Sensorimotor Adaptation of Vowel Production in Stop Consonant Contexts

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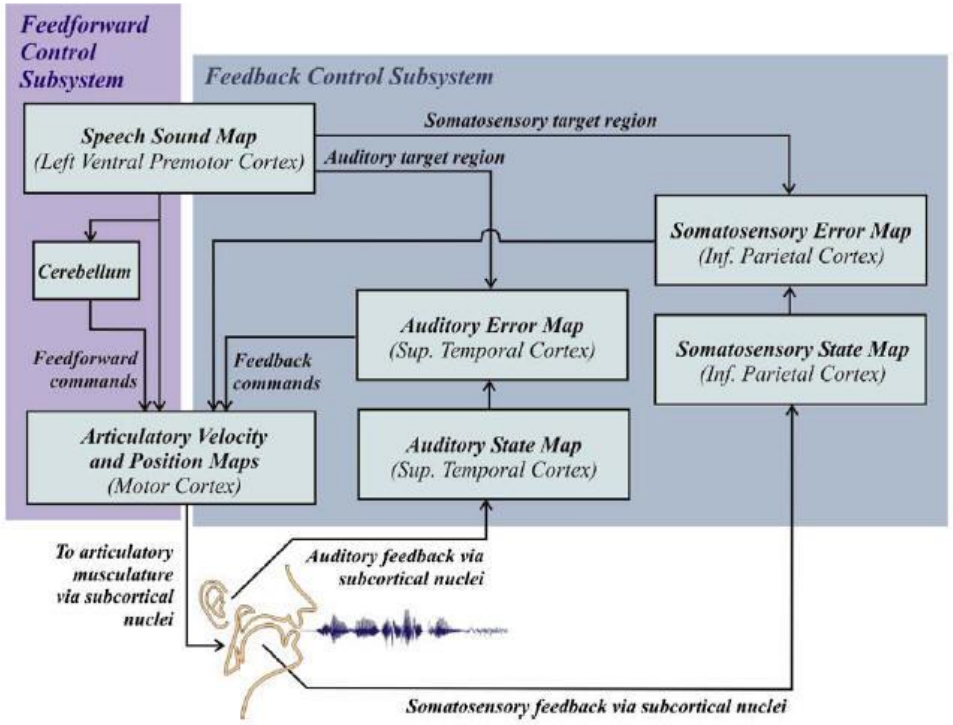
MCNAIR SCHOLARS PROGRAM

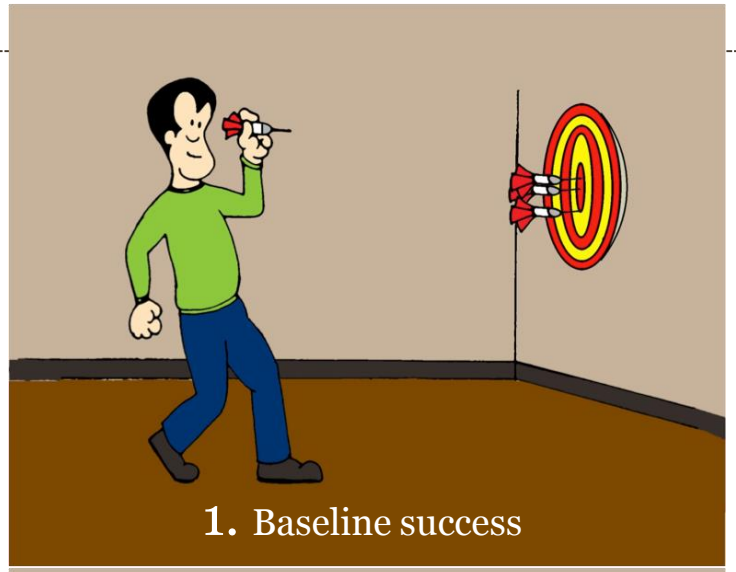
Introduction

- Relationship between auditory feedback and speech motor learning
- **Sensorimotor adaptation (SA)** is a short-term, involuntary form of learning in which a change occurs in movement based on sensory feedback errors.
- In speech, adaptation is an involuntarily learned change in an articulatory movement due to perturbed auditory feedback.

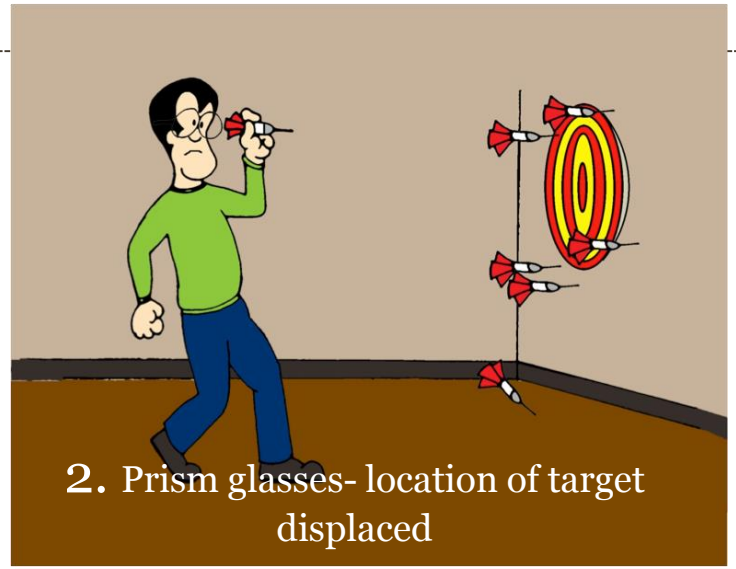


Guenther (2006)

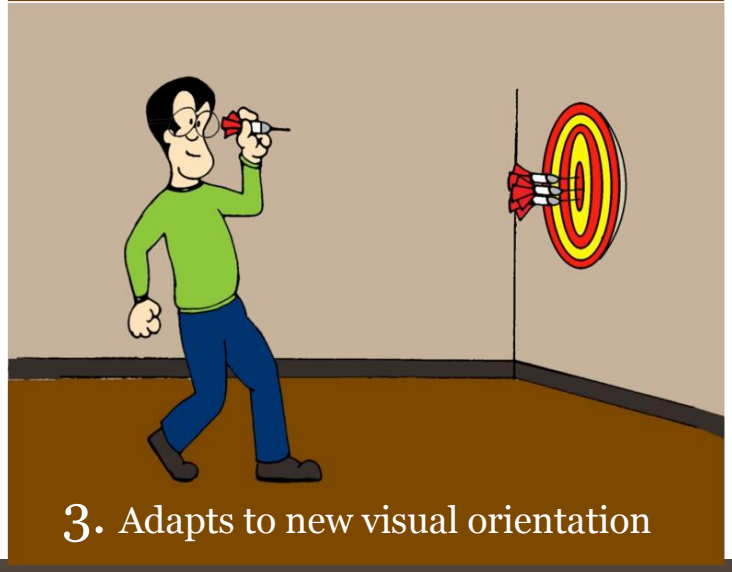
Visual Adaptation Experiment



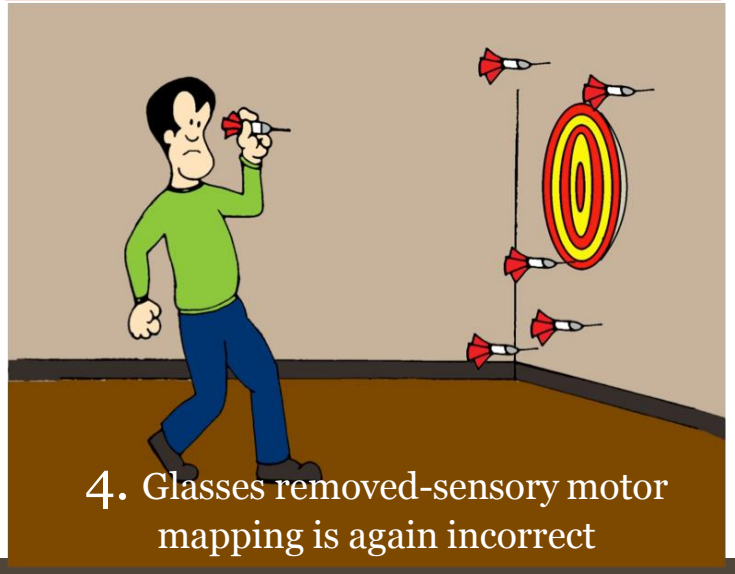
1. Baseline success



2. Prism glasses- location of target displaced



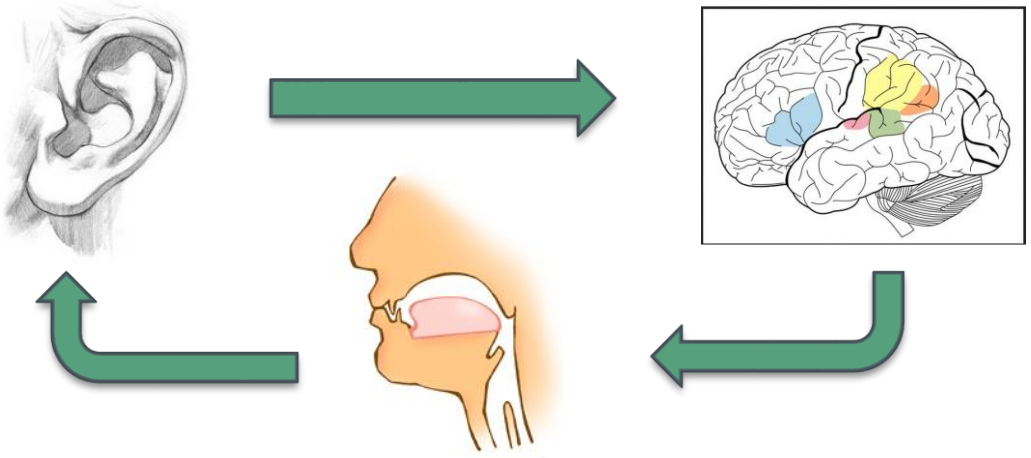
3. Adapts to new visual orientation



4. Glasses removed-sensory motor mapping is again incorrect

Compensation and Adaptation

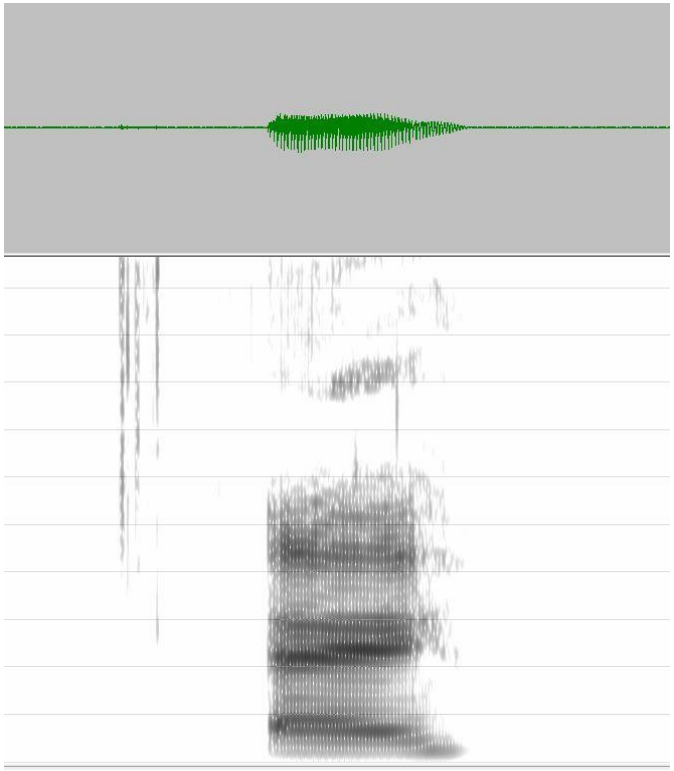
- Experimental perturbations to auditory feedback produce **compensatory** changes in a speaker's articulation.
- **Adaptation** is demonstrated if speakers continue those compensatory articulations after auditory feedback has been eliminated by masking noise.
- Adaptation-based learning could be further developed to help those with motor speech disorders, for whom there are currently no effective treatments.
  - Stroke, TBI, neurodegenerative disorders → weakened muscles for speech production



Background Information: Formants

- Formants
  - High-energy acoustic resonance patterns that reflect positions of articulators
  - Acoustically, vowels are defined by their two lowest resonant frequencies (F1 and F2)

- How does implementing a change in auditory feedback affect vowel formant values?

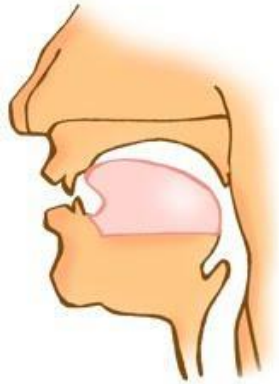


Spectrographic representation of vowel /e/

Stop Consonants

- Begin with occlusion of the airway at the place of articulation
- Buildup of air pressure behind the occlusion in the oral cavity
- After the pressure builds up, the airway is abruptly opened and a burst of air is released
- Stop sounds that were analyzed included /p/ and /t/

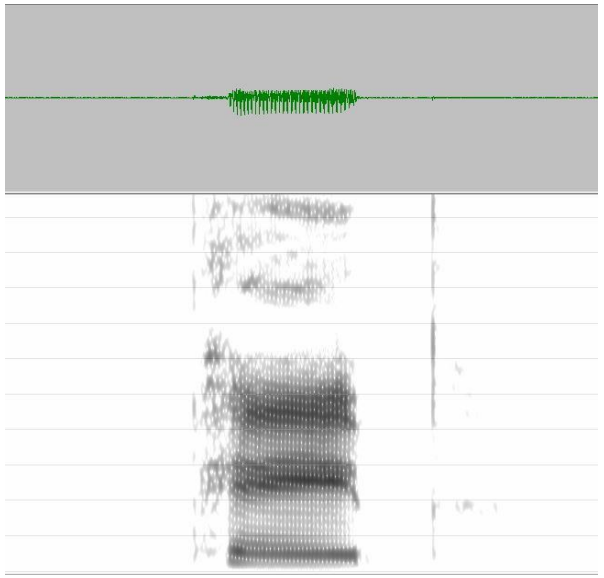
Bilabial consonant /p/



Alveolar consonant /t/

Coarticulation

- Speech sounds are not produced identically in different contexts, but rather they depend upon the preceding or following speech sounds.
- Different consonant contexts have varying effects on vowel formants due to competing demands on the articulators.
- What consonant contexts can elicit the greatest amount of SA?



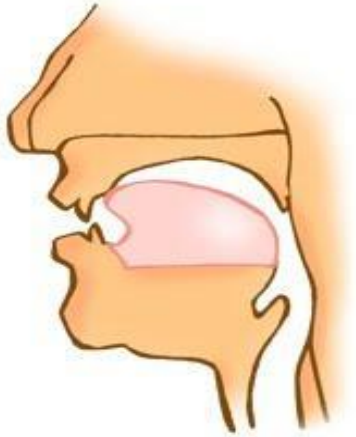
Research Questions

- Do speakers compensate and adapt to acoustic perturbations of F1 and F2?
- Are these compensations and adaptations in the opposite direction of the perturbation?
- Will there be a greater amount of compensation and adaptation for the word /pep/ (“pape”) rather than /tet/ (“tate”) because of the bilabial consonant context?

Hypothesis

- Manipulating auditory feedback by shifting formant values is hypothesized to elicit SA, whereby the amount of adaptation is expected to be greater for the word /pep/ (“pape”) rather than /tet/ (“tate”) because there is less competition for articulatory placement of the tongue during production of bilabial consonants.

Bilabial Consonant /p/



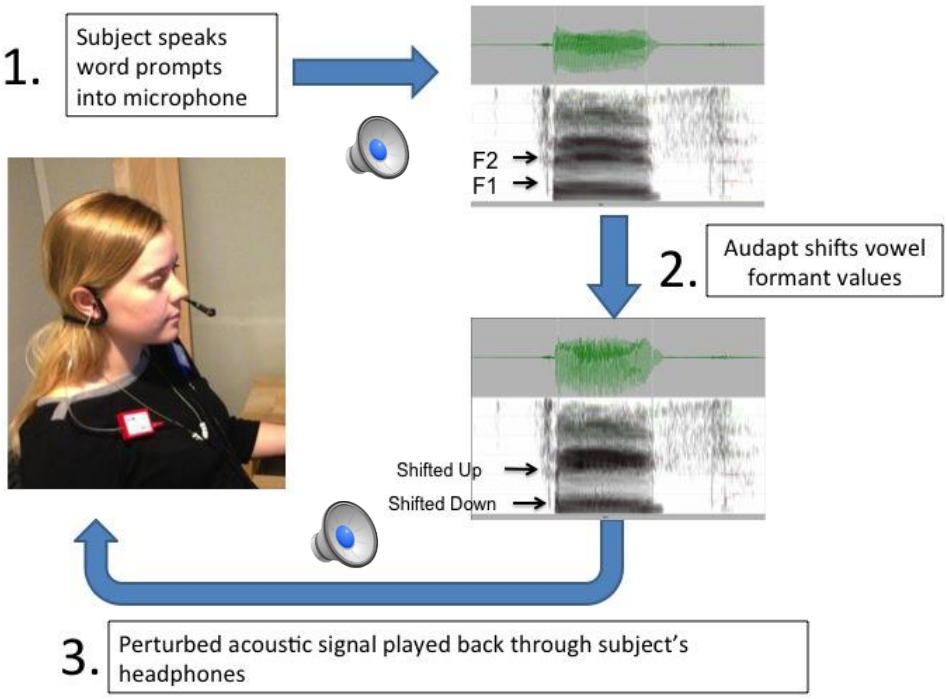
Alveolar Consonant /t/

Methodology

- Using *Audapt* software, the vowel /e/ in the words /pep/ (“pape”) and /tet/ (“tate”) was perturbed to sound closer to the /i/ vowel.

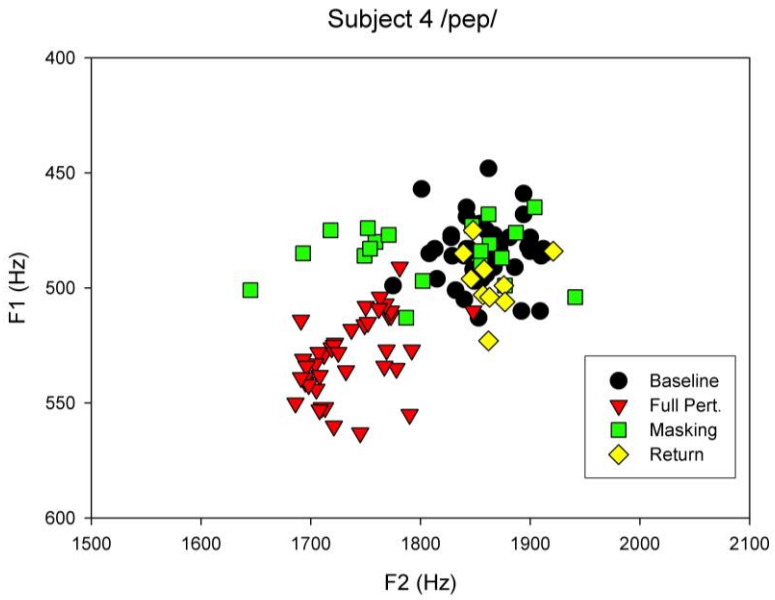
- This caused participants to perceive an error in vowel articulation.

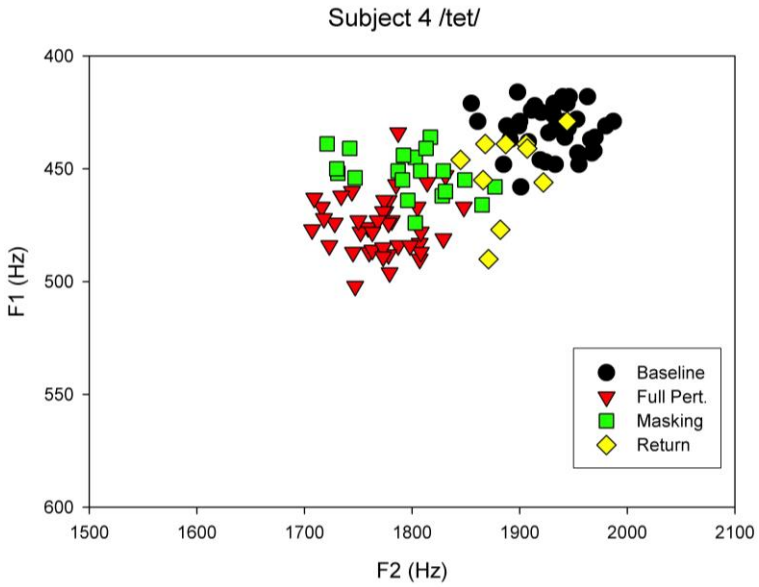
Stage	Learning Behavior	Auditory Feedback Condition
Baseline	Baseline	Unperturbed
Ramp	Training	Gradual F1 shift down & F2 shift up
Full Pert	Compensation	Constant max F1 shift down & F1 shift up
Masking	Adaptation	Noise: no auditory feedback
Return	Baseline	Unperturbed



Results

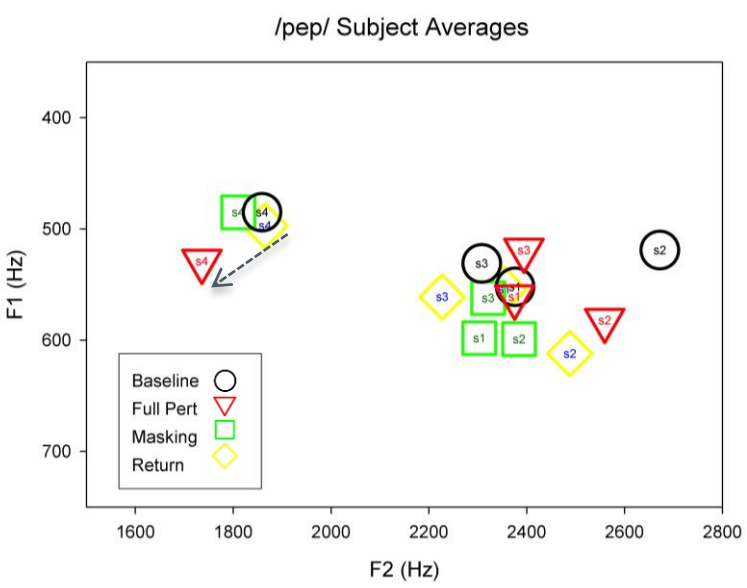
- Graphs show acoustic measurements characterizing information about tongue movement: F1 and F2
- **Compensation** is evaluated by comparing the values from baseline to full perturbation.
- **Adaptation** is evaluated by comparing the values from baseline to masking.

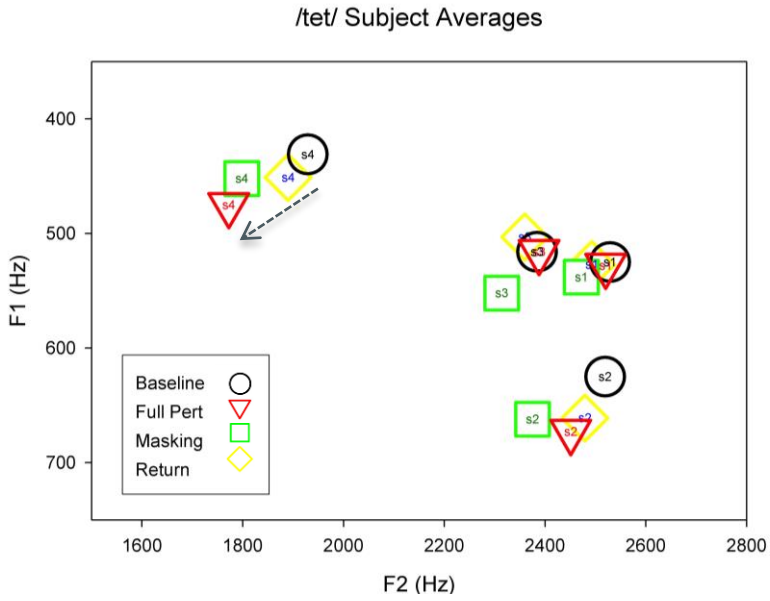




Conclusion

- For /pep/ (“pape”), there appears to be a greater degree of compensation and adaptation across subjects.
- 3/4 subjects displayed a shift in their formant values consistent with the hypothesis.
- Magnitude of the shift was greater for /pep/ (“pape”), indicated by the greater spread of data points across phases.



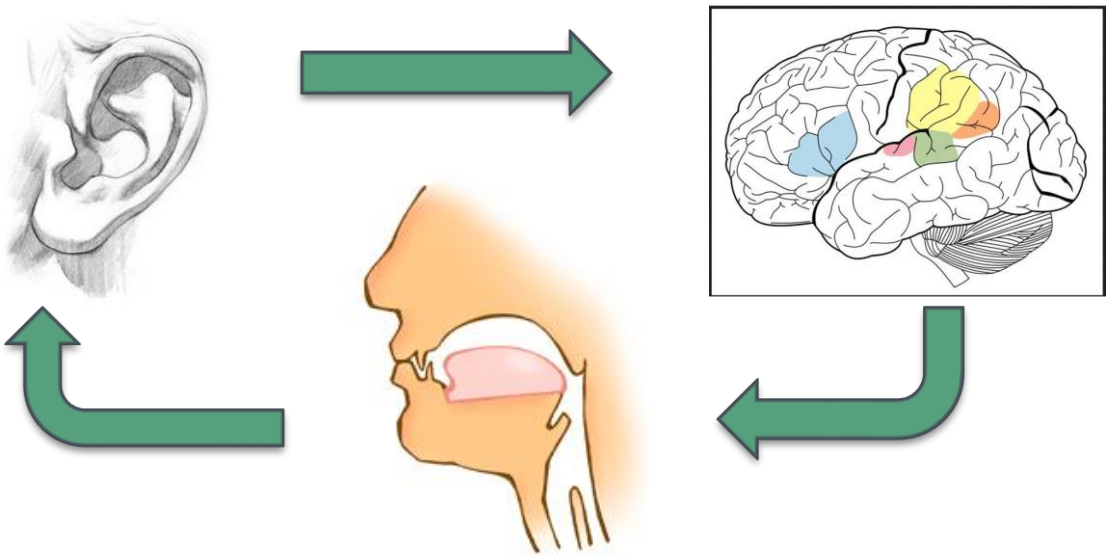


Limitations

- Oftentimes, SA occurs in experimental conditions, but the effects weaken with time.
- SA is not yet well understood as a form of long-term rehabilitation.
- Current digital signal processing techniques are limited for those with disordered speech because they require a robust vocal quality.

Broad Impact: Clinical Relevance

- Stepping stone to help understand how typical speakers respond to auditory feedback manipulations
- Understand how speech sound environments affect how a vowel can be adapted
- Knowledge of SA can be further developed to use as a tool for therapy to make unconscious articulatory changes of those with disordered speech



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