Neural Correlates of Statistically-Driven Auditory Selective Behavior

Ole Bialas [1] Sahil Luthra [2] Erin Smith [3] Lori L. Holt [4] Frederic Dick [5] Edmund C. Lalor [1]

[1]University of Rochester [2]Carnegie Mellon University [3]University of Washington [4]University of Texas at Austin [5]University College London

Selective Attention and Statistical Learning

- While attention is often conceived as interplay of bottom-up saliency and top-down processing, recent work shows how **experience** can push attention towards features aligning with statistical **regularities**.
- For example, sounds of a particular frequency that occur more often, are detected **faster** and more **accurately**, suggesting that listeners track global stimulus **probability** [1].

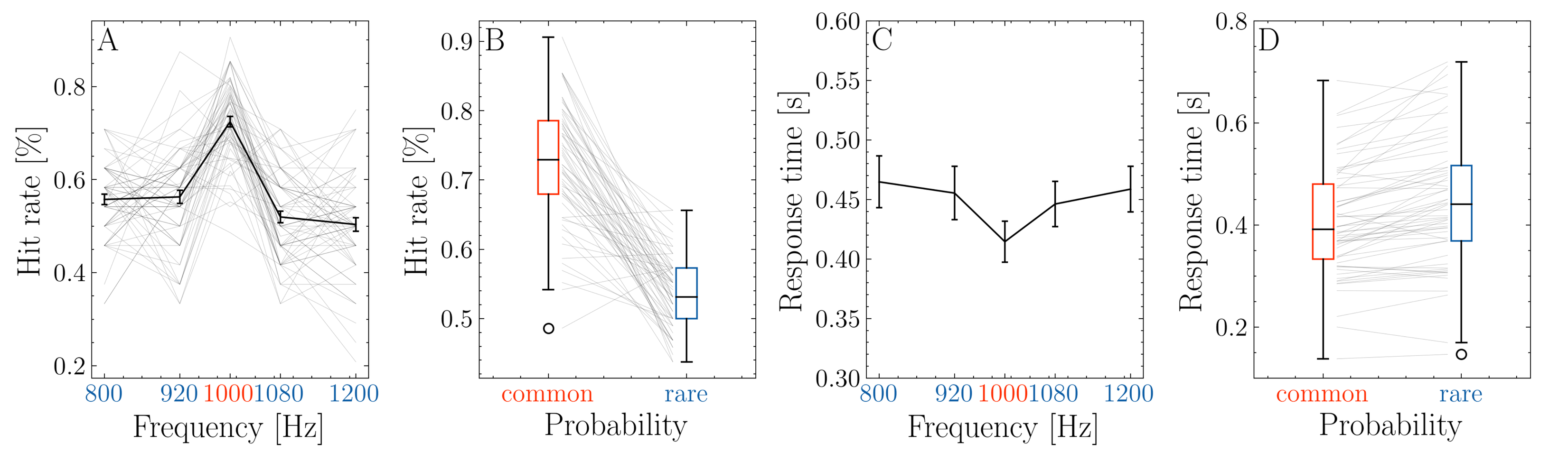

Figure 1. Performance in detection task tracks stimulus probability (reproduced from [1]). **A** & **C**: hit rate and response time across frequencies show maximum/minimum at the common 1000 Hz tone. **B** & **D**: common differ from rare tones irrespective of their frequencies.

- This suggests **exaggerated** neural responses to **expected** stimuli, counter to a large literature on oddball paradigms, consistently showing that **unexpected** stimuli evoke exaggerated responses [2].

A Tone Detection Task Optimized for EEG

- Participants must detect **near-threshold** tones in constant background **noise** while being prompted by a traffic light.
- Tones have two different frequencies (1/1.2 kHz), one of which is randomly chosen as **common** (75%), the other as **rare** (25%).
- Tones are presented 0.75 dB above the threshold estimated with a 3-down-1-up **staircase**.
- Four participants each completed **800 trials**, divided into 20 blocks

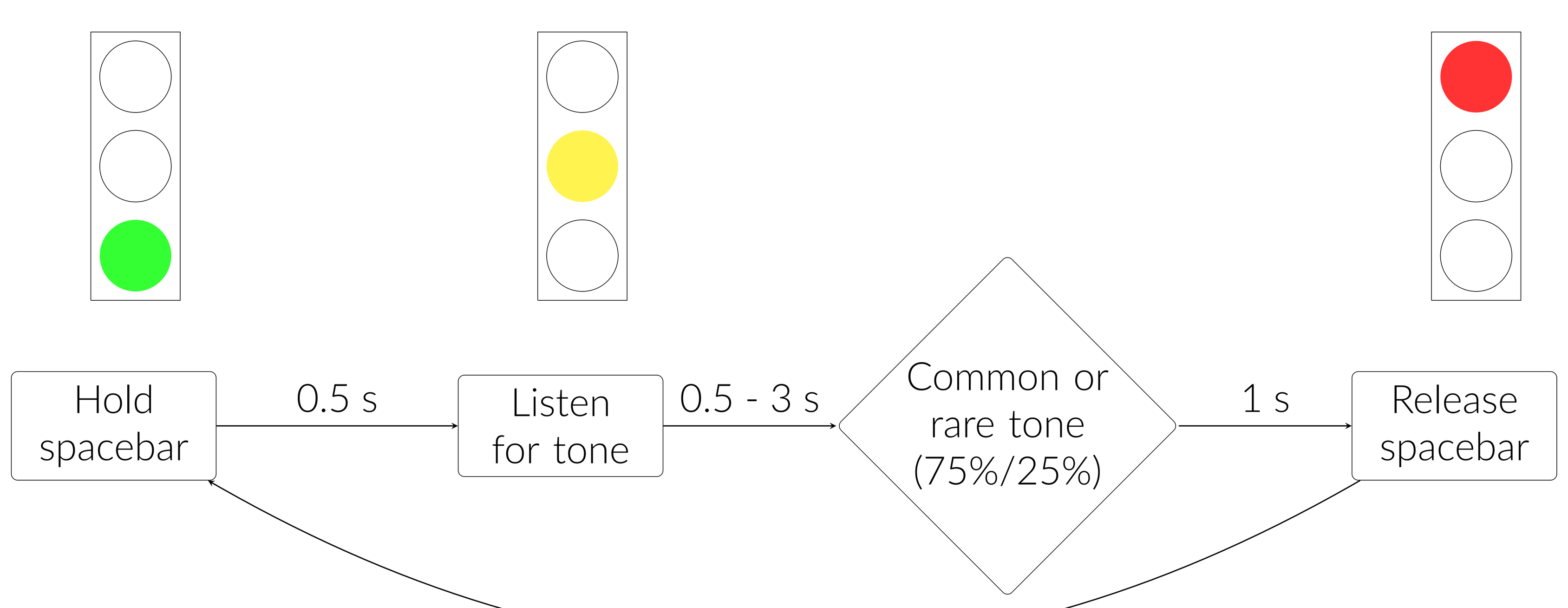

Figure 2. Flow of a single trial in the tone detection task. Traffic lights indicate the visual display at every point.

Common Tones are Detected Faster and More Accurately

- Consistent with previous findings, **common** tones were detected with higher **accuracy** and faster than **rare** tones [1].
- The differences in hit rate and response time were highly **correlated** across participants.

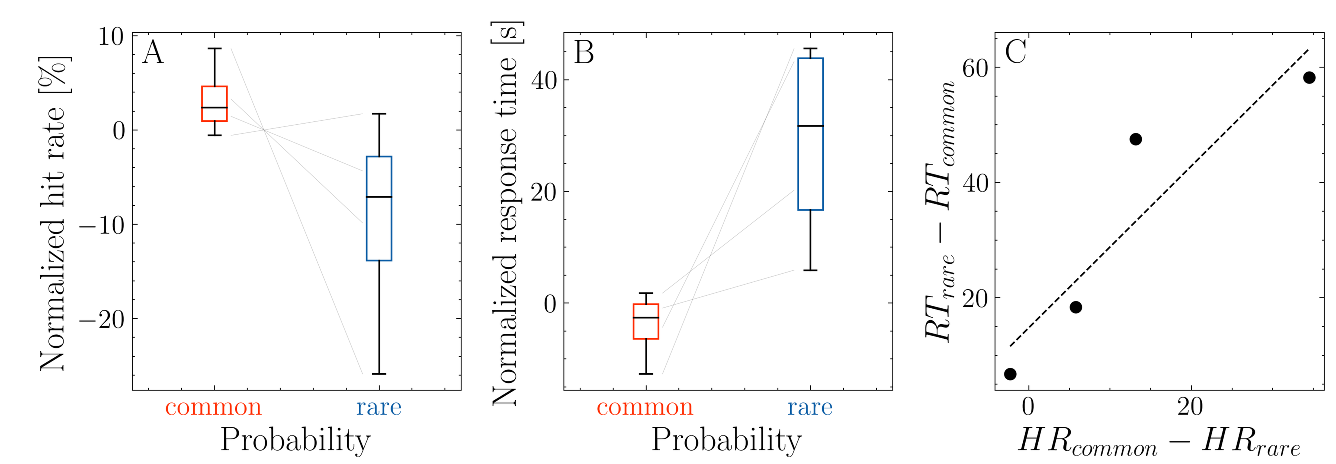

Figure 3. Stimulus probability affects detection accuracy and hit rate. **A** and **B**: hit rate and response time relative to each participants mean performance. **C**: relationship between the changes in hit rate and response time.

Detected Tones Evoke Auditory Responses

- Averaging across all **missed** or **detected** tones revealed that only the latter yielded clear auditory evoked response potentials (ERPs).
- ERPs showed typical **N1** and **P3**, which were **delayed** roughly 100 ms - most likely due to the low sound intensity.
- These finding are **consistent** with previous reports on EEG responses during near-threshold tone detection [3].

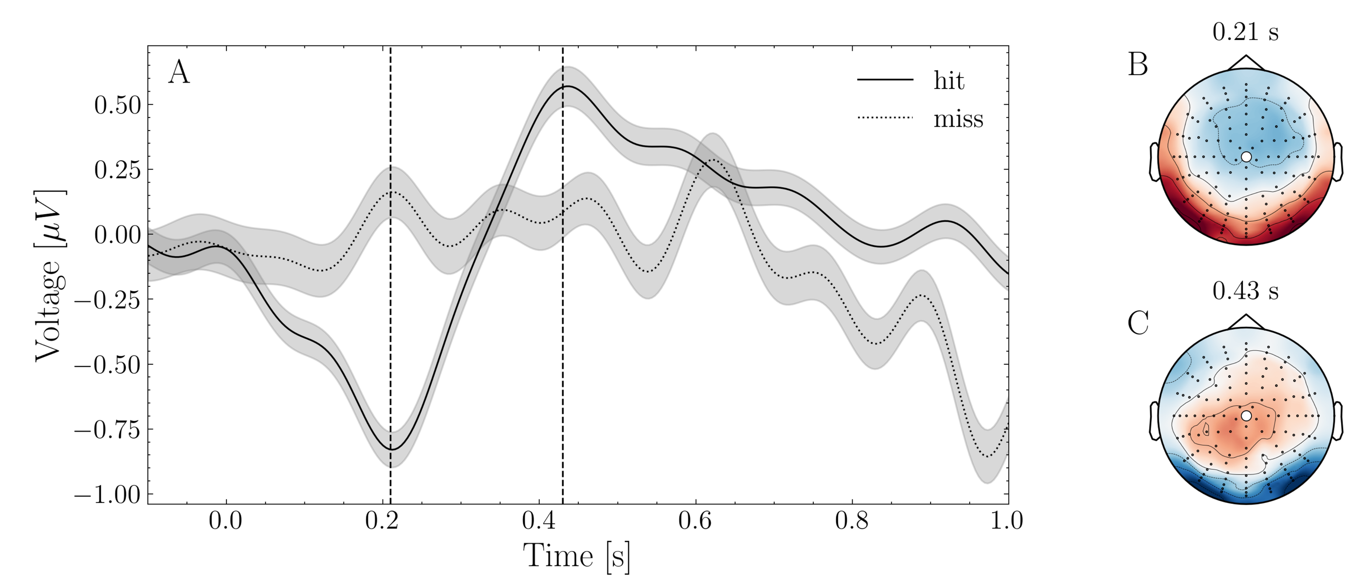

Figure 4. Detected, but not missed tones elicit auditory ERPs. **A**: Mean ERPs at one central channel. **B** and **C**: topographical distribution of the N1 and P3 components (marked by dashed lines in A).

References

[1] Sijia Zhao, Christopher A Brown, Lori L Holt, and Frederic Dick. Robust and efficient online auditory psychophysics. *Trends in hearing*, 26, 2022.

[2] Risto Näätänen, Petri Paavilainen, Teemu Rinne, and Kimmo Alho. The mismatch negativity (mmn) in basic research of central auditory processing: a review. *Clinical neurophysiology*, 118(12), 2007.

[3] Benedikt Zoefel and Peter Heil. Detection of near-threshold sounds is independent of eeg phase in common frequency bands. *Frontiers in psychology*, 4, 2013.

[4] Alain de Cheveigné and Lucas C Parra. Joint decorrelation, a versatile tool for multichannel data analysis. *Neuroimage*, 98, 2014.

Are Common Tones Processed Faster?

- We used a spatial **filter** to emphasize the **difference** between conditions [4] and used bootstrap **resampling** to account for the different number of common and rare tones.
- Both ERPs showed highly **similar** time courses and topographies except that the **N1** component in the response to common tones had a larger **amplitude** and shorter **latency**.
- While this is a small **preliminary** sample, there is a remarkable correspondence between **behavioral** and **neural** response latency.

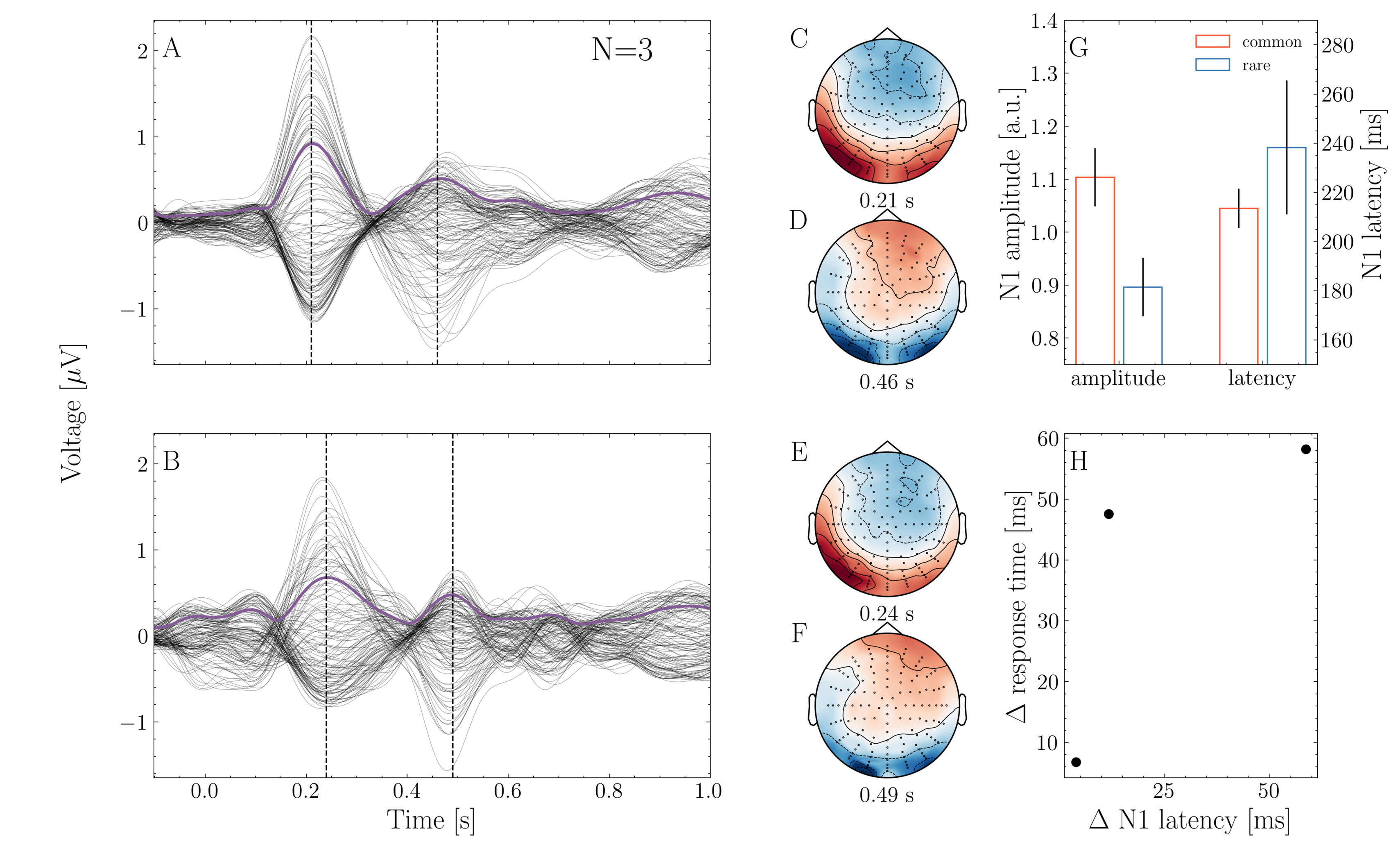

Figure 5. **A** and **B**: group average ERP to common and rare tones. Black lines show channels, the purple lines shows global field power (GFP). **C**-**F**: topographical distribution of voltage at the time points indicated by dashed lines in A and B. **G**: GFP amplitude and latency of the N1 component for common and rare tones. **H**: Relationship between the differences in response times and N1 latency across common and rare tones.

Investigating Selective Attention Across Modalities and Species

- This project is part of a larger research effort that combines various **complementary** modalities to characterize the **neural basis** of statistically-driven selective attention on the micro-, meso- and macroscale with high **spatial** and **temporal** precision.

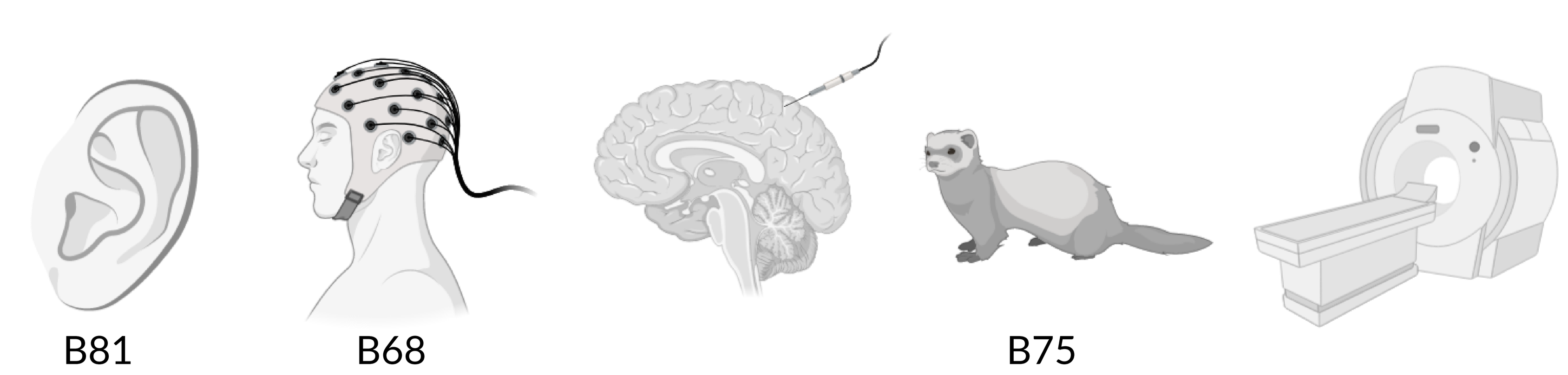

Figure 6. We investigate statistical learning across different modalities - from left to right: psychoacoustics, scalp EEG, intracranial EEG, electrophysiology and functional MRI.

Funded by the National Science Foundation (2219521)

APAN 2023, Washington DC

obialas@ur.rochester.edu