

Auditory Neural Responses Modulated by Attention and Correlated with Perceptual Detectability

“Foreground and Background at the Cocktail Party”

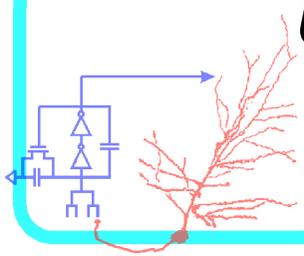
Jonathan Z. Simon

Mounya Elhilali

Juanjuan Xiang

Shihab Shamma

University of Maryland, College Park



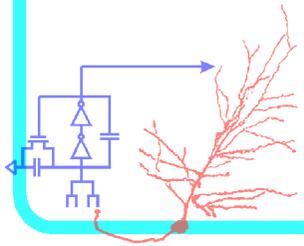
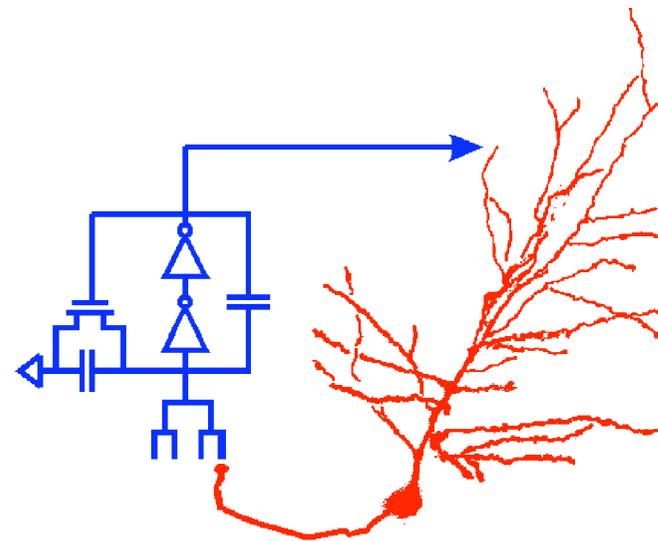
Thanks to

David Poeppel

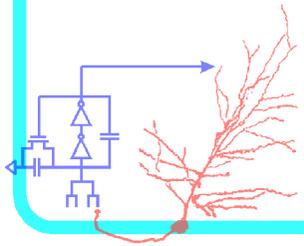
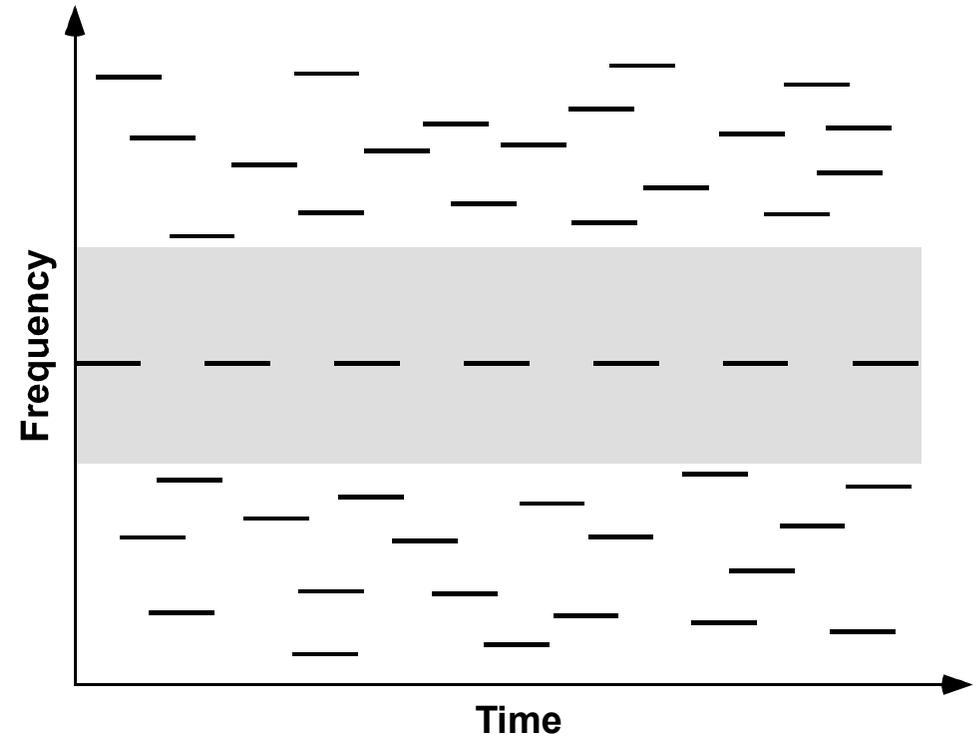
Jeff Walker

Supported by

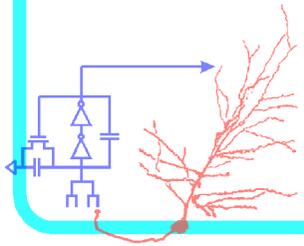
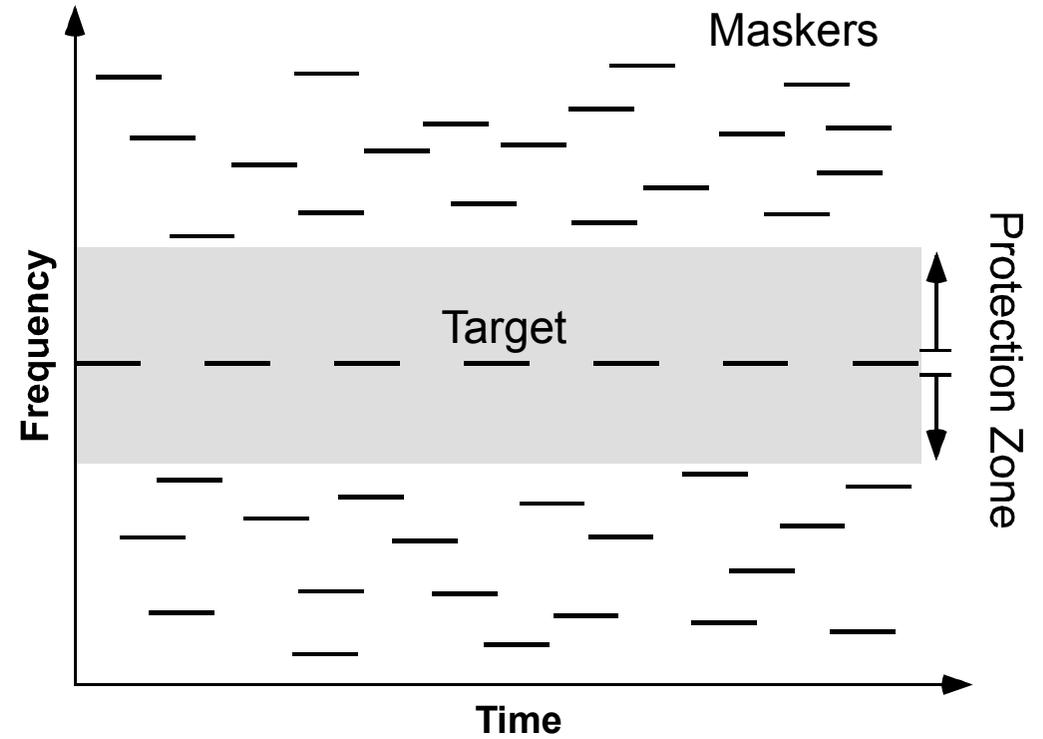
NIDCD & NIA (via CRCNS)



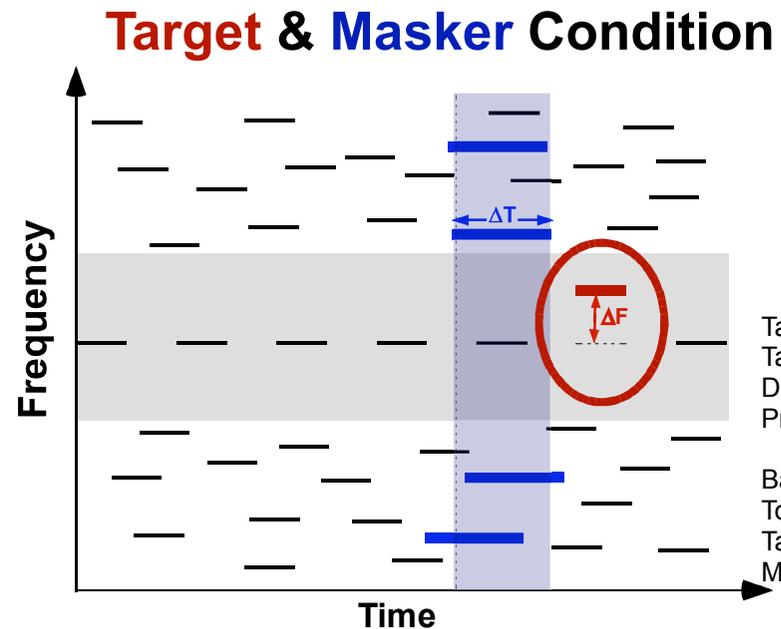
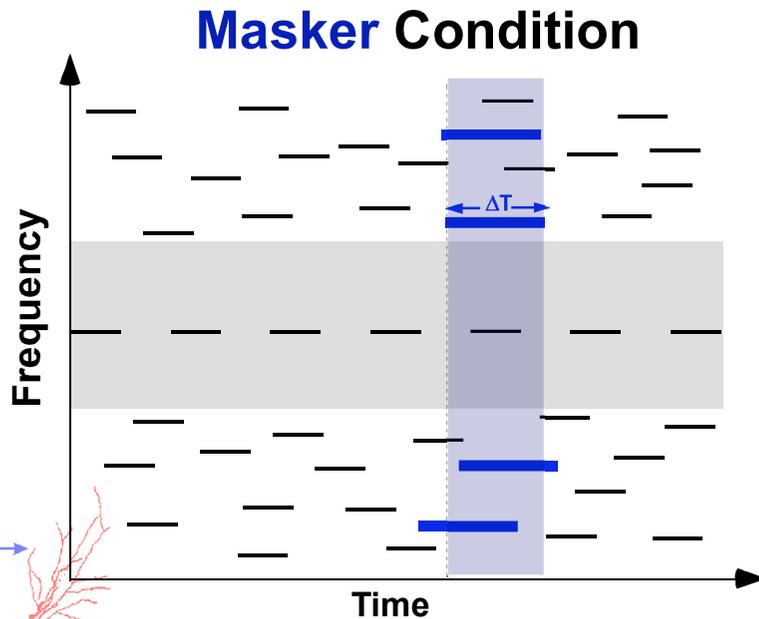
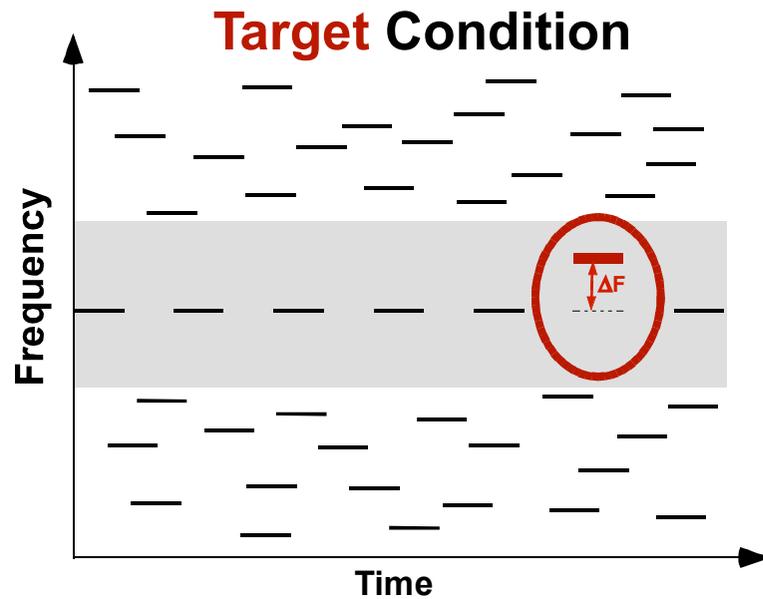
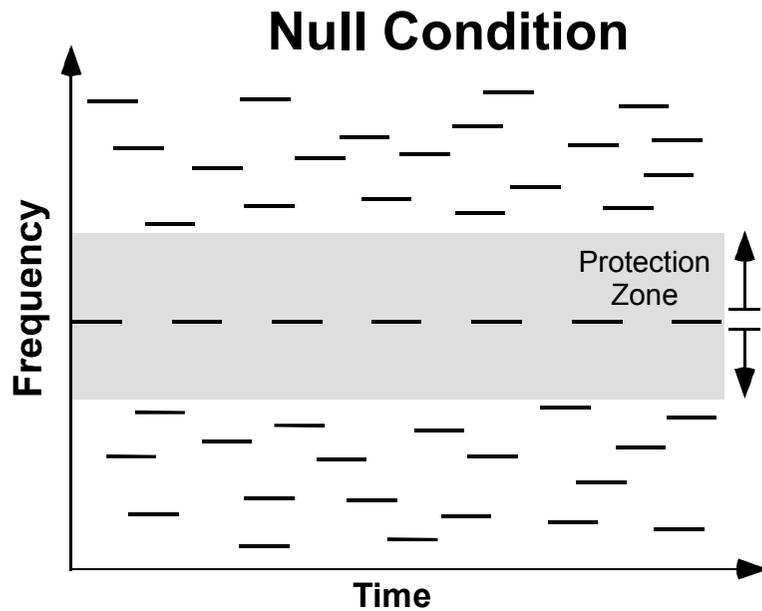
Introduction



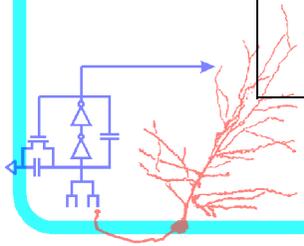
Introduction



Experimental Paradigm

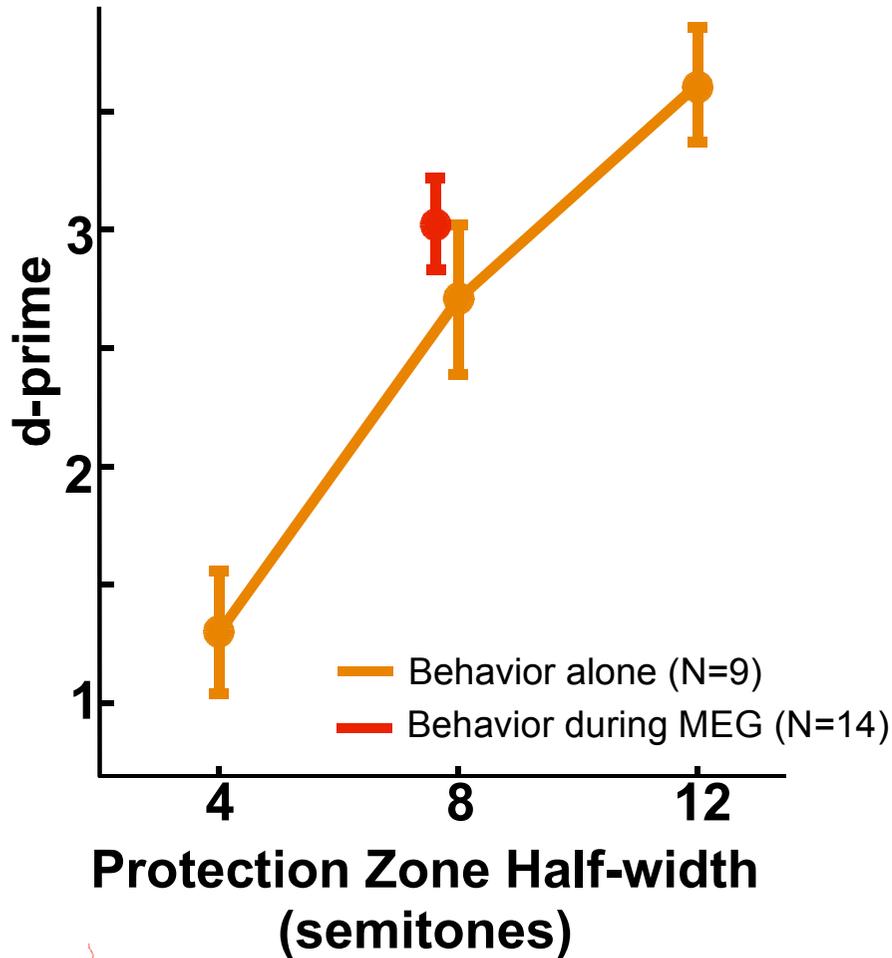


Target rate: 4Hz
Target rove: 250-500 Hz
Duration: 5.5 s
Protection Zone:
4, 8, 12 st/ 8 st
Band: 5 Oct @ 353 Hz
Tone dur: 75 ms
Target dev: +/- 2 st
Masker dev: 400 ms

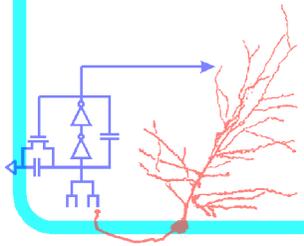
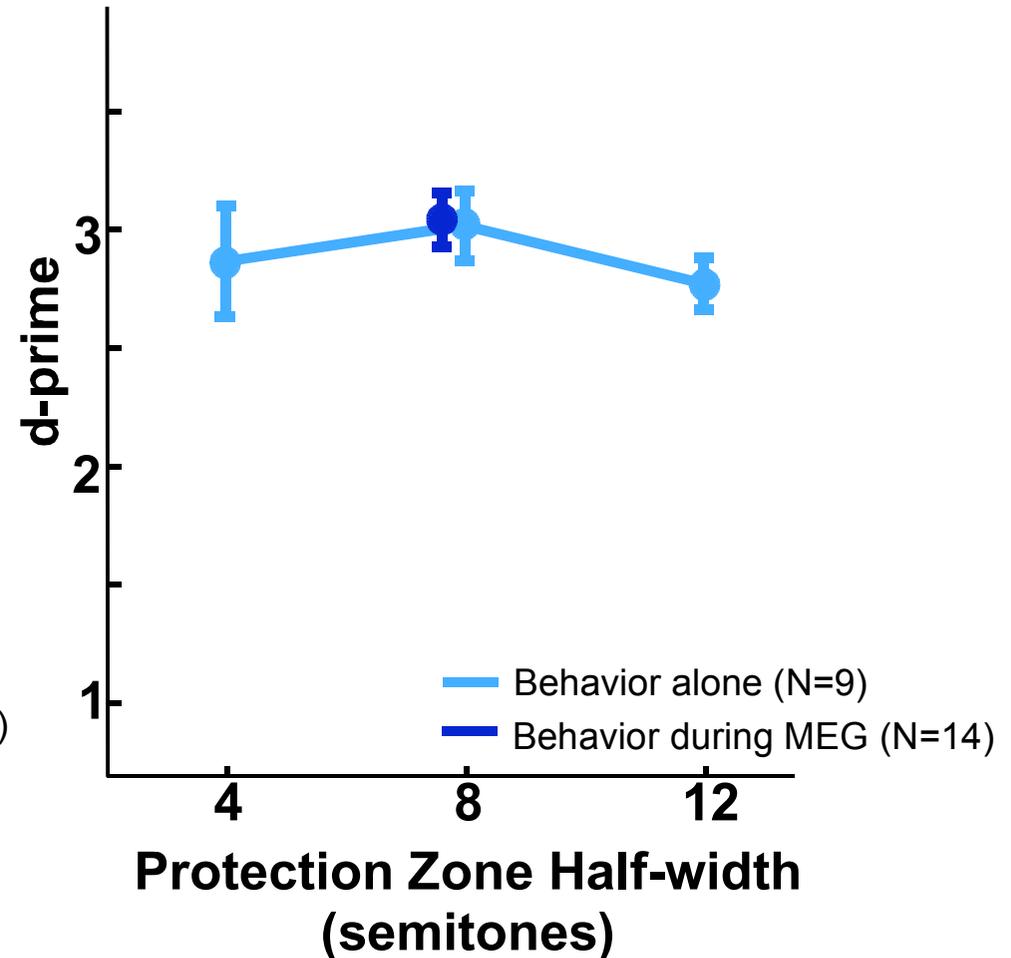


Behavior for Target and Masker Tasks

Behavioral Performance for Target Task

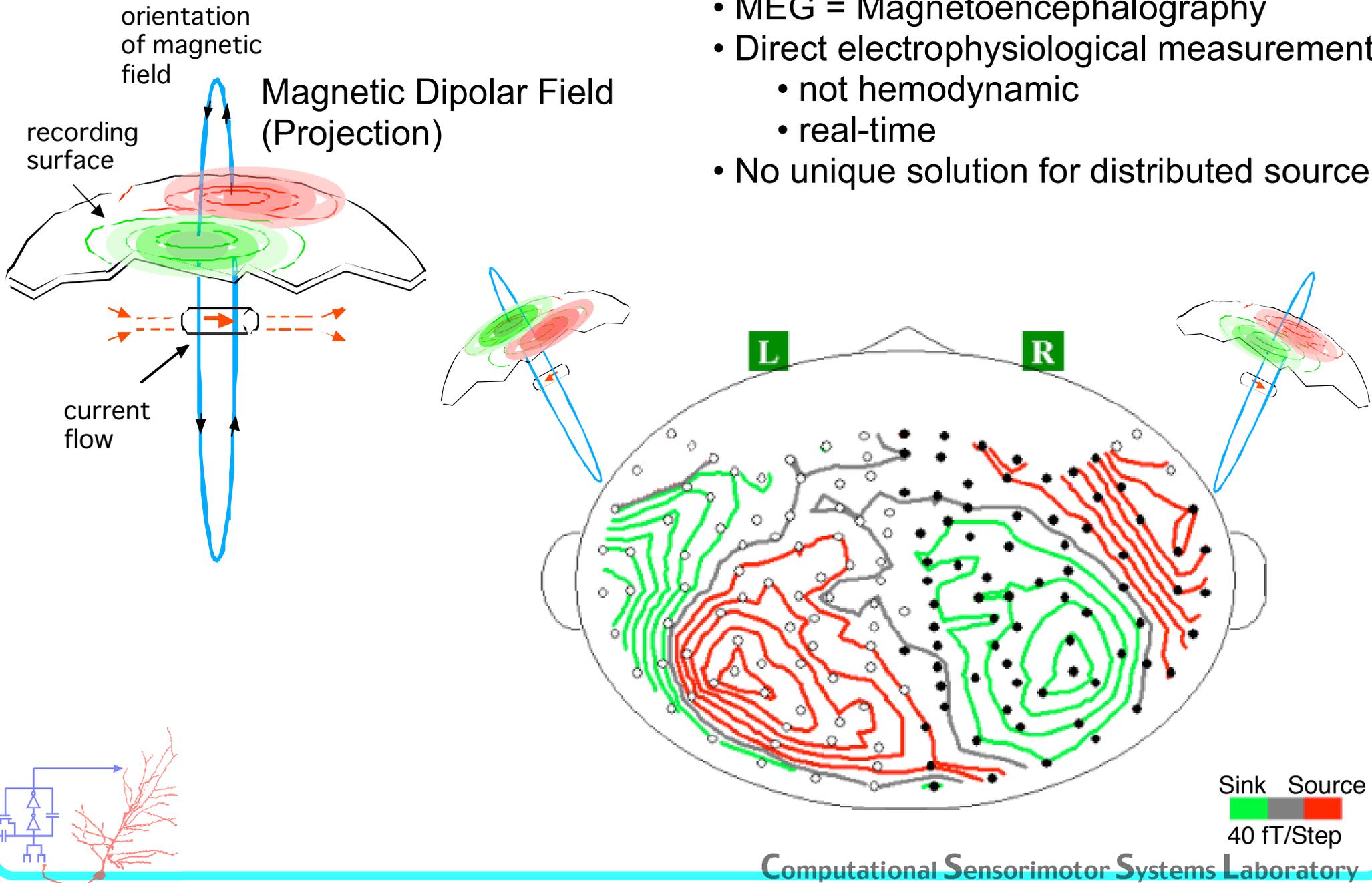


Behavioral Performance for Masker Task



MEG Measures Neural Currents

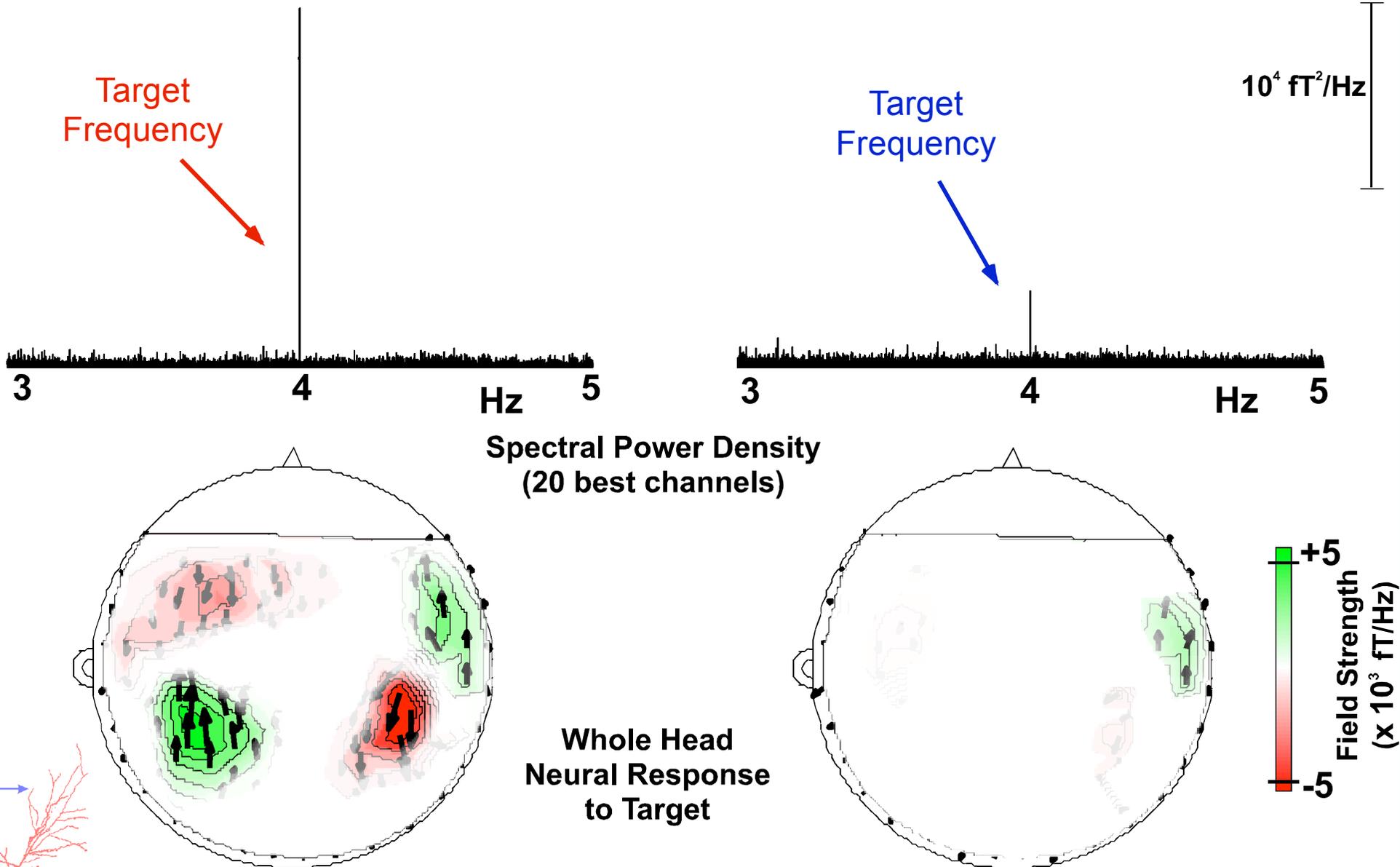
- MEG = Magnetoencephalography
- Direct electrophysiological measurement
 - not hemodynamic
 - real-time
- No unique solution for distributed source



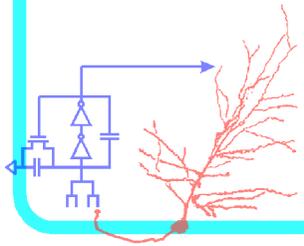
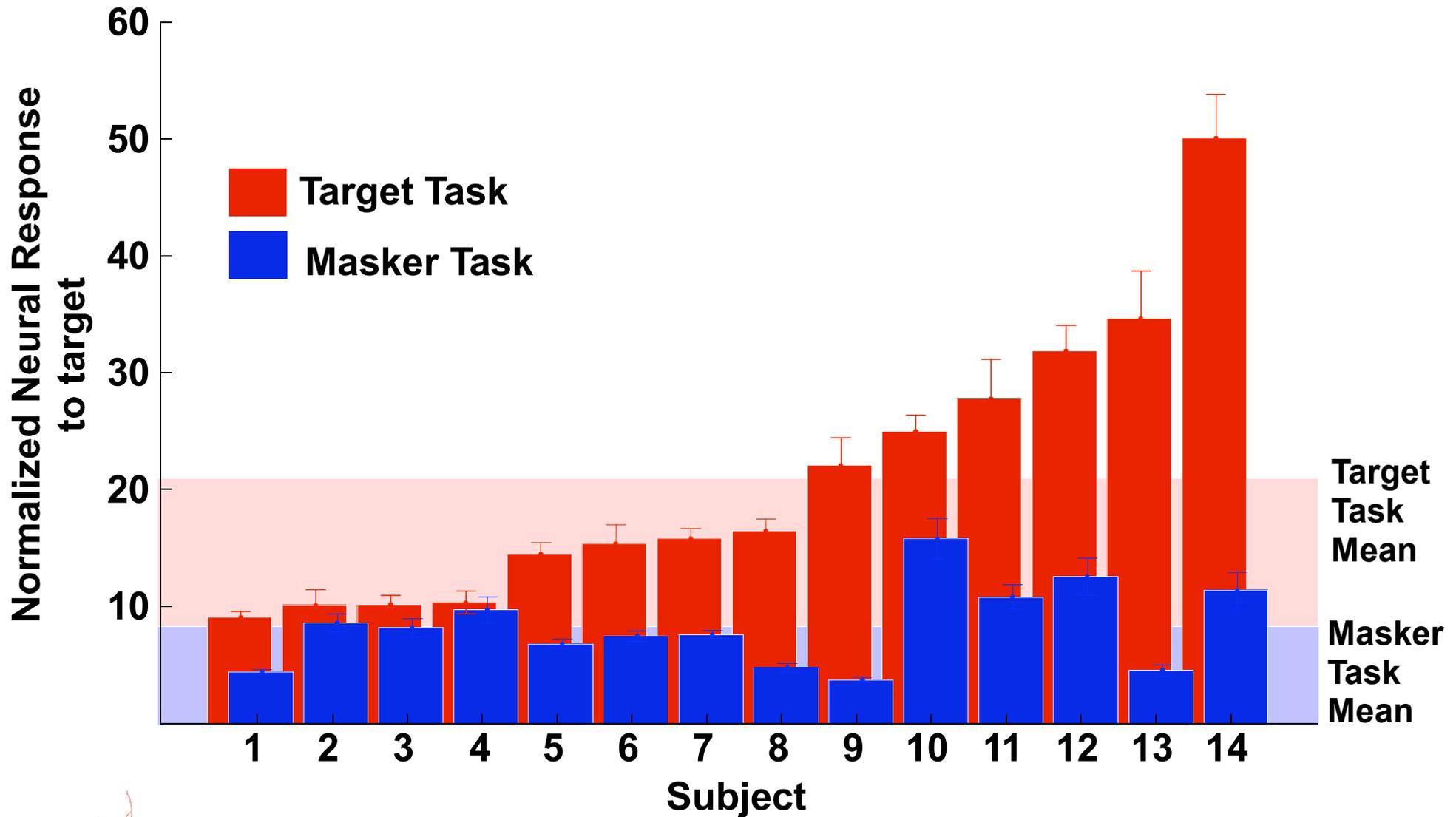
Neural Response to Target

Neural Response to Target
Target Task

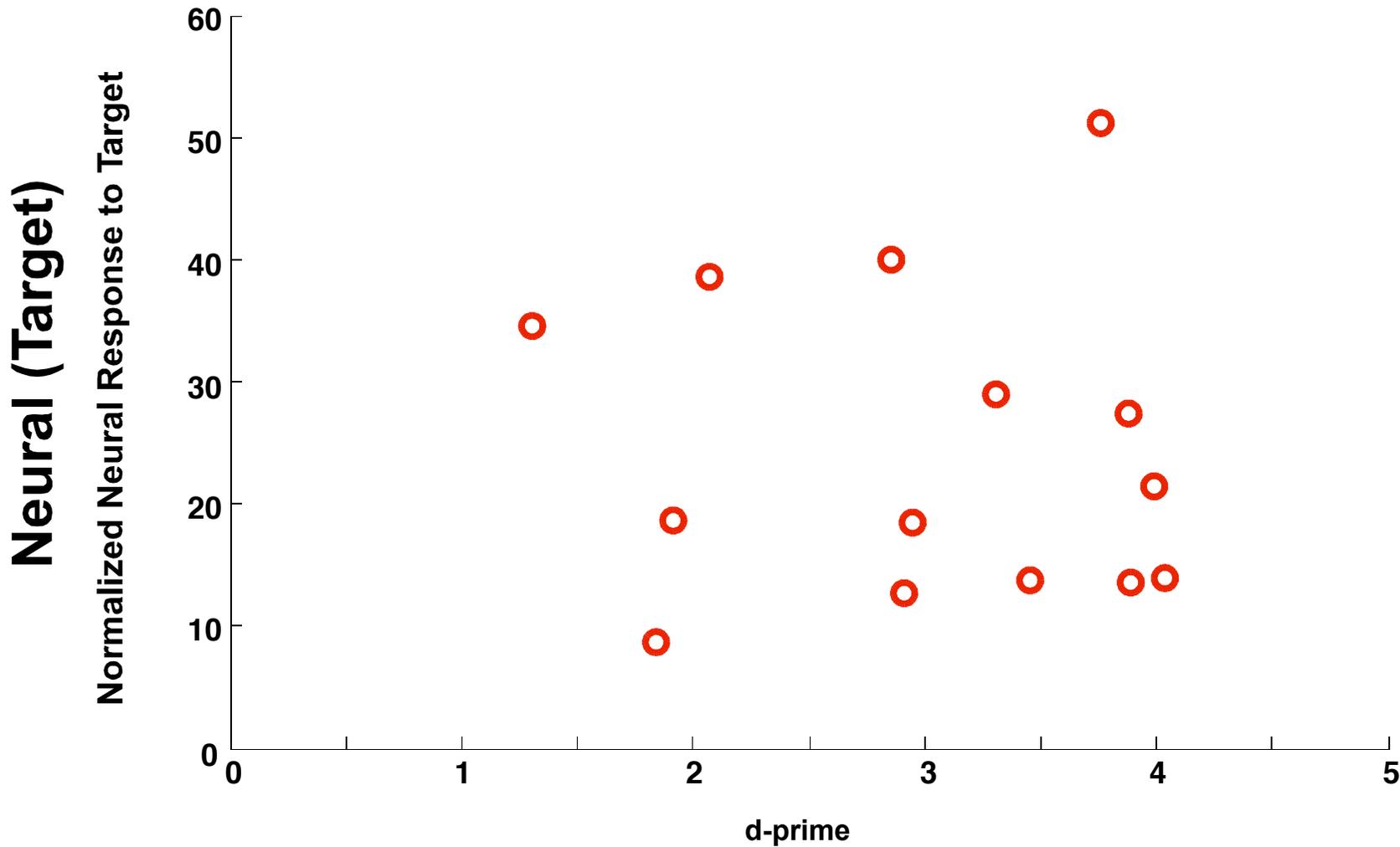
Neural Response to Target
Masker Task



Neural Response to Target by Task

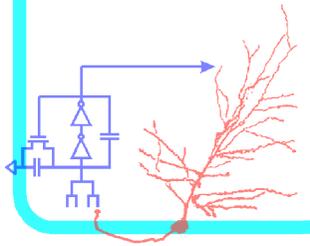


Neural Response to Target vs. Behavior



Behavior (Target)

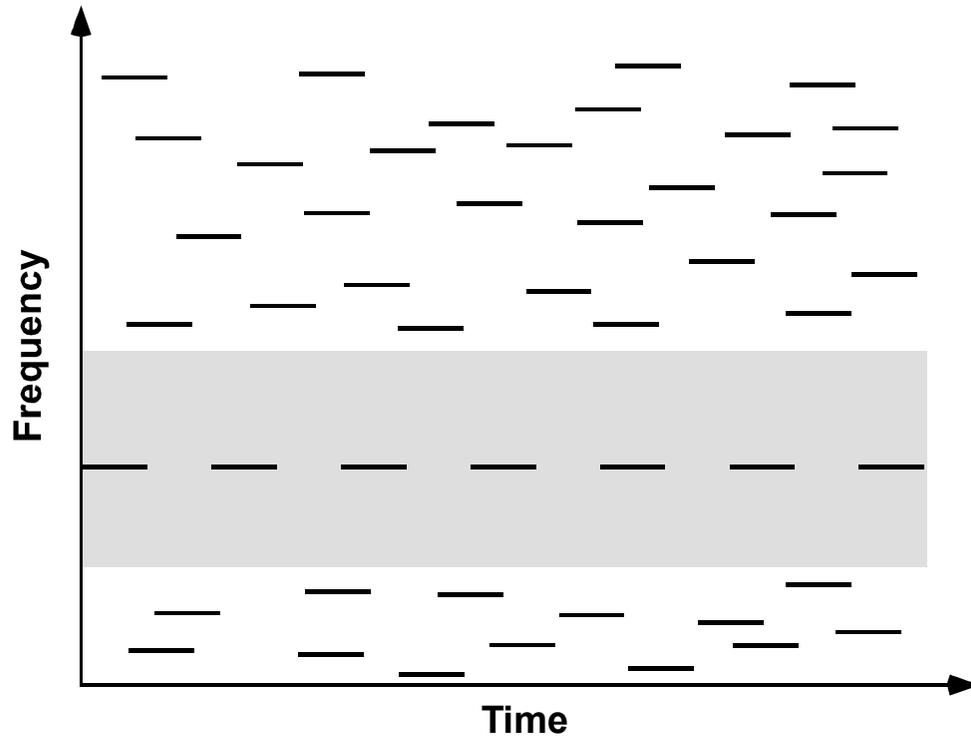
Target Task



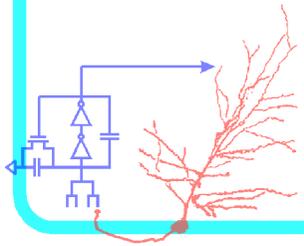
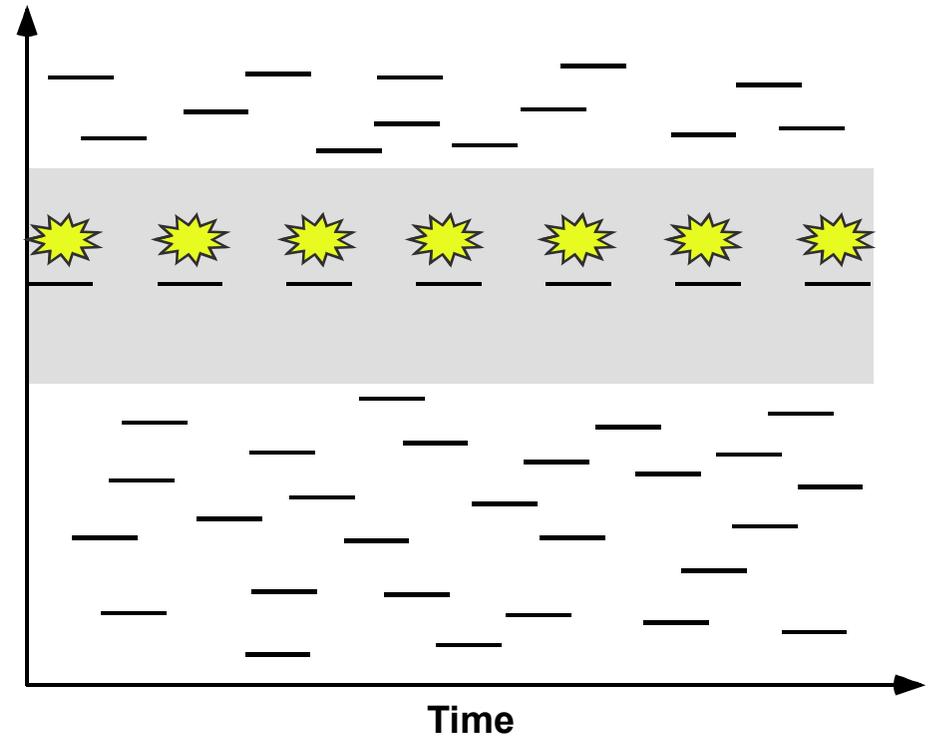
Effect of Target Frequency

Auditory Pop-out

Low-frequency Target



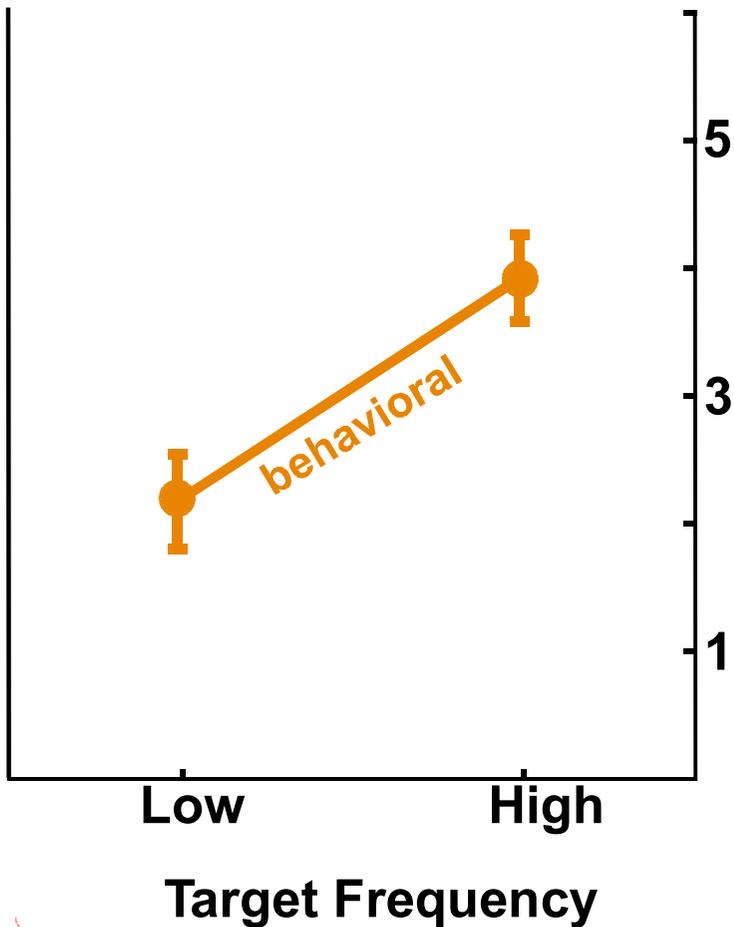
High-frequency Target



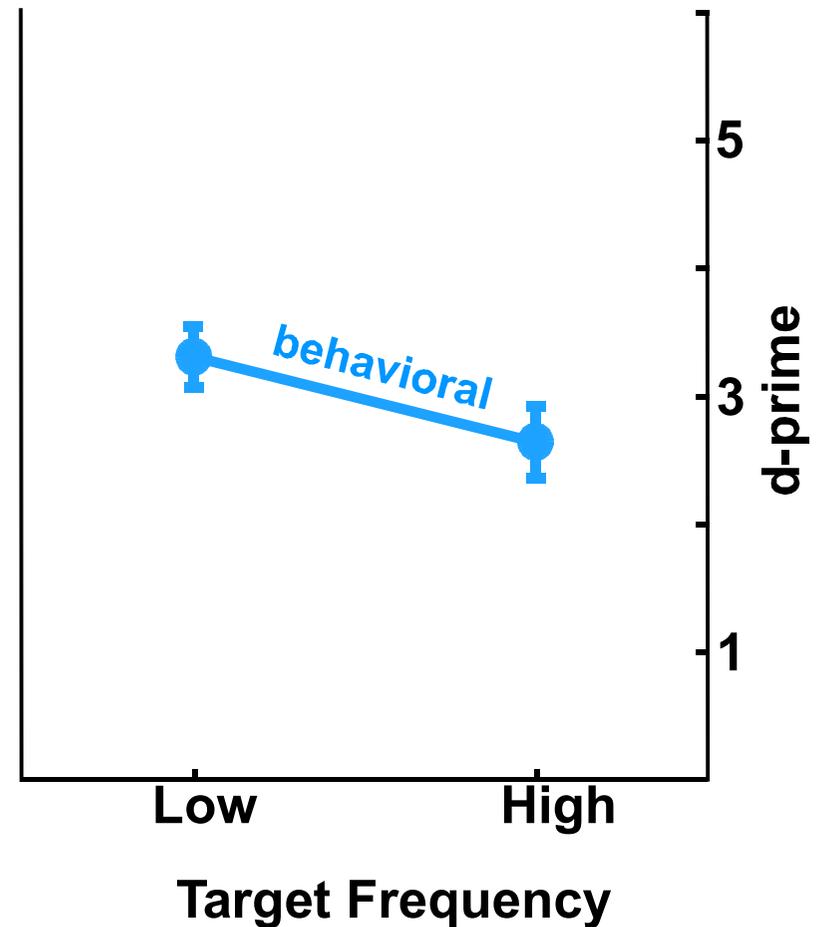
Effect of Target Frequency

Auditory Pop-out

Target Task

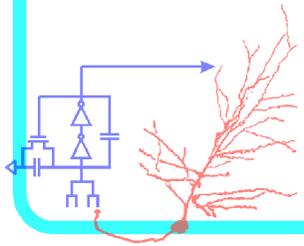


Masker Task



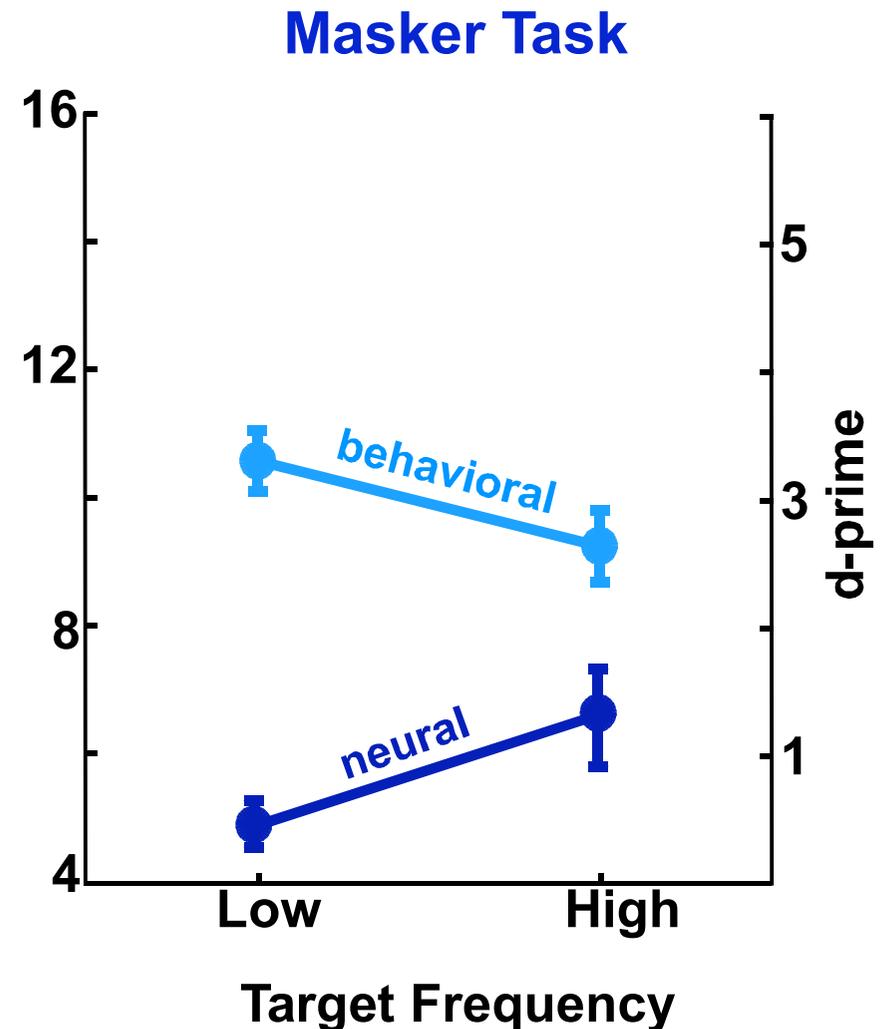
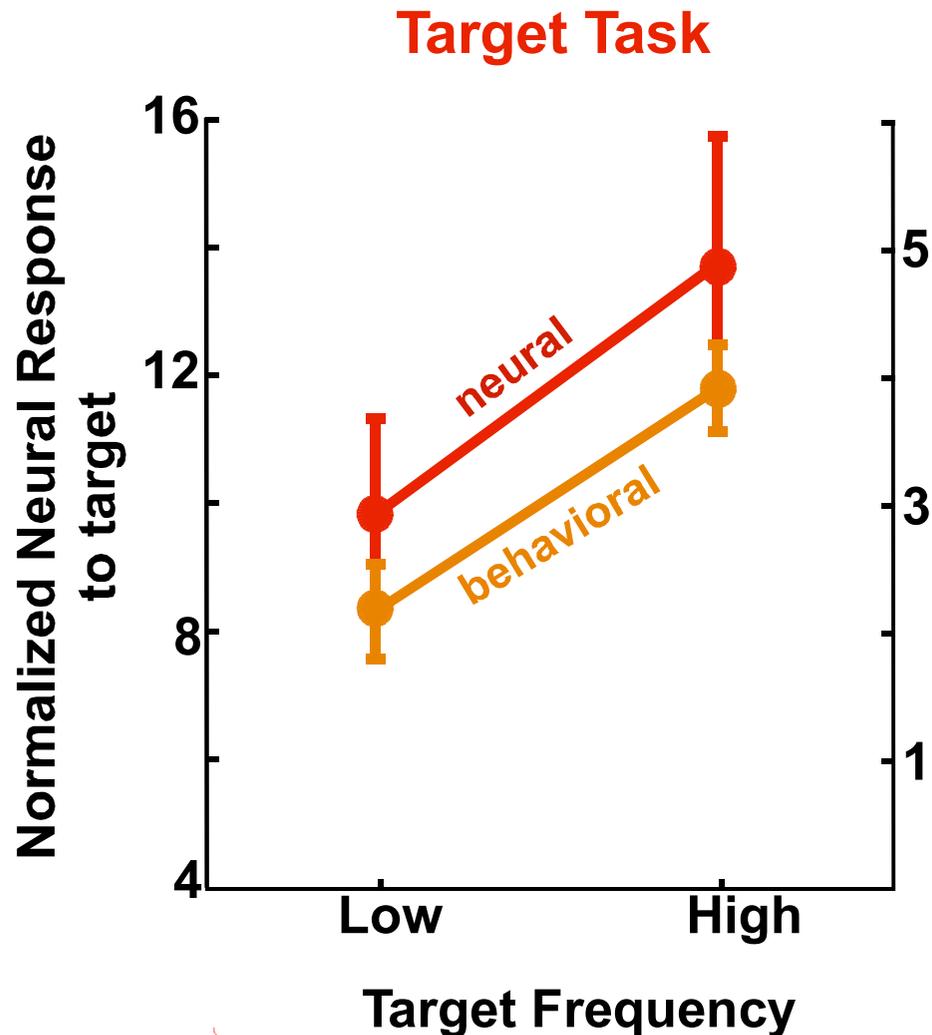
— Behavior from MEG (N=14)

— Behavior from MEG (N=14)



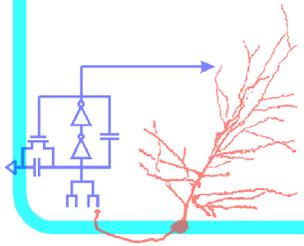
Effect of Target Frequency

Auditory Pop-out

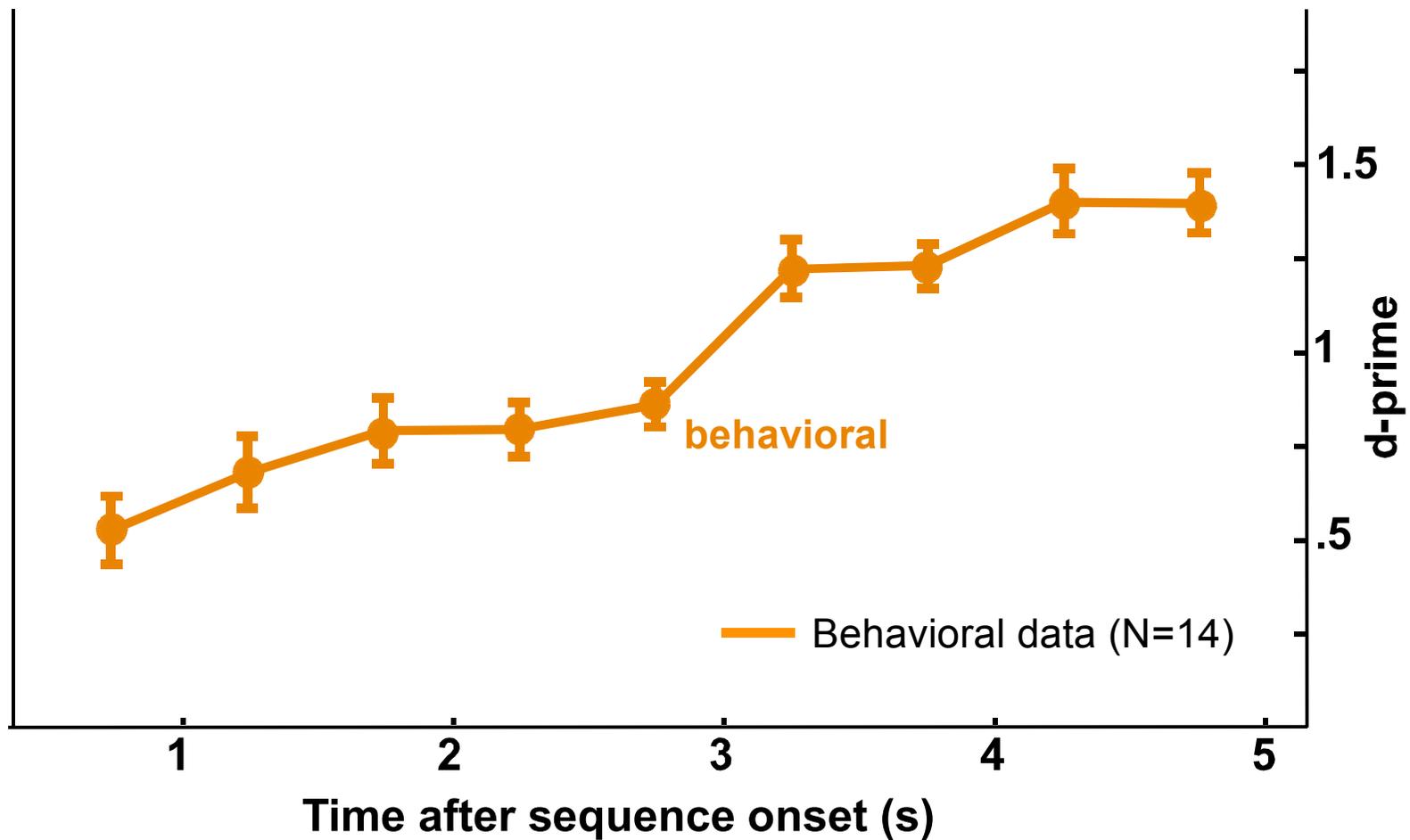


— Neural response (N=14)
— Behavior from MEG (N=14)

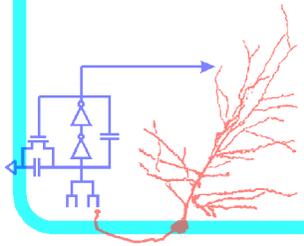
— Neural response (N=14)
— Behavior from MEG (N=14)



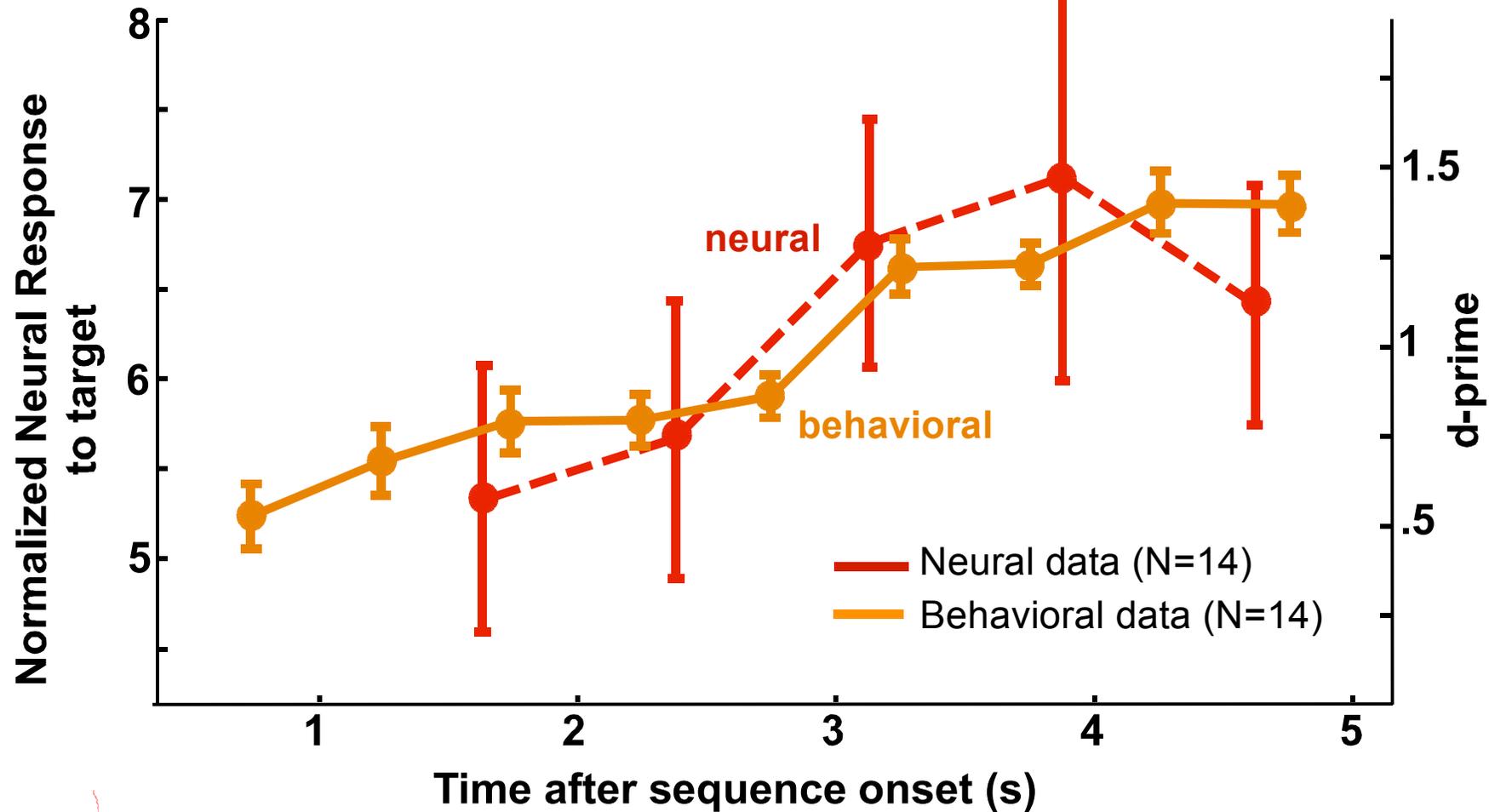
Behavioral & Neural Build-ups



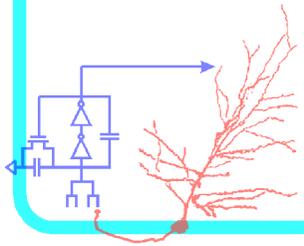
Target Task



Behavioral & Neural Build-ups

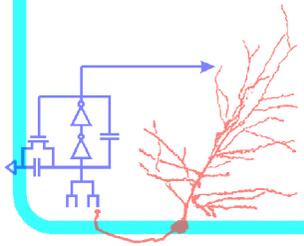


Target Task



Summary

- Strong Neural Response to Target (despite Maskers)
- Attention strongly modulates Neural Response
- Change in Behavior correlates with Change in Neural Response
 - + Auditory Pop-out
 - Target Pop-out correlates with Neural Response
 - Target Pop-out interferes with Masker Task
 - + Similar buildup for Behavioral & Neural Response



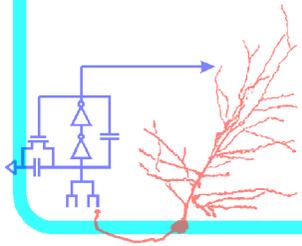
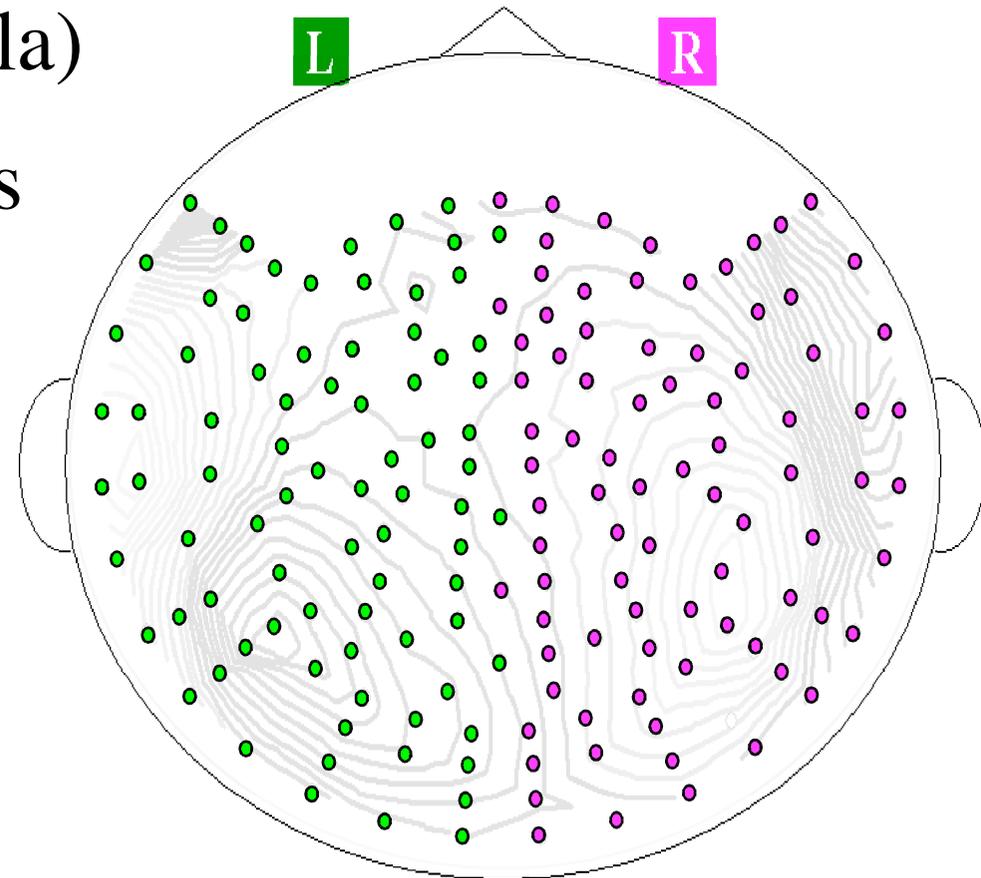
Magnetoencephalography (MEG)

- Non-invasive, Passive, Silent
- Simultaneous Whole-Head Recording (~200 sensors)
- Sensitivity

high: ~ 100 fT (10^{-13} Tesla)

low: $\sim 10^4 - \sim 10^6$ neurons

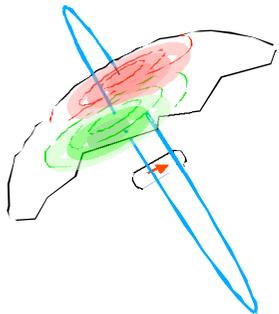
- Temporal Resolution: ~ 1 ms
- Spatial Resolution
coarse: ~ 1 cm
ambiguous



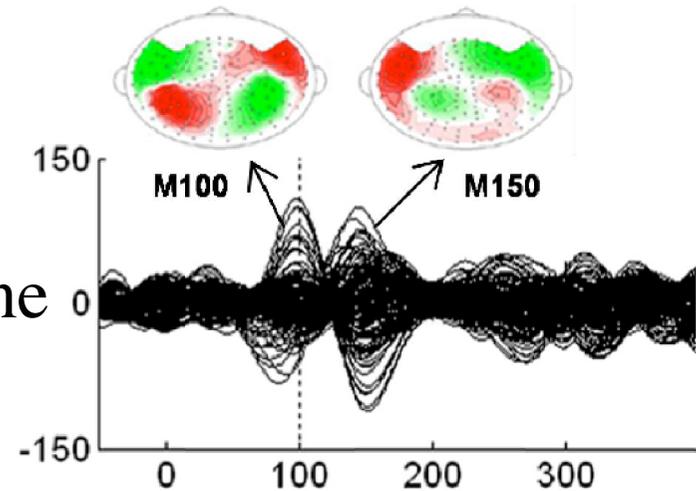
Time Course of MEG Responses

Evoked Responses

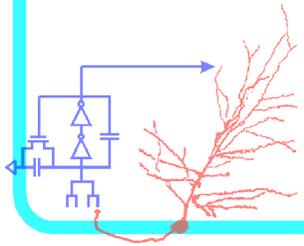
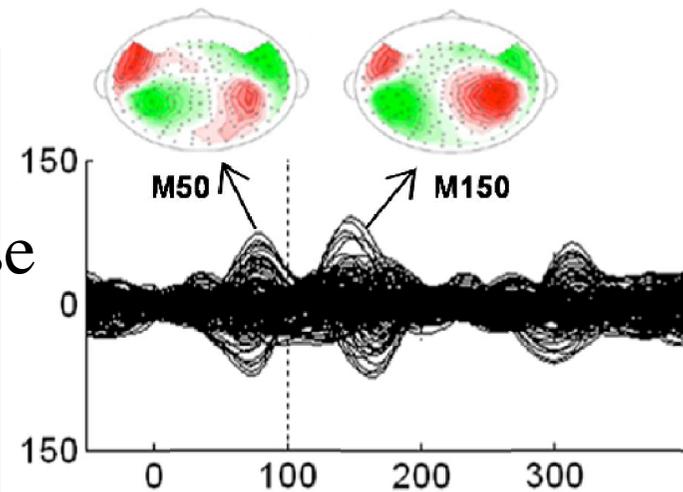
MEG Events Time-Locked
to Stimulus Event



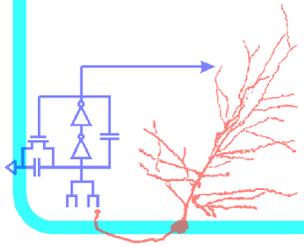
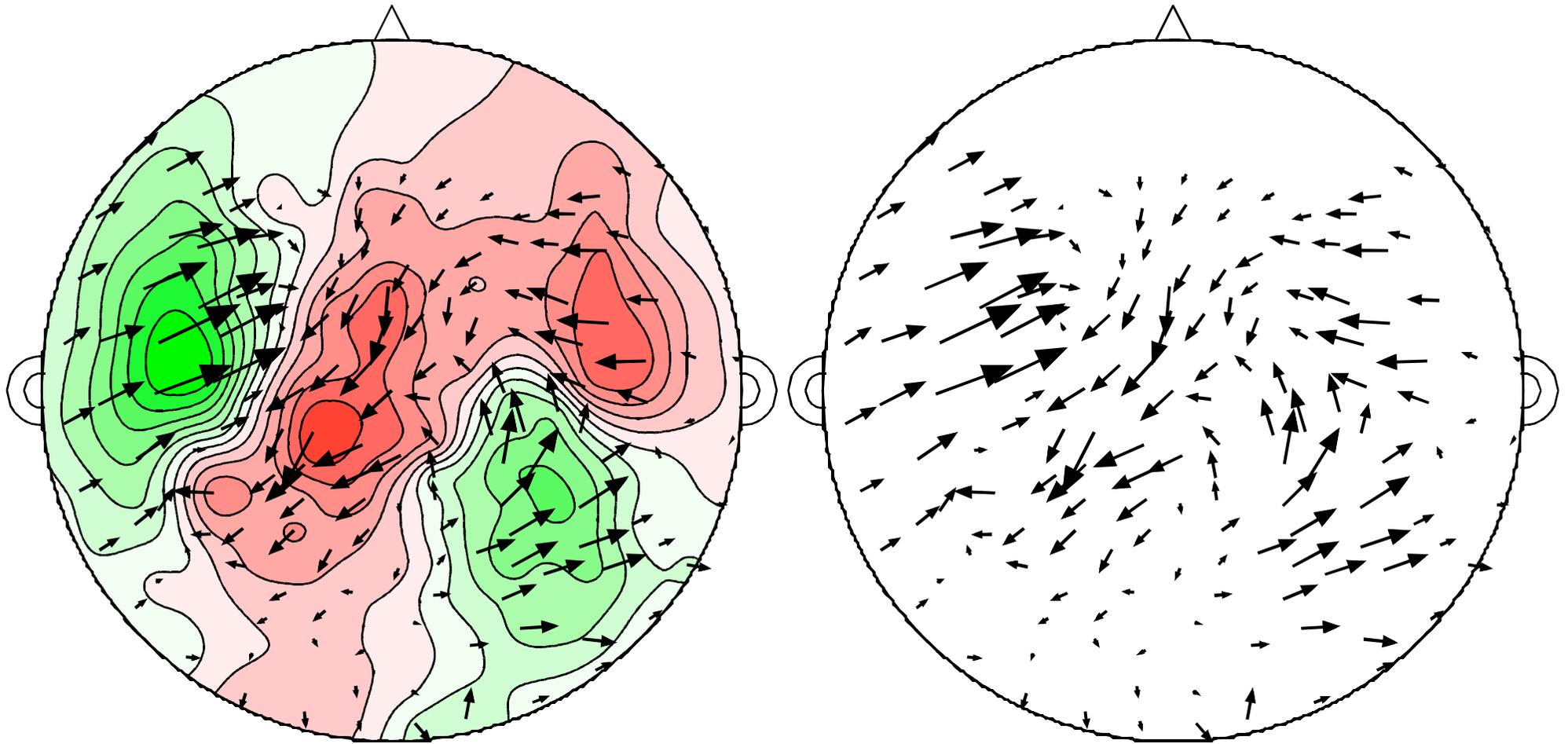
Pure Tone



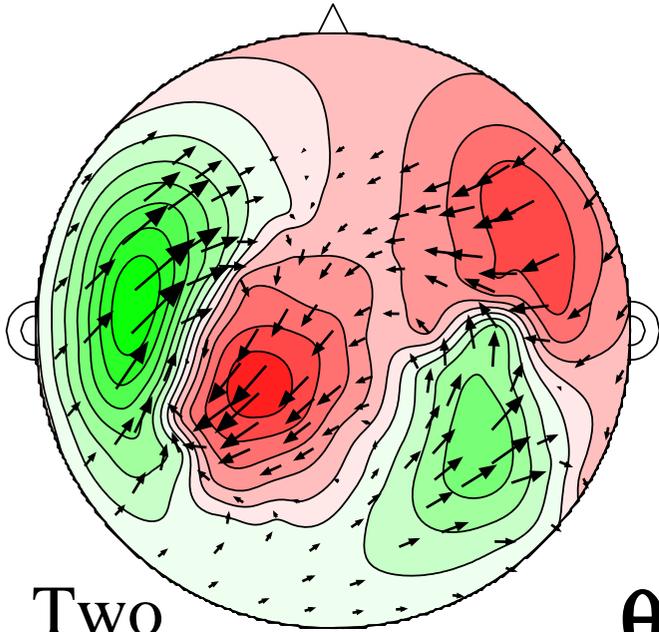
Broadband Noise



Complex Magnetic Field



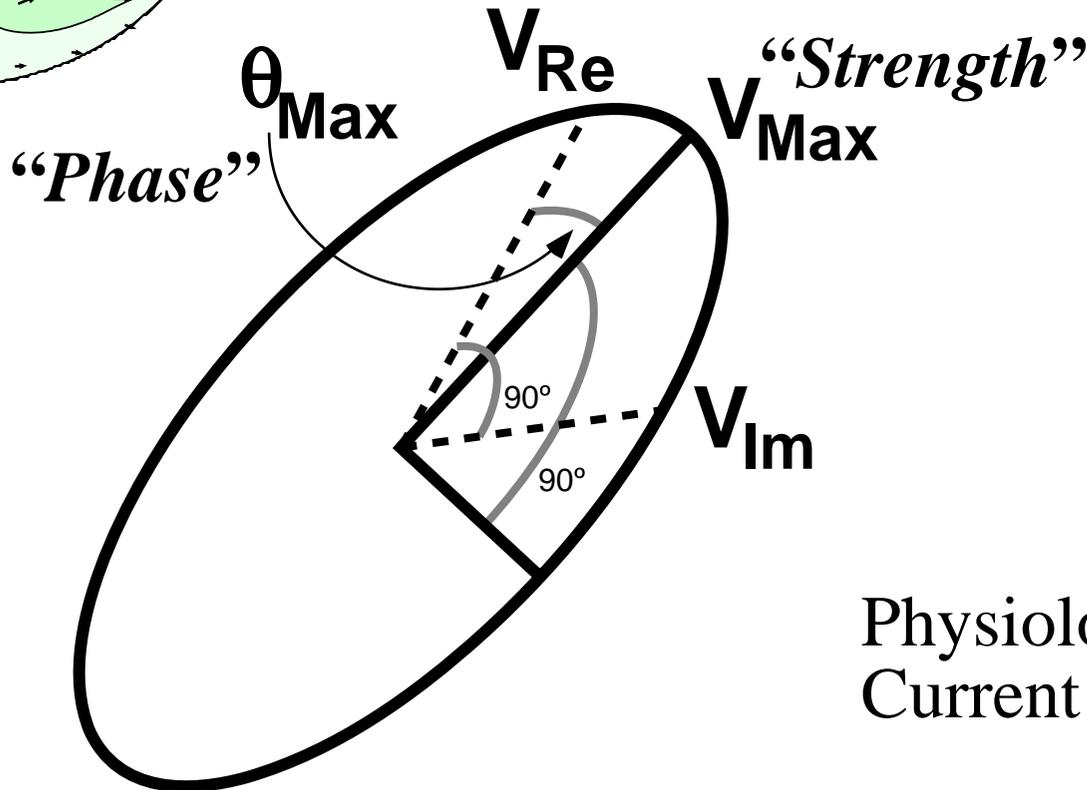
Complex Equivalent-Current Dipoles



$$\vec{V} = \vec{V}_{\text{Re}} + i\vec{V}_{\text{Im}}$$

$$\vec{V}(\theta) = \vec{V}_{\text{Re}} \cos(\theta) + \vec{V}_{\text{Im}} \sin(\theta)$$

Two
Dipole
Fit



“Sharpness”

$$\eta = \frac{|V_{\text{Min}}|}{|V_{\text{Max}}|}$$

$$0 < \eta < 1$$

\hat{V}_{Max} , \hat{V}_{Min}
Orientations

Physiologically Simple
Current Sources: $\eta = 0$