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Sense of agency is flexible during speech production

INTRODUCTION

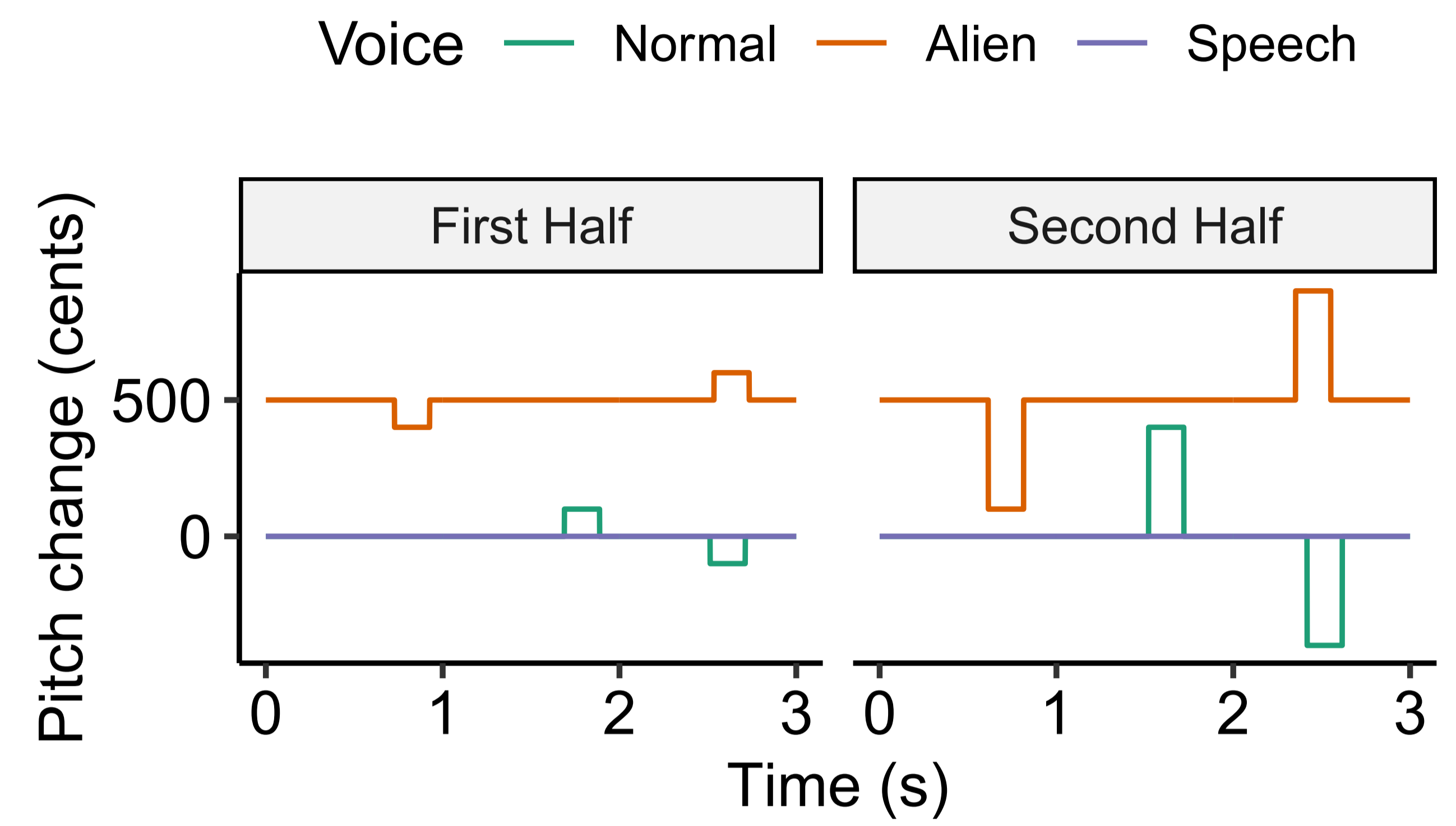
- Auditory feedback is used during speech production both for error monitoring as well as for generating a sense of agency (SoA) [1]
- The comparator model suggests the sense of agency arises from a comparison between perceived sensory feedback and predictions of the sensory consequences of actions
- If so, mismatching auditory feedback should lead to a decrease in the sense of agency
- Speakers typically compensate for unexpectedly pitch-shifted auditory feedback [1,2]
- Large shifts (± 400 cents) lead to smaller responses than smaller shifts (± 100 cents) [3]
 - large shifts less likely to be self-generated
 - less SoA \rightarrow smaller compensation responses

RESEARCH QUESTION

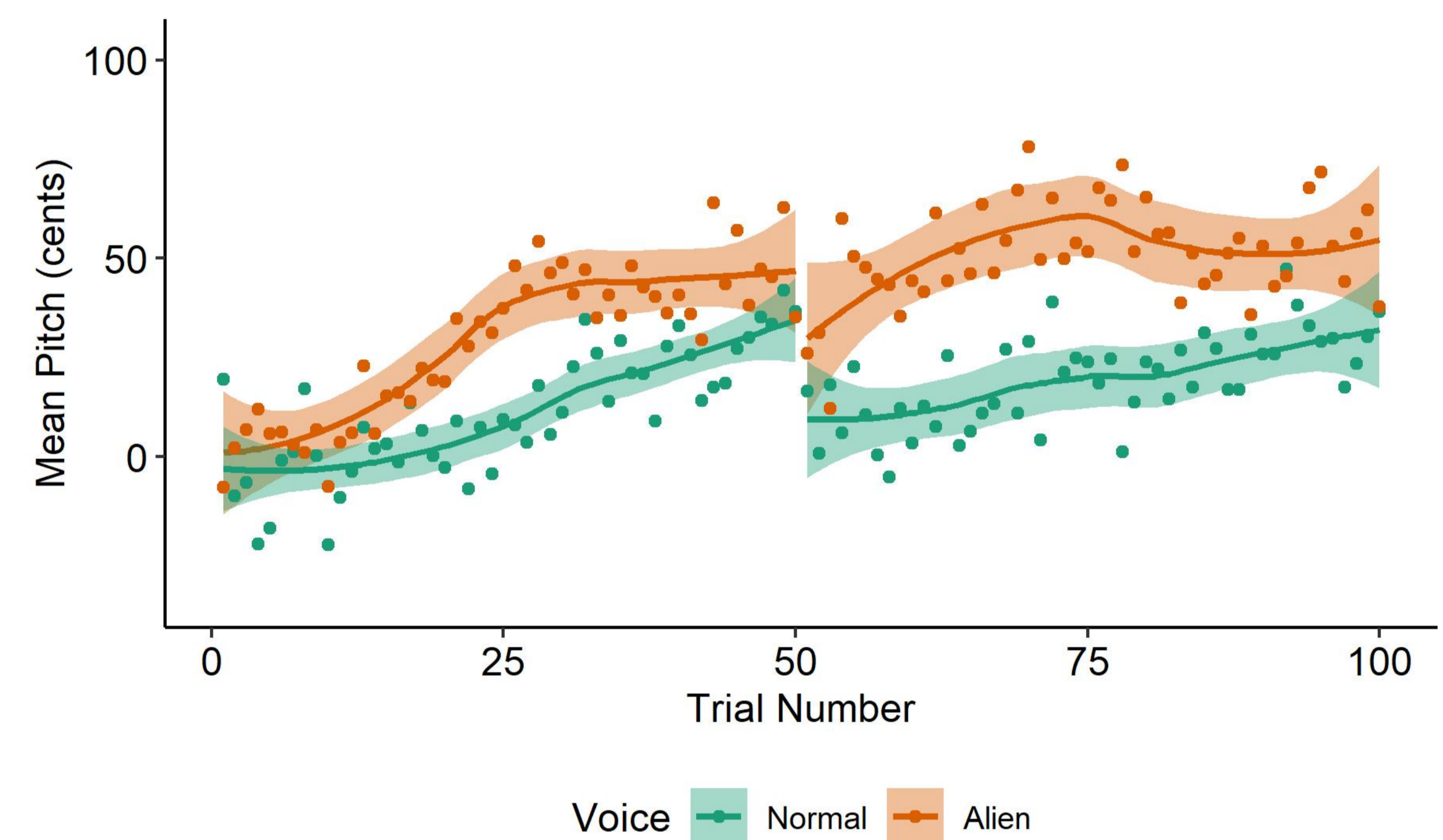
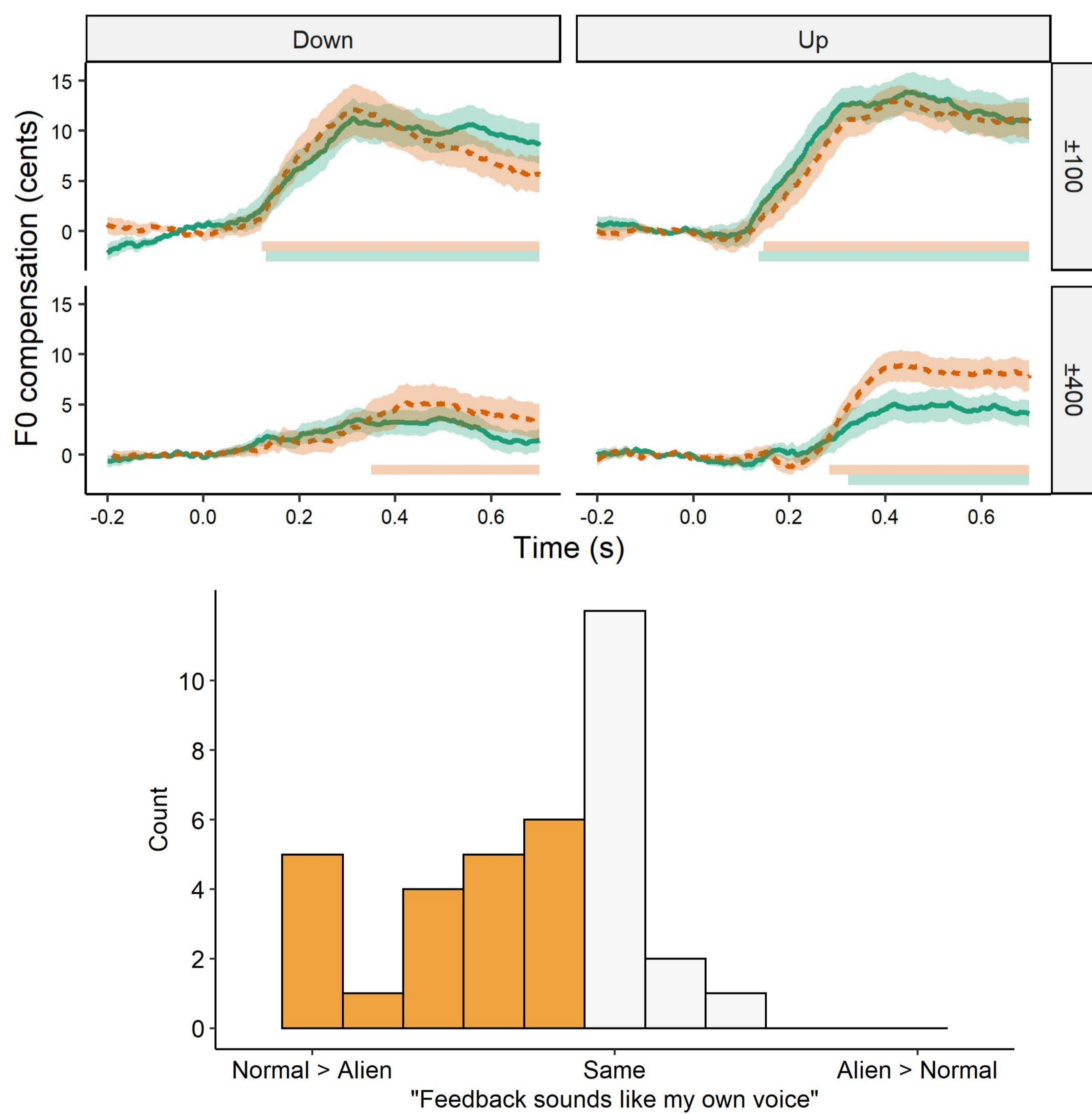
Does alien voice feedback reduce the sense of agency as measured by responses to unexpectedly pitch-shifted auditory feedback?

EXPERIMENTAL DESIGN

- 200 vocalizations (3s /e/) with normal or "alien" voice feedback (constant +500 cents pitch shift)
- up to 3 short pitch shifts per vocalization: -400, -100, +100, +400 cents
- Intershift interval of 600 to 800ms
- Feedback at +10dB relative to mic signal
- Response magnitude = peak compensating deviation from average baseline (-200ms to 0ms)
- Exp 1: feedback voices blocked (N = 36)
- Exp 2: feedback voices randomized (N = 38)



EXPERIMENT 1

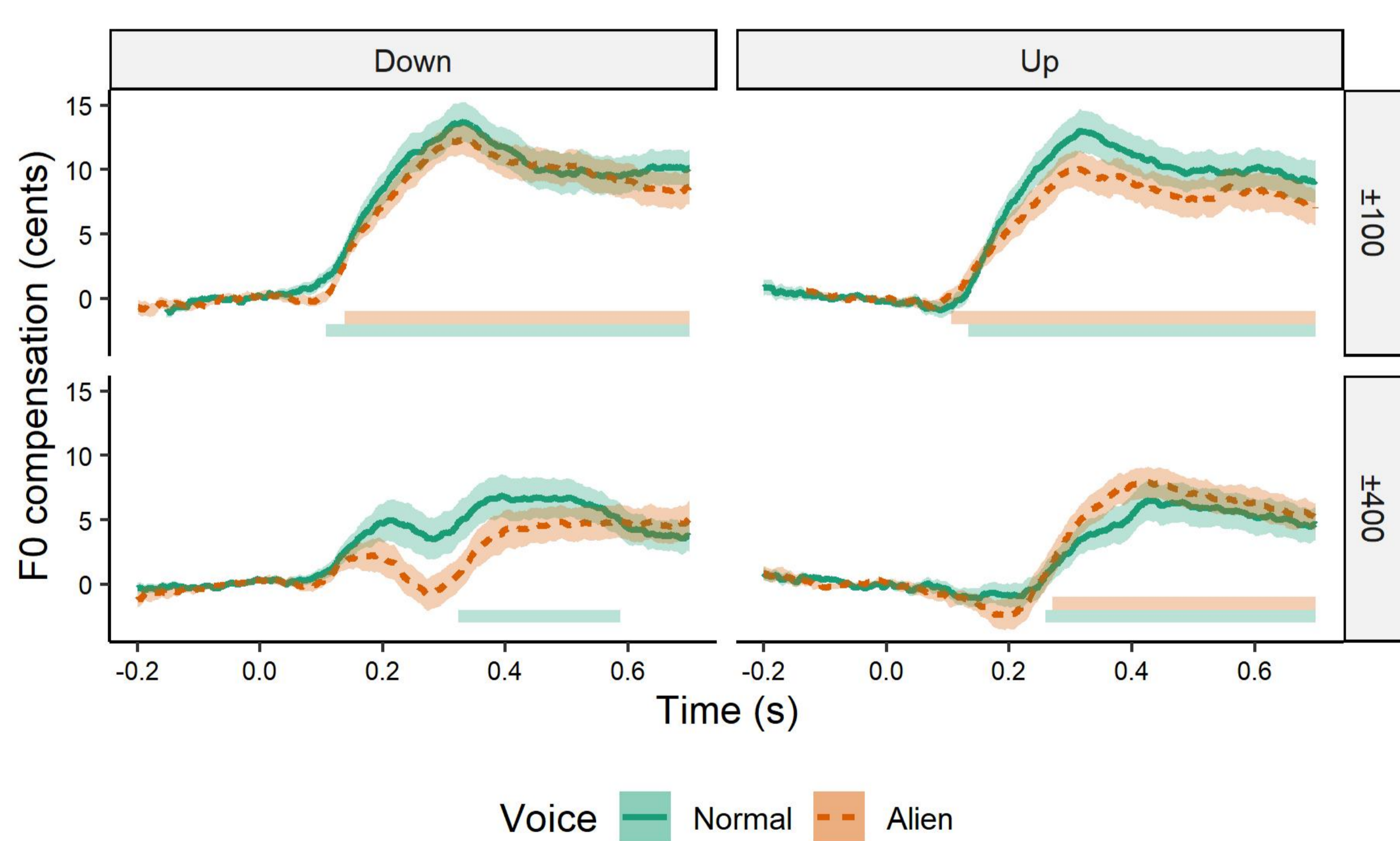


Almost all conditions show clear compensatory responses, both for normal and alien voice feedback, suggesting that alien voice feedback did not decrease SoA

Over the course of the experiment, participants tended to align pitch with the alien voice condition, which has previously been argued to be suggestive of a sense of agency over the auditory signal [5, 6]

Individual variability in how participants consciously experienced the alien voice feedback

EXPERIMENT 2



Almost all conditions show clear compensatory responses, both for normal and alien voice feedback, suggesting that alien voice feedback did not decrease SoA

DISCUSSION

- Across all conditions, participants show clear compensatory responses, indicative of SoA
- Little or no effect of alien voice
- Smaller responses to larger pitch shifts
- No difference between experiments
- Participants tended to align pitch to alien voice
- Participants quickly accept alien voice as new referent pitch
- Flexible agency is not driven by learning during the experiment
- Agency may be driven by temporal covariance rather than absolute match: downward shifts in alien voice elicit compensation
- The fact that one's voice sounds different through headphones is not problematic given flexible SoA

[1] Burnett, Freedland, Larson, & Hain. JASA, 1998.
[2] Franken, Acheson, McQueen, Hagoort, & Eisner, Psychonomic Bulletin & Review, 2018.
[3] Korzyukov, Tapaskar, Pflieger, Behroozmand, Lodhavia, Patel, Robin, & Larson. Clinical Neurophysiology, 2015
[4] Scheerer, Behich, Liu, & Jones. Neuroscience, 2013.

[5] Tajadura-Jiménez, Banakou, Bianchi-Berthouze, & Slater. Scientific Reports, 2017.
[6] Zheng, MacDonald, Munhall, and Johnsrude. PLoS ONE, 2011.