (Cai *et al.*, 2008).



## METHOD

### Experimental setup

-The participant was seated, wearing headphones and instructed not to talk after the experiment had started.

-A microphone was held by the experimenter in front of the participant.

-The participant was instructed to wait for a green signal on the screen and then produce the vowel /u/ 20 times, as clearly as possible.

- A lip-tube (2.0 cm long by 2.5 cm wide) was placed between the lips of the participant before the 3<sup>rd</sup> block of the experiment and left there until the end of the 5<sup>th</sup> block.

### Data analysis

-F0, F1, and F2 values were extracted at vowel midpoints for the 120 /u/ tokens produced by each participant.

- The participants were divided into 3 groups based on their compensation strategies:

- SS compensators: those who started to compensate in block 3 (lip-tube, perturbed auditory feedback) (n=5);
- AUD compensators: those who minimally compensate in block 3 (lip-tube) but did so in block 4 (no AUD feedback) (n=6);
- Followers: those who followed the lip-tube perturbation and did not compensate with AUD feedback (n=9);
- LME models were built using R.

Block 1	Block 2	Block 3	Block 4	Block 5	Block 6
No lip-tube	No lip-tube	Lip-tube	Lip-tube	Lip-tube	No lip-tube
Natural auditory feedback	No auditory feedback	Auditory feedback perturbation	No auditory feedback	Natural auditory feedback	Natural auditory feedback

## RESULTS

Figure 1: Average perceptual score  $(F1+F2)/2 - F0$  in Bark according to the block and position in the block (first or second half) for each group of participants (error bars are standard errors)

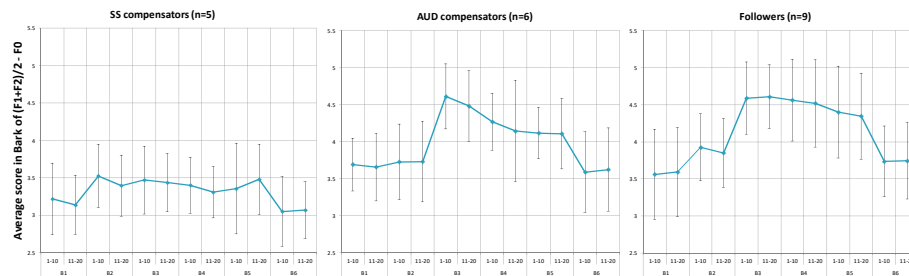
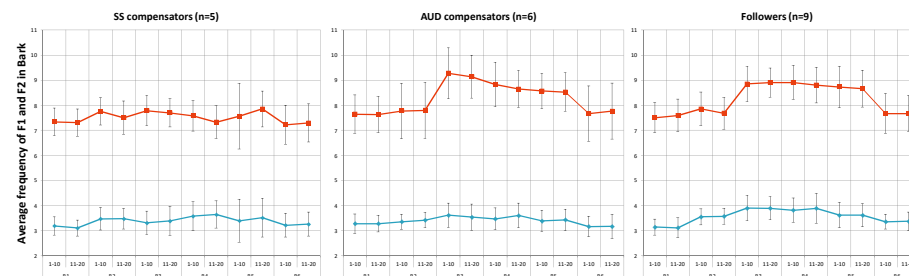


Figure 2: Average F2 and F1 values in Bark according to the block and position in the block (first or second half) for each group of participants (error bars are standard errors)



## DISCUSSION

- There appear to be three distinct responses to SS (lip) perturbation:
  1. compensation for SS perturbation when no auditory consequences are heard (SS)
  2. no compensation for SS perturbation when AUD feedback is corrected (AUD)
  3. no compensation

- The SS compensators' F2 values during block 3 were not higher than values from blocks 1 and 2, suggesting the immediate minimization of somatosensory feedback error (primacy of somatosensory feedback over auditory feedback).

- The AUD compensators' F2 values increased in block 3 and began gradually decreasing before access to natural auditory feedback was restored, suggesting that both auditory and somatosensory feedback were integrated in the compensation.

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