The role of auditory feedback in speech production

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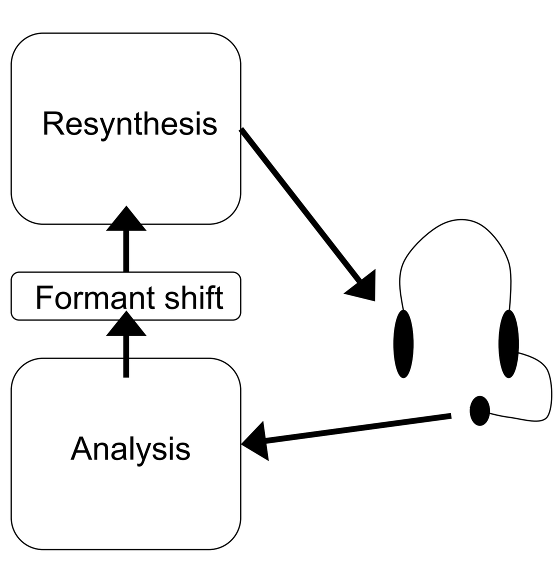
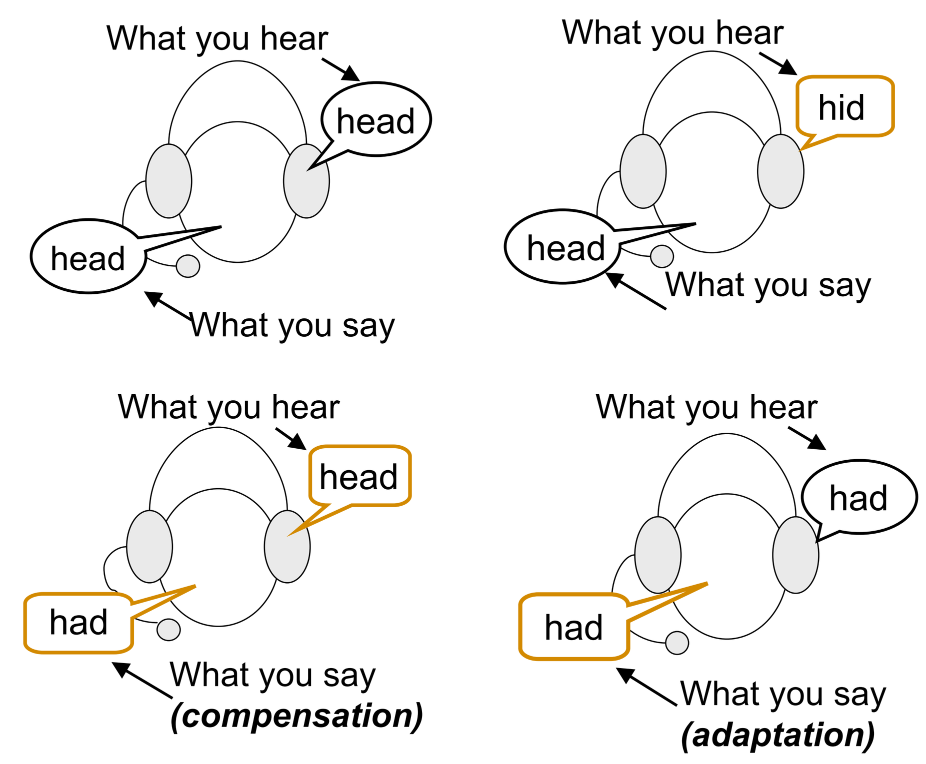
BACKGROUND

How Sensorimotor Adaptation works

Setup



Procedure



Previous work

F0: Small upward shifts in F0 feedback cause subjects to speak with lower F0. Large upward shifts in F0 cause subjects to speak with higher F0. Many sizes of shifts have been tested (e.g., Burnett et al., 1998).

F1 & F2: Regardless of size, subjects always oppose the direction of auditory feedback shift when they speak. These tests always use the same feedback shift size, 200 Hz (e.g., Purcell & Munhall, 2006).

Compensation is always *partial*. That is, subjects never respond to a 200 Hz shift in F1 feedback with a 200 Hz change in production. Instead, they tend to change their production by 50-100Hz.

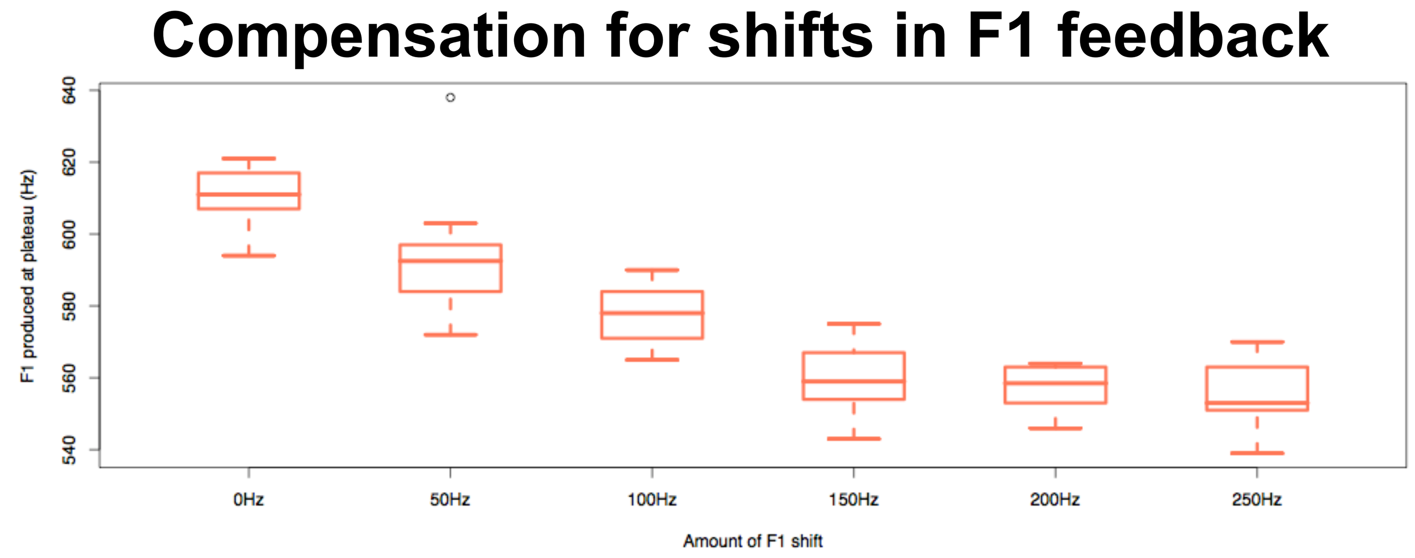
Questions

(1) Is compensation partial due to proximity of lexical items or vowels?

(2) What is our production target in the word 'head'?

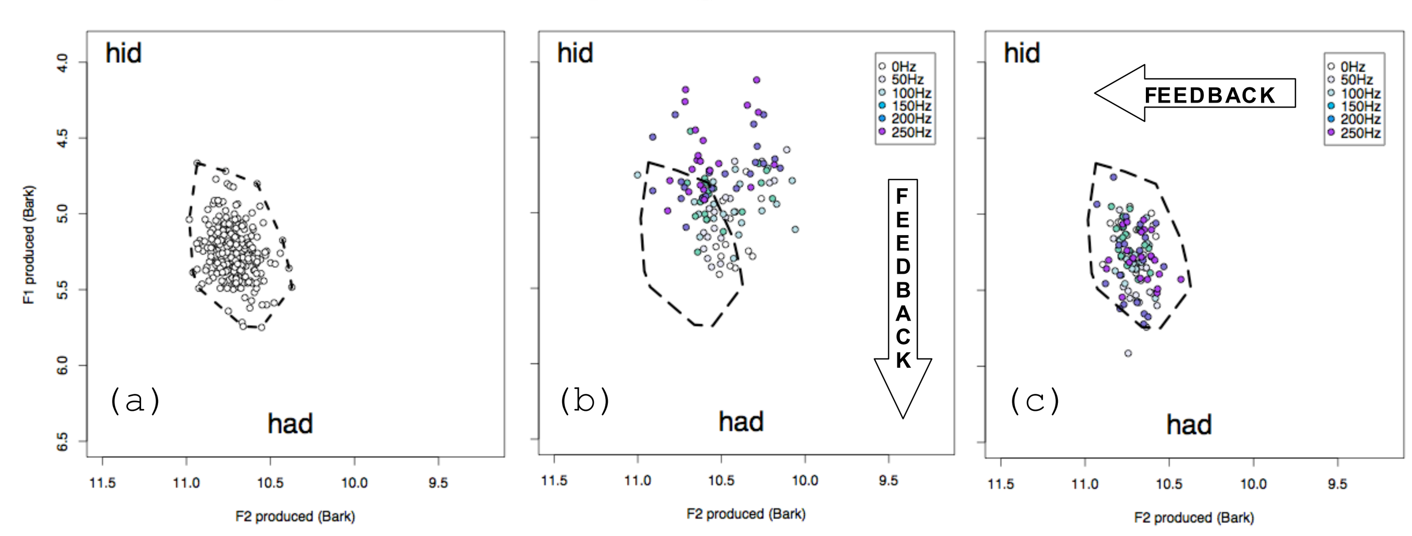
RESULTS & DISCUSSION

Compensation for shifts in F1 feedback



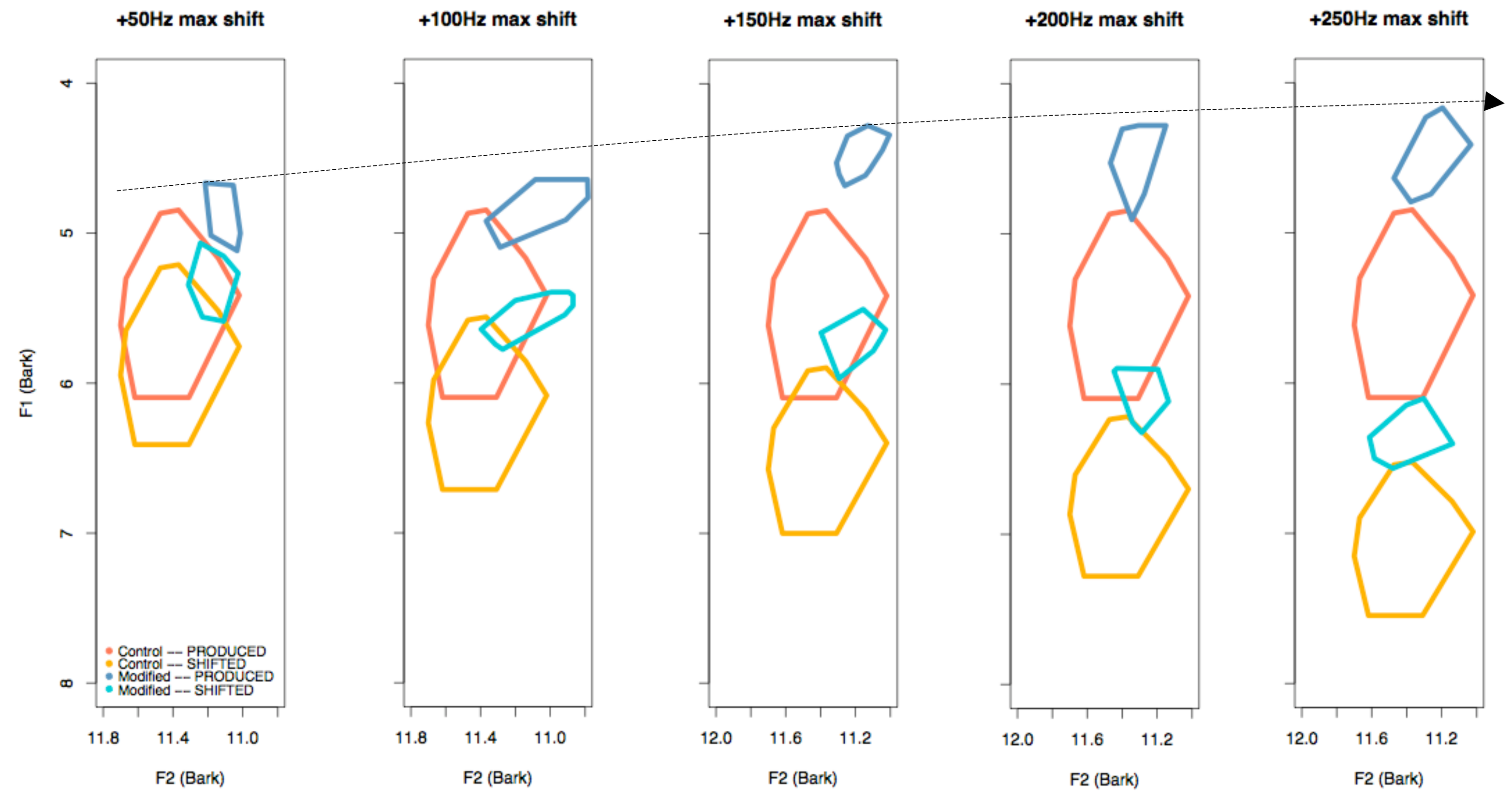
F1 (from /ɛ/ in 'head') produced by a typical subject in response to shifts in F1 auditory feedback. Each box represents a set of 20 consecutive productions.

Compensation progression: F1 vs. F2



A typical subject (s02)'s production of /ɛ/ (a) over 360 trials with no change in feedback (the dotted line is the convex hull of the subject's /ɛ/ vowel space), (b) over 360 trials with a 0-250Hz shift in F1 feedback, (c) over 360 trials with a 0-250Hz shift in F2 feedback.

Visualizing partial compensation



Red polygons show the convex hull of a typical subject's baseline /ɛ/ vowel space. Dark blue hulls encompass the subject's productive vowel space with shifted feedback. Cyan hulls encompass the vowel space that the subject *heard* in response to his production. Subjects tend to change their production, keeping the vowels they hear further within their baseline region for small shifts than for large shifts. Every subject has a compensation limit.

Feedback compensation

Consistent with previous literature, subjects demonstrated clear compensation for shifted auditory feedback, as measured by mean formant produced.

Here, we further characterize compensation:

- relative to a speaker's baseline vowel space
- as a function of increasing shift magnitudes
- in terms of movement in the F1/F2 plane.

Compensation is asymmetrical

Speakers aim for F1 and F2, but the two formants are not equally important.

- In English, **F1 is an important cue** to vowel identity.
- Because back vowels in English are rounded, F2 and F3 tend to covary. **F2 is a less informative cue.**
- We would expect that F2 compensation would be more significant in a language with rounded and unrounded front vowels (e.g., Swedish, Turkish)

A somatosensory boundary hypothesis

Targets have acoustic and somatosensory components (Larson, 2008).

- We shifted auditory feedback, but not somatosensory feedback.
- For small shifts in auditory feedback, there is only a small discrepancy between somatosensory and auditory feedback.
- For large shifts in auditory feedback, there is a large discrepancy between somatosensory and auditory feedback.
- Individual differences in compensation could be due to relative contributions of acoustic and somatosensory feedback.

Each subject's compensation seems to approach an asymptote.
We hypothesize that this limit reflects the point at which concurrent somatosensory feedback inhibits further compensation for auditory feedback.

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