

SPEECH PRODUCTION IN RESPONSE TO MULTIPLE PERTURBATIONS OF AUDITORY FEEDBACK

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Background Speakers monitor their production by comparing constantly the results of their motor commands (used as auditory feedback) with the sound they predicted. But the processing of auditory feedback is condition dependent and speaker dependent:

In general, speakers **compensate** for perturbations of their auditory feedback because they perceived the discrepancy between the intended and the perceived sounds (e.g.[1]).

However, some speakers sometimes **follow** the perturbations instead of compensating for them (e.g.[2]).

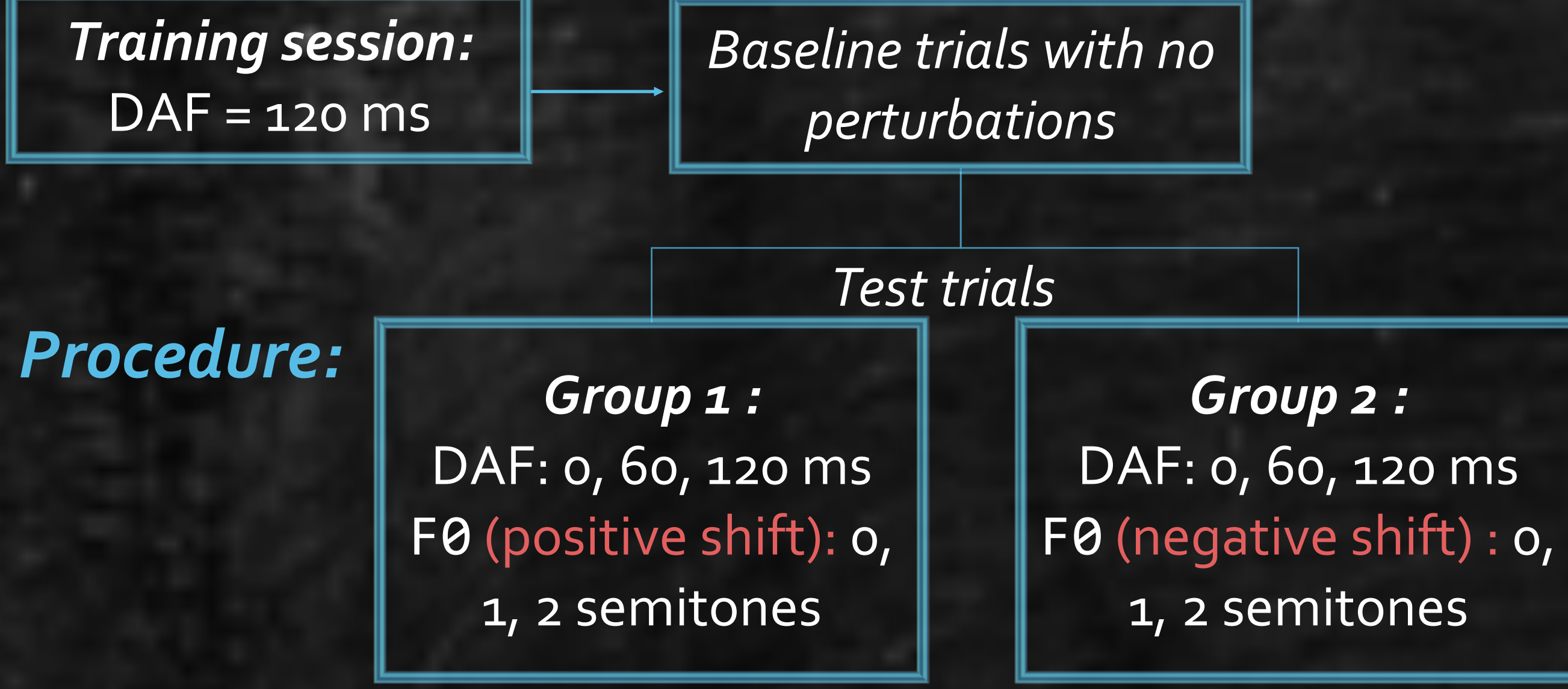
Objective In order to better understand the source of the variability of speakers' response to perturbations of auditory feedback, we investigated the **interactive effects** of Delayed Auditory Feedback (DAF) and consistent F₀ shift of auditory feedback on the production of the speakers who produced utterances composed of syllables varying in complexity. The consistent F₀ shift of auditory feedback made the speakers perceive their voice as being different to their usual voice but nevertheless predictable.

Method

Participants: 20 French female native speakers



The speakers' manipulated voices were played back in real time through earphones.



The speakers were asked to repeat several times (organized in blocs of six repetitions) three French sentences with random perturbation combinations for each repetition.

Stimuli:

- **For training:** the French text "La bise et le soleil"
- **For Baseline and test trials:** three French sentences differed in syllabic complexity:
 - CV: /vivjɛ vi lə vɛ/
 - CVC: /ʒaklin ʒɛs lə ʒus/
 - CCV(C): /bɔadle bɛiz lə bɔa/

Discussion & Conclusion

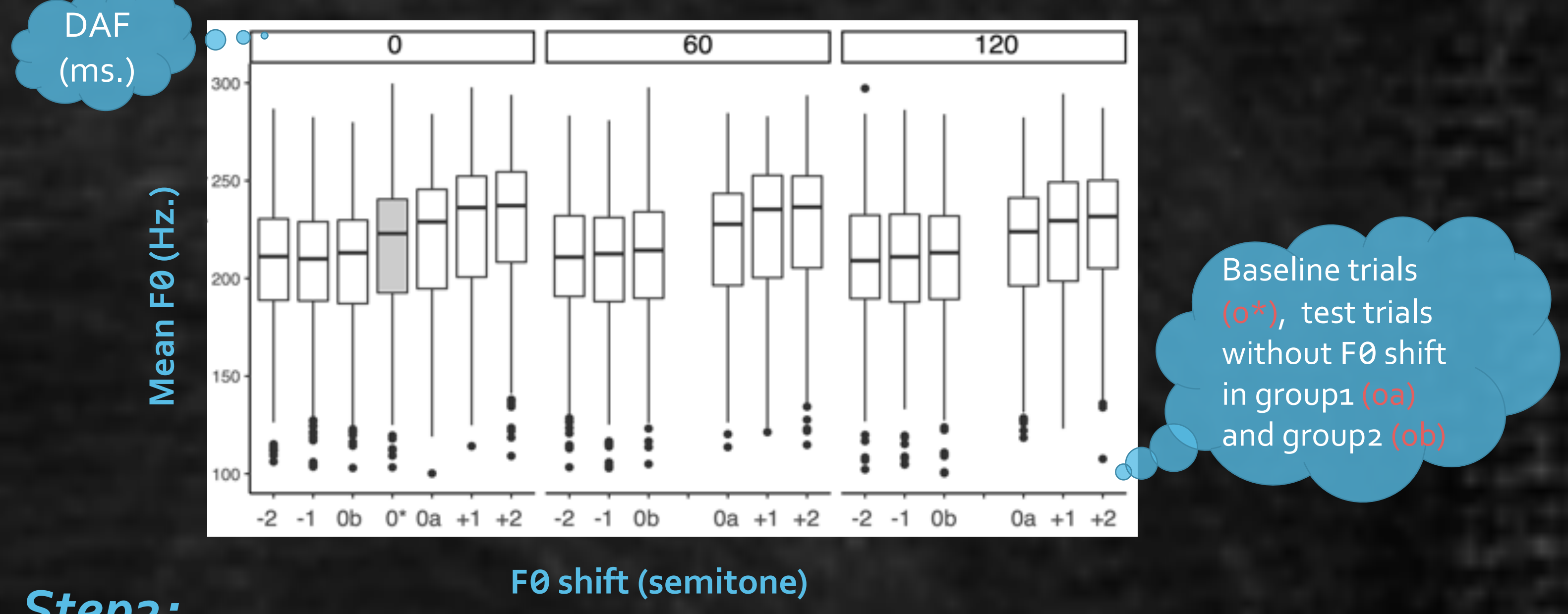
- When the F₀ of auditory feedback was continuously perturbed in the same direction during connected speech production, speakers tended to **follow the perturbation**.
- According the interactive alignment model ([4]), this is an expected consequence of the predictability of the F₀ shift and of the presence of simultaneous perturbations.
- Due to these manipulations, the sensorimotor system may adapt its functioning to the heard sounds as it happens when processing **the sound another speaker's voice**. This adaptation should result in a form of phonetic convergence. Therefore, we should observe an interaction between the effects of F₀ shift and DAF on speech production.
- The **variability** in the production of segmental material was related to DAF and syllabic complexity.
- However, no direct interactive effects between F₀ shift and DAF on speakers' production was observed. Further work is required in order to compare the behavior of the speakers analyzed in this study to that of a group of speakers who are **exposed only to DAF**.

Analyses & Results

Step1:

- **COMPARING** the **mean F₀** of the accented vowels obtained in the Baseline trials with that obtained with no DAF during the test trials separately for speakers of the two groups. We focused our analyses on the accented vowels, because it was shown that accented vowels could be more sensitive to the perturbations of auditory feedback (e.g.[3]).

RESULT: In average the speakers trended to follow the F₀ shift



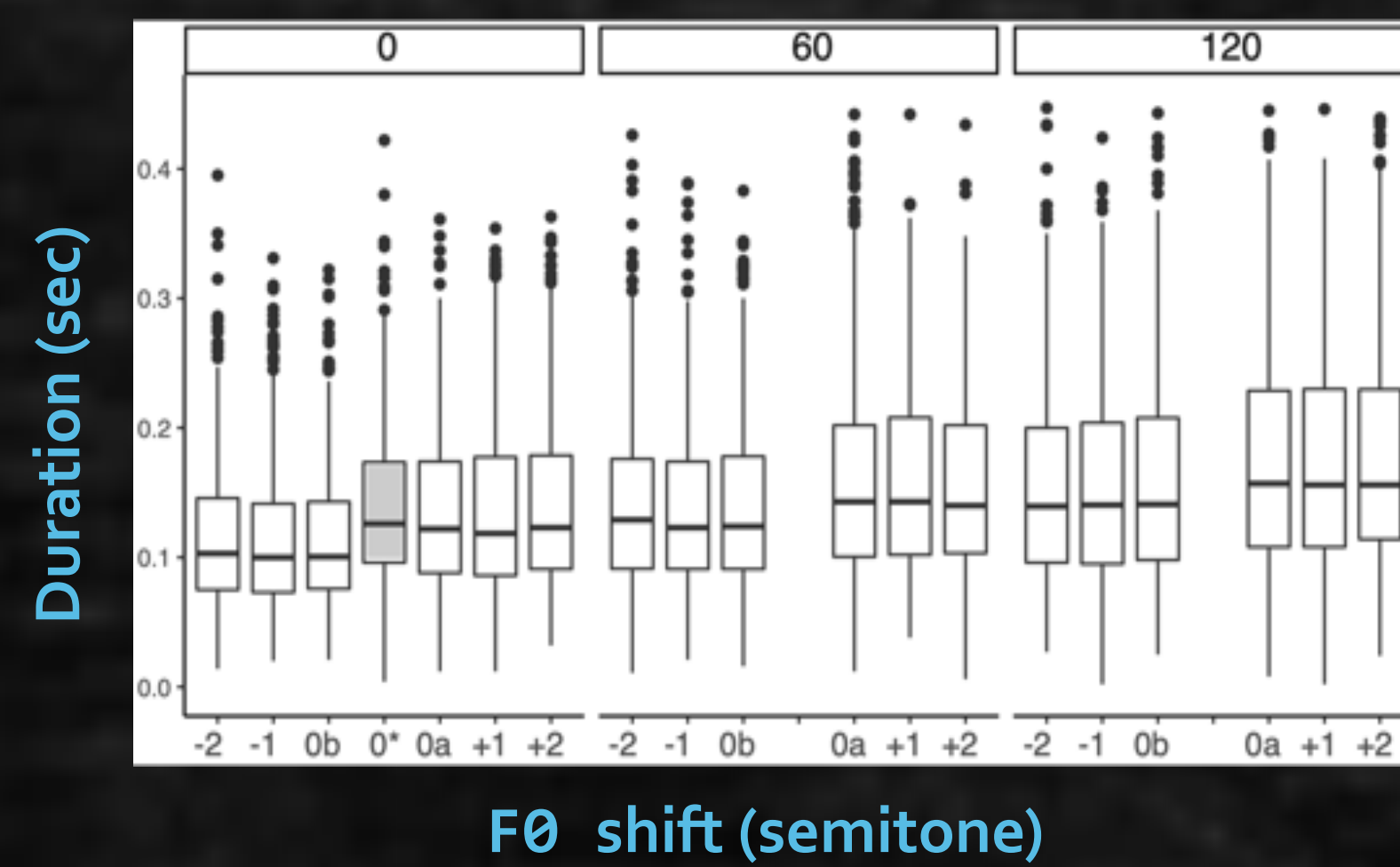
Step2:

- **RUNNING** **speaker specific linear regressions** with the same model specification and **REMOVING** speakers for which the effect of the F₀ shift went in the opposite direction with respect to the group (2 speakers from group1 and 3 speakers from group2) in order to further investigate the responses of the speakers who followed the F₀ shift to perturbations.

Step3:

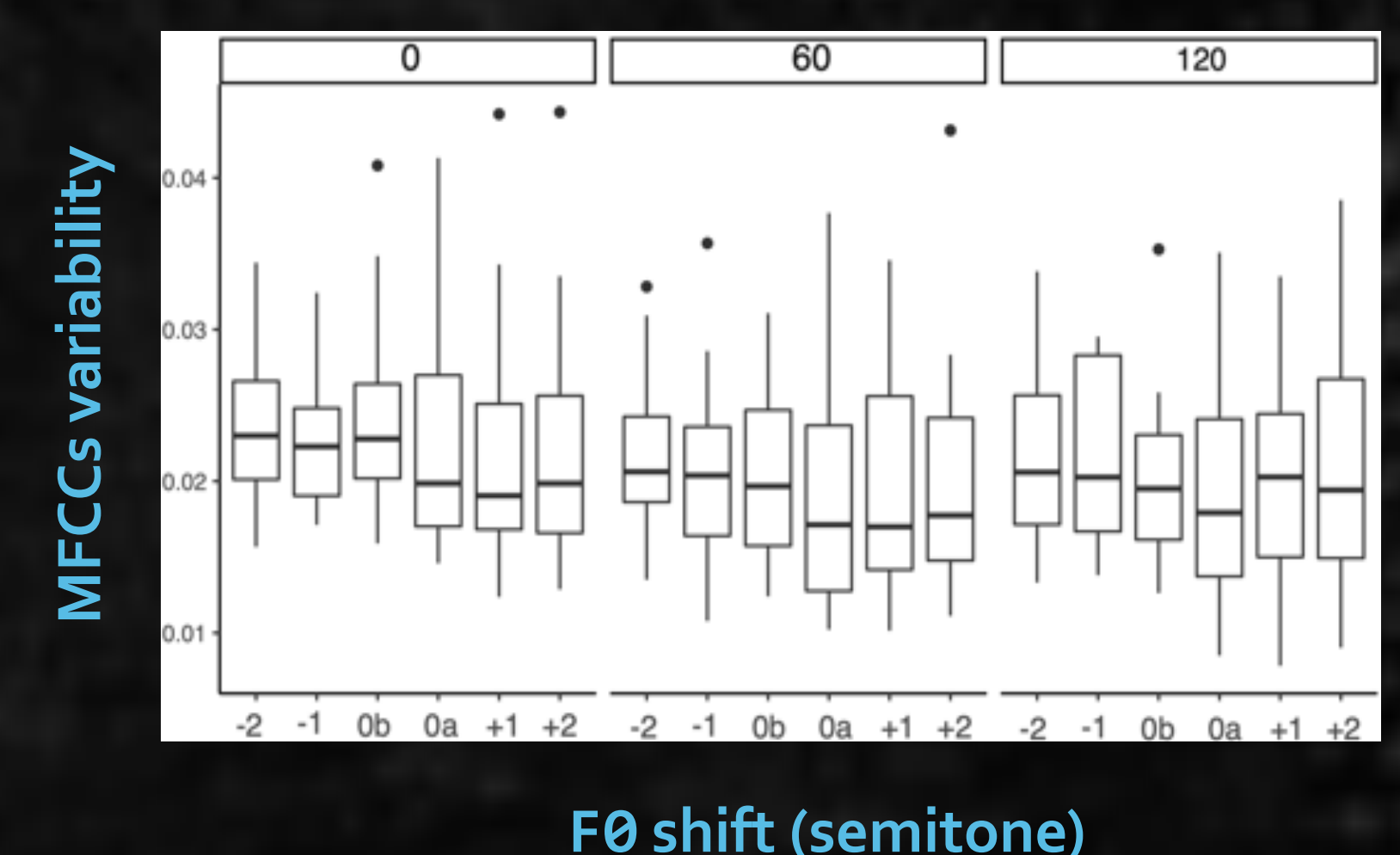
- **TESTING** the effects of DAF, F₀ shift, syllabic complexity and that of their **triple interaction** on accented vowels' duration, on their average F₀ and on variability of spectral change patterns (as captured by the mean absolute deviation of the average squared change of Mel-Frequency Cepstral Coefficients trajectories [MFCCs]).

RESULTS:



- The lengthening of syllables was the most important effect of DAF on speakers' production.
- The degree of DAF was positively correlated with the duration of the accented vowels for the two groups.

- A small delay in auditory feedback (60ms) reduced significantly the variability of the spectral change patterns.
- This variability increased with higher syllabic complexity.



Reference

1. Burnett, T. A., Freedland, M. B., Larson, C. R., & Hain, T. C. (1998). Voice F₀ responses to manipulations in pitch feedback. *JASA*, 103(6), 3153–3161.
2. Behroozmand, R., Korzyukov, O., Sattler, L., & Larson, C. R. (2012). Opposing and following vocal responses to pitch-shifted auditory feedback: Evidence for different mechanisms of voice pitch control. *JASA*, 132(4), 2468–2477.
3. Kalveram, K. T., & Jäncke, L. (1989). Vowel duration and voice onset time for stressed and nonstressed syllables in stutterers under delayed auditory feedback condition. *Folia Phoniatrica*, 41(1), 30–42.
4. Pickering, M. J., & Garrod, S. (2013). An integrated theory of language production and comprehension. *Behavioral and Brain Sciences*, 36(4), 329–347.