Lexical information guides retuning of neural patterns in perceptual learning of speech

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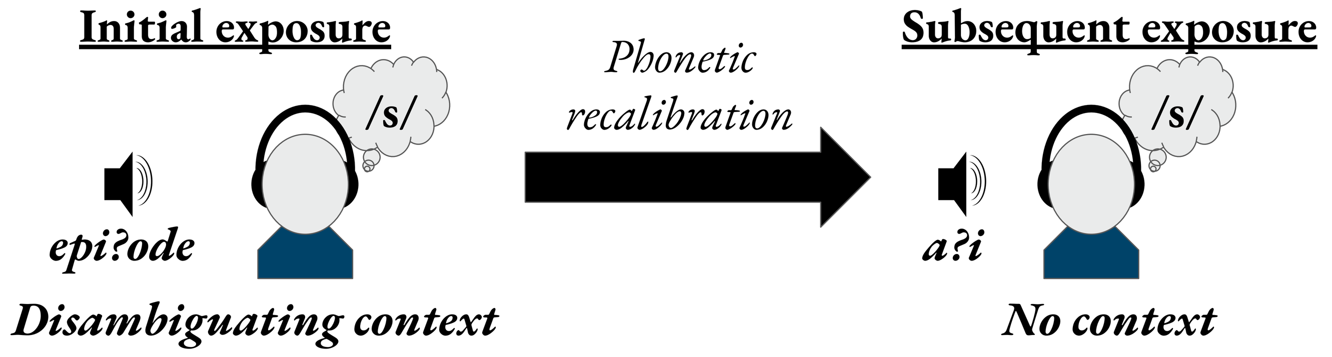
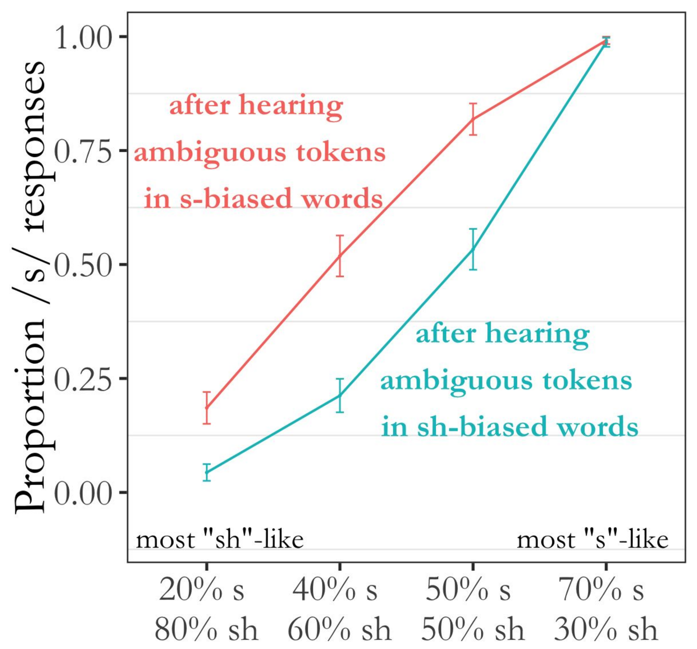
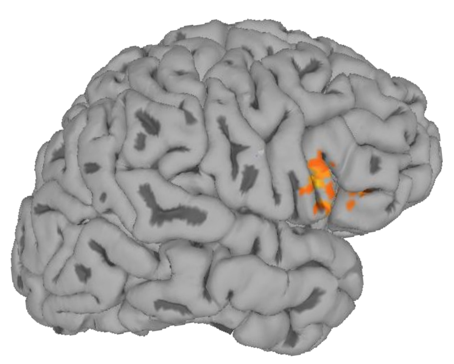
Introduction

Interpretation of ambiguous phonemes is influenced by **context** (e.g., lexical knowledge, accompanying text). Such context also guides perception in future encounters, a phenomenon known as **phonetic recalibration** or **perceptual learning for speech.**[1,3,6,7]



Myers and Mesite (2014) investigated the neural basis of lexically guided perceptual learning.[6] **Right frontal** brain regions showed differential responses to ambiguous tokens as a function of previous exposure.





Region that showed lexical context effects on subsequent processing of speech

How does the underlying **pattern of neural activity** change when phonetic recalibration occurs?

Neuroimaging Methods

Archival fMRI data[6] came from **24** subjects who completed alternate blocks of **lexical decision** and **phonetic categorization**. During lexical decision, participants either heard ambiguous tokens in s-biased contexts (e.g., *epi?ode*; n=12) or sh-biased contexts (e.g., *refre?ing*; n=12).

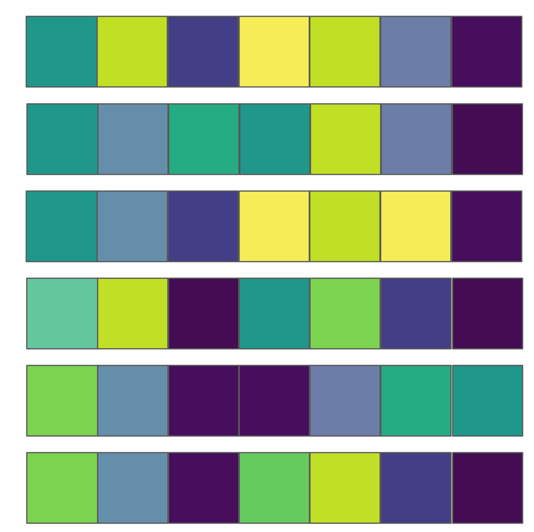
s-bias group (n=12)	Lexical Decision (*epi?ode*)	Phonetic Categorization (asi-ashi)	LD	PC	LD	PC	LD	PC	LD	PC
sh-bias group (n=12)	Lexical Decision (*refre?ing*)	Phonetic Categorization (asi-ashi)	LD	PC	LD	PC	LD	PC	LD	PC

Study used a **fast event-related** design with **sparse sampling** (stimuli presented in 1-sec silent gap after each 2-sec scan).

Analysis Approach

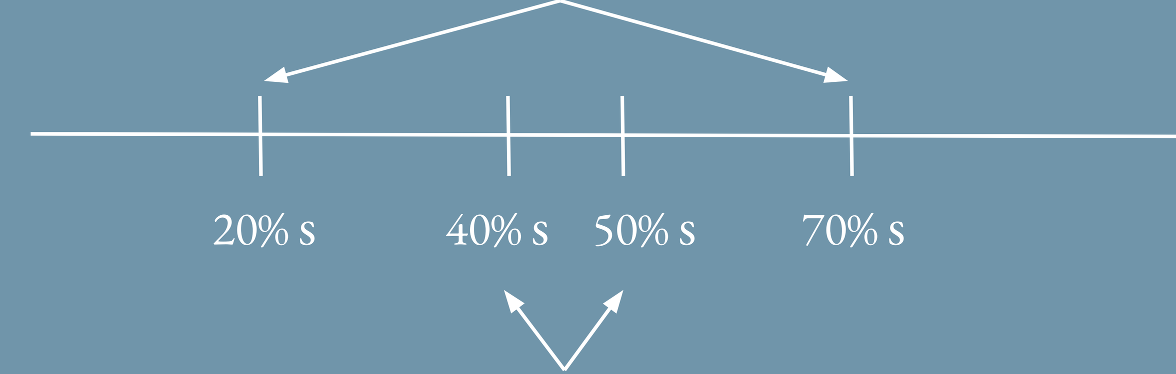
Multi-voxel pattern analysis (MVPA) considered the pattern of beta weights[5] across all voxels on each phonetic categorization trial.

Trial	Acoustics	Percept	Hypothetical Pattern
1	20% s	S	
2	40% s	S	
3	50% s	S	
4	40% s	SH	
5	50% s	SH	
6	70% s	SH	



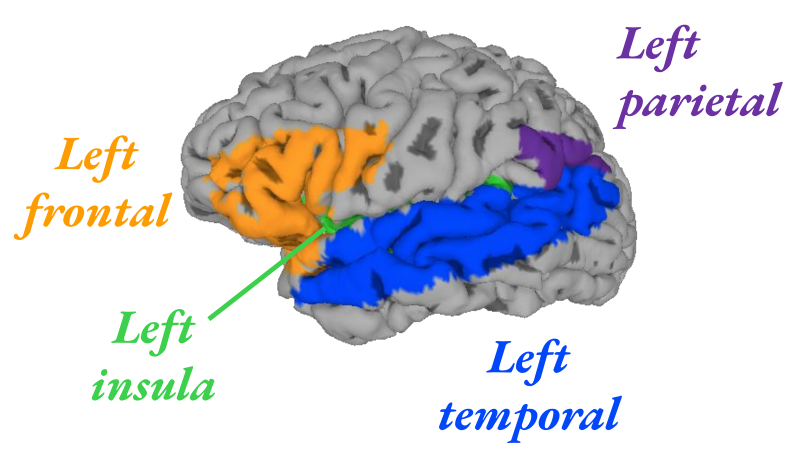
Note that categorization of ambiguous tokens was influenced by the contexts in which listeners had previously encountered such stimuli, though there was still **considerable variability** in their categorization from trial to trial.

A support vector machine was **trained** on patterns from **unambiguous** trials,



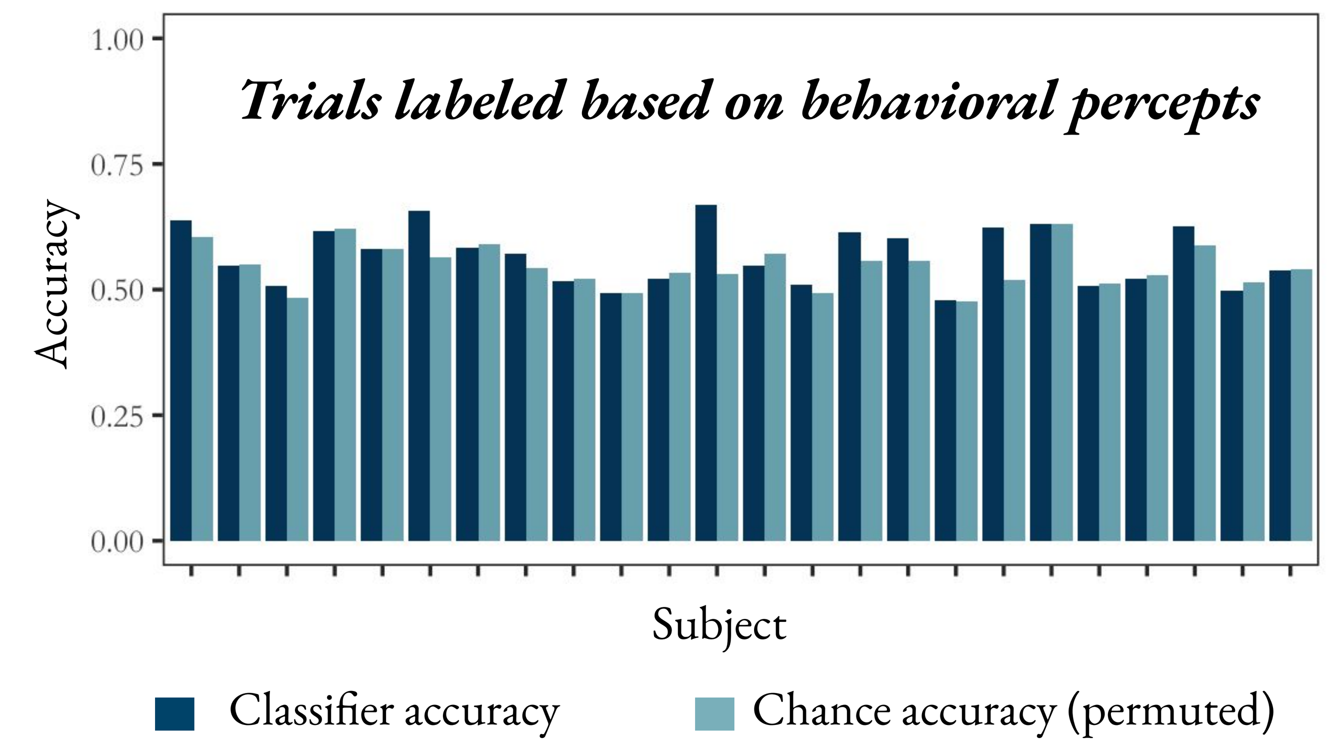
and **tested** on patterns from **ambiguous** trials, which were either labeled based on physical **acoustics** or based on trial-by-trial behavioral **percepts**.

Initial analyses considered all voxels in a set of anatomical regions of interest (ROIs) known to be involved in language processing. Follow-up analyses considered each ROI separately. Right hemisphere analogs were considered but are not shown.



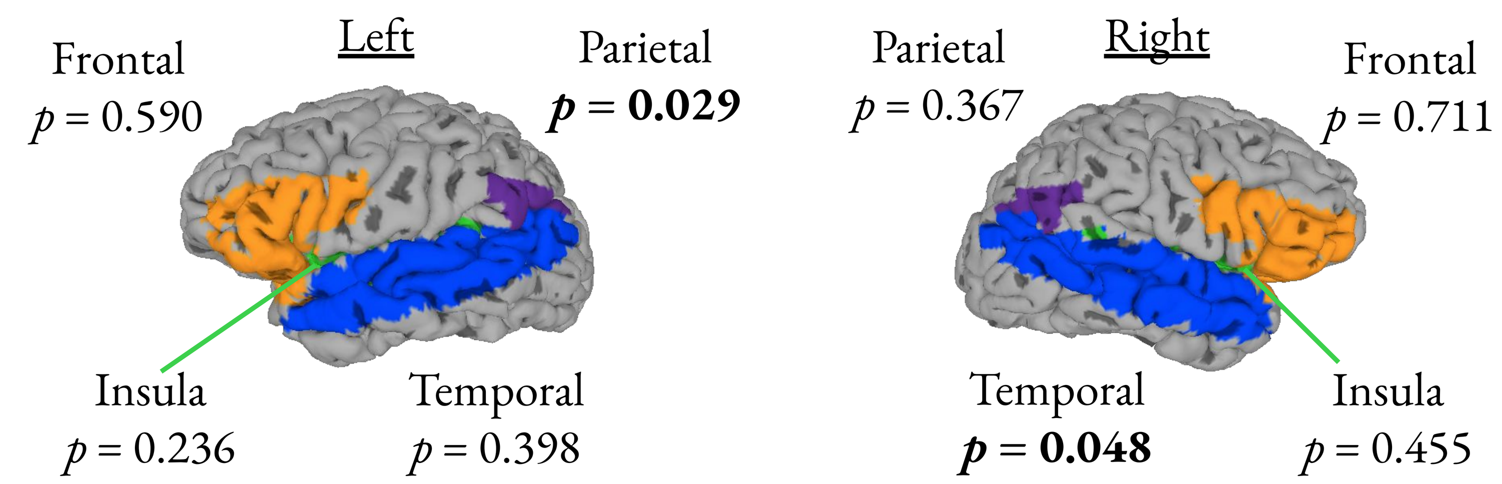
Cross-validation was achieved with a leave-one-run-out approach. Recursive feature elimination was used to identify the most informative voxels. To estimate chance levels, we also conducted 100 permutations in which training labels were shuffled.

Results and Discussion



Classification was significantly above chance when tested on behavioral **percepts** ($p = 0.012$) but not when tested on physical **acoustics** ($p = 0.998$).

Follow-up analyses of percept classification considered smaller ROIs.



Brain activity (especially in left parietal regions) reflects listeners' **ultimate perception** of ambiguous speech sounds, not necessarily the actual acoustics.

- A previous phonetic recalibration study used text to guide interpretation of ambiguous speech sounds in nonword contexts and found that listeners' interpretation of the ambiguous sound was recoverable from the pattern of activity in **left superior temporal gyrus (STG).**[1]
- In a phoneme restoration study, trial-by-trial neural responses in left STG differed depending on how a noisy stimulus was perceived.[4]
- Notably, these previous results emerged in analyses that did not consider the activity of left parietal regions in their ROIs.
- Our data suggest a role for ***left parietal*** regions in phonetic recalibration. These regions may be particularly important when lexical knowledge guides recalibration, as left parietal activity has been specifically tied to lexical influences on phonetic processing[2].

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