

Disrupted feedforward but spared feedback control during speech in patients with cerebellar degeneration

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Summary

Patients with cerebellar degeneration (CD) are **impaired** in adapting speech to consistent auditory feedback perturbations, suggesting impaired feedforward control.

This impairment is observed when the perturbation is introduced abruptly or gradually.

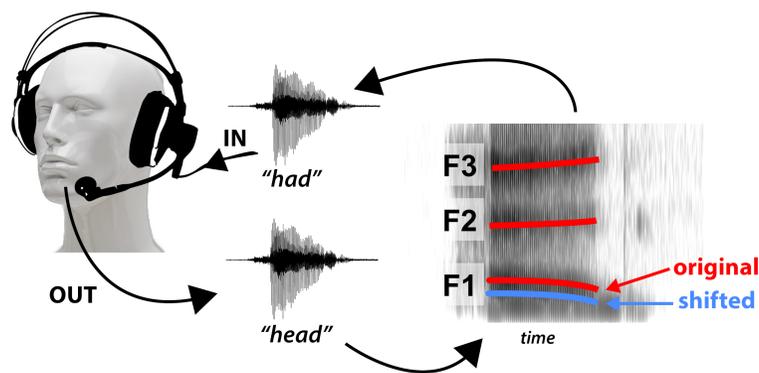
In contrast, CD patients show an **increased** on-line compensatory response to randomly introduced F1 perturbations, a response dependent on feedback control.

Cerebellar degeneration selectively disrupts feedforward, but enhances feedback, speech motor control.

General methods

PROCEDURE:

- Manipulate first vowel formant (F1) in real time [1]
- Playback loud enough to mask original speech
- Create sensory error between expected and received auditory feedback



PARTICIPANTS:

Patients with cerebellar degeneration (n = 19)

- Differing pathologies: SCA2 (2), SCA3 (2), SCA5 (1), SCA6 (2), SCA7 (1), SCA8 (2), unknown (9)
- Speech mildly impaired: 2.4 (1.8) on ICARS speech scale (0-8)
- No other speech/hearing problems or neurological disorders

Healthy matched controls (n= 14)

- Age- and gender-matched
- No speech or hearing problems

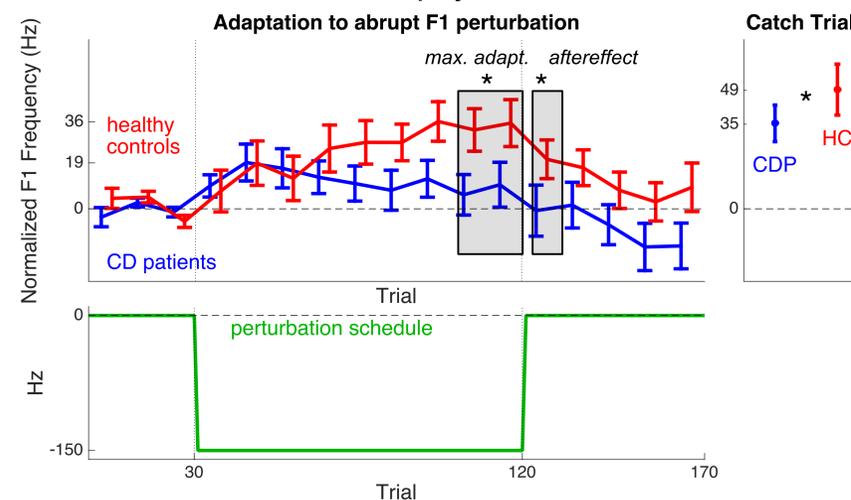
Feedforward control Adaptive response

F1 perturbation was introduced gradually or abruptly. Some studies have shown cerebellar patients may retain the ability to adapt to gradual perturbations [2,3], though others have not [4,5]. Gradual was always tested first.

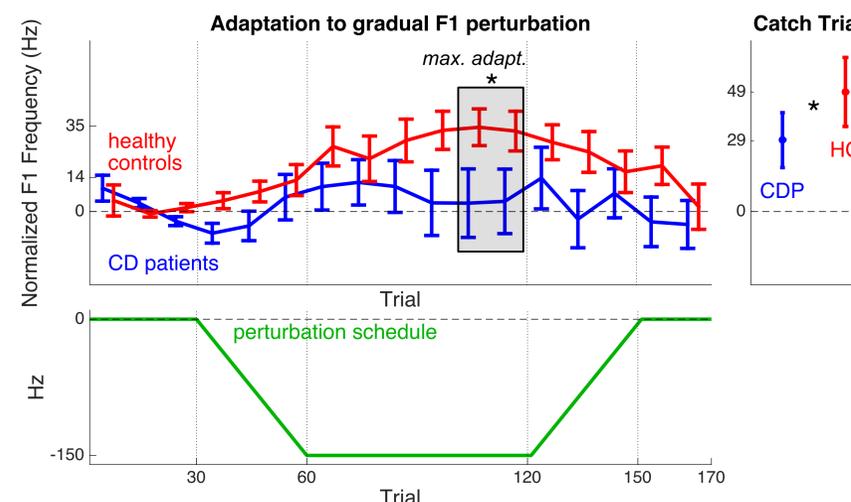
“Catch” trials were included in which auditory feedback was eliminated and masking noise was increased in volume:

- 20 catch trials randomly distributed during trials 60-120 of each block.
- Note that loud masking noise causes general increase in F1 [2]

CD patients show **impaired** adaptation to consistent F1 perturbations introduced abruptly.



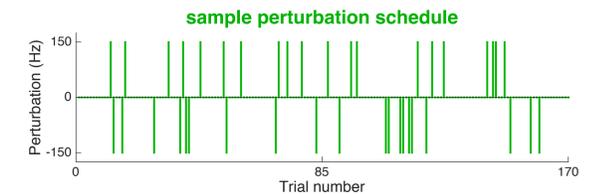
Adaptation is **also impaired** in patients when the perturbation is introduced gradually.



Feedback control Compensatory response

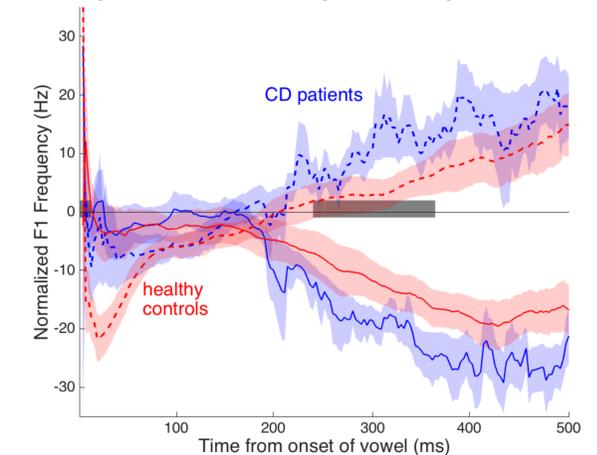
F1 was perturbed by 150 Hz (increase or decrease) on random subset of trials for the duration of the trial.

- Increased on 20 trials; decreased on 20 trials.
- No more than 3 consecutive trials with perturbations and same perturbation never repeated on consecutive



CD patients show **greater** within-trial compensation to unexpected perturbations.

Compensation for unexpected F1 perturbations



References

- [1] Katseff S, Houde J, Johnson K (2012) Partial Compensation for Altered Auditory Feedback: A Tradeoff with Somatosensory Feedback? Language and Speech 55: 295-308.
- [2] Criscimagna-Hemminger SE, Bastian AJ, Shadmehr R (2010) Size of error affects cerebellar contributions to motor learning. J Neurophysiol 103: 2275-2284.
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- [4] Gibo TL, Criscimagna-Hemminger SE, Okamura AM, Bastian AJ (2013) Cerebellar motor learning: are environment dynamics more important than error size? J Neurophysiol 110: 322-333.
- [5] Schlerf JE, et al. (2013) Individuals with cerebellar degeneration show similar adaptation deficits with large and small visuomotor errors. J Neurophysiol 109: 1164-1173.
- [6] Summers WV et al. (1988) Effects of noise on speech production: acoustic and perceptual analyses. J Acoust Soc Am 84: 917-928.

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