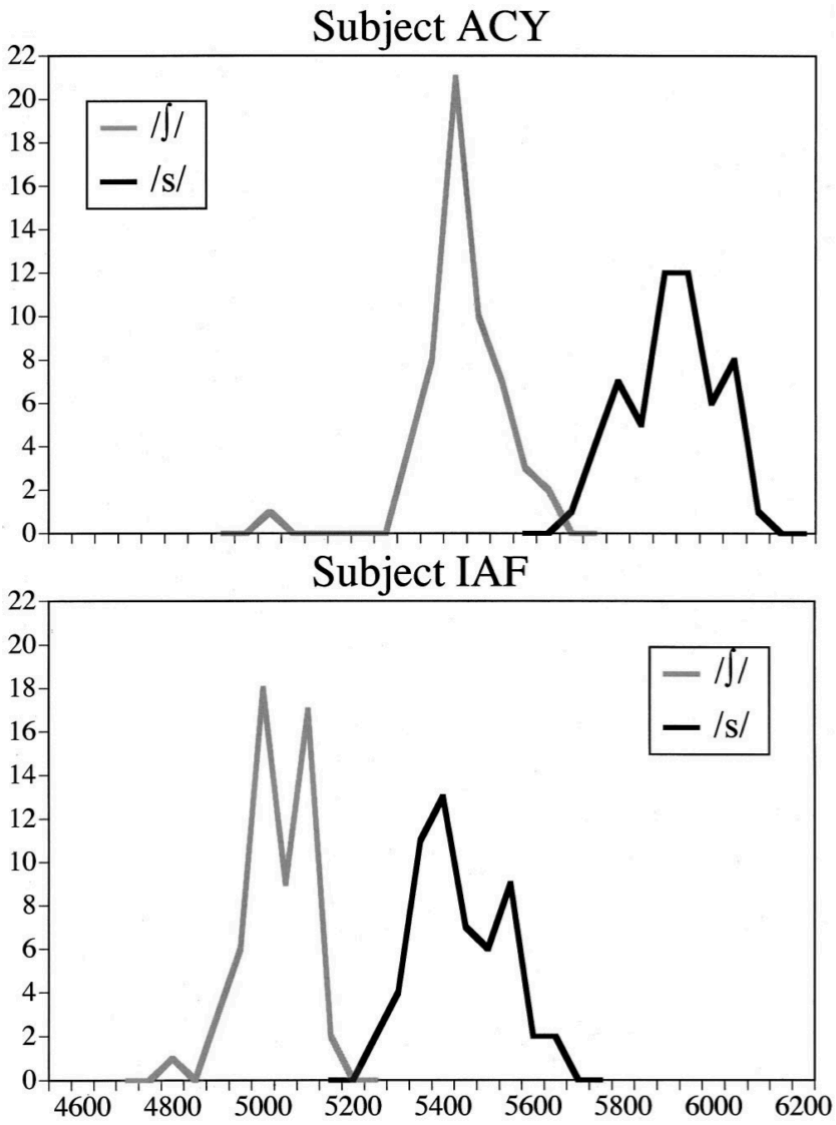
Adaptation in Speech Perception Pt. 2

BCS 152

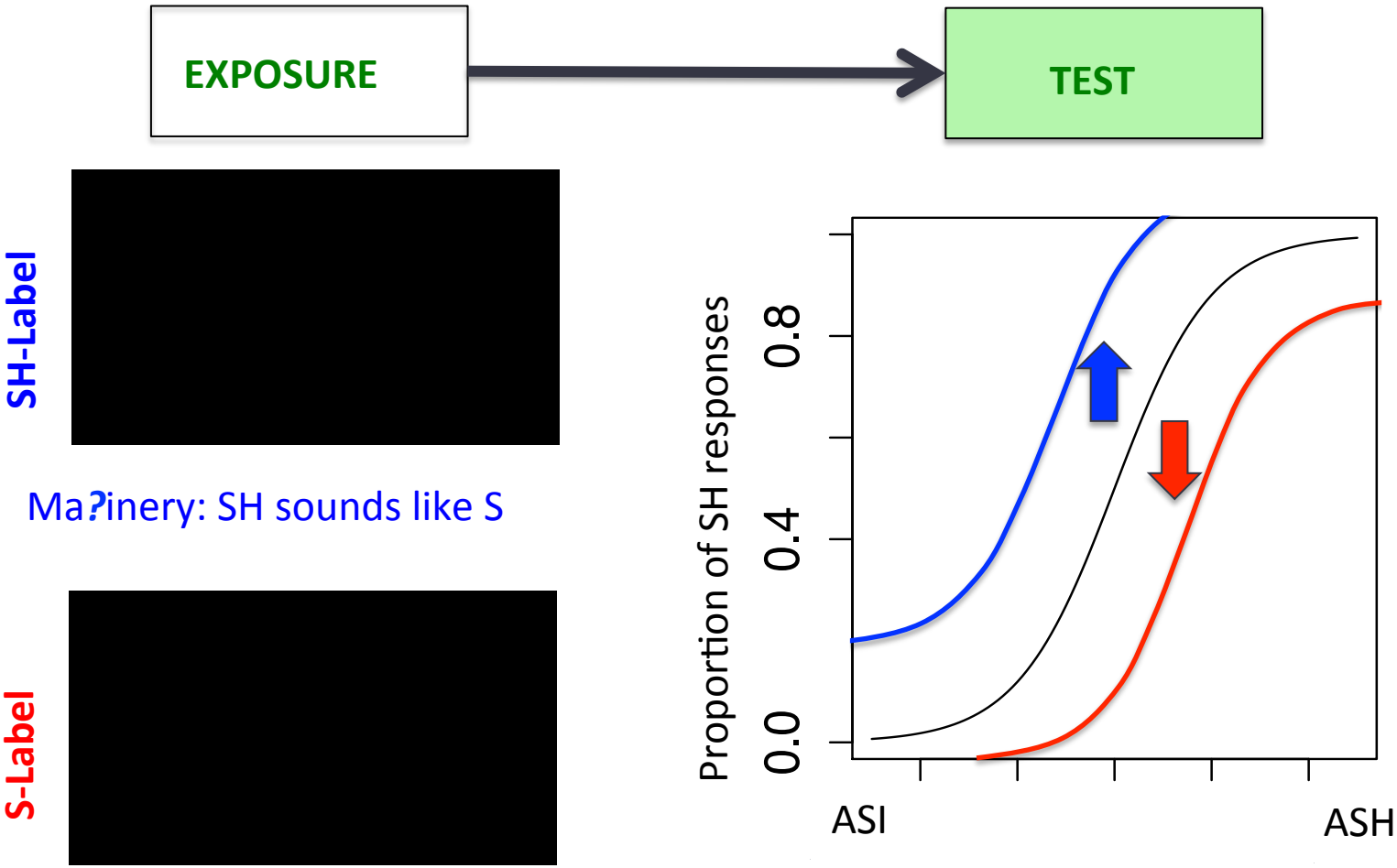
8 October 2018

Last lecture...

- Substantial variability between speakers
- Listeners need to be able to **adapt**

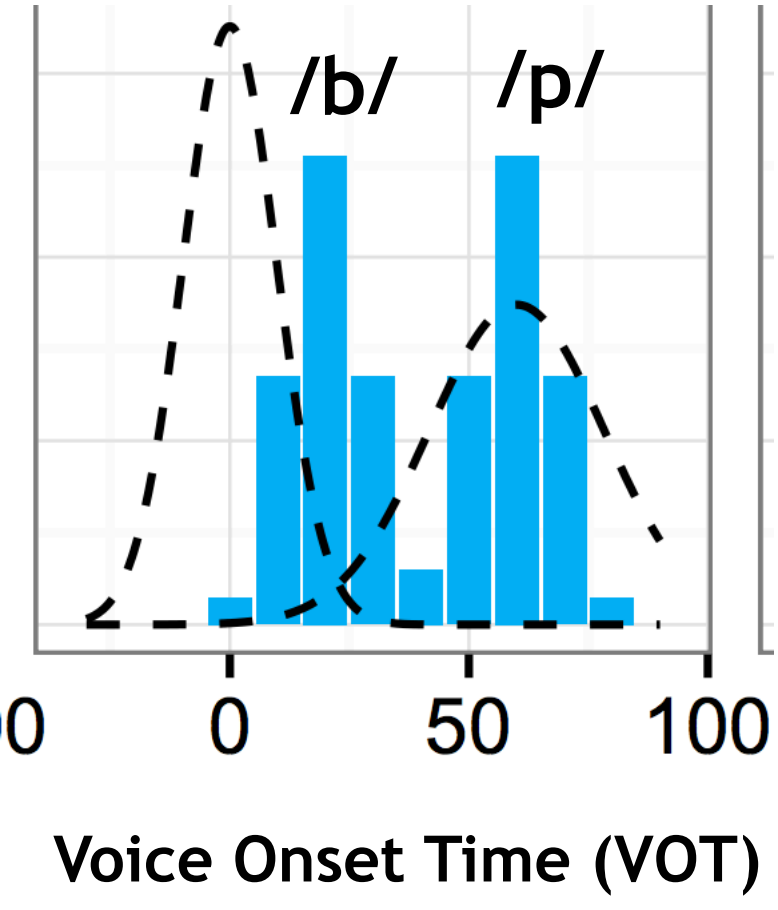


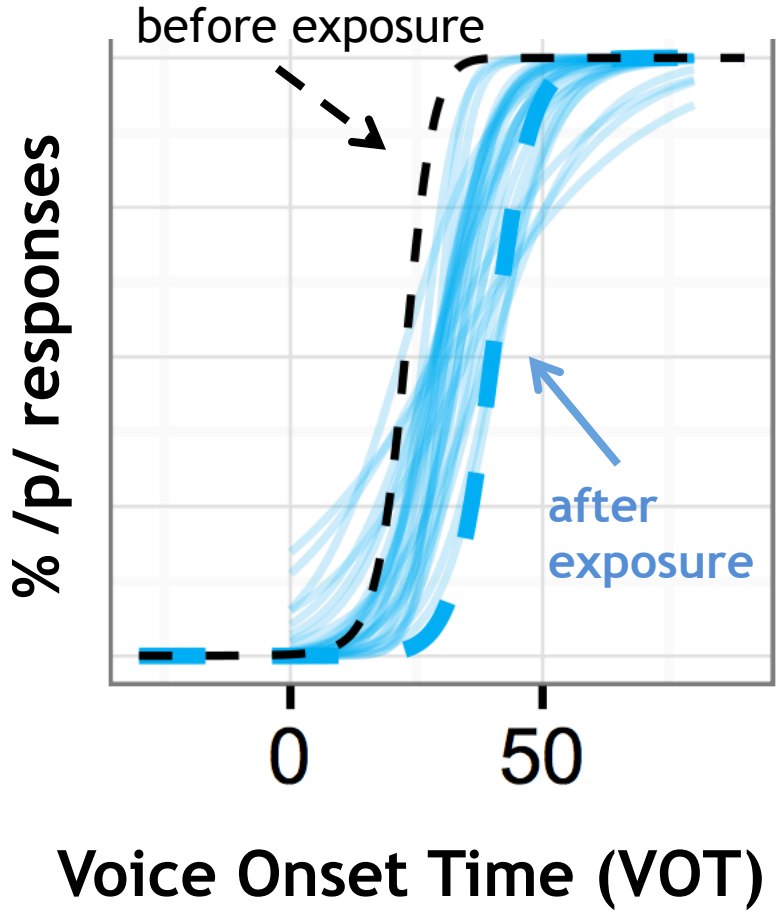
Listeners can adapt to shifted production of a sound contrast



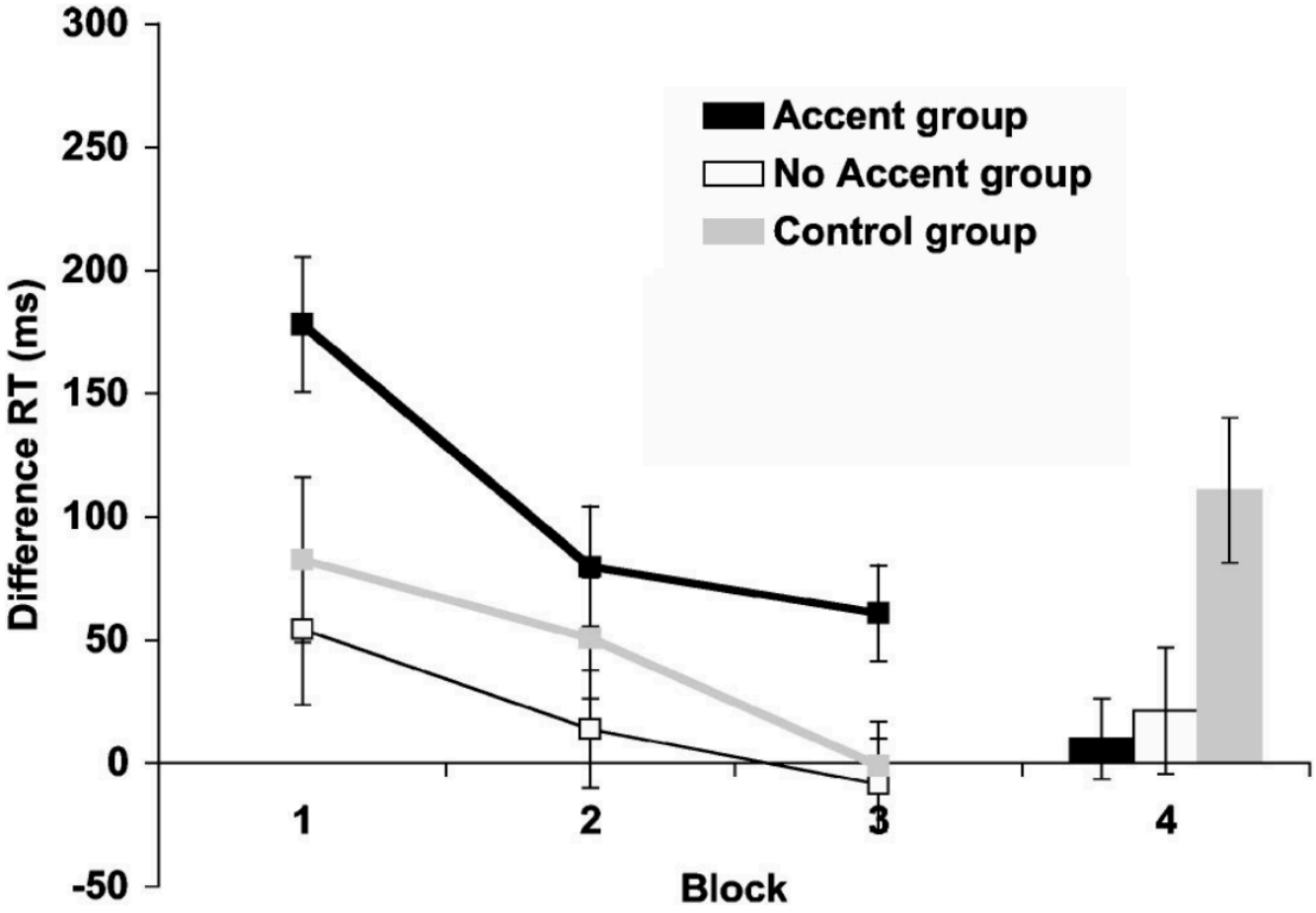
(e.g. Norris et al. 2003, Kraljic & Samuel, 2005)

…even when they don't get labeled data

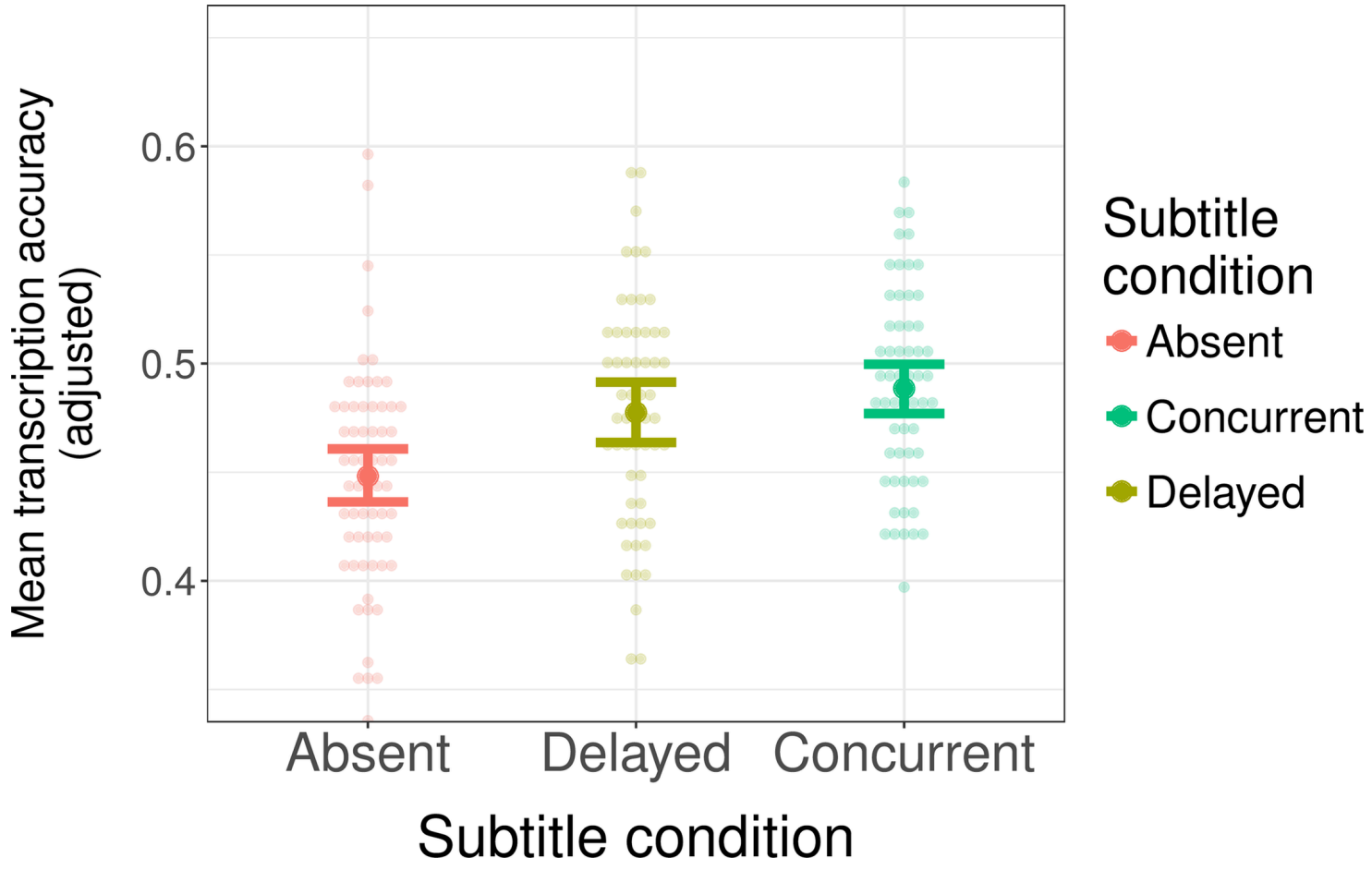




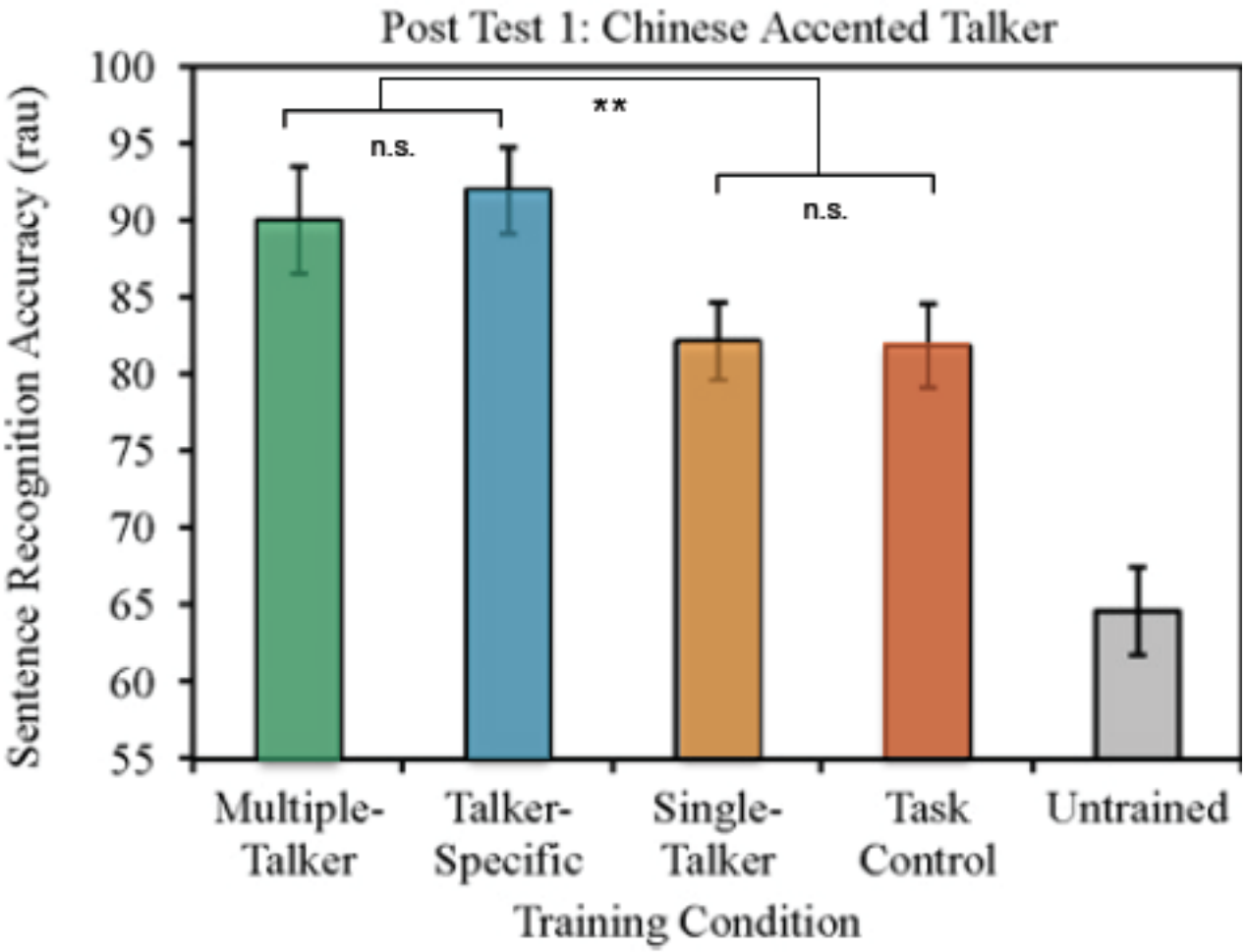
When listening to a new accent, listeners improve quickly



Additional lexical information improves performance



Variability helps: more varied exposure to an accent → better adaptation to a new speaker with that accent



Questions about last lecture?

Roadmap

- Use of prior world knowledge & language knowledge during perceptual adaptation
- Speech perception & adaptation in the brain
- Adaptation as a broader theory of speech perception

Using Language and World Knowledge During Adaptation

How Constrained is Adaptation?

- Kraljic & Samuel (2006): listeners generalized category shift to a new speaker
  - even though there was no evidence that the new speaker had the same shift

- So is adaptation just a low-level process applied regardless of context?

Spoiler: No

- 2 examples of listeners using higher-level knowledge during perceptual adaptation:
  - world knowledge and causal inference
  - prior knowledge about typical characteristics of native language

Use of World Knowledge

Reasoning about the cause of a speaker's shifted productions

Maybe she just says /sh/ weird because she's got a pen in her mouth!

Kraljic & Samuel (2008);
Liu et al. (2018)

Listeners ‘explain away’ shifted productions that have another available cause

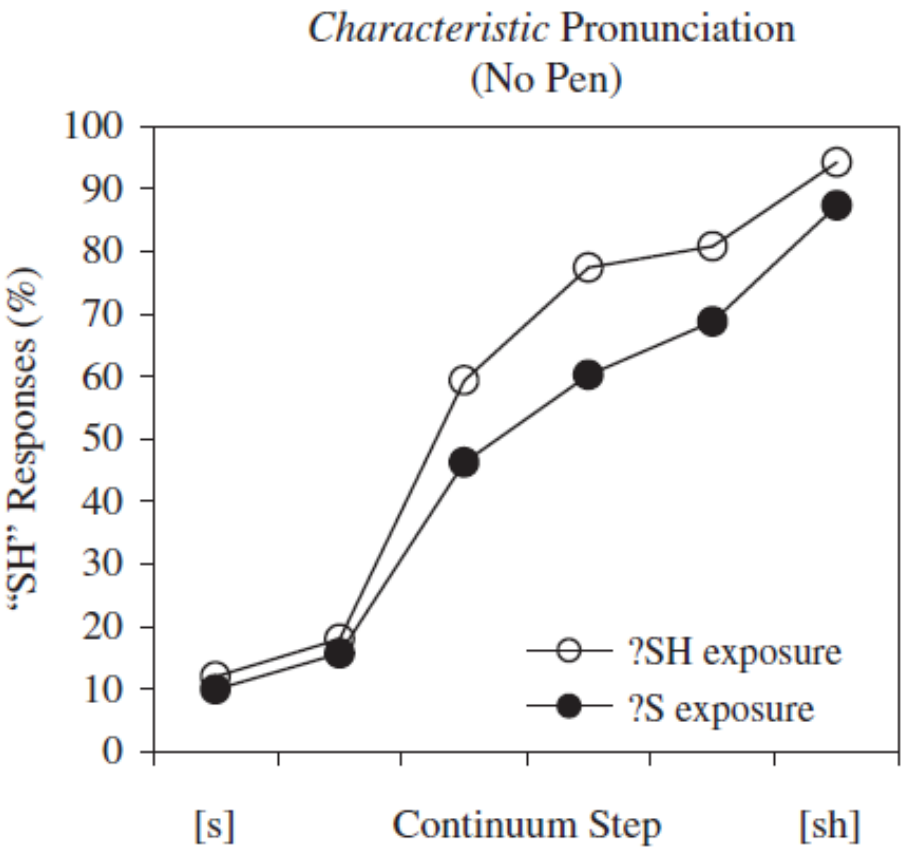


Fig. 3. Percentage of ‘‘SH’’ responses for each categorization-test item in the audiovisual conditions as a function of perceptual-learning condition (?SH vs. ?S). Results are shown separately for the characteristic-pronunciation and incidental-pronunciation conditions.

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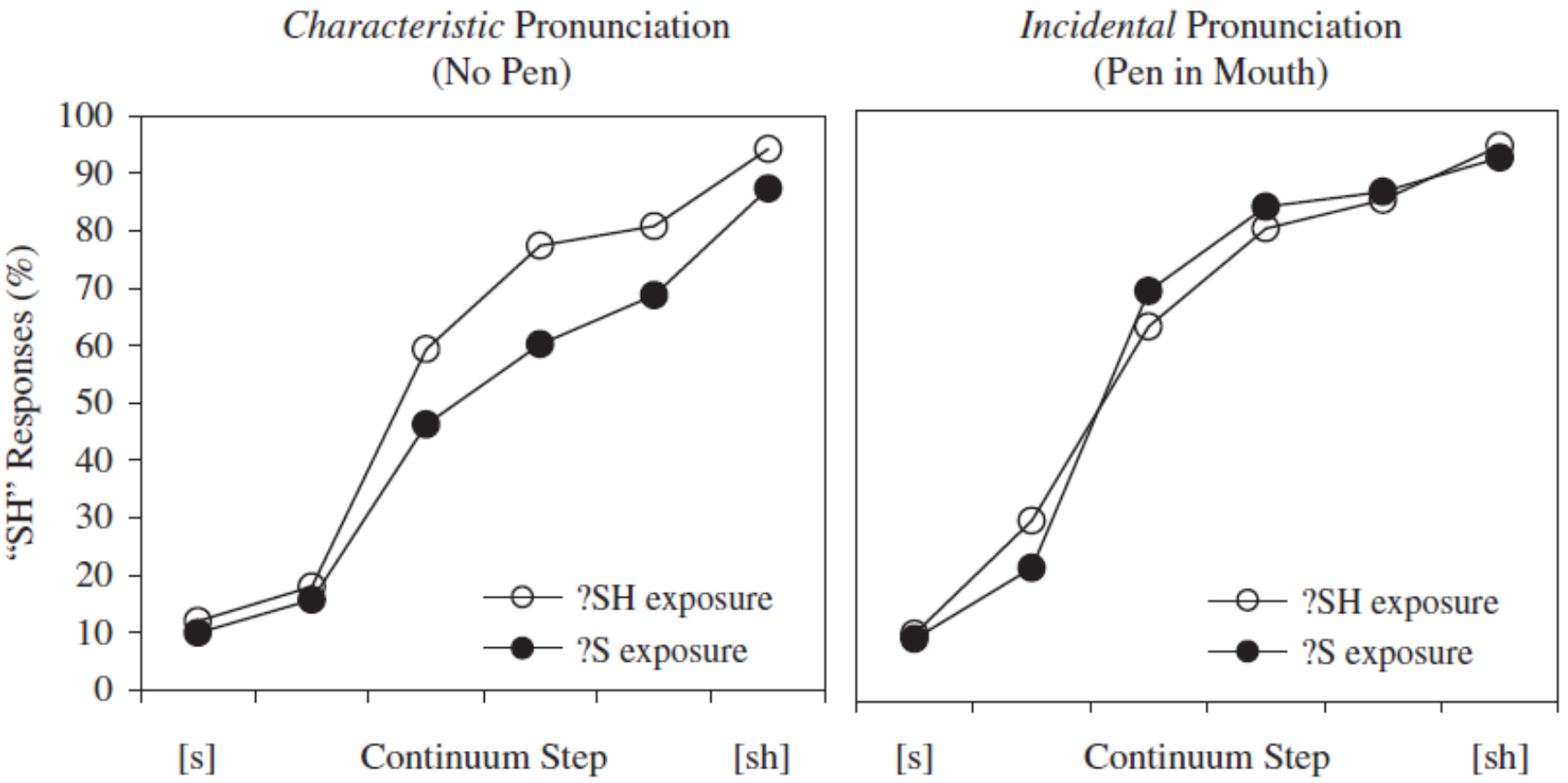

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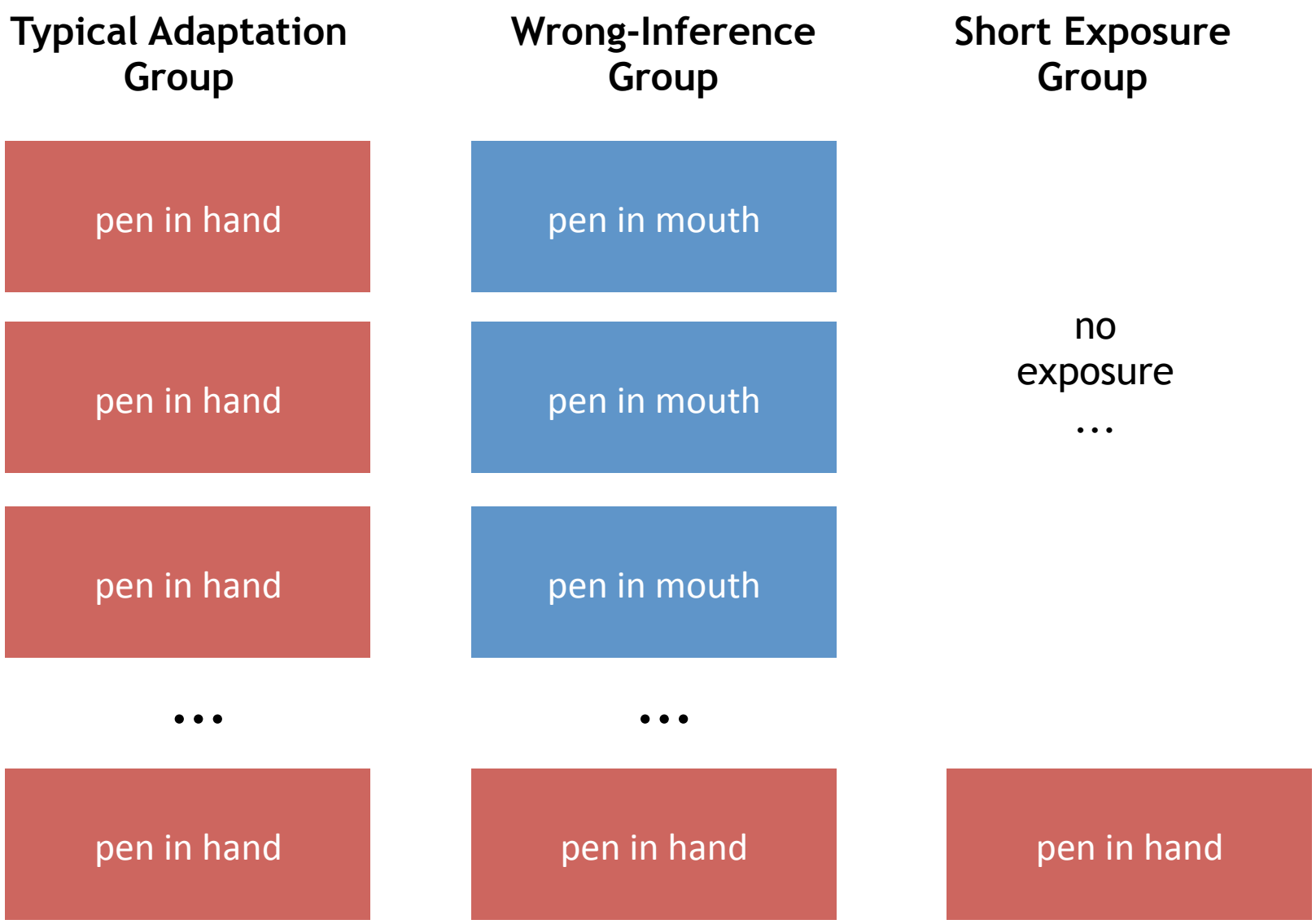
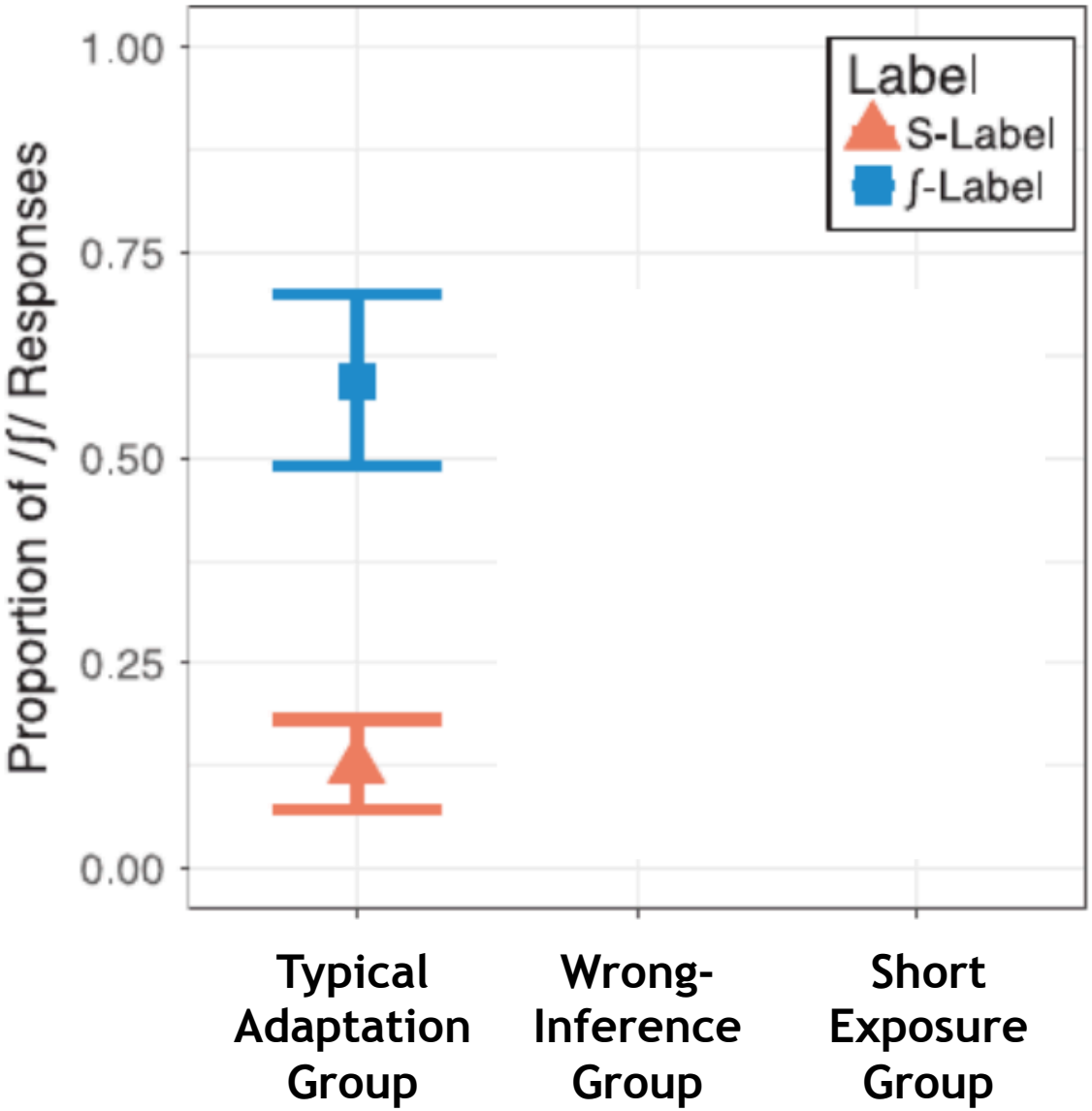
Liu et al. (2018): can listeners recover from the wrong inference?




Proportion of /ʃ/ Responses
1.00
0.75
0.50
0.25
0.00
Label
S-Label
ʃ-Label
Typical Adaptation Group
Wrong-Inference Group
Short Exposure Group

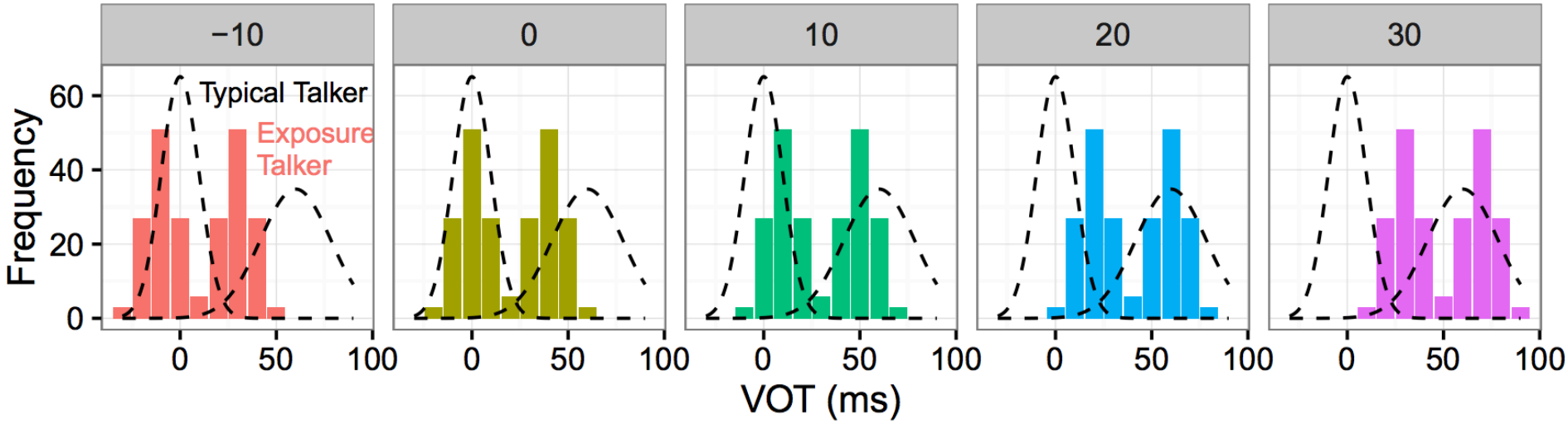
- Listeners' perceptual behavior is actually quite sophisticated

- Use general-purpose world knowledge and causal reasoning during adaptation
  - able to quickly recover from wrong inferences

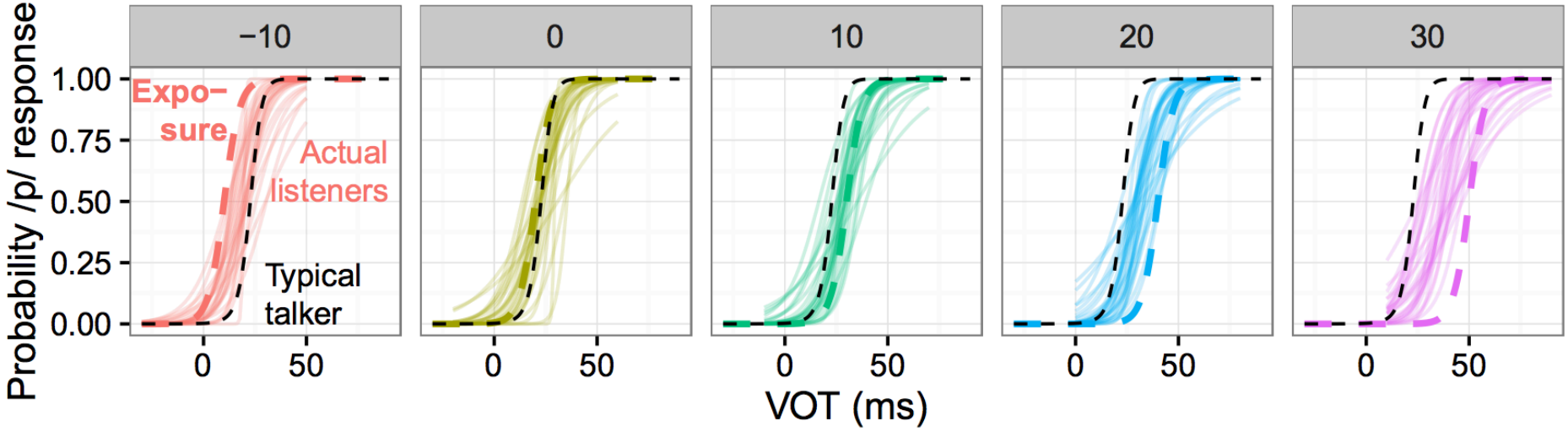
Use of Prior Linguistic Knowledge

Kleinschmidt et al. (2016): Plausibility of category shifts

- Different groups exposed to different shifts
- Some shifts are more plausible for English than others

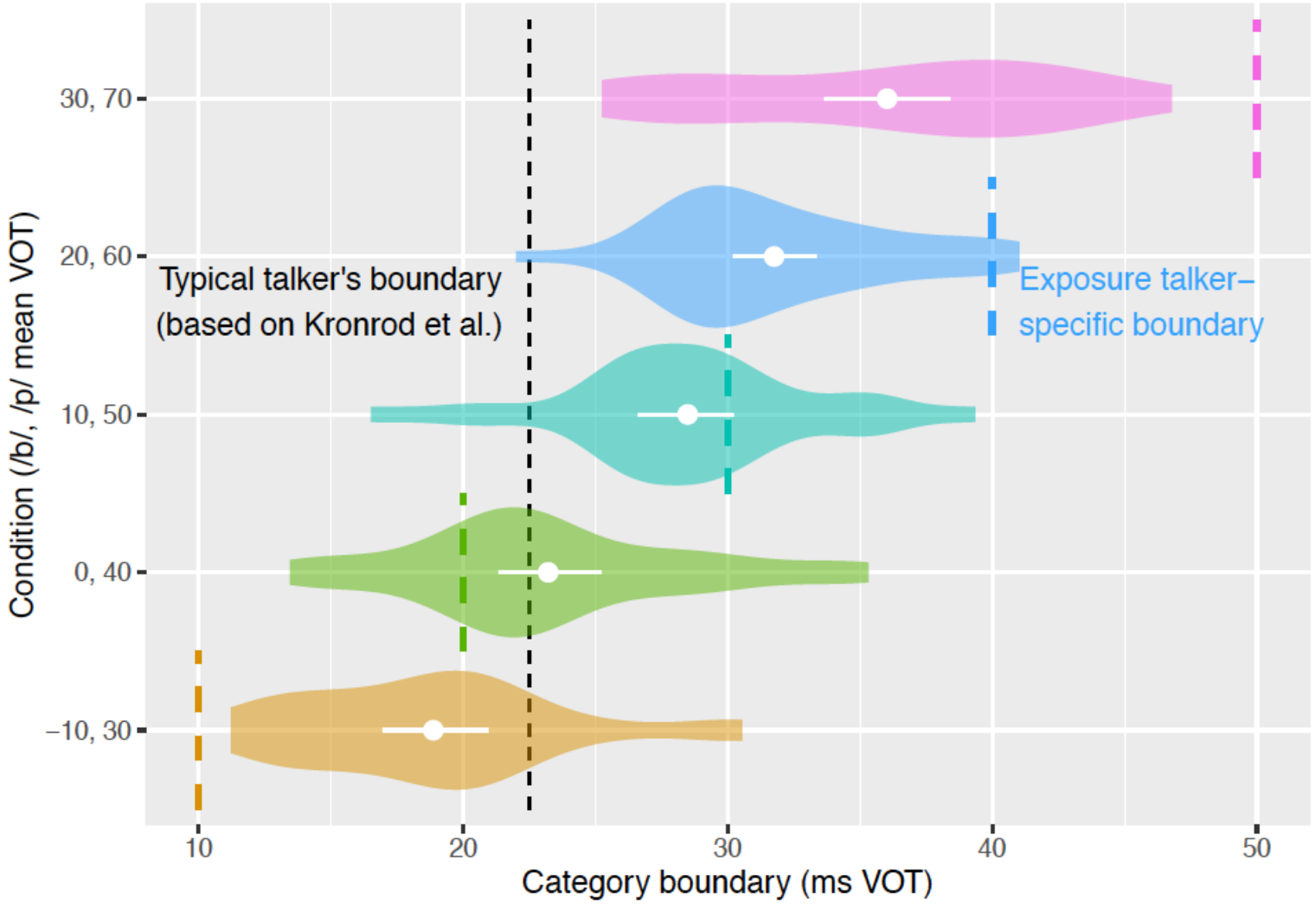


- Listeners shift toward the exposure distribution



colored solid lines: individual subjects' categorization responses

- But adaptation isn't perfect



- How far listeners shift is proportional to how close the shift is to the typical boundary

- Adaptation constrained by expectations about how *plausible* the shift is given prior knowledge about language

The Neural Basis of Speech Perception and Adaptation

- How does the brain represent categories of speech sounds?

- Do these representations change when the categories change (i.e., with perceptual adaptation)?

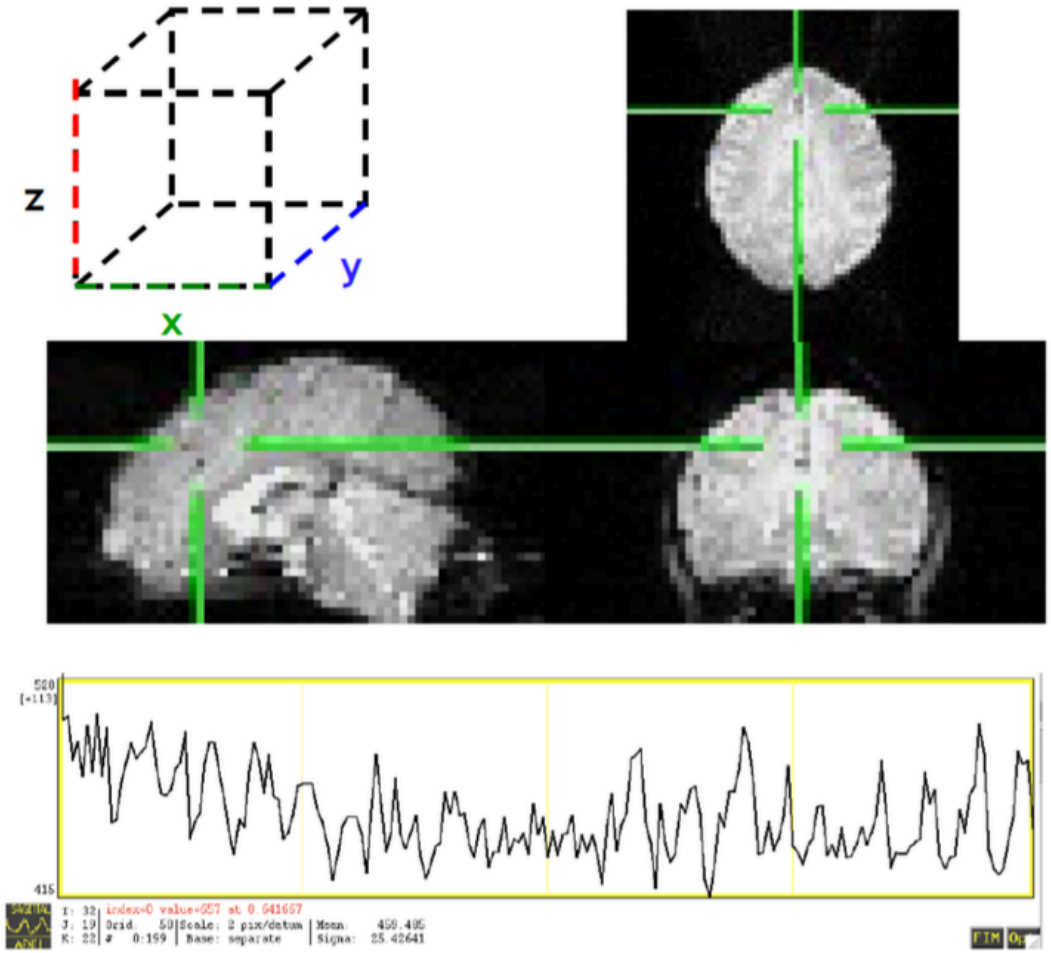
How do we study the brain?

- Electroencephalography (EEG)
- Magnetoencephalography (MEG)
- Electrocorticography (ECoG)
- **Functional Magnetic Resonance Imaging (fMRI)**

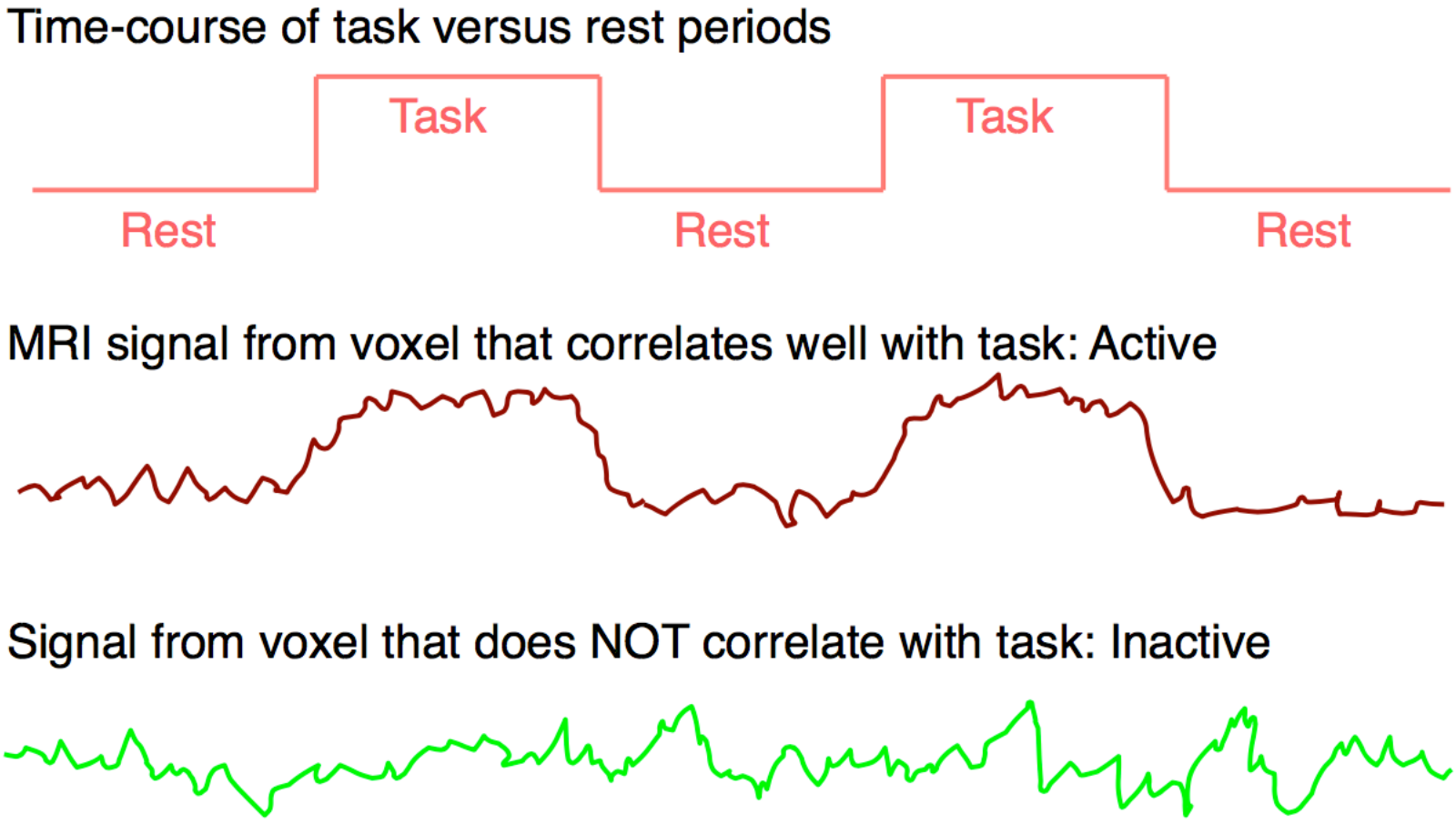
fMRI

- Blood Oxygenation-Level Dependent (BOLD) signal
  - more oxygenated blood going to an area → area is more active

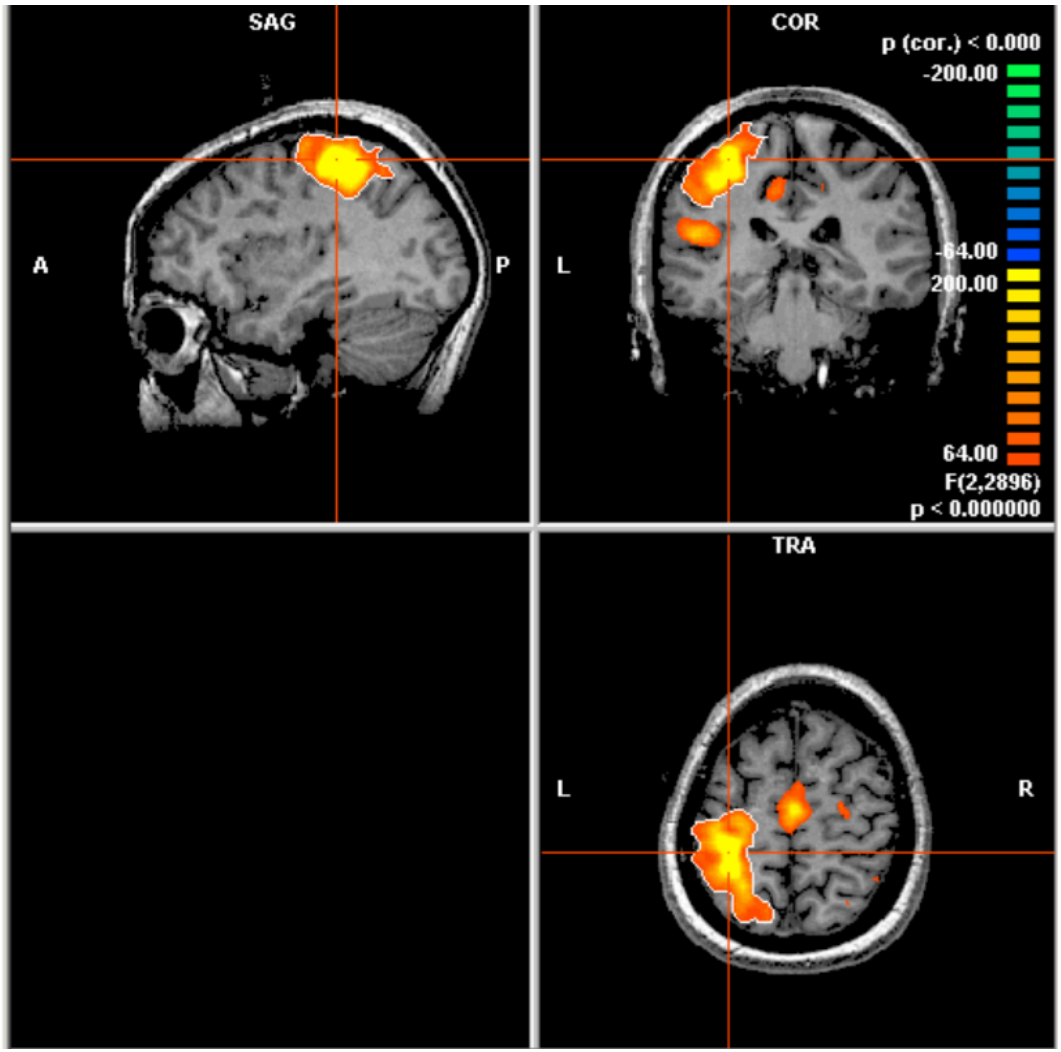
- measure individual voxels (3D pixels)
- get time series of BOLD signal over time



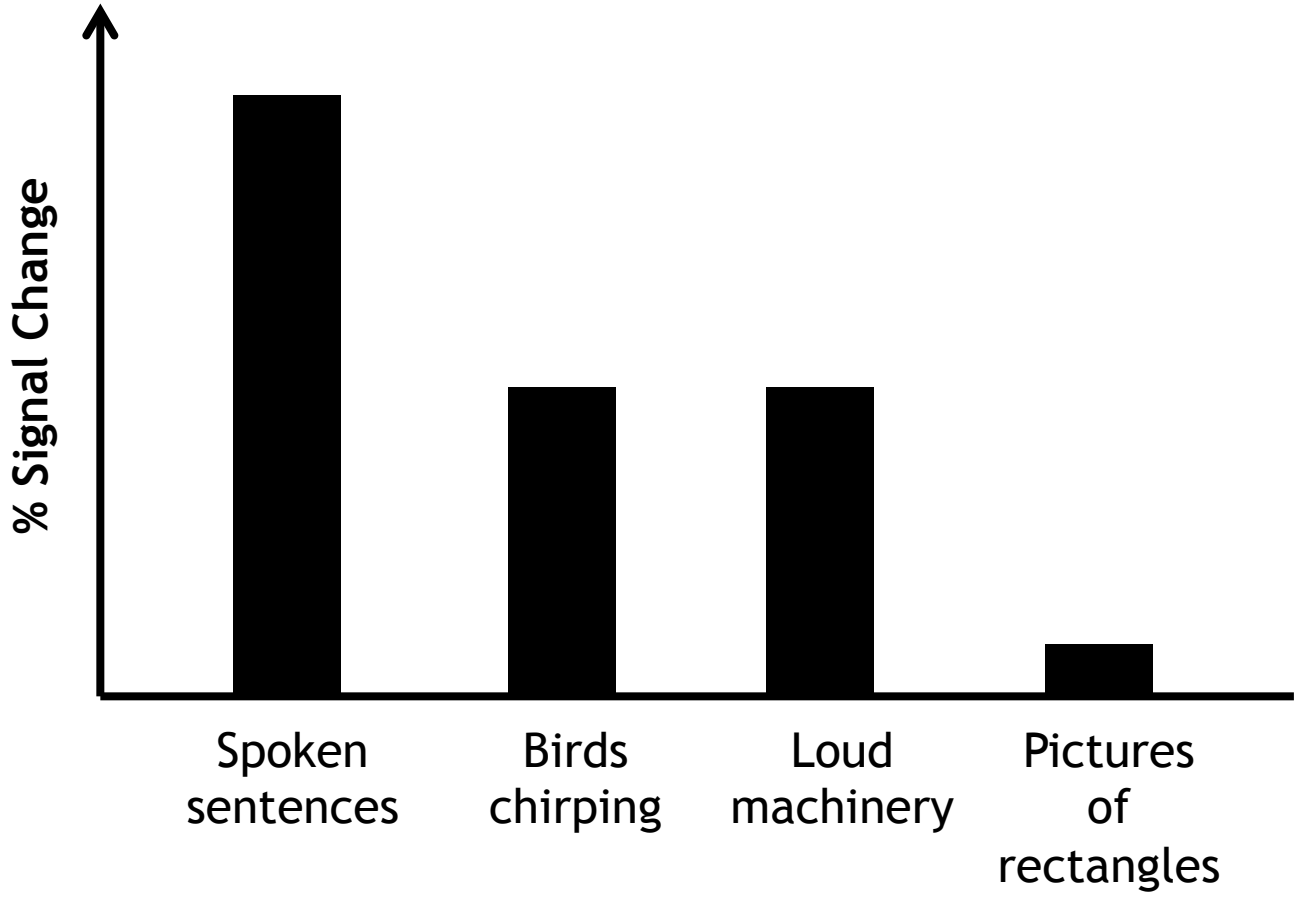
- Compare activation during experimental task vs. during rest (or simpler task)



We show the areas that correlated well with the task using colored blobs



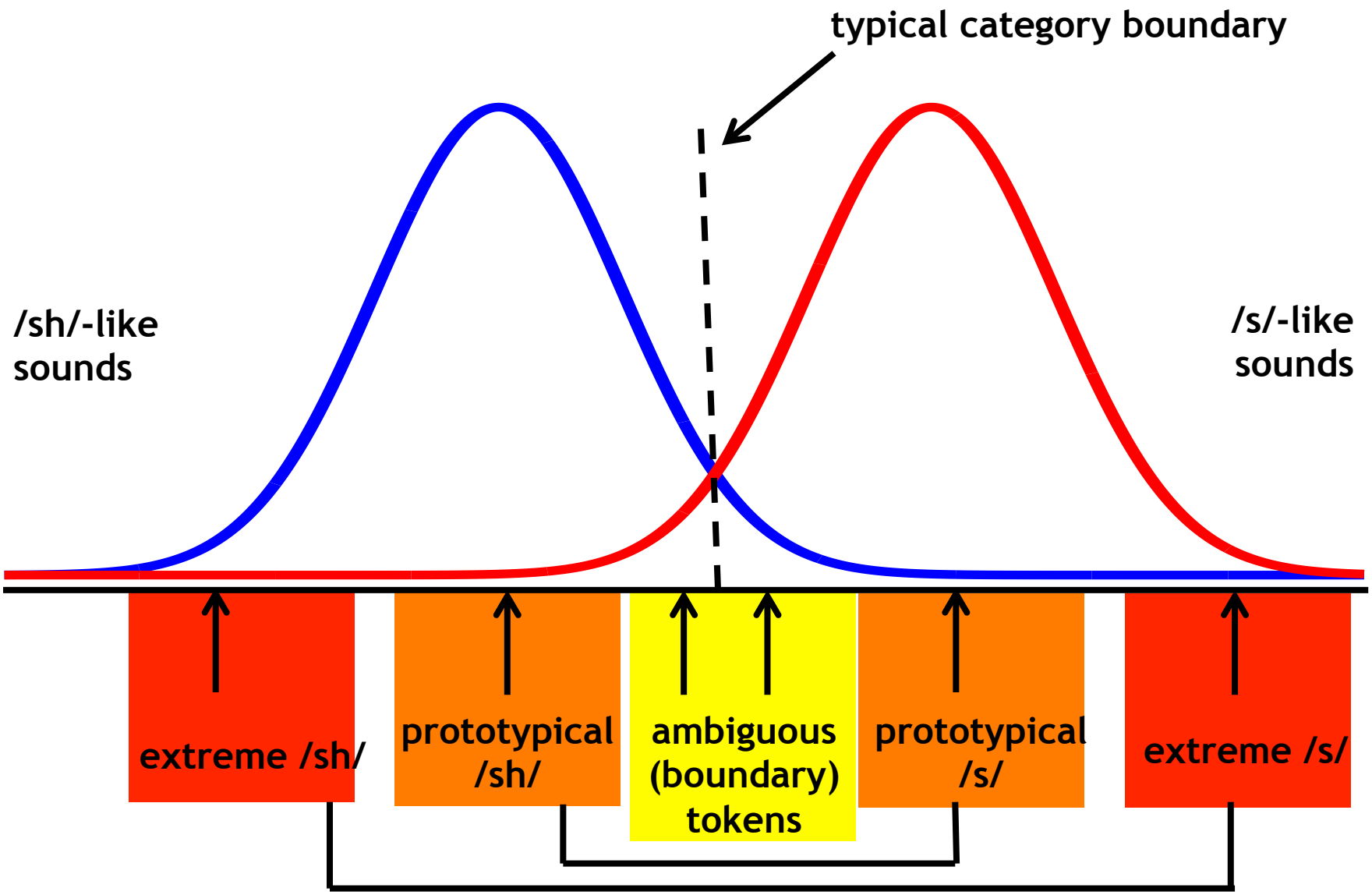
We can also quantify not just whether an area was active, but how active it was for different tasks



How does the brain represent speech categories?

- Categorical vs. Gradient
- Experimental strategy: compare brain activations to different within- and between-category stimuli

Categorical? Gradient?



Predictions

If the brain represents categories:

response to ambiguous tokens >

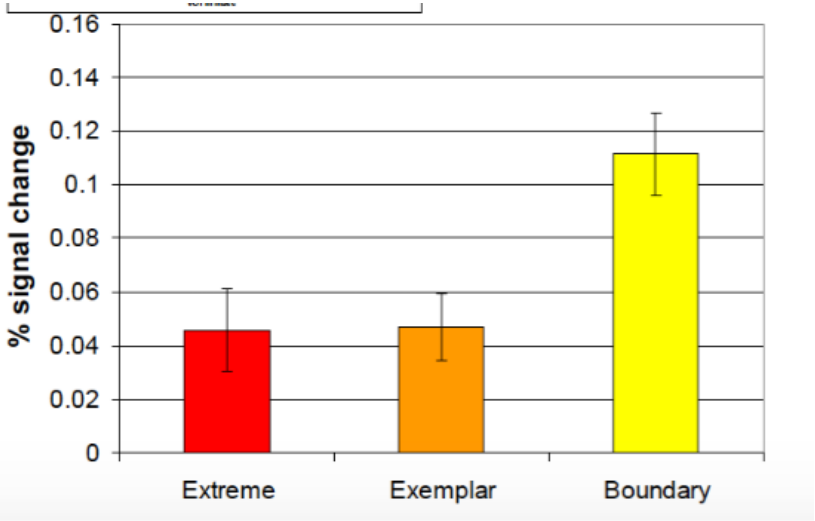
response to prototypical and extreme tokens

If the brain represents gradience within a category:

response to ambiguous **and** extreme tokens >
response to prototypical tokens

Why not Both?

Inferior Frontal Gyrus (Broca's Area): categorical representations



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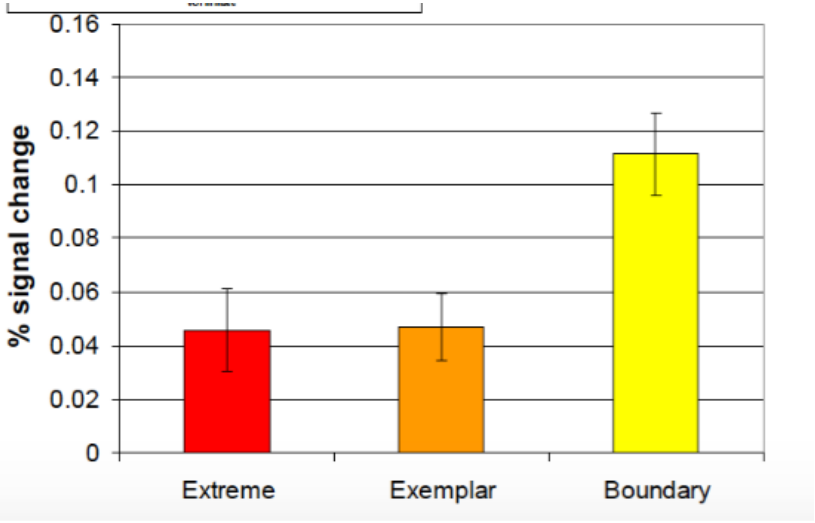
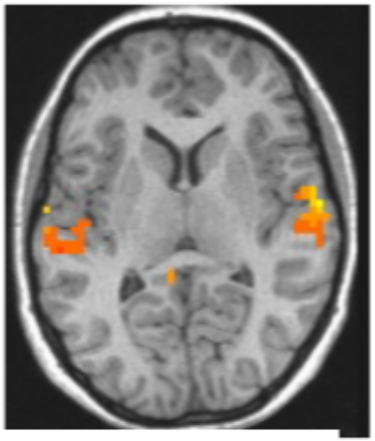
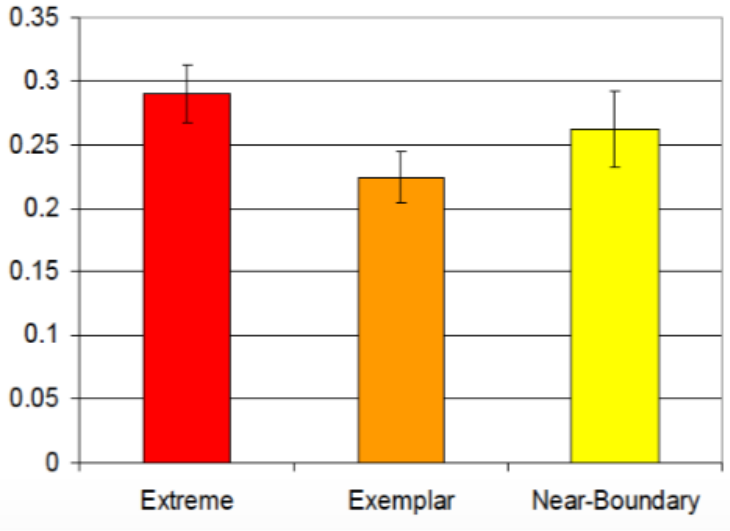
Inferior Frontal Gyrus (Broca's Area): categorical representations



Superior Temporal Gyrus (STG): goodness-of-fit representations



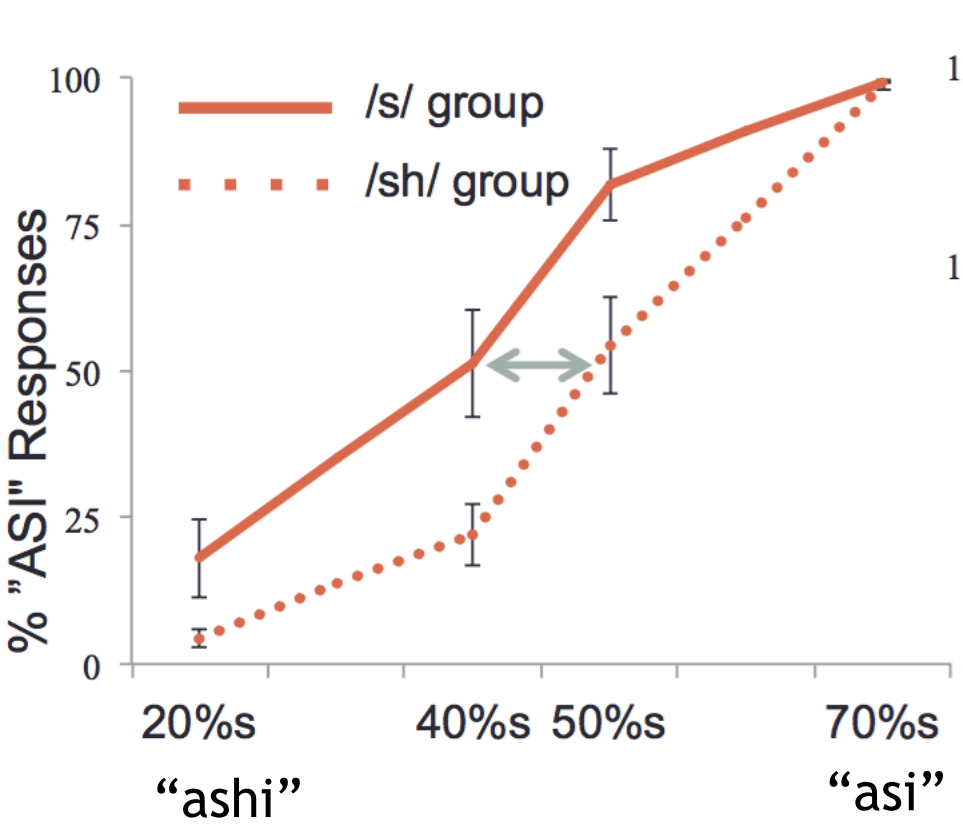


Myers & Mesite (2014): Does the brain change its categorical representations during perceptual adaptation?

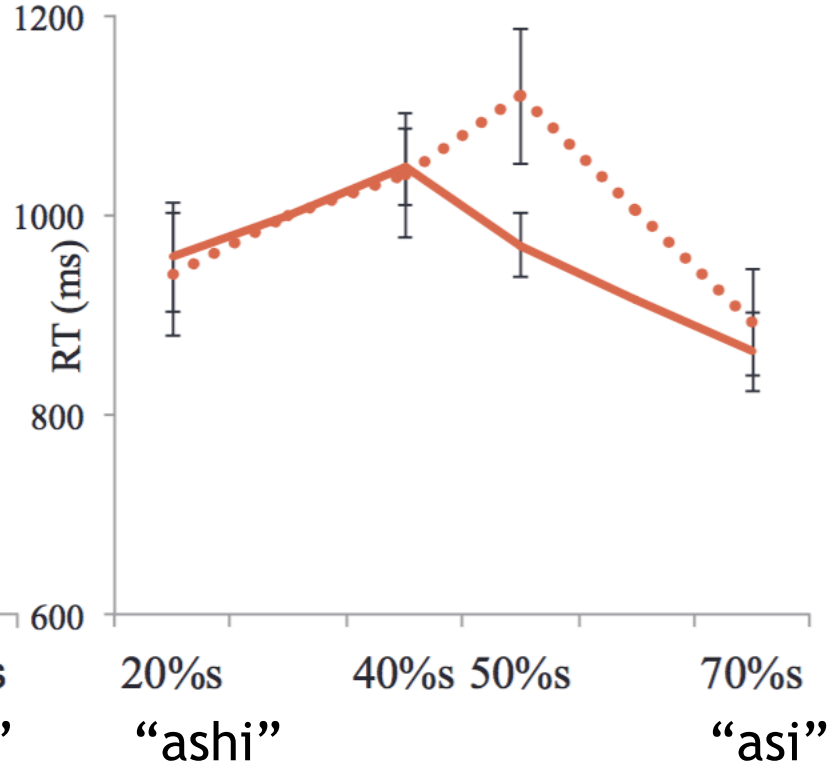
- Perceptual adaptation task in fMRI scanner
- Record brain response to stimuli along different parts of the continuum
- Compare changing behavioral category boundary to LIFG category boundary

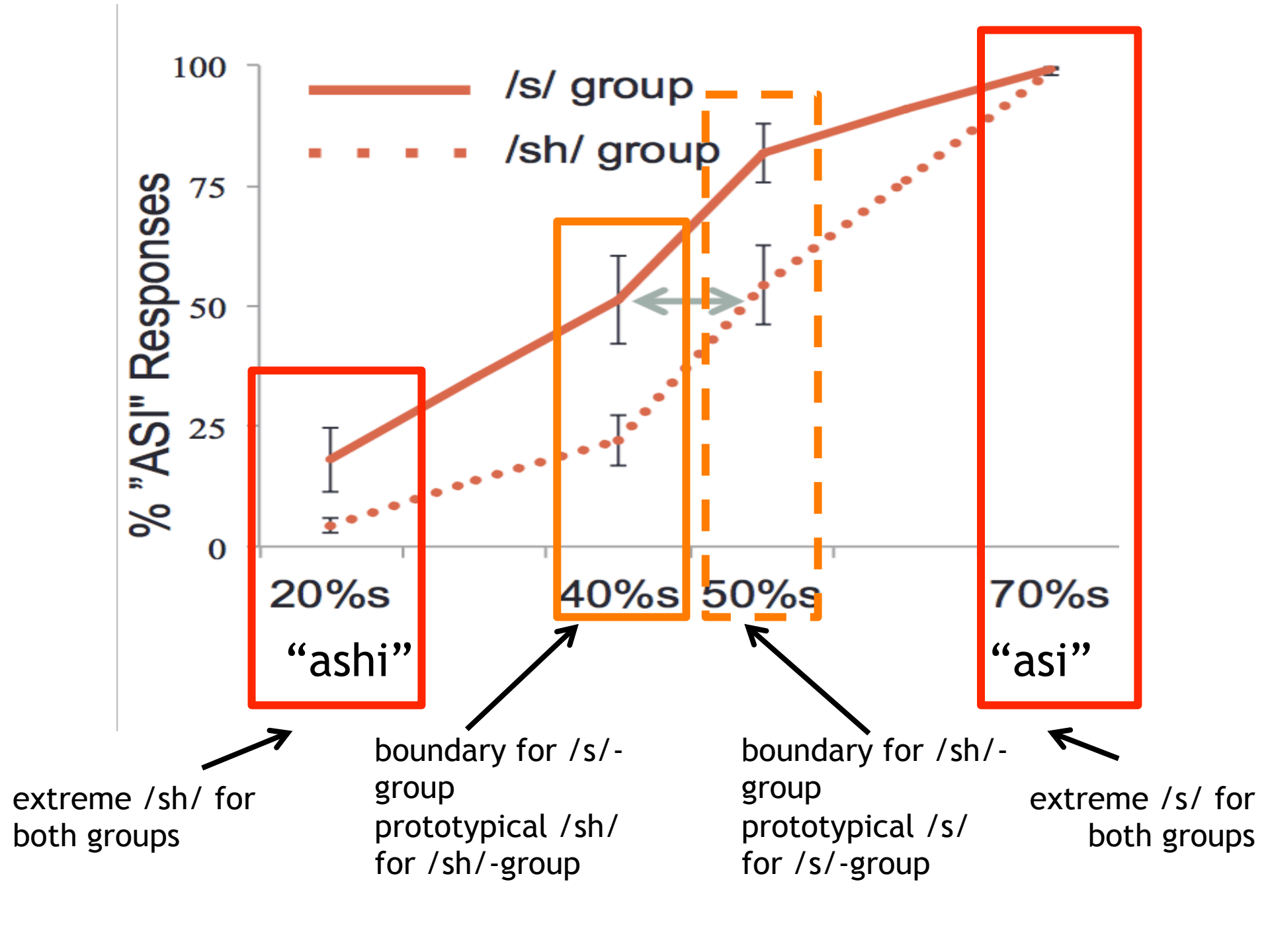
Behavioral Results

Categorization



Discrimination




100
75
50
25
0
% "ASI" Responses
/s/ group
/sh/ group
20%s
"ashi"
40%s
50%s
70%s
"asi"
extreme /sh/ for both groups
boundary for /s/-group prototypical /sh/ for /sh/-group
boundary for /sh/-group prototypical /s/ for /s/-group
extreme /s/ for both groups

Prediction

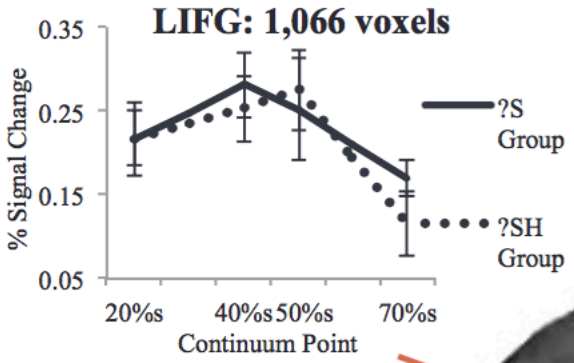
For categorical areas (like IFG):

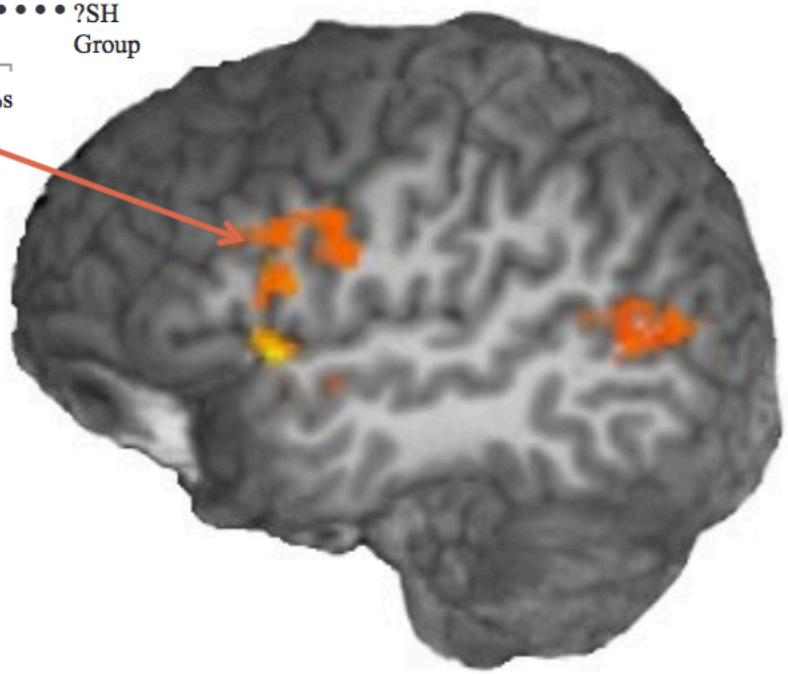
response to ambiguous tokens >

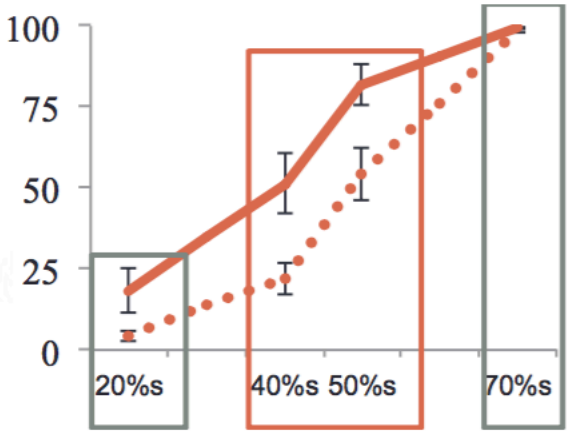
response to prototypical and extreme tokens

If representations change, we should see different patterns of activation in the two groups

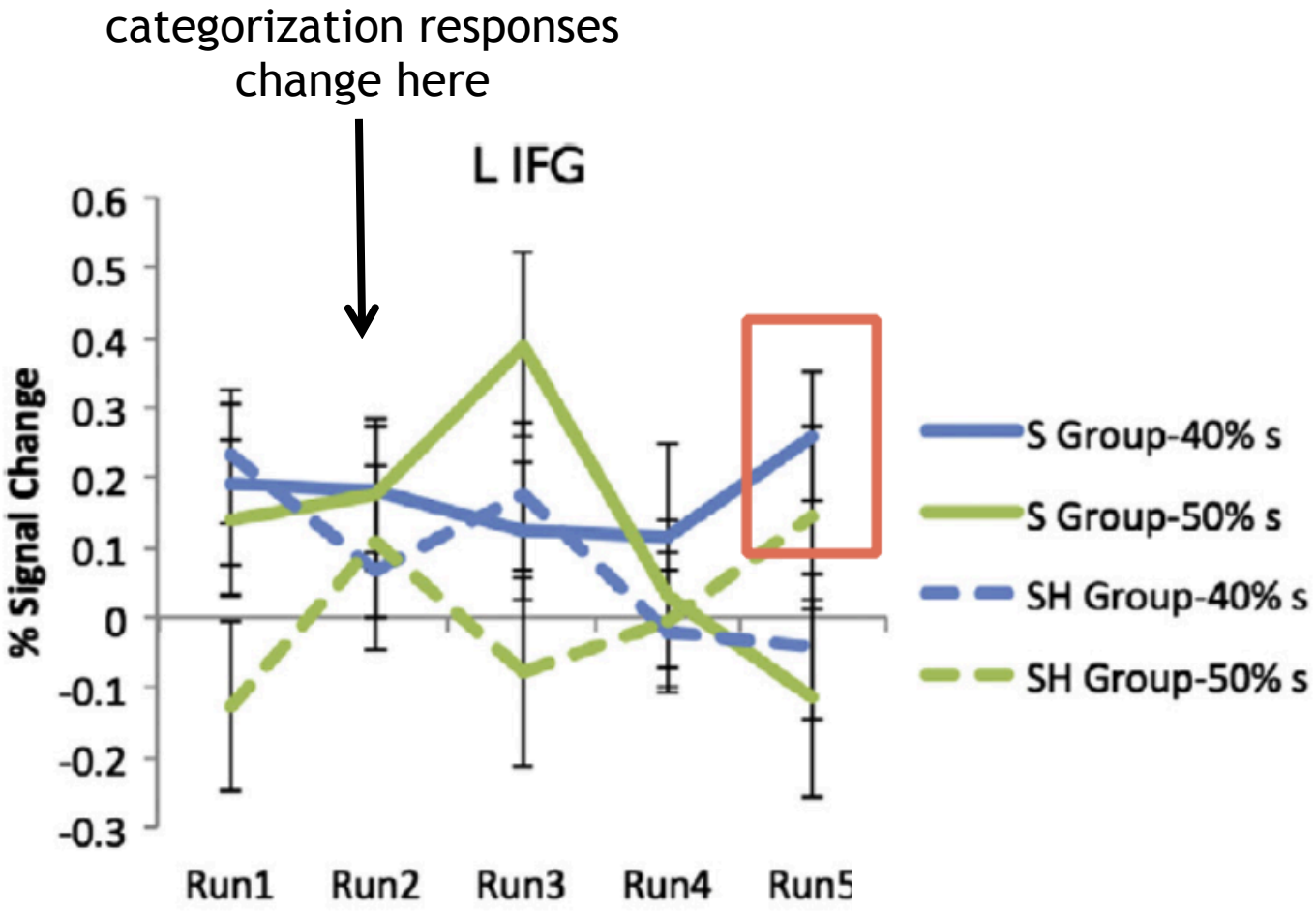
IFG shows shift in boundary







- Changes in IFG representations lag behind behavioral changes



- The brain represents speech sounds both gradiently *and* categorically

- Representations in categorical areas (inferior frontal gyrus) can change during perceptual adaptation

- This change lags behind behavior
  - what neural mechanism supports the change? do higher-level areas contribute to inferring new categories and pass this down to IFG?
  - what happens when you're talking to multiple people at once?