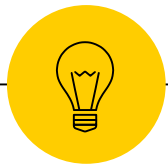


# Ad Hoc Phonetic Categorization and Prediction



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## **Levels** of perception

**Acoustic**

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**Phonetic**

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**Phonemic**

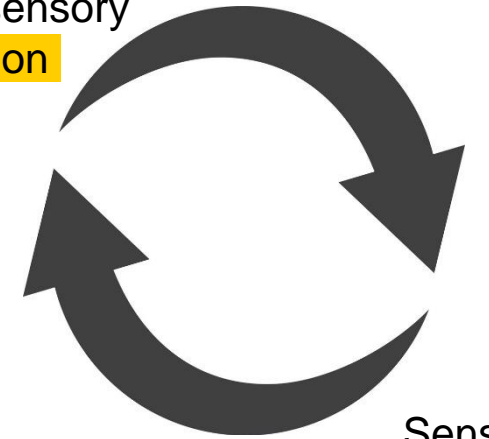
- Sensory
- Intermediate
- Conceptual



## Predictive coding

- Prediction in the auditory system:
  - Predictions are encoded neuronally.
  - Predictions are hierarchically organized.
  - Different information is encoded at different hierarchical levels.
- **Goal of the system:** *reduce prediction error.*

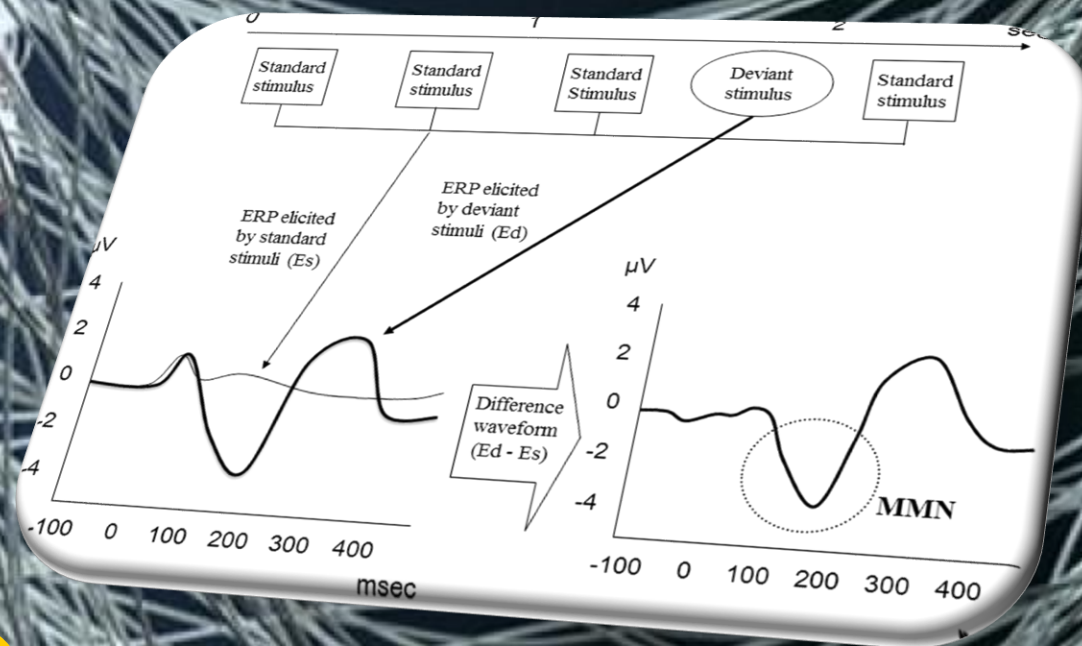
**Model** is used to  
make sensory  
**prediction**



Sensory  
**Input** is used to  
**update** the model

## Neural signature of prediction error:

- Mismatch Negativity (MMN)
- Frequent repeated standard(s)
- Infrequent deviant



Näätänen, Gaillard, & Mäntysalo (1978), Näätänen (1992),  
Näätänen, Paavilainen, Rinne, & Alho (2007)



## Experiment 1 – Across-category contrast

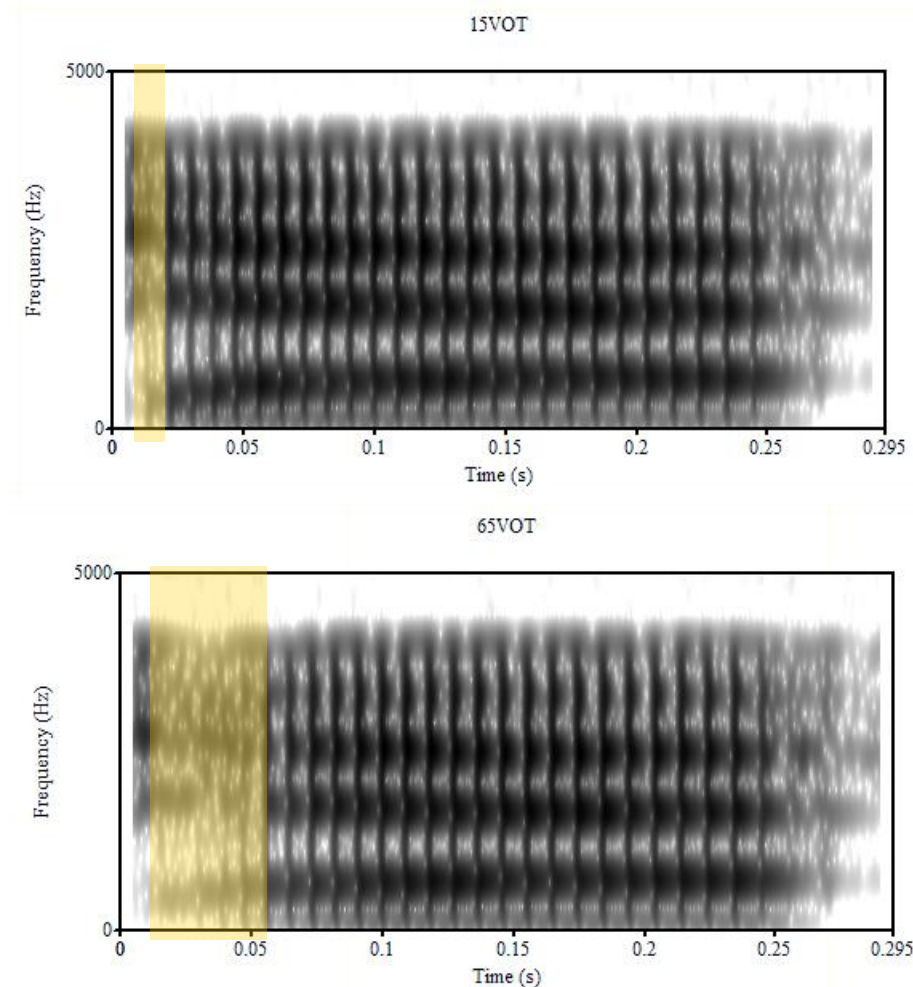
**Participants:** 37 undergrads at the University of Delaware

**Stimuli:** Klatt-synthesized [dæ] and [tæ] syllables, sampled from VOT continuum

- 290ms
- 65dB

**Blocks:** High, Low

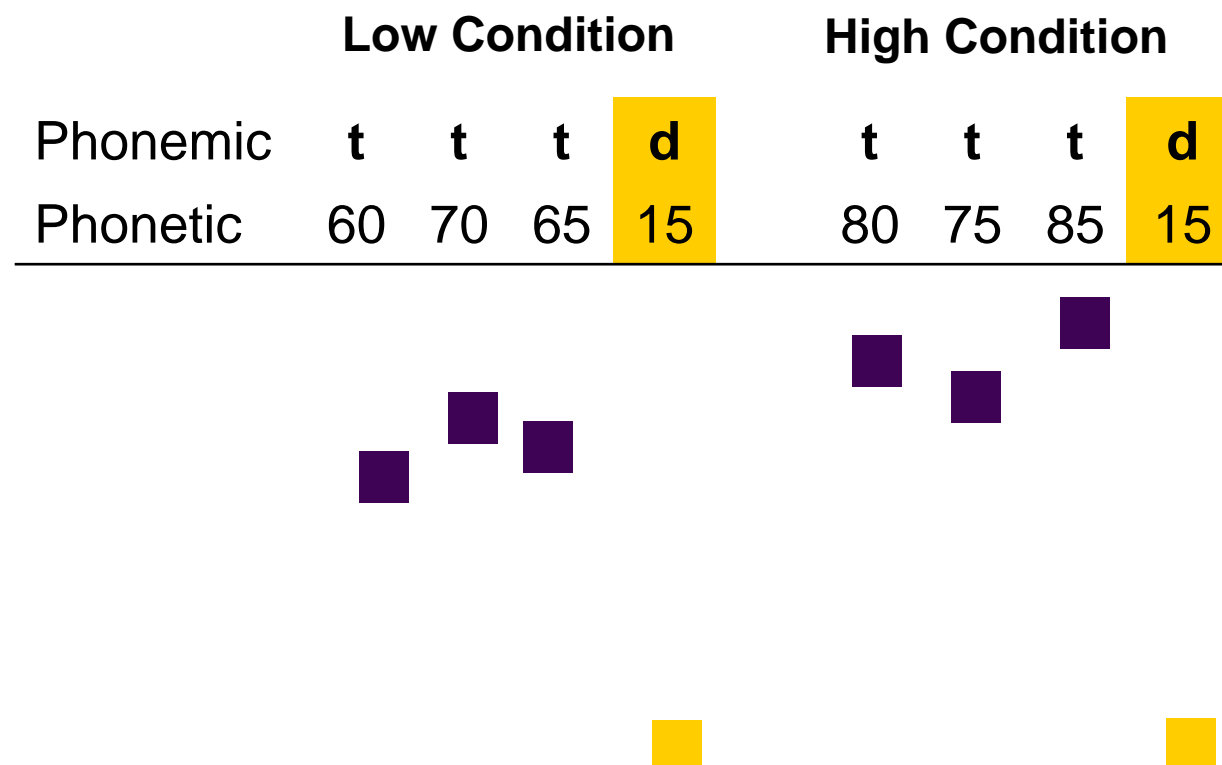
- Low: 60, 65, 70ms VOT
- High: 75, 80, 85ms VOT





## Experiment 1 – Across-category contrast

- **Phonemic** level prediction:
  - Equivalent prediction error (MMN) in both conditions.
- **Phonetic** level prediction:
  - Greater magnitude prediction error (MMN) with greater phonetic distance.

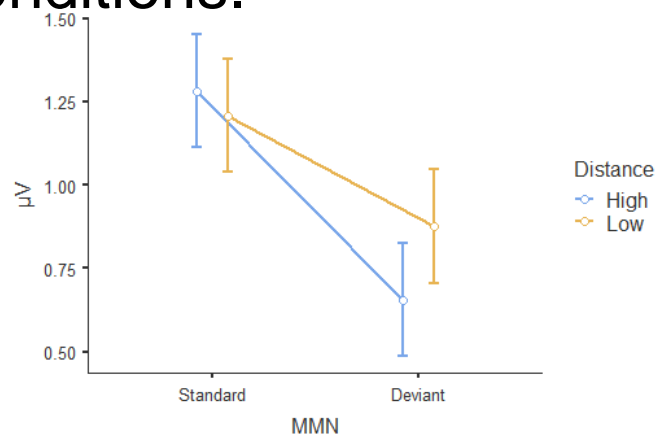






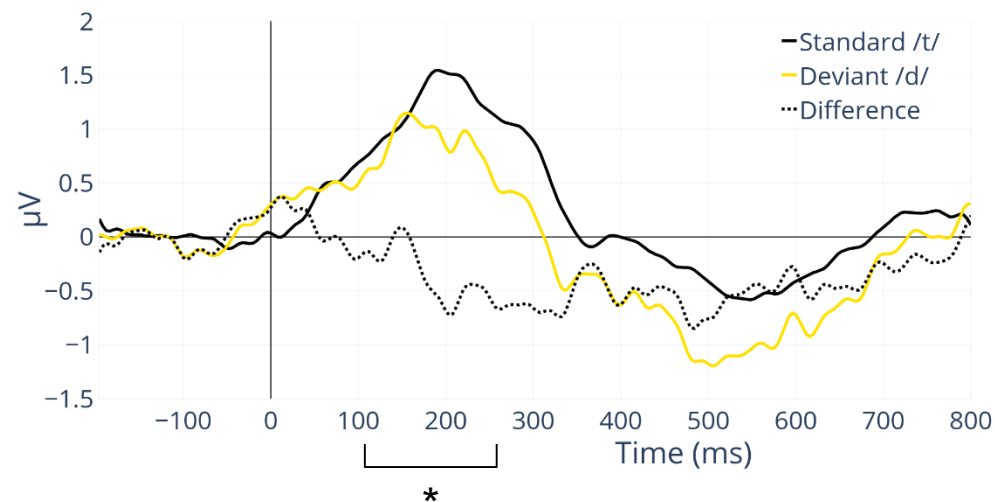
## Results

No difference between conditions.

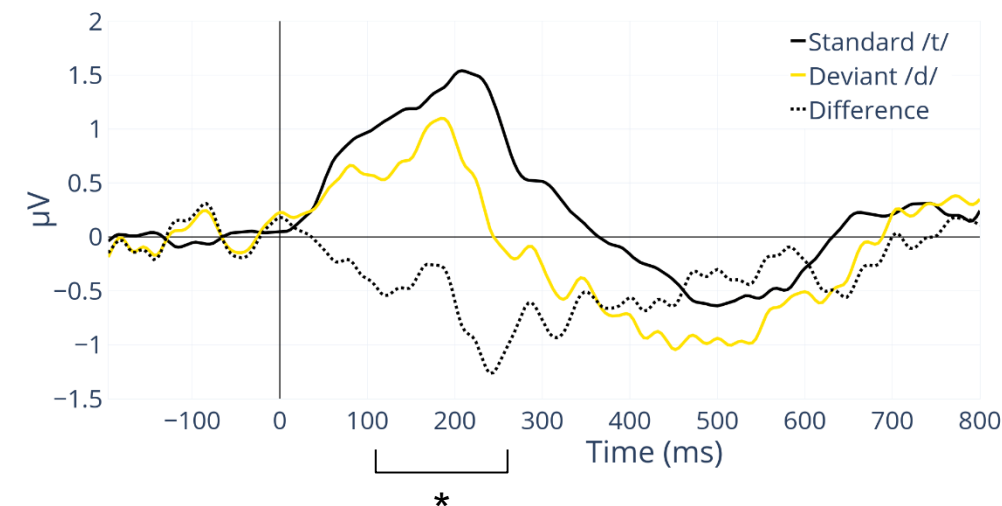


Phonemic prediction –  
no phonetic prediction.

### Low Condition



### High Condition





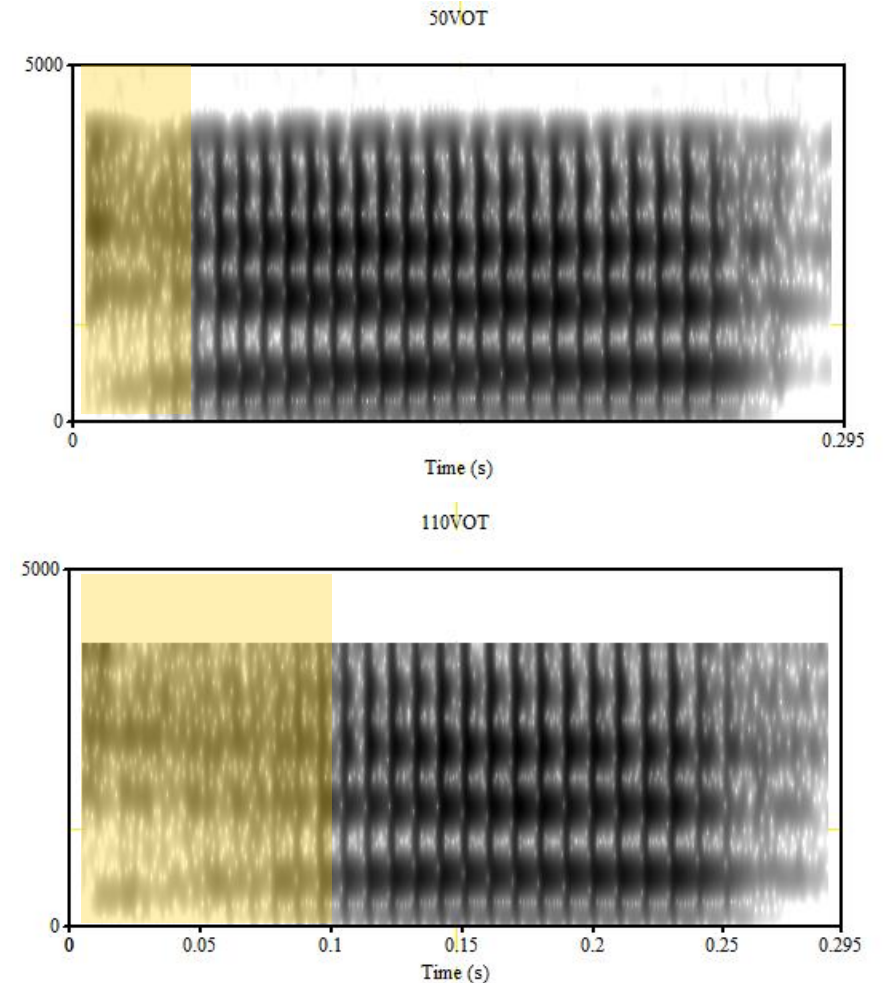
## Experiment 2 – Within-category contrast

**Participants:** 27 undergrads at the University of Delaware

**Stimuli:** modified stimuli from Exp 1  
– all VOT values increased by 35ms

**Blocks:** High, Low

- Low: 95, 100, 105ms VOT
- High: 110, 115, 120ms VOT







## Experiment 2 – Within-category contrast

- **Phonemic** level prediction:
  - No prediction error (MMN) in either condition.

	Low Condition				High Condition			
Phonemic	t	t	t	t	t	t	t	t
Phonetic	95	105	100	50	115	110	120	50

- **Phonetic** level prediction:
  - Prediction error (MMN) in both conditions.
  - Greater magnitude prediction error (MMN) with greater phonetic distance.

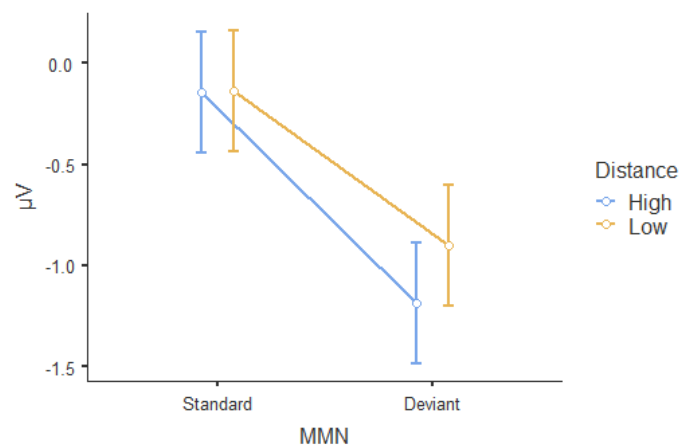




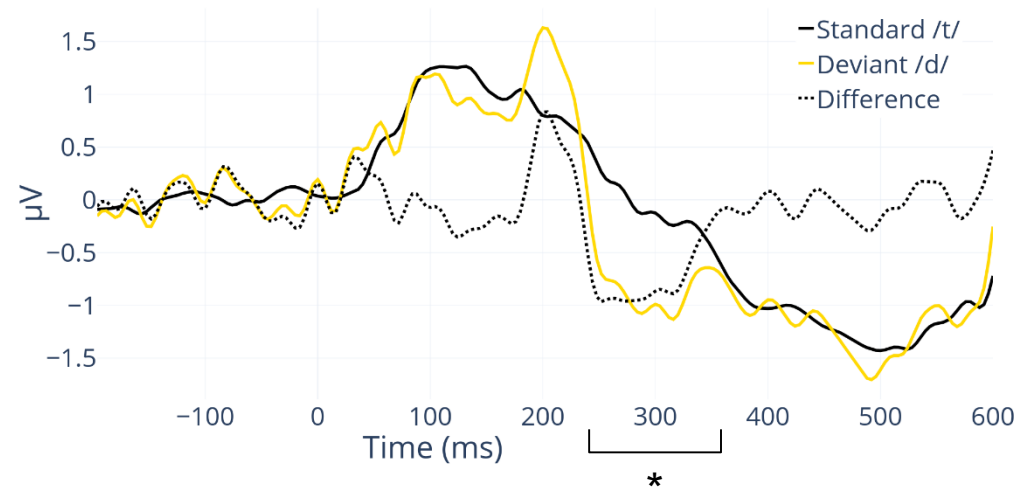
## Results - EEG

Mismatch in both conditions.

No difference between conditions.

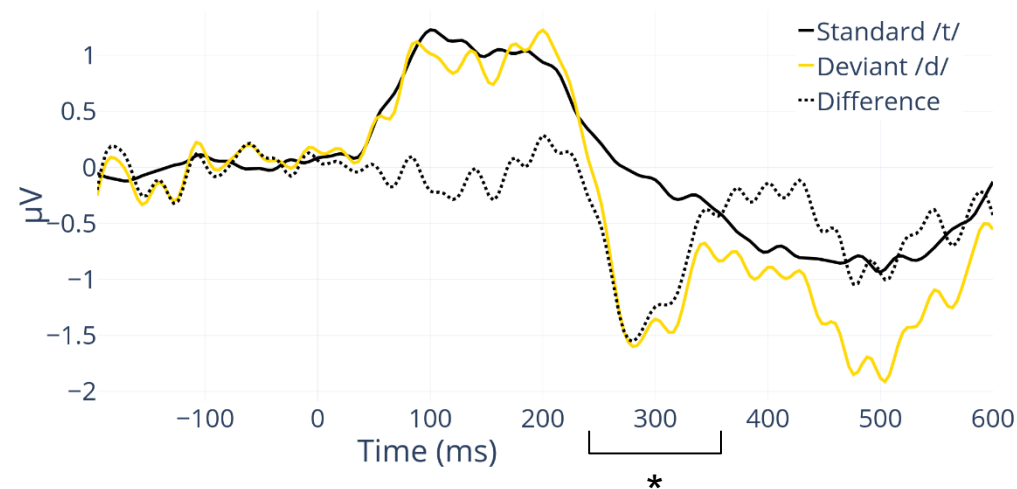


### Low Condition



\*  $p < 0.05$

### High Condition

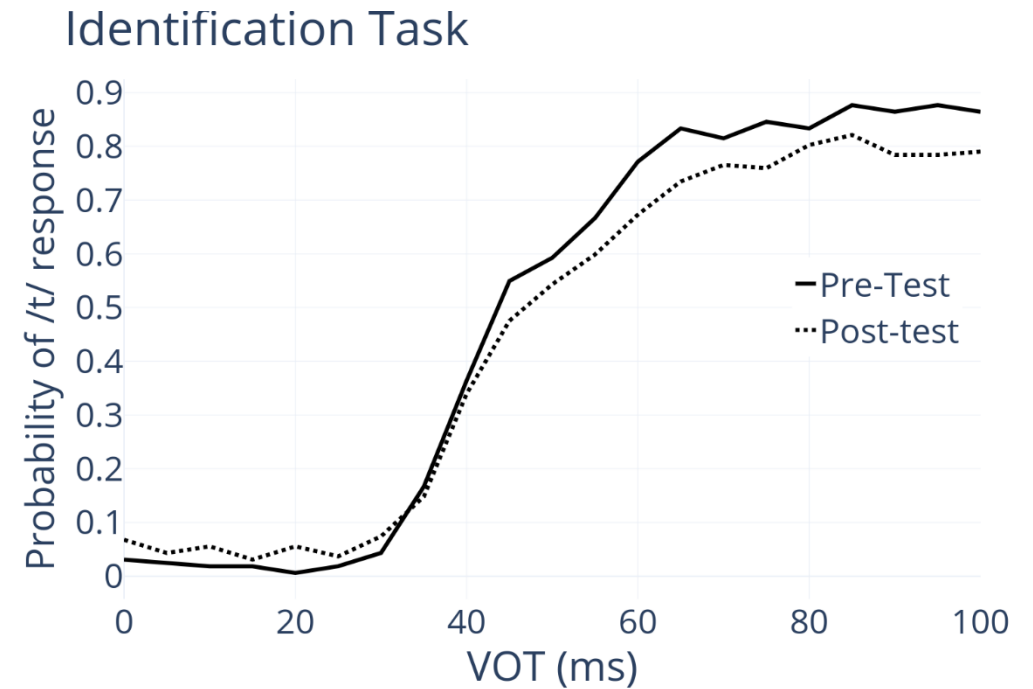




## Results - Categorization

- VOT categorization pre- and post-test
- Threshold analysis for each participant

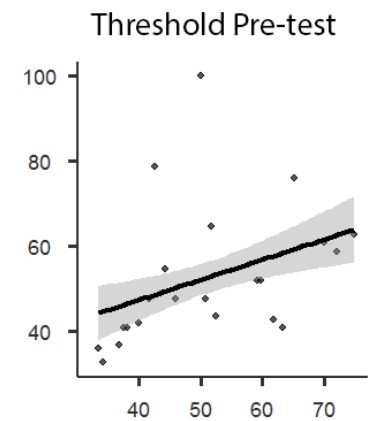
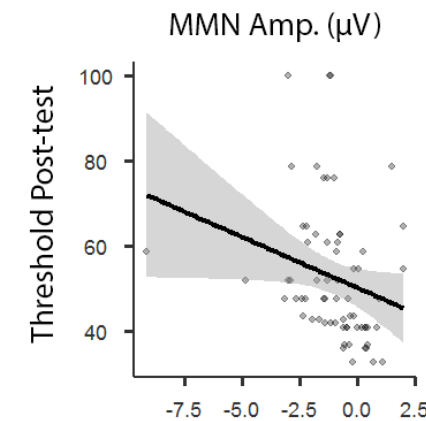
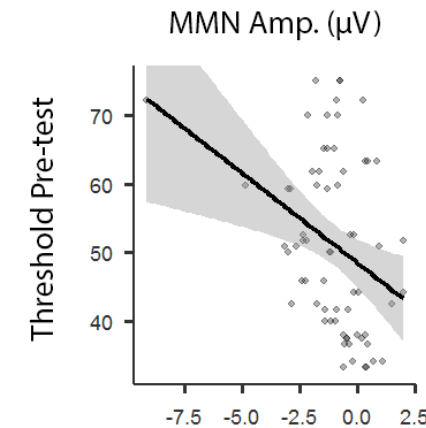
Identification Task		
	Session 1	Session 2
N	26	26
Mean	52.7	54.6
Median	51.3	51.7
Standard deviation	13.5	15.9
Minimum	33.4	32.5
Maximum	76.5	99.8
Shapiro-Wilk p	0.139	0.081





## Results - Correlation

- **Significant** negative correlation between voicing threshold and MMN.
- Higher threshold > more negative MMN response
- Participants who categorize the 50ms VOT stimulus as /d/ are much more likely to have an MMN than participants who categorize all stimuli as /t/.



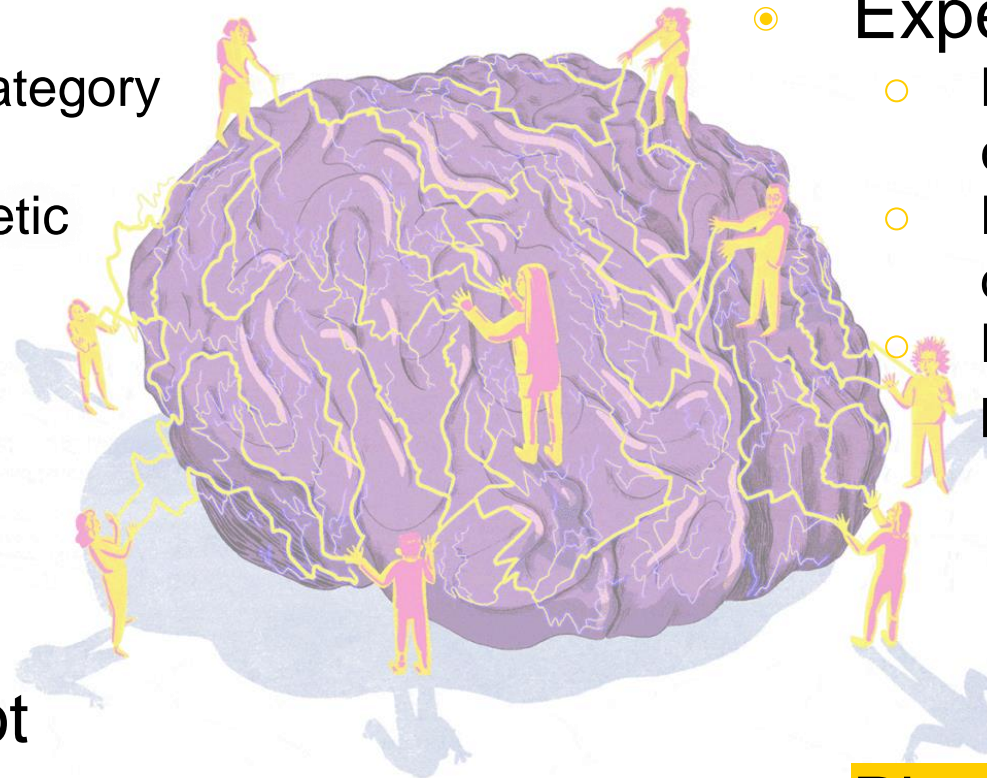


## Discussion

- Experiment 1

- MMN to **across**-category contrast
- No effect of phonetic distance

- **Phonemic** (but not phonetic) prediction.



- Experiment 2

- MMN to **within**-category contrast
- No effect of phonetic distance
- MMN correlates with perceptual threshold
  - Contrast is not within-category for all subjects!

- **Phonemic** (but not phonetic) prediction.



## Conclusion

- In response to phonetically-varying input – the auditory system does **not** make phonetically-detailed predictions.
  - Predictions are only maintained at the **category** level.





## Thanks to my collaborators



Chao Han



Arild Hestvik



Lena Herman