Noninvasive neurostimulation of sensorimotor adaptation in speech production

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Summary

Repeated exposure to disparity between motor plans and auditory feedback during speech production results in auditory-motor adaptation

Perturbing F1 in auditory feedback during speech production results in a concomitant and proportionate change in the produced F1.

Transcranial direct-current stimulation (tDCS) can be used to alter neural excitability in focal areas of the brain.

Participants read target words aloud as their auditory feedback was perturbed in real time by raising F1 by 30%.

Participants' speech showed an increasing magnitude of adaptation of F1 over time during anodal tDCS compared to sham.

tDCS affects the behavioral response during auditory-motor adaptation, which may have implications for sensorimotor training in speech disorders.

Procedure

Stimuli: The words *bed*, *dead*, and *head* – presented in a random order.

Dependent measure: Participants read the target words aloud; their speech was recorded for acoustic analysis of F1 and F2.

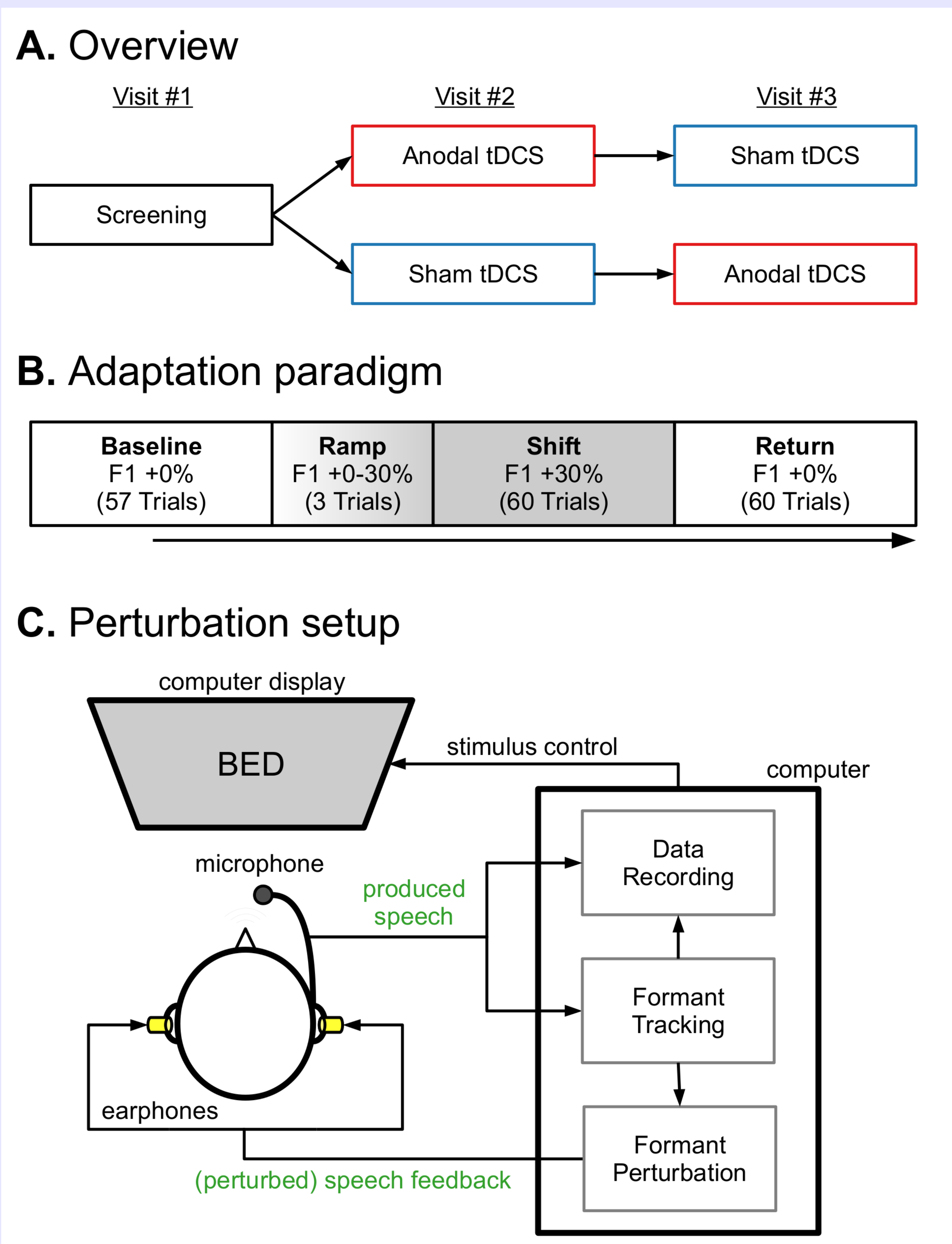
Baseline phase: Participants heard unaltered auditory feedback.

Ramp phase: Participants heard a real-time resynthesized version of their speech using *Audapter*, with F1 shift increasing linearly from +0% to +30%.

Shift phase: Auditory feedback of speech with F1 always shifted by +30% of participants' productions.

Return phase: Participants heard unaltered feedback.

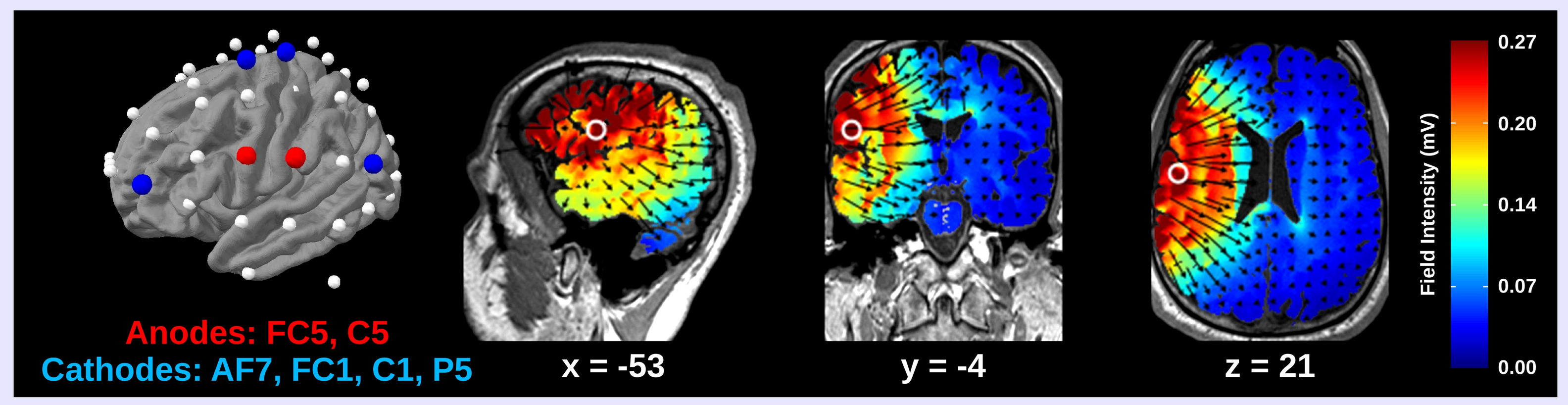
Design



tDCS Methods

High-definition transcranial direct current stimulation (HD-tDCS): 6 electrodes (2 anodes, 4 cathodes) were placed at designated locations on the scalp targeting left ventral premotor / motor cortex. Participants received 2 mA of anodal stimulation during the task (≤ 20 minutes). Resistance at each channel was < 10 Ω.

HD-tDCS location and current flow maps

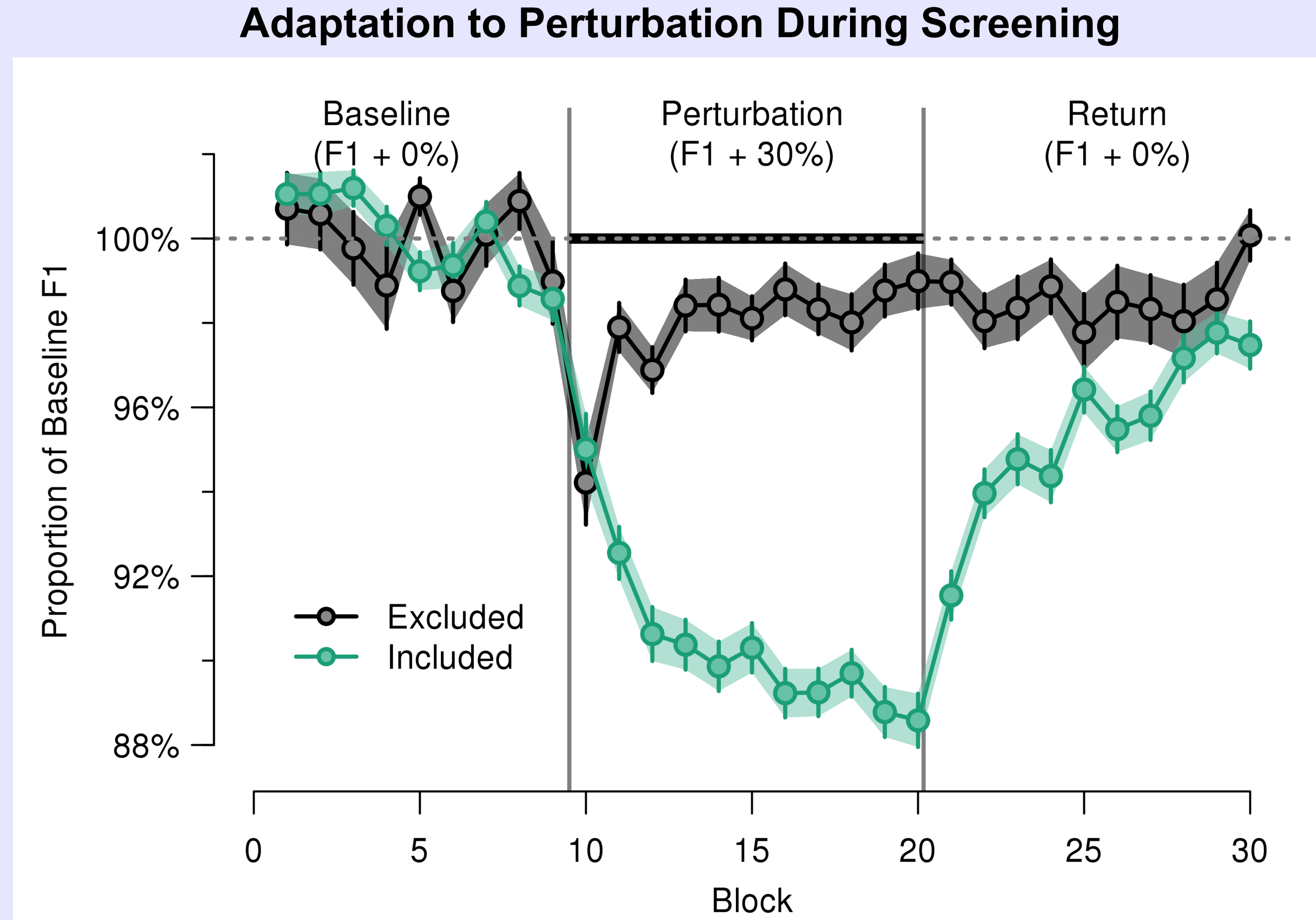


Adaptation Screening

Participants: N = 18 right-handed, native speakers of American English, age 18-29 years and without speech, language, or hearing deficits completed the tDCS study.

Exclusion: (i) Participants who did not demonstrate an adaptation effect in response to auditory feedback perturbation of at least 5% during the second half of the "stay" phase of the screening visit; (ii) Participants who did not complete all sessions; (iii) Participants who declined to undergo tDCS.

Adaptation to Perturbation During Screening



Acknowledgments

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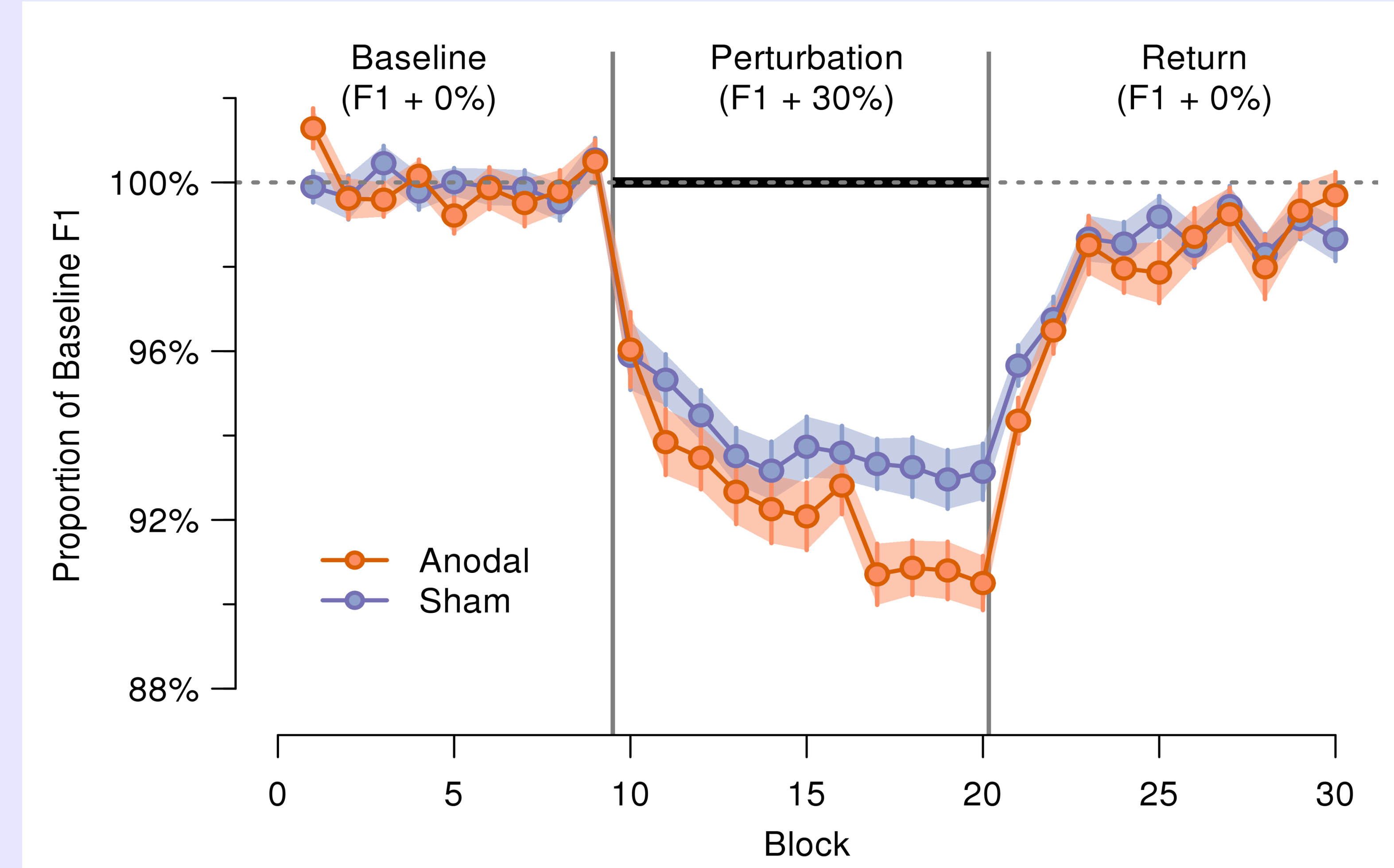
Results

F1 Adaptation to Perturbation During Anodal vs. Sham tDCS

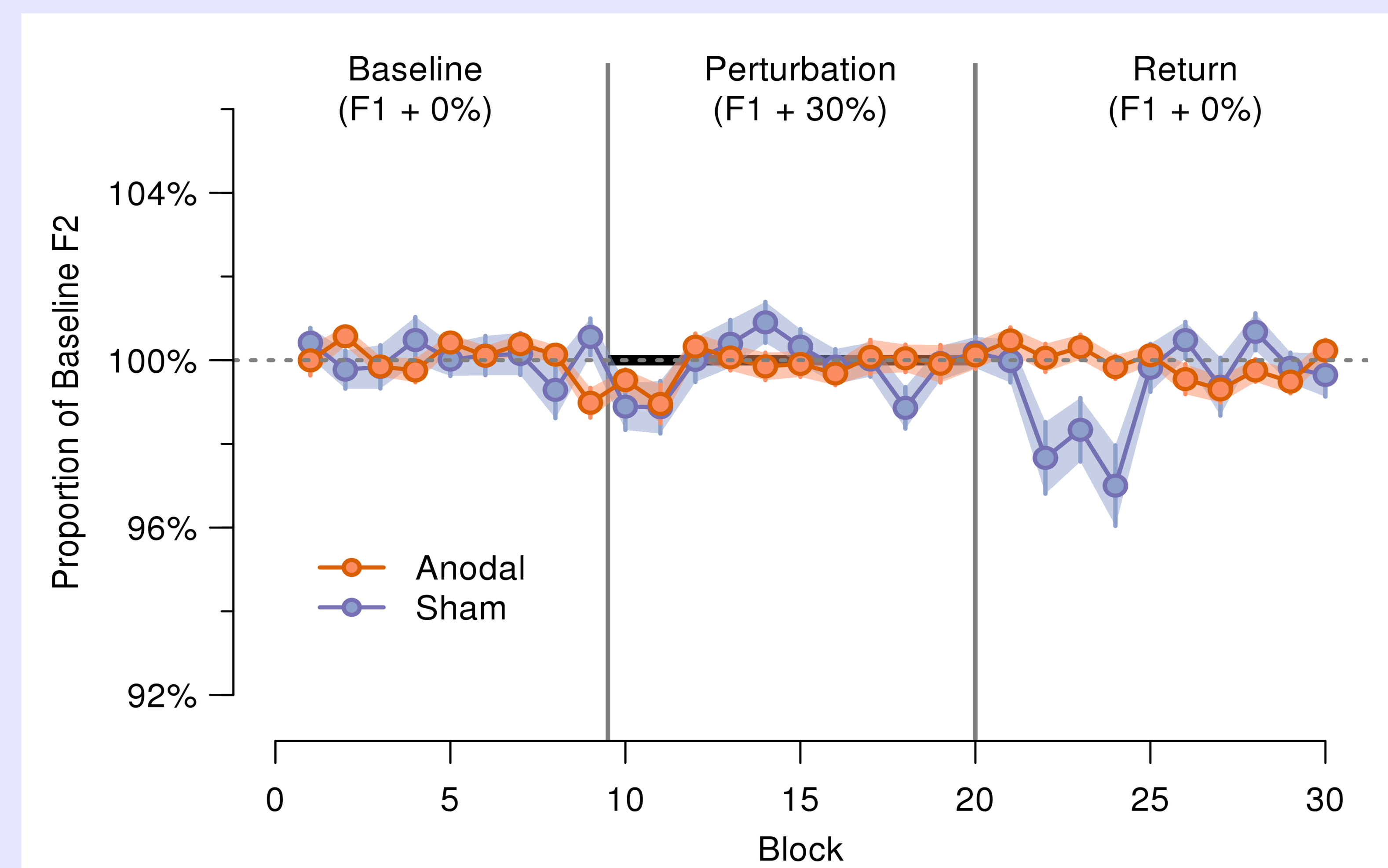


▲ Mixed-effects linear models revealed that **Anodal stimulation** resulted in significantly greater F1 adaptation magnitude compared to **Sham** during the perturbation phase [t = -6.53, $p \ll 0.001$], and a greater increase in adaptation over time [t = -2.48, p = 0.013].

▲ There was no effect of stimulation on F1 recovery or recovery time [both $p \geq 0.22$].

▼ There was no effect of stimulation on F2 during perturbation [both $p \geq 0.50$], but withdrawal of perturbation resulted in instabilities in F2 during sham, but not anodal stimulation: [t = -3.55, $p < 0.001$].

F2 Adaptation to Perturbation During Anodal vs. Sham tDCS



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