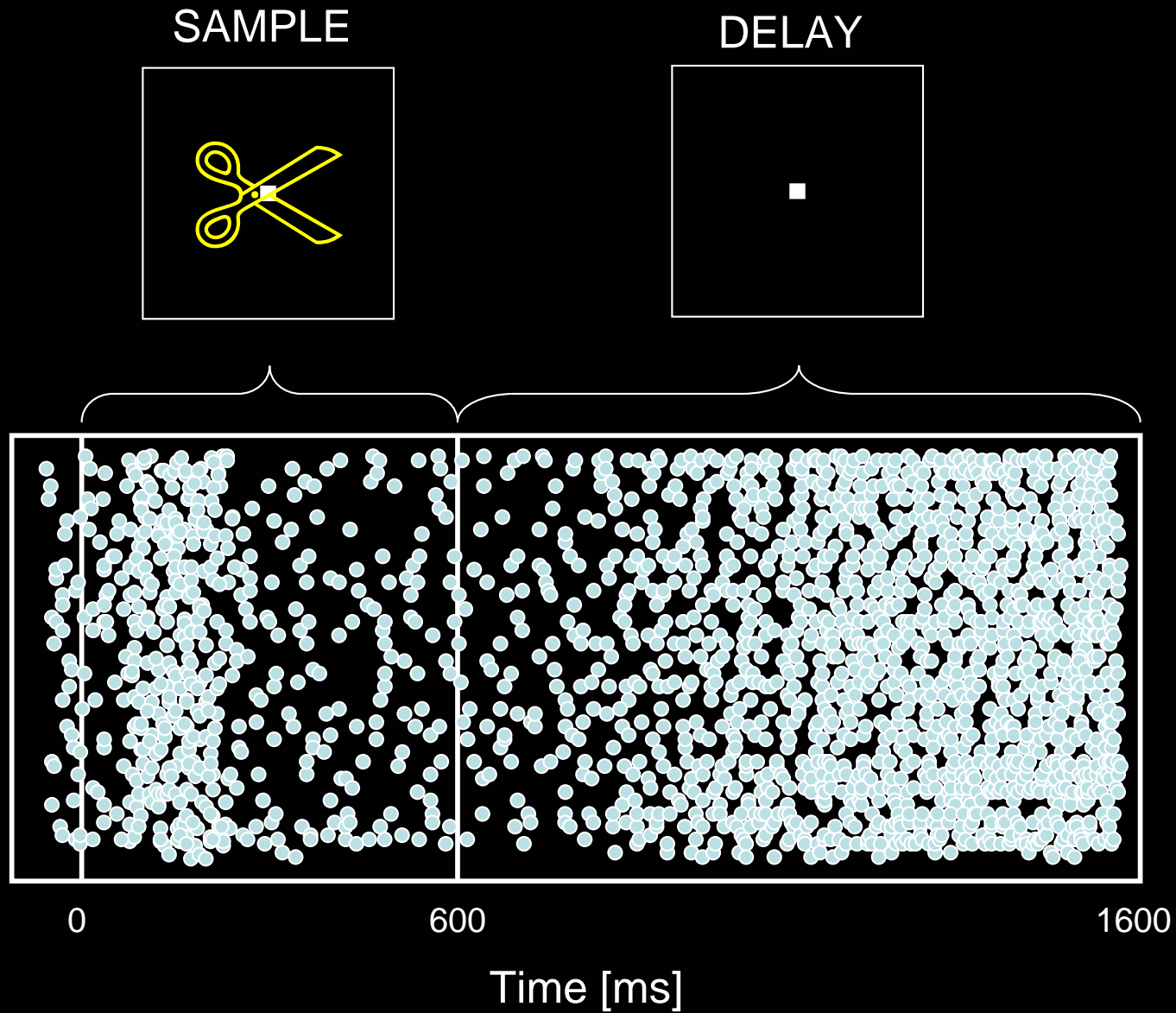


PHASE LOCKING OF SINGLE NEURON ACTIVITY TO THETA  
OSCILLATIONS DURING WORKING MEMORY IN MONKEY  
EXTRASTRIATE VISUAL CORTEX

Gregor Rainer  
Max Planck Institute for biological cybernetics  
Tübingen, Germany

*gregor.rainer@tuebingen.mpg.de*

# Working memory and *delay activity* in prefrontal cortex

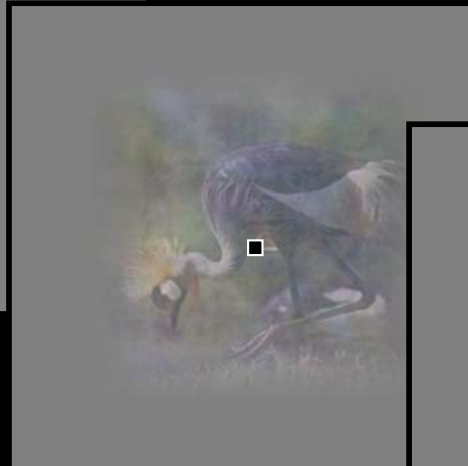


# Behavioral task

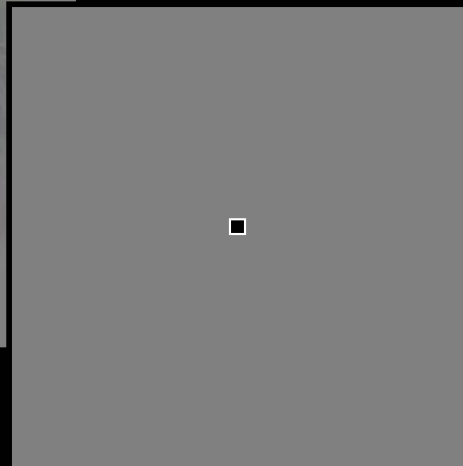
Fixation (1000ms)



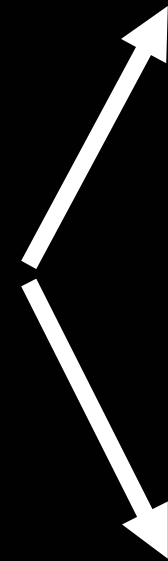
Sample (350ms)



Delay (1000ms)



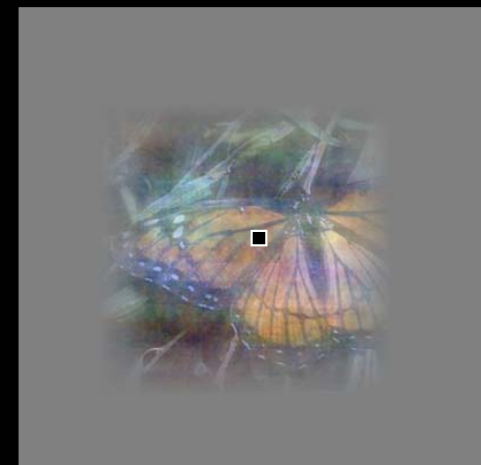
50%



Probe (Match)



Probe (non Match)

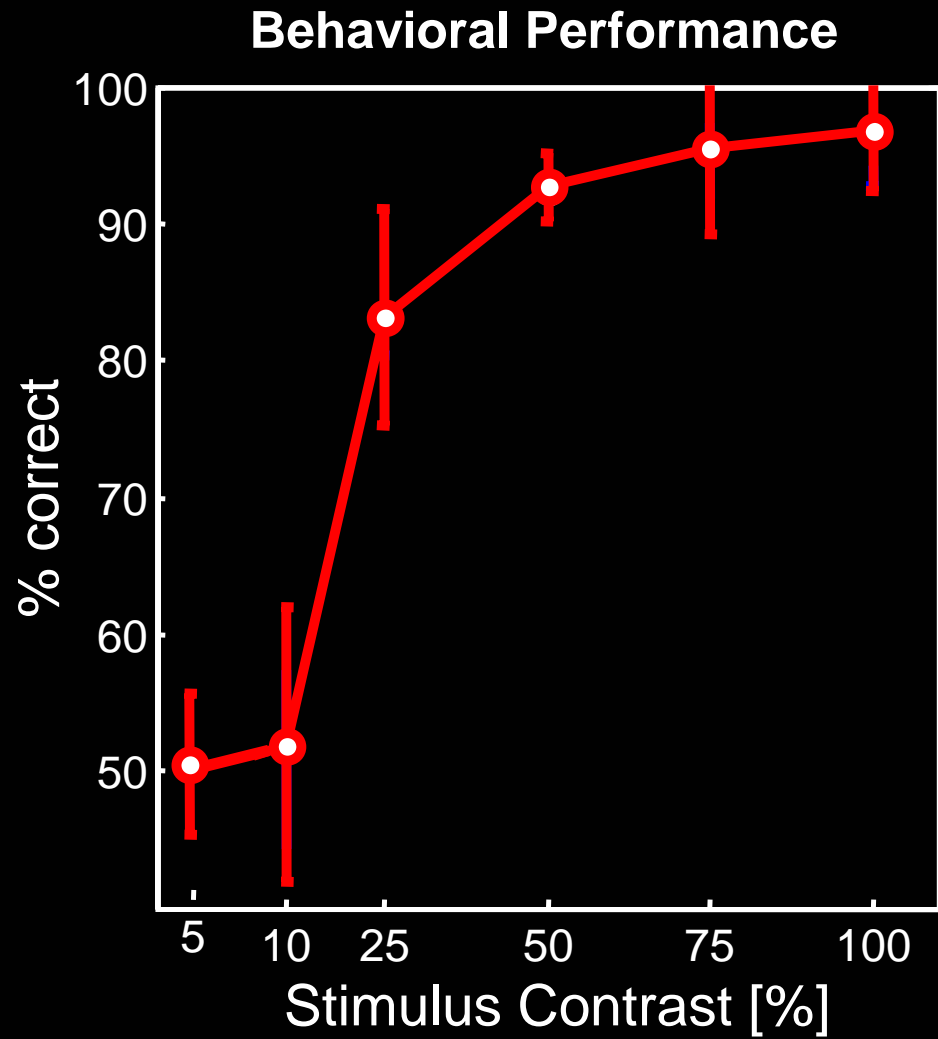


50%

10°

Sample: One of eight stimuli at one of six contrasts (5, 10, 25, 50, 75, 100%).  
Probe: One of eight stimuli always at 100% contrast.

# Performance varied systematically with sample contrast

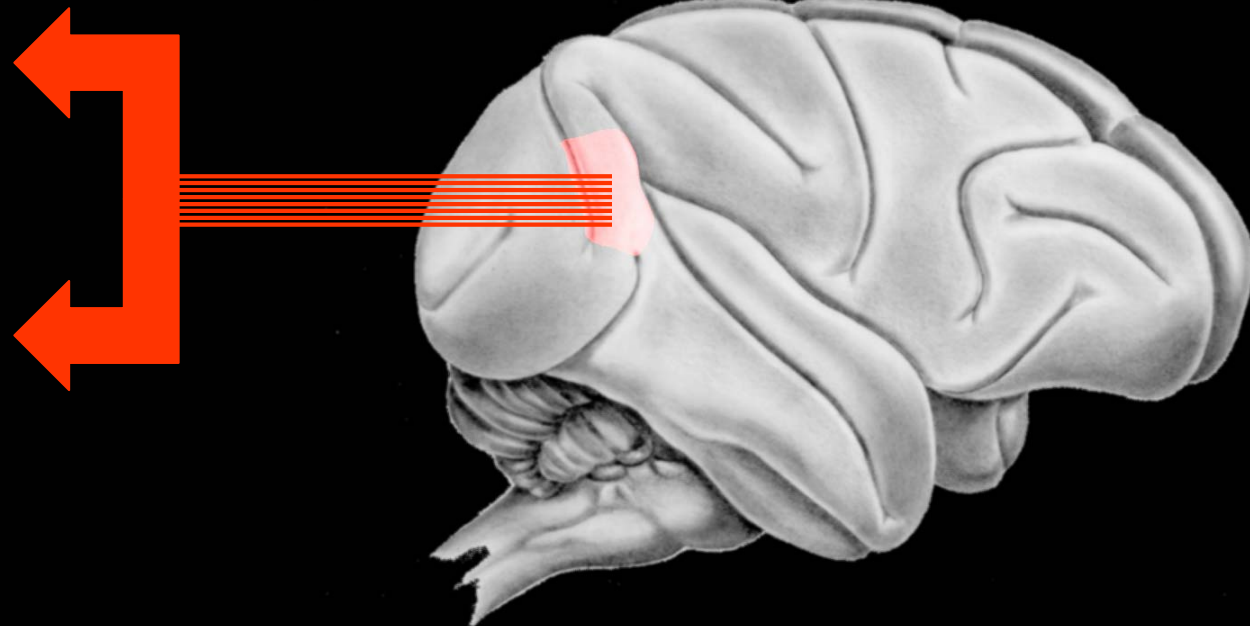


# Neurophysiological recordings

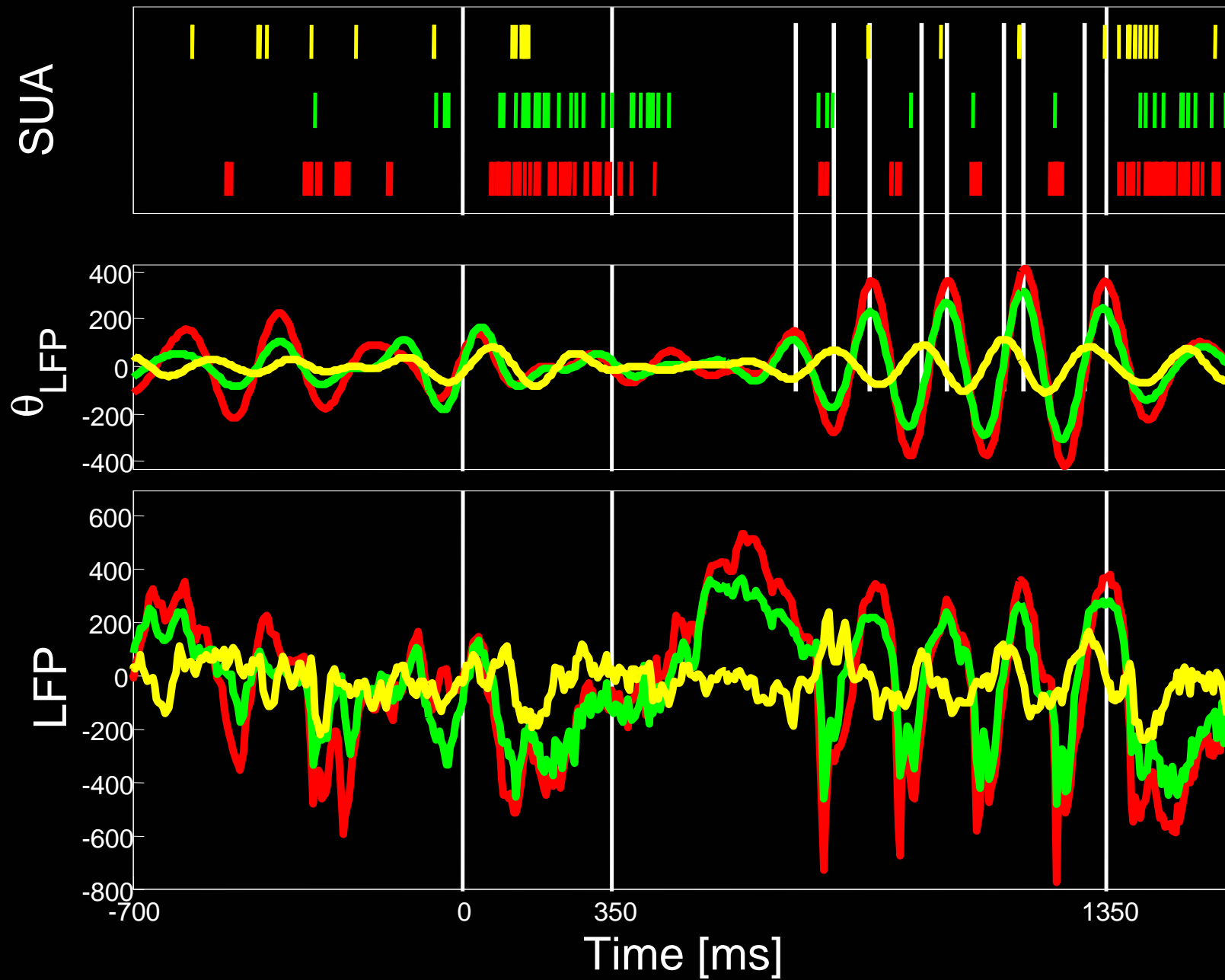
Up to 6 single Tungsten electrodes ( $1 - 2\text{M}\Omega$  at 1kHz)  
Electrode Separation 1 to 5 mm  
1 - 2 single neurons per channel

LFP: .1Hz-100Hz  
s/rate 200Hz

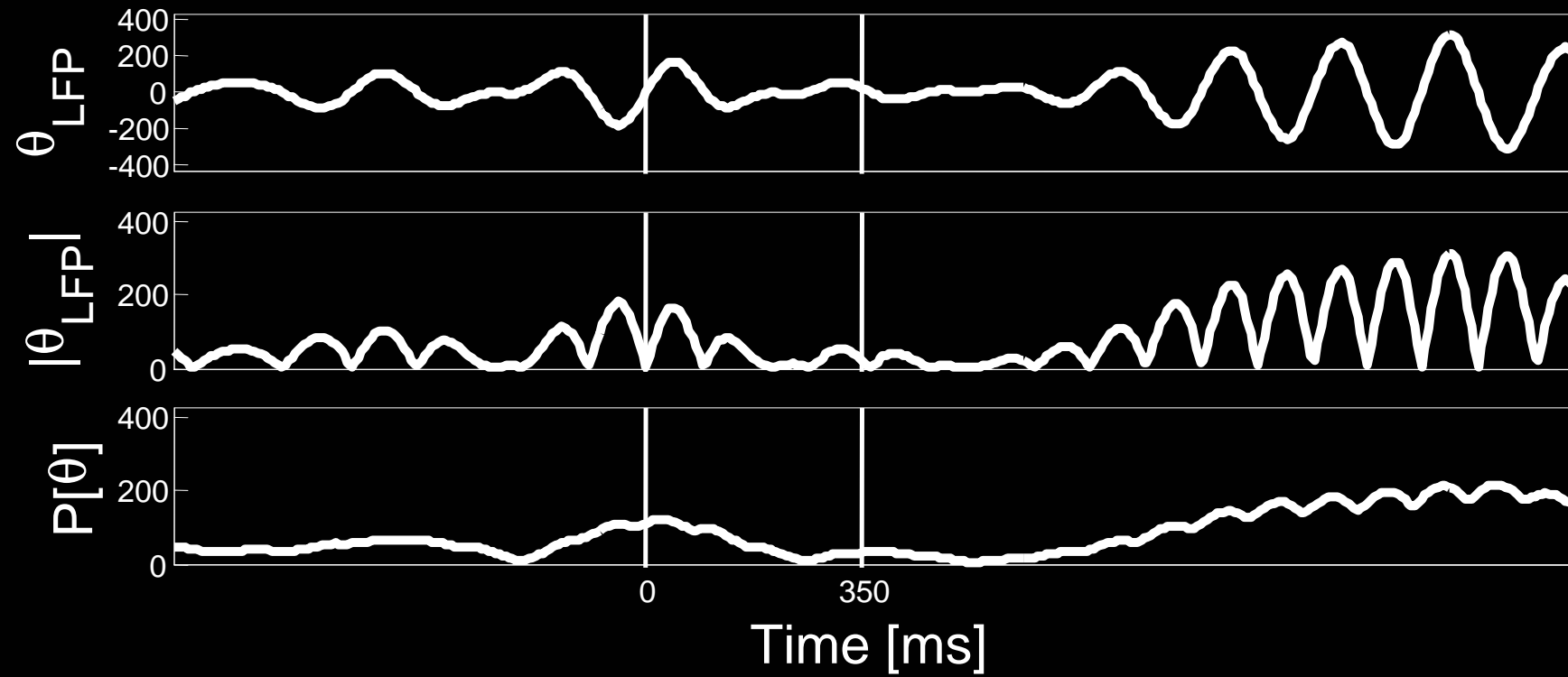
SUA: 300Hz-4kHz  
s/rate: 22kHz



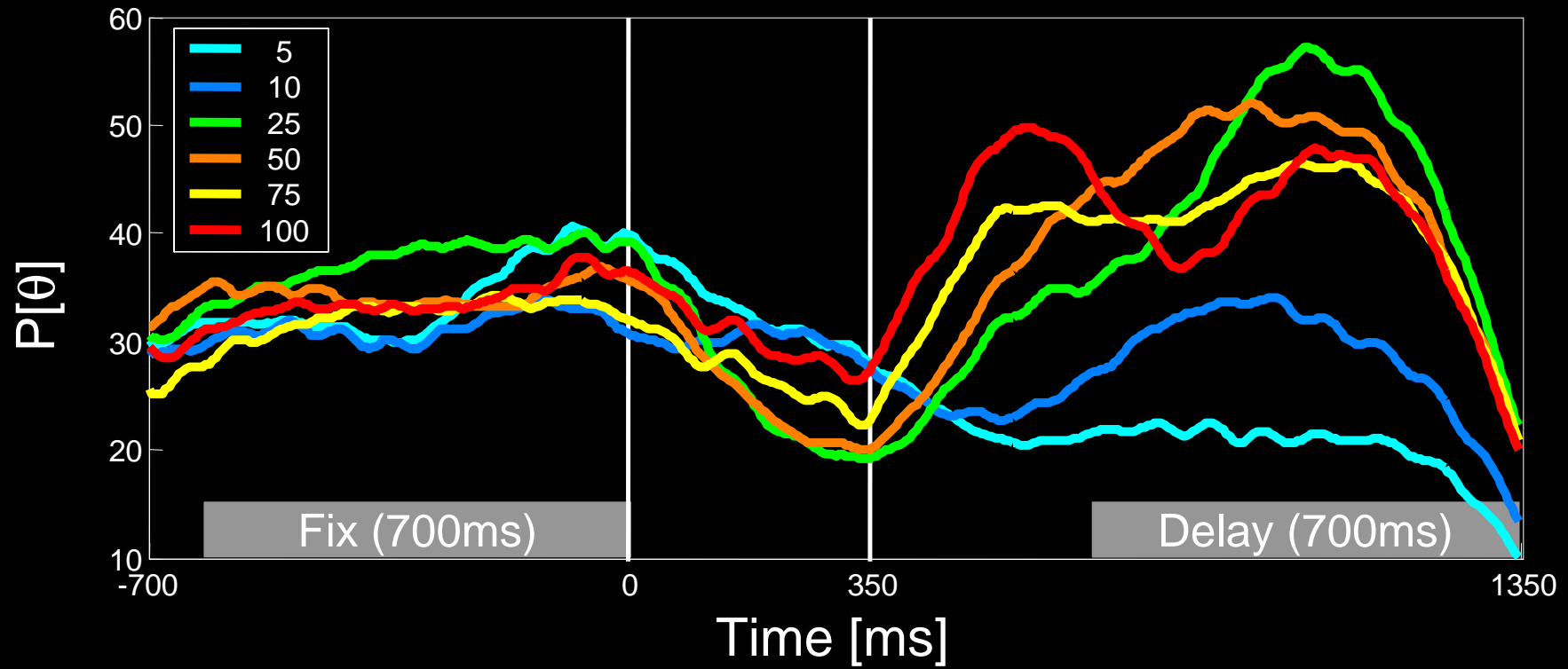
# Example single trial multisite recordings from V4



# Estimation of $\theta$ -power

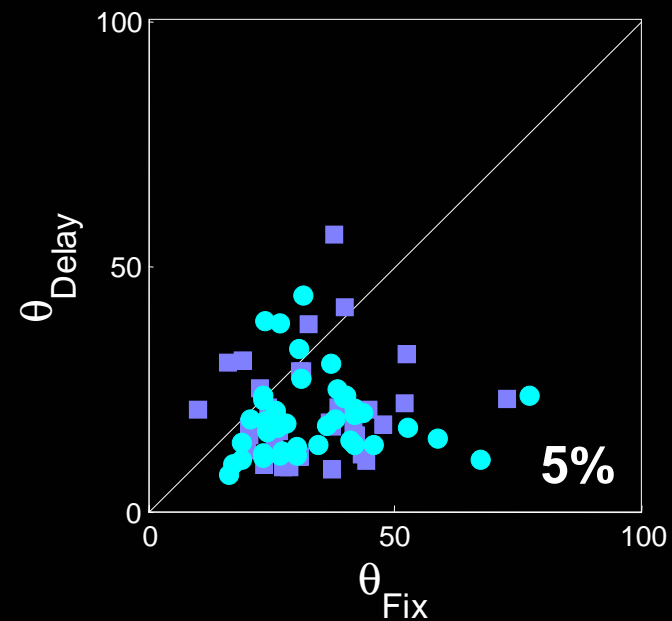
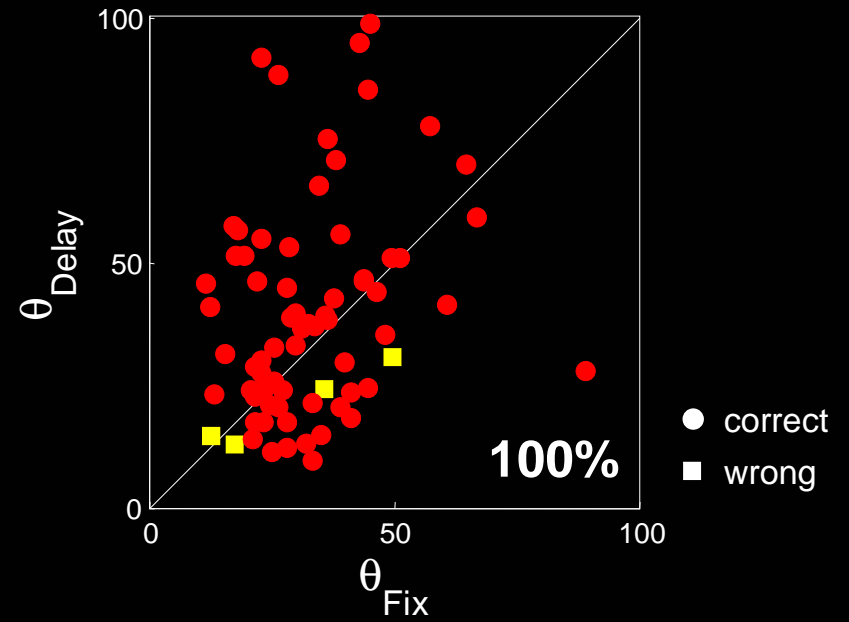
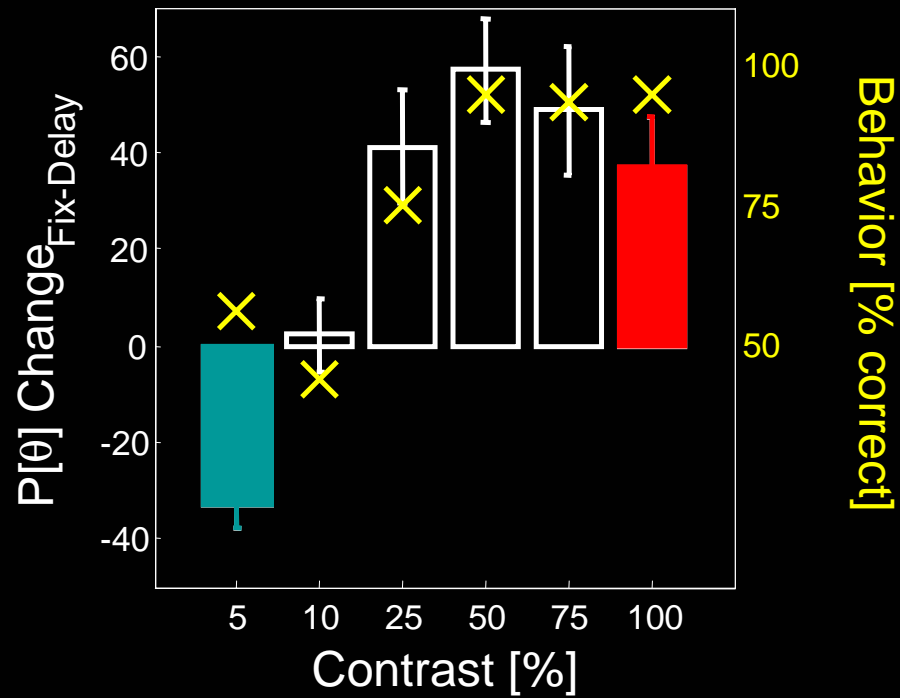


# $\theta$ -power timecourse at example V4 site

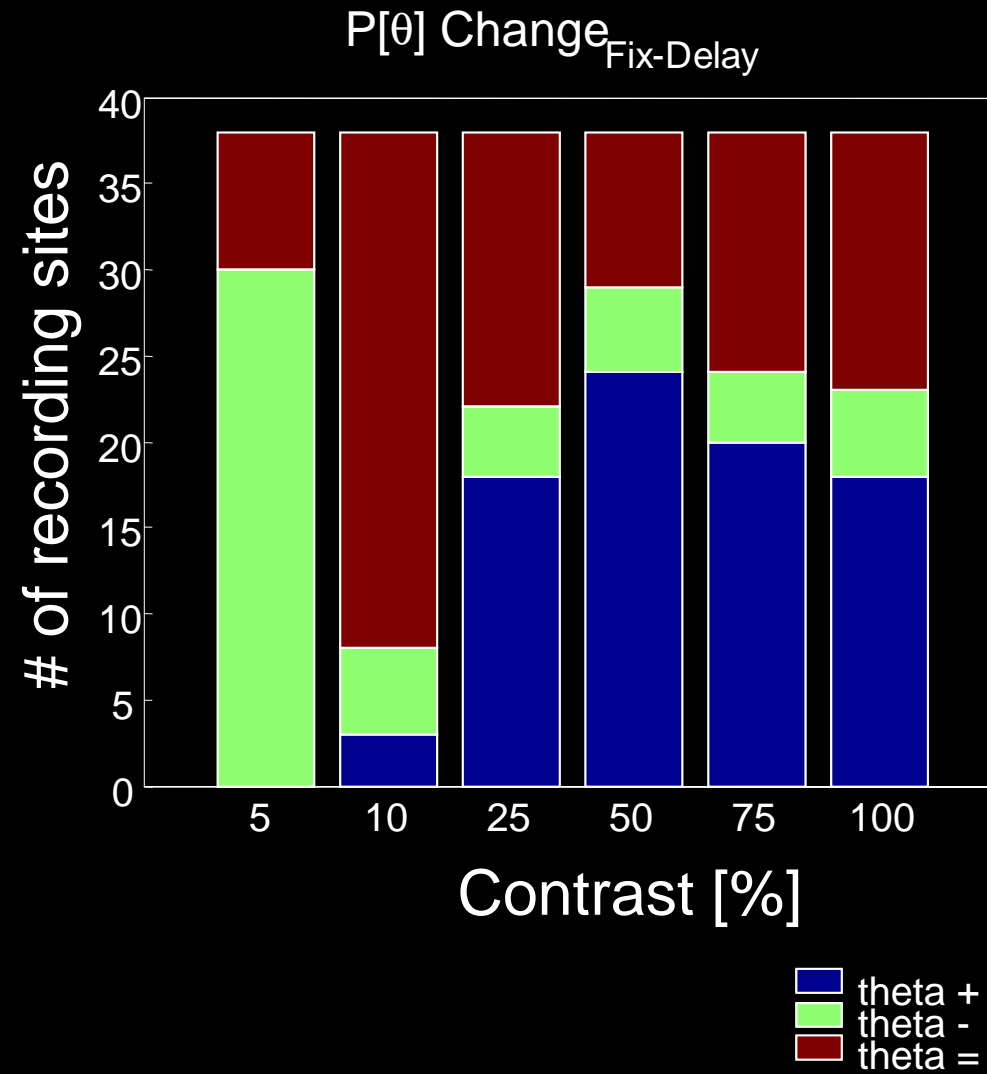




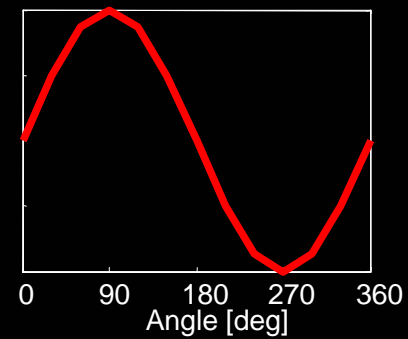
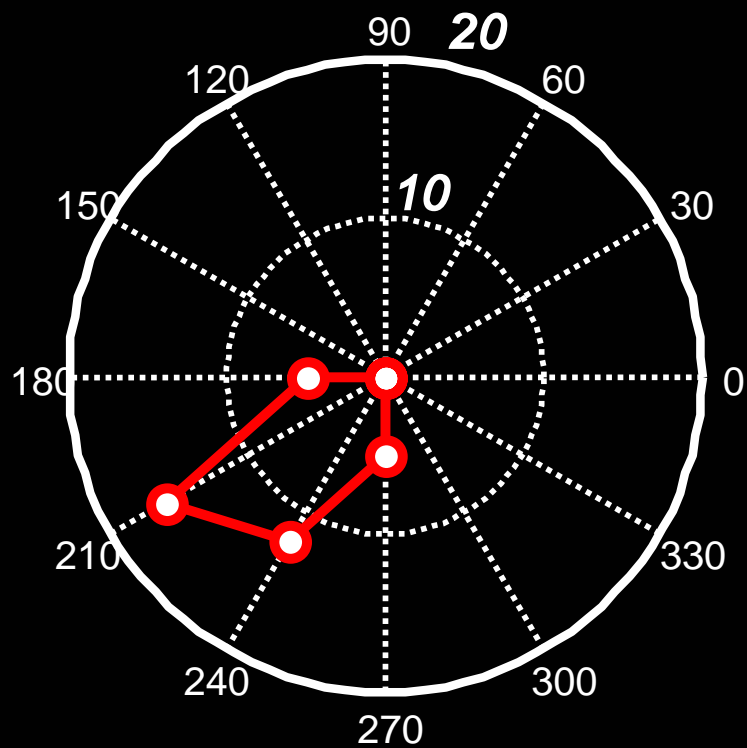
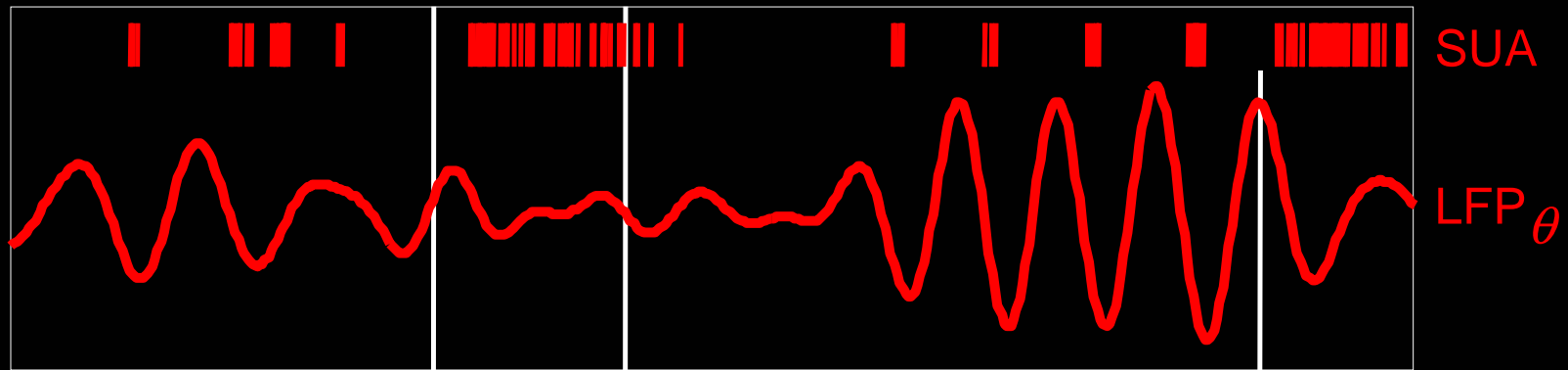
# Memory-specific elevation in $\theta$ -power at example site



# Summary for all recorded sites

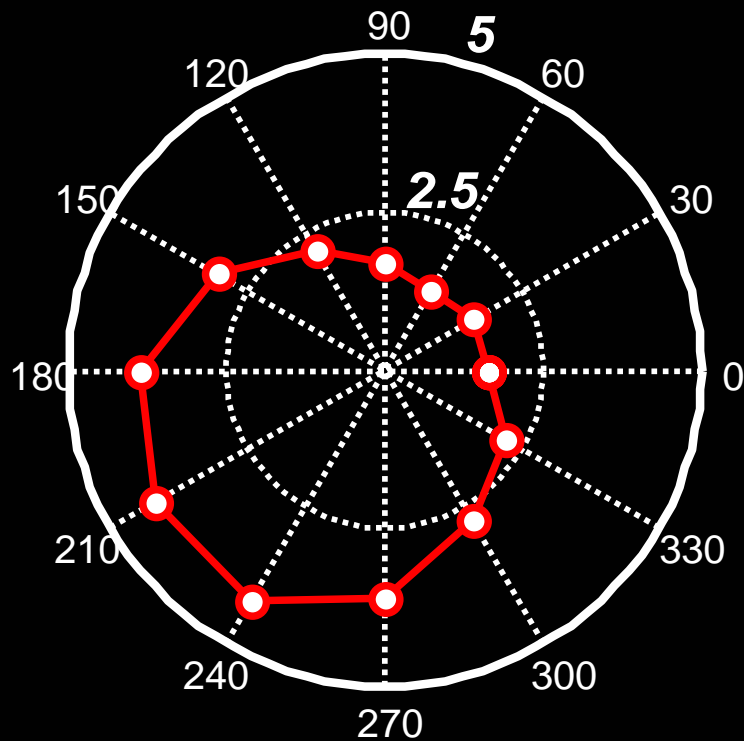


# Single trial $\theta$ phase locking of SUA

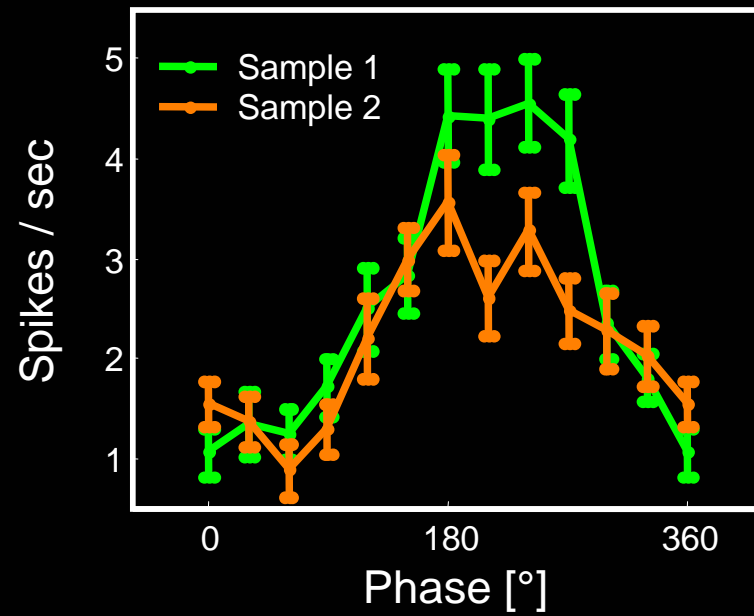


# $\theta$ oscillation structured SUA

*average of 300 repetitions at high contrast (>10%)*



*Sample object selectivity*



# Conclusions

- We observed working memory related  $\theta$  (4–8 Hz) oscillations of the local field potential in monkey extrastriate visual cortex.
- $\theta$  oscillations structured single unit activity, such that neurons tended to preferentially fire at particular phases of the oscillation.
- These findings suggest an involvement of extrastriate visual cortex in working memory.