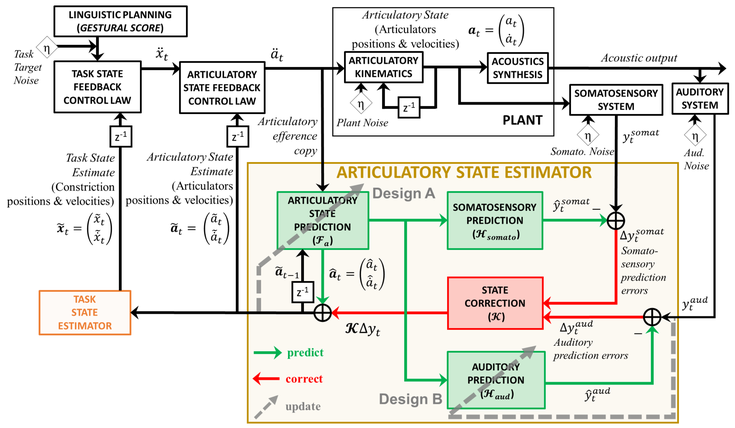
Sensorimotor adaptation in a hierarchical state feedback control model of speech

KS Kim[1], JL Gaines[2], B Parrell[3], V Ramanarayanan[4,5], SS Nagarajan[6], JF Houde[4]

[1]Department of Speech, Language, and Hearing Sciences, Purdue University, [2]UC Berkeley-UCSF Graduate Program in Bioengineering,
[3] Department of Communication Sciences and Disorders, University of Wisconsin–Madison, [4]Department of Otolaryngology-Head and Neck Surgery, University of California, San Francisco,
[5]Modality.AI, [6]Department of Radiology and Biomedical Imaging, University of California, San Francisco

Introduction and Method

- Auditory prediction error-based mechanisms involved in speech auditory-motor adaptation were examined via the feedback aware control of tasks in speech (FACTS) model.
- Consistent with theoretical perspectives in both non-speech and speech motor control, the hierarchical architecture of FACTS relies on both the higher-level task (vocal tract constrictions) as well as lower-level articulatory state representations.

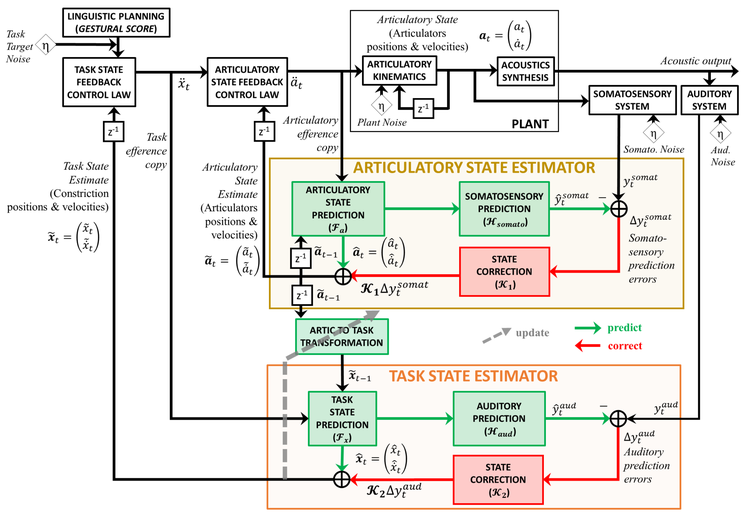


Design A

Auditory prediction errors updated the forward model that predicted the current articulatory state.

Design B

Auditory prediction errors updated the auditory forward model.



Design C

Used a new hierarchical architecture with separate state feedback control loops for the articulatory level and the task level.

Auditory prediction errors updated the articulatory-to-task transformation.

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Mollaei, F., Shiller, D. M., & Gracco, V. L. (2013). Sensorimotor adaptation of speech in Parkinson's disease. *Movement Disorders: Official Journal of the Movement Disorder Society*, *28*(12), 1668–1674.
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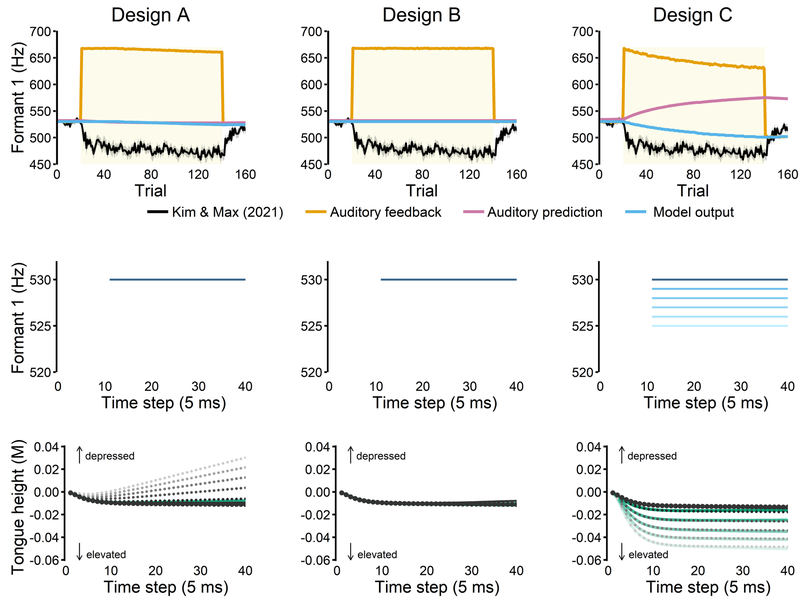
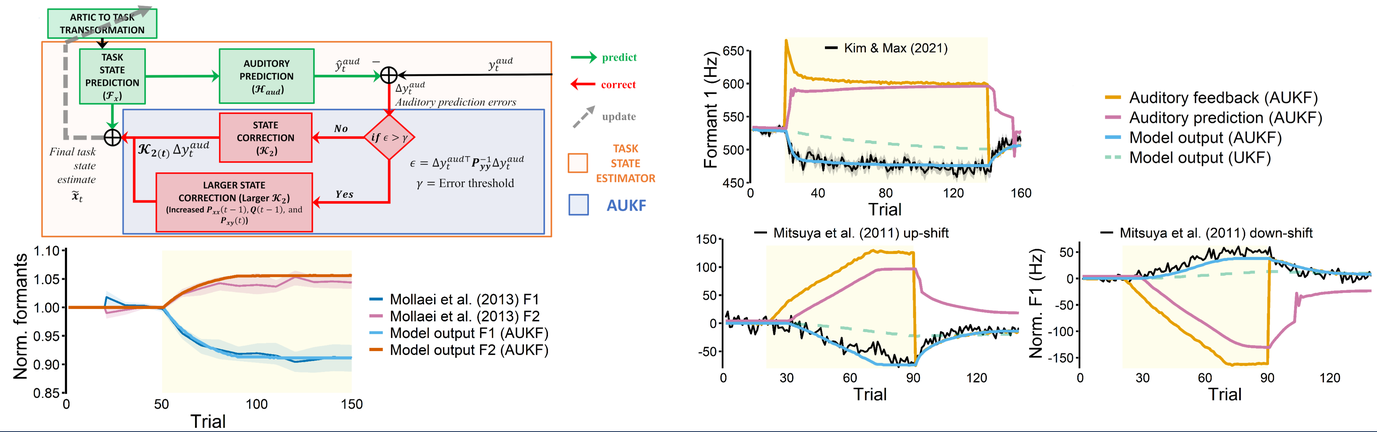
Results



- Updating forward articulatory state (Design A) or sensory prediction models (Design B) did not cause adaptation.
- Updating the task state transformation model produced adaptation (Design C).
- The adaptive changes in Design C could also be observed in the articulatory space (e.g., tongue height).
- Nonetheless, the simulated adaptation was smaller and slower than adaptation observed in experimental data because the Kalman filter assumed a high magnitude of random noise in the sensory signals.

Design C implemented with AUKF produces realistic adaptation

In order to simulate more realistic sensorimotor adaptation, we implemented a simple adaptive unscented Kalman filter (AUKF) in Design C.



Conclusions

- We found that adaptive behavior was present only when prediction errors updated the articulatory-to-task state transformation.
- In contrast, designs in which prediction errors updated forward sensory prediction models alone did not generate adaptation.
- FACTS demonstrated that prediction errors can drive adaptation through task-level updates.

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