Single-formant feedback alteration elicits multi-formant compensation

Shira Katseff
Department of Linguistics, Univ. of California at Berkeley
skatseff@berkeley.edu

Keith Johnson
Department of Linguistics, Univ. of California at Berkeley

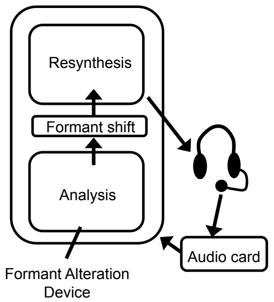
John Houde
Department of Otolaryngology, Univ. of California at San Francisco

Background

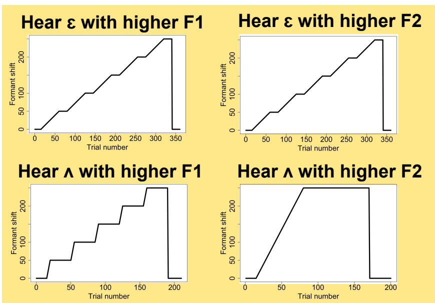
Subjects whose auditory feedback is experimentally altered in real time *compensate* by changing their speech production to oppose the alteration (Houde & Jordan, 2002). Compensation for altered auditory feedback tends to be *partial* and sensitive to the vowel being manipulated (Purcell & Munhall, 2008).

Materials and Methods

Subjects wear formant-shifting headphones and produce monosyllabic CVC words containing the target vowel (ɛ or ʌ). In experiments 1-3, formants are shifted stepwise, with steps at +50, +100, +150, +200, and +250 Hz. Steps contain 20 trials each in Experiments 1 & 2, and 30 trials each in Experiment 3. Formants were ramped for 65 trials up to a single plateau (90 trials long) in experiment 4.



4 types of formant shifts

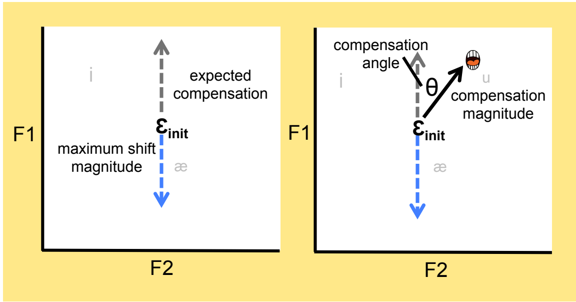


Measurements

Compensation magnitude: Euclidean Bark distance between formants produced during the last 20 trials of the highest formant shift step and the average vowel formants during the no-shift condition.

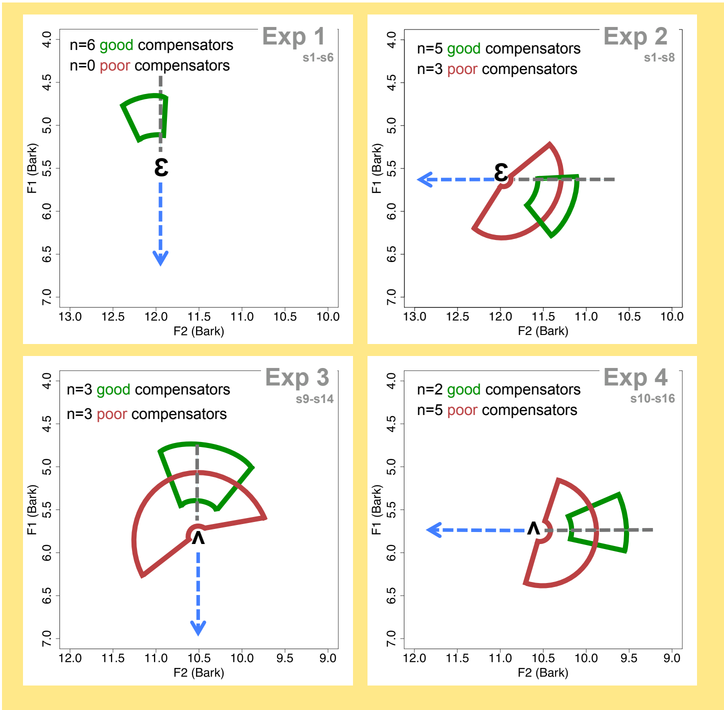
Shift magnitude: Euclidean Bark distance between formants heard at each trial of the highest formant shift step and the average vowel formants during the no-shift condition.

Compensation angle: The angle between the compensation magnitude vector and the shift magnitude vector. This angle is 0 if the subject directly opposes the feedback shift, and nonzero if the subject produces formants that do not oppose the feedback shift.



Results

Compensation at the highest formant shift step is indirect.



Each sector contains 90% of vowel formants produced across subjects in the experimental group.

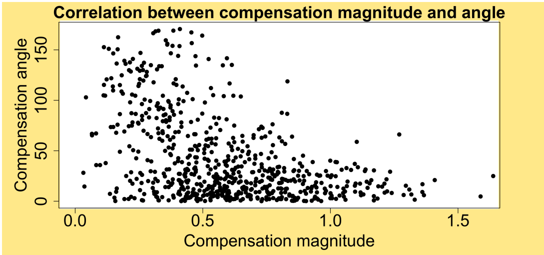
Hearing altered F1 *or* F2 feedback causes production changes in F1 *and* F2 across all experimental conditions.

Across subjects, compensation angle was greater than 0 for all experiments. However, there was significant intersubject variability because some subjects did not compensate for altered feedback. *Poor compensators* (red sectors) wander around their baseline regions and fail to oppose the feedback shift. They are characterized by relatively small compensation magnitudes and variable compensation angles.

In these analyses, good compensators (green sectors) had compensation magnitudes that were greater than 2 standard deviations of their baseline vowel regions. Baseline vowel regions were calculated from a control condition in which subjects produced 360 CVC words with no feedback shift.

Poor compensators behave unpredictably.

Poor compensators produce a wide variety of compensation angles, while good compensators produce uniformly low compensation angles.



References

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Purcell, DW & Munhall, KG (2006). Adaptive control of vowel formant frequency: Evidence from real-time formant manipulation. Journal of the Acoustical Society of America 120(2): 966-977.

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