

**Mapping the microcircuitry of attention:  
attentional modulation varies across cell classes in visual area V4.**

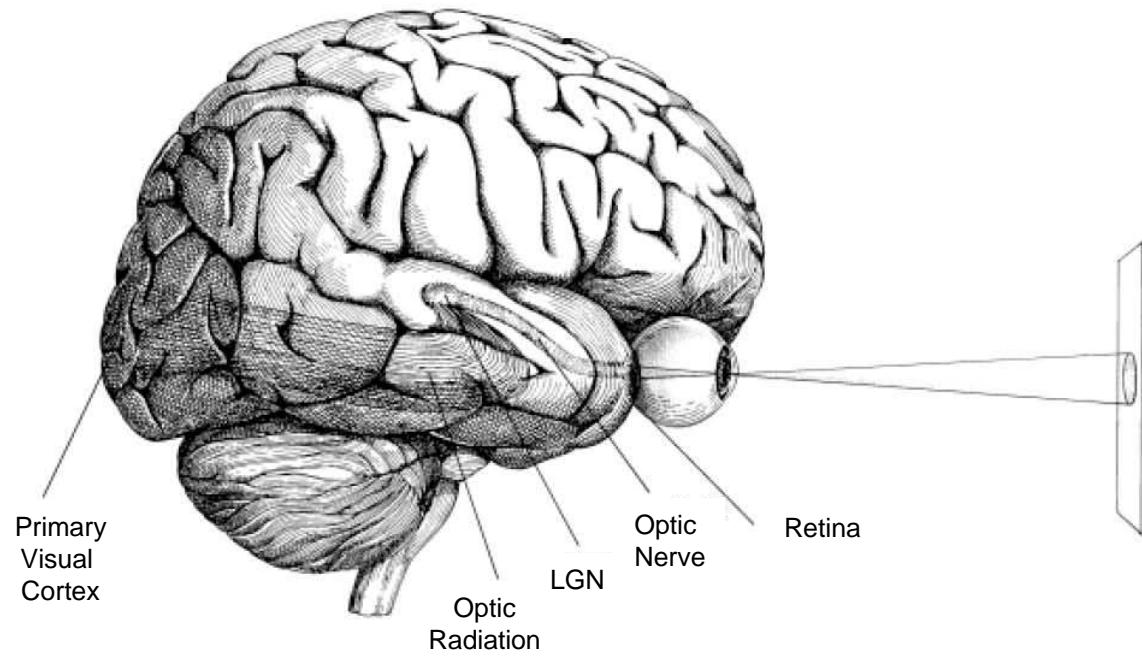
**Jude F. Mitchell  
Kristy A. Sundberg  
John H. Reynolds**

**Sloan-Swartz  
Centers for Theoretical Neurobiology  
Annual Summer Meeting 2007**



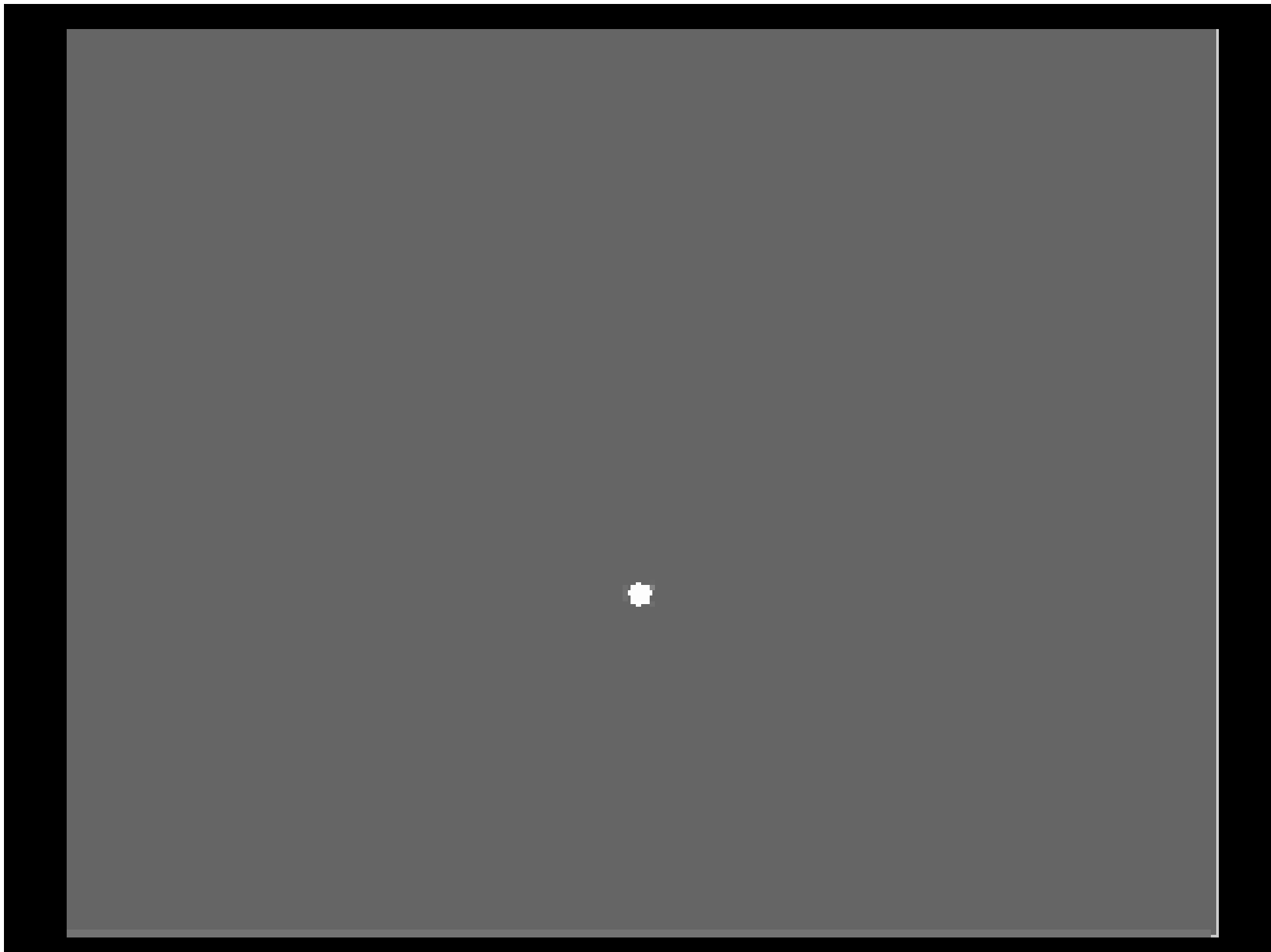
**SALK INSTITUTE**  
**FOR BIOLOGICAL STUDIES**

**Visual system as a limited capacity  
information processing system**

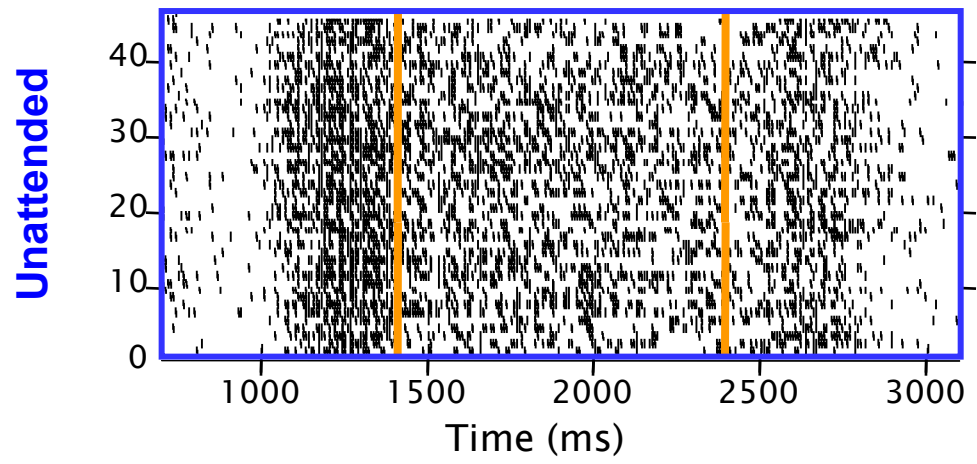


**Task**

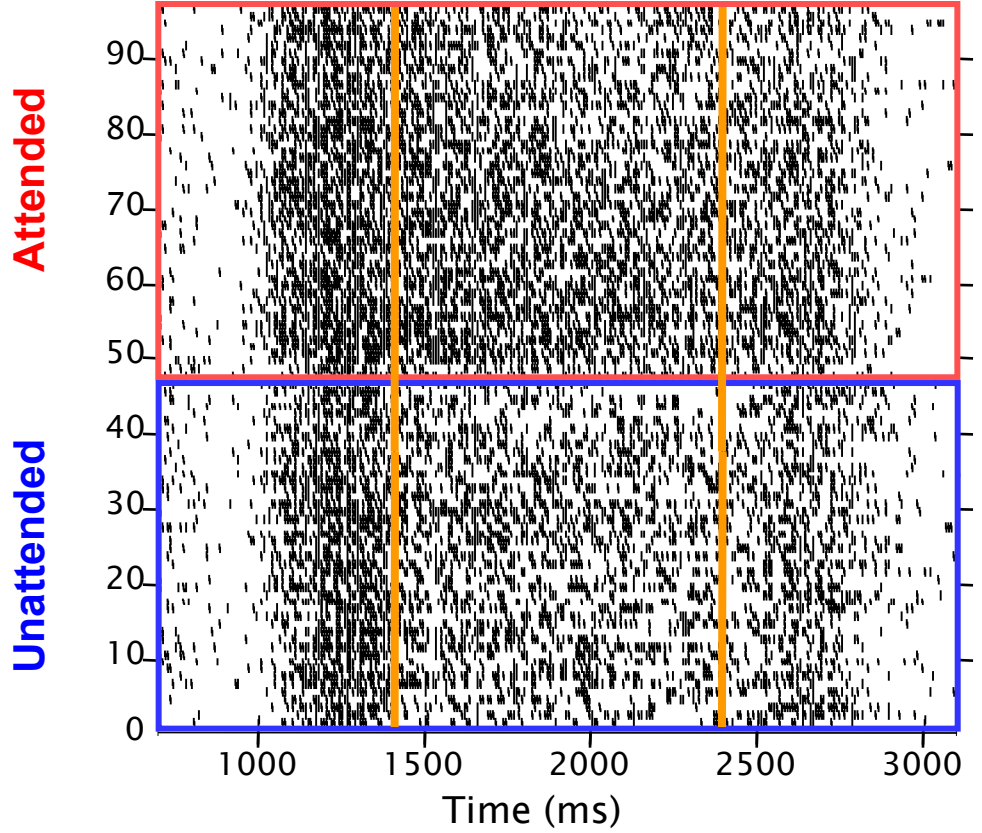




Stimulus in RF

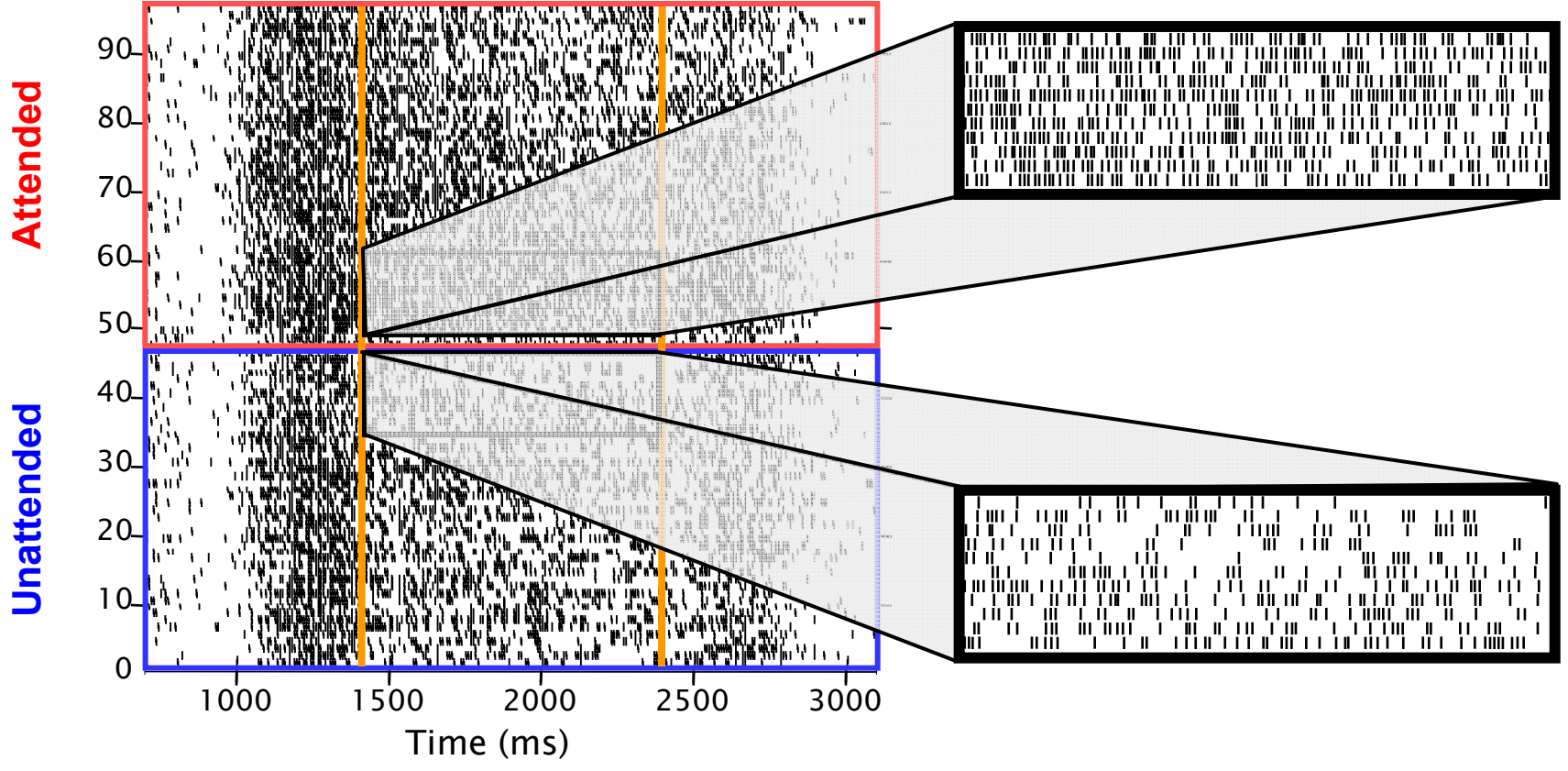


Stimulus in RF

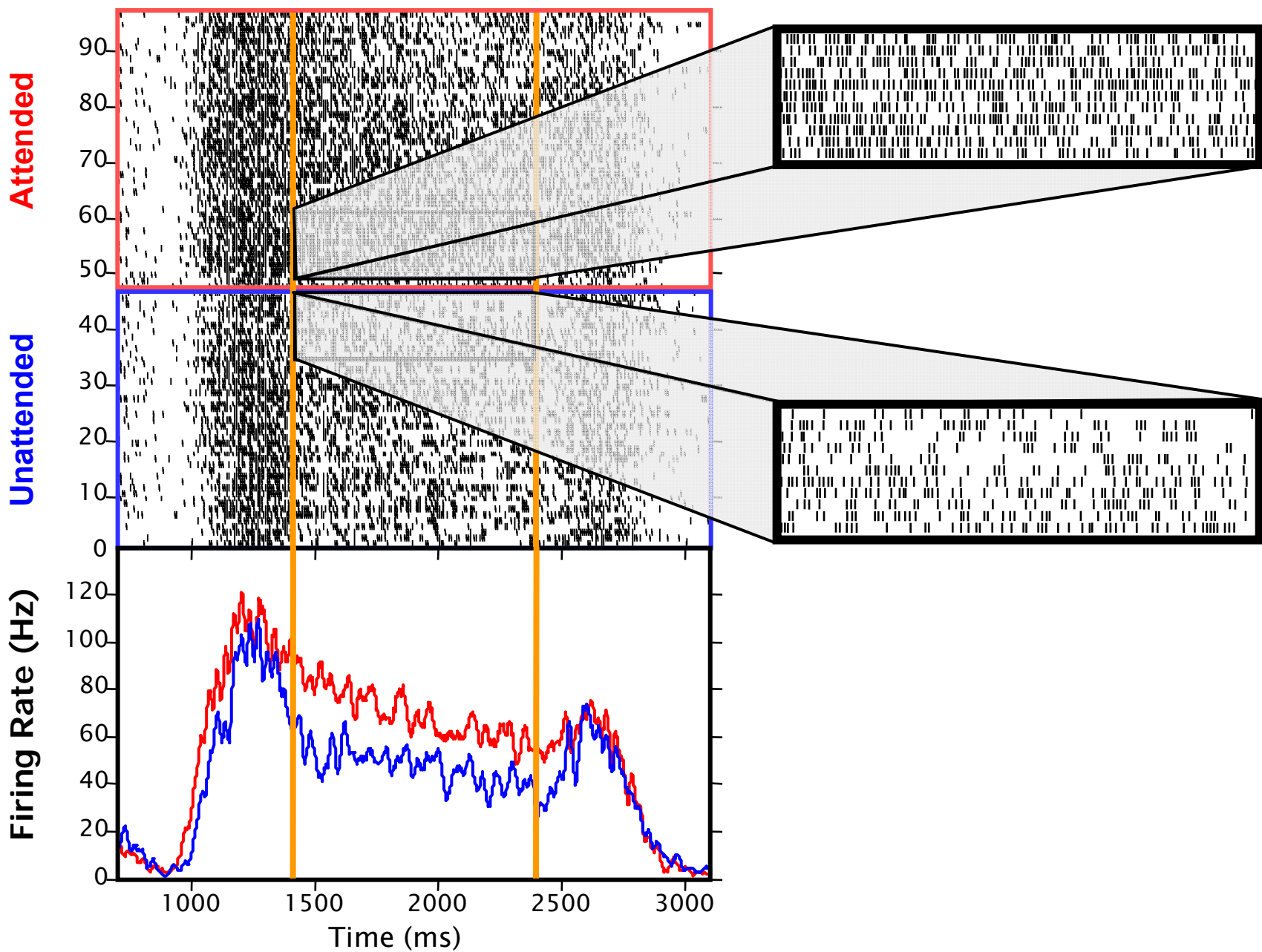




Stimulus in RF

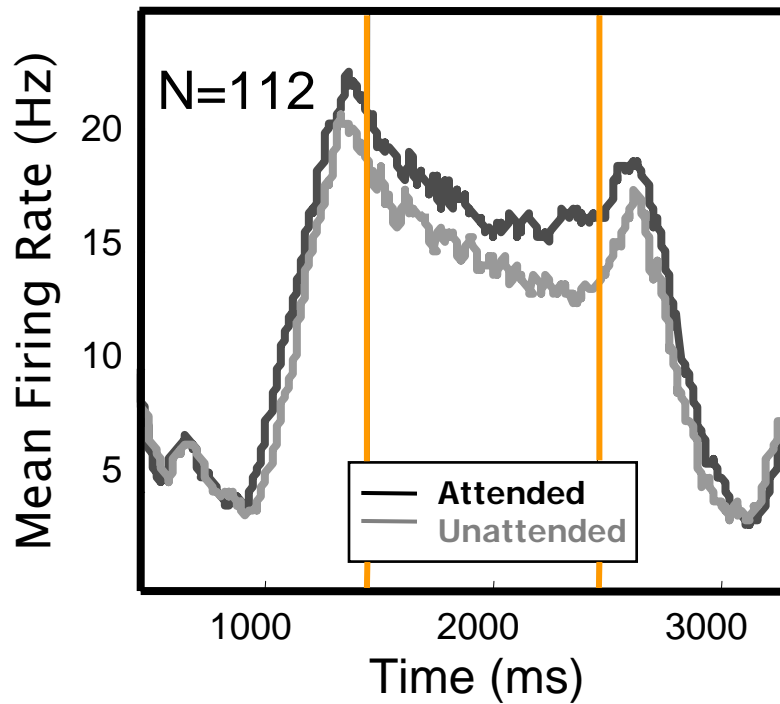


Stimulus in RF



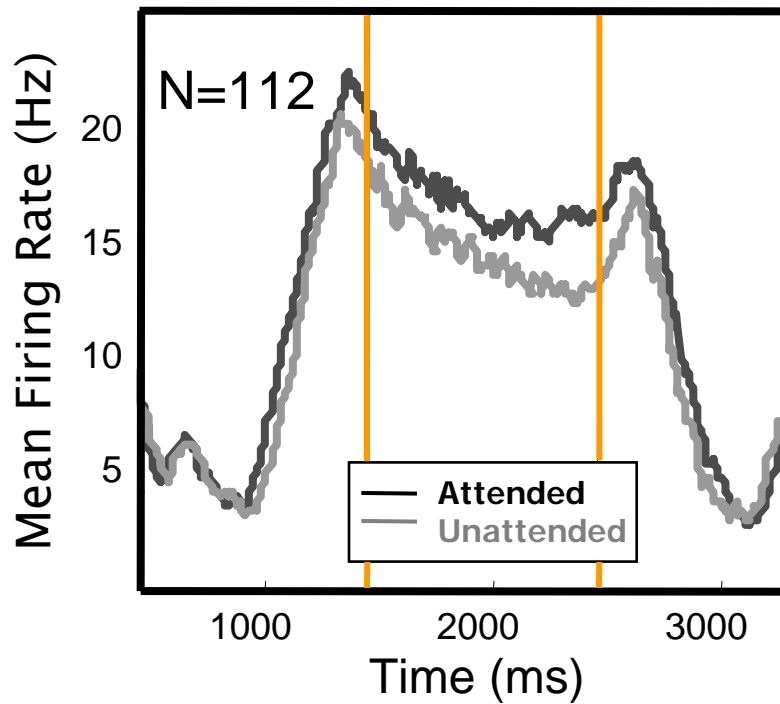
# Attention-dependent modulation of firing rate

## Population Average Responses

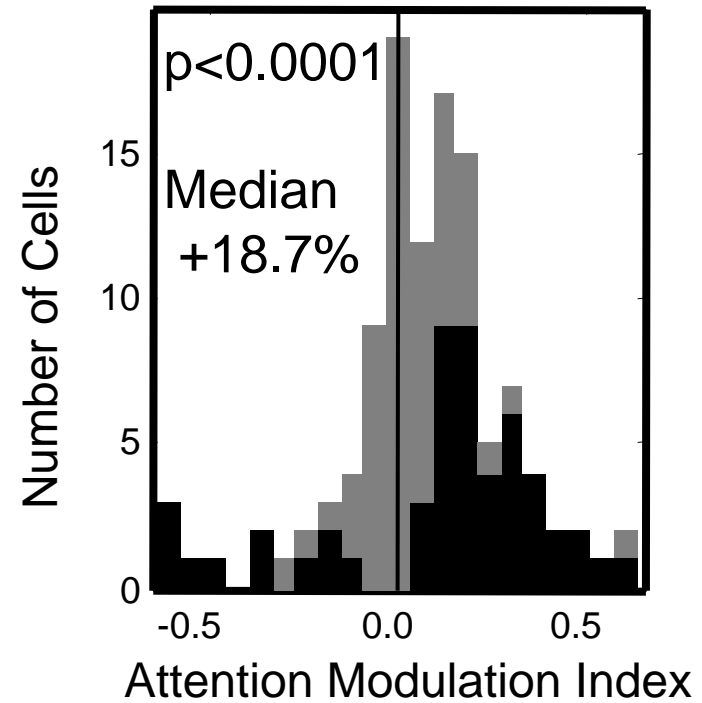


# Attention-dependent modulation of firing rate

## Population Average Responses



## Across Neurons



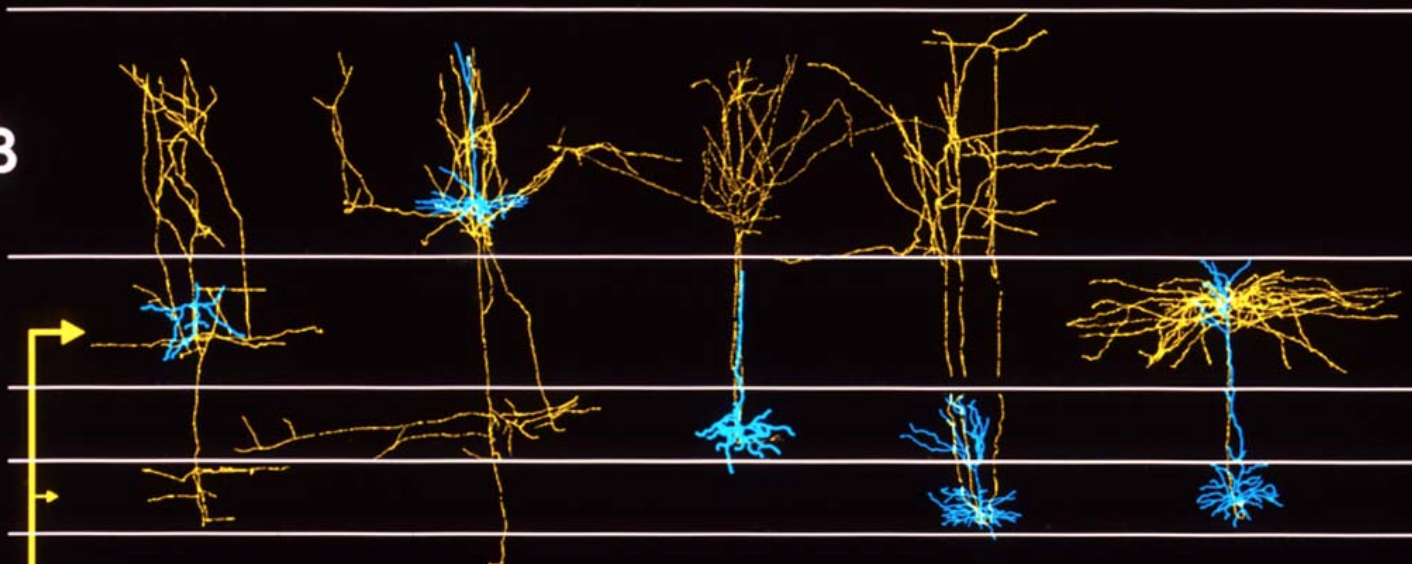
2-4B

4C

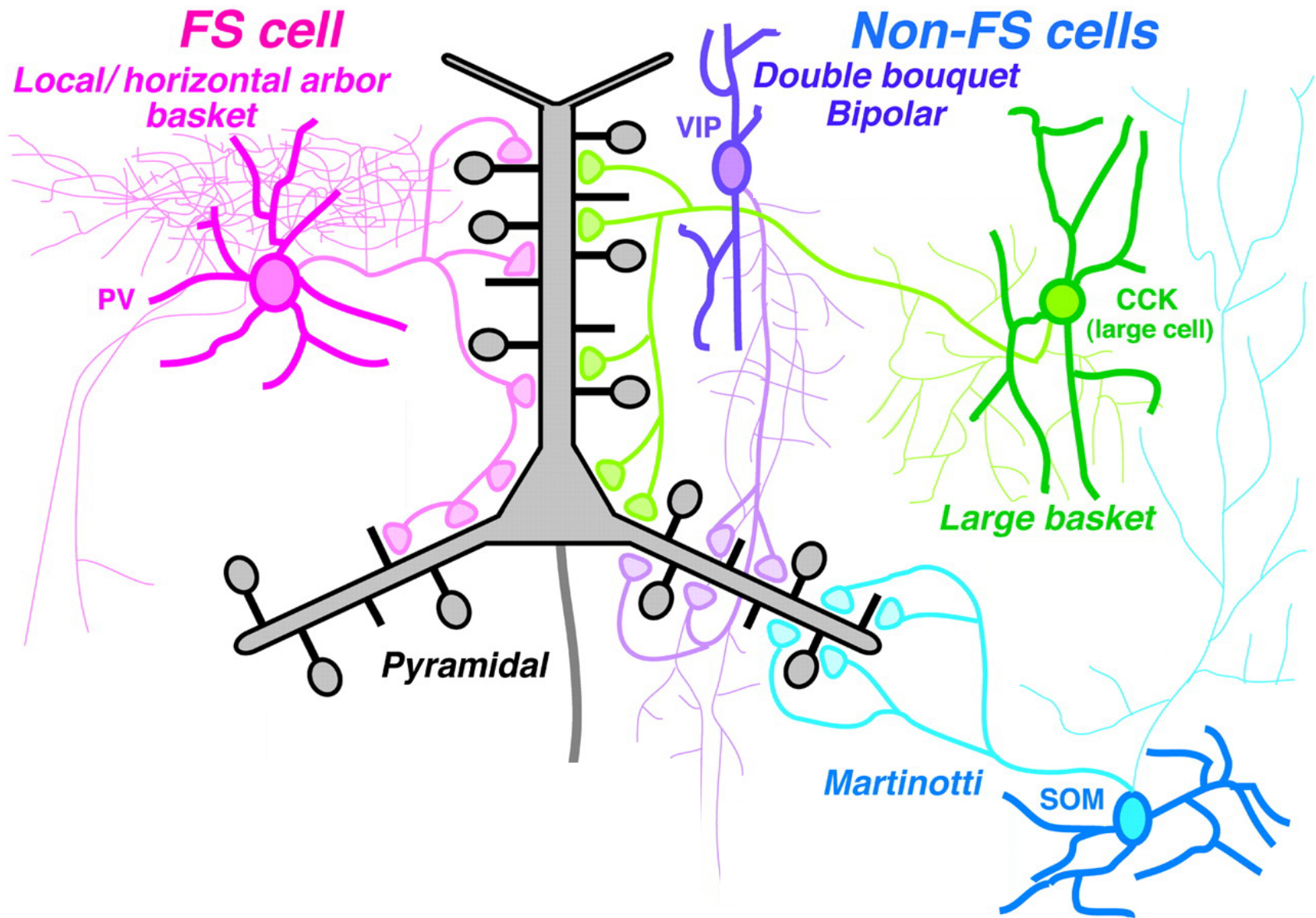
5

6

LGN



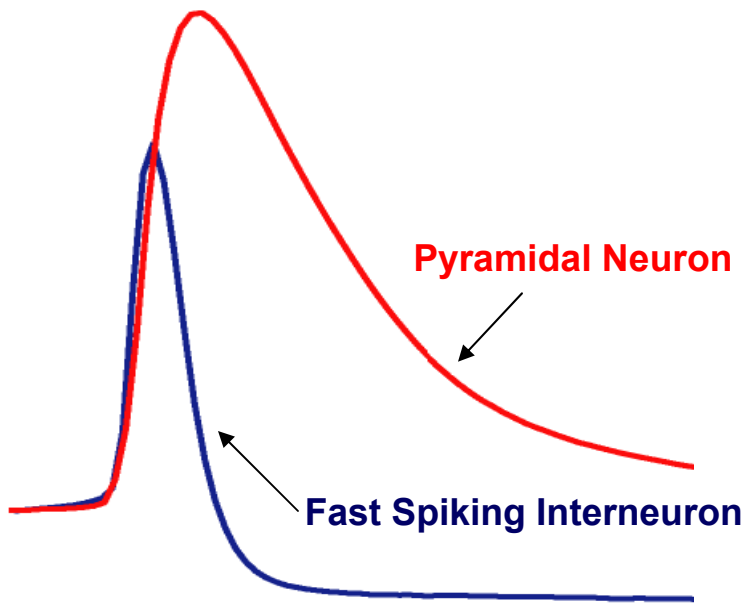
Callaway, 1998





From Kawaguchi

# Pyramidal and Fast Spiking Inhibitory Interneuron Action Potentials

Intracellular action potential

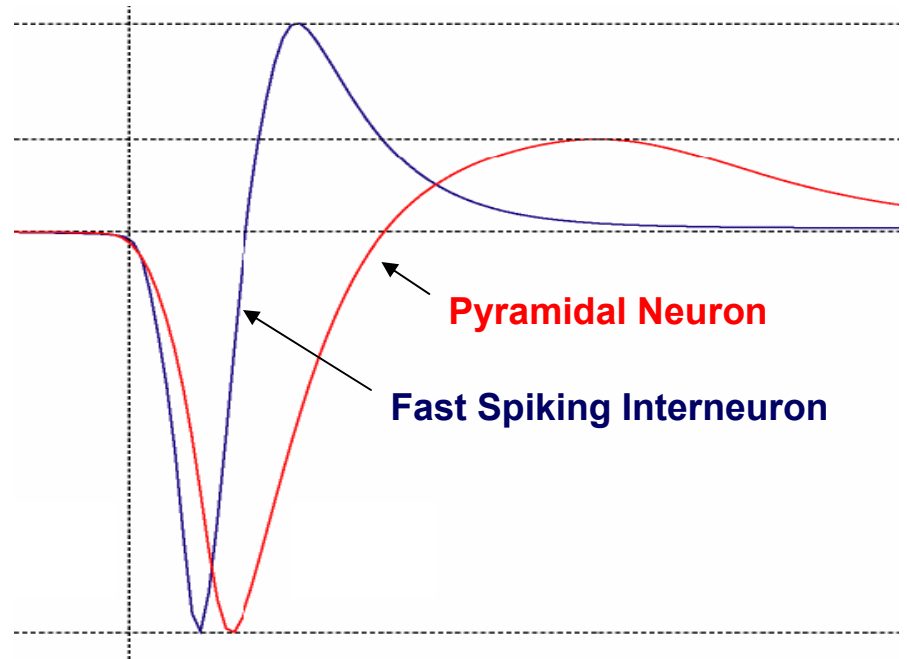




A   
B 



2 ms

Extracellular action potential



A   
B 

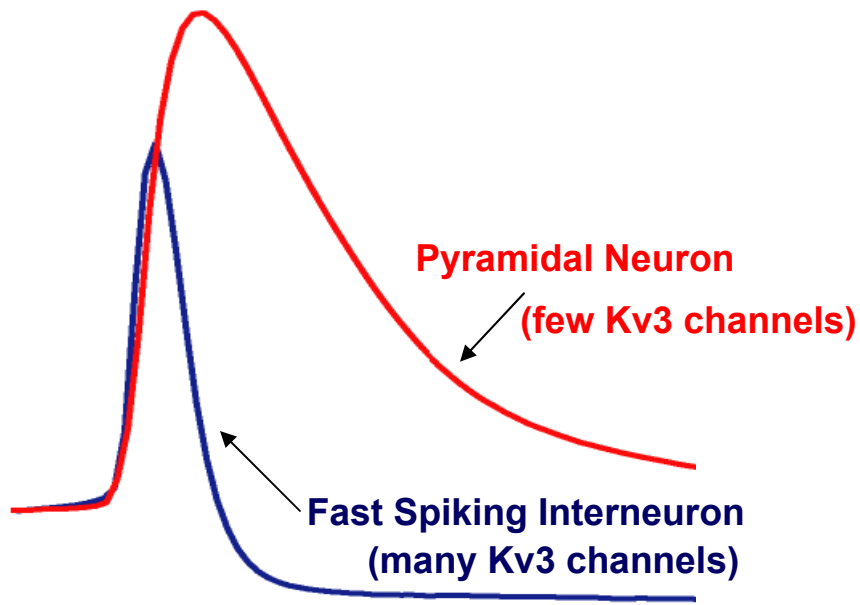
Hasenstaub et al., 2005

c.f. Henze et al., 1999

Goldman-Rakic et al.

# Pyramidal and Fast Spiking Inhibitory Interneuron Action Potentials

Intracellular action potential

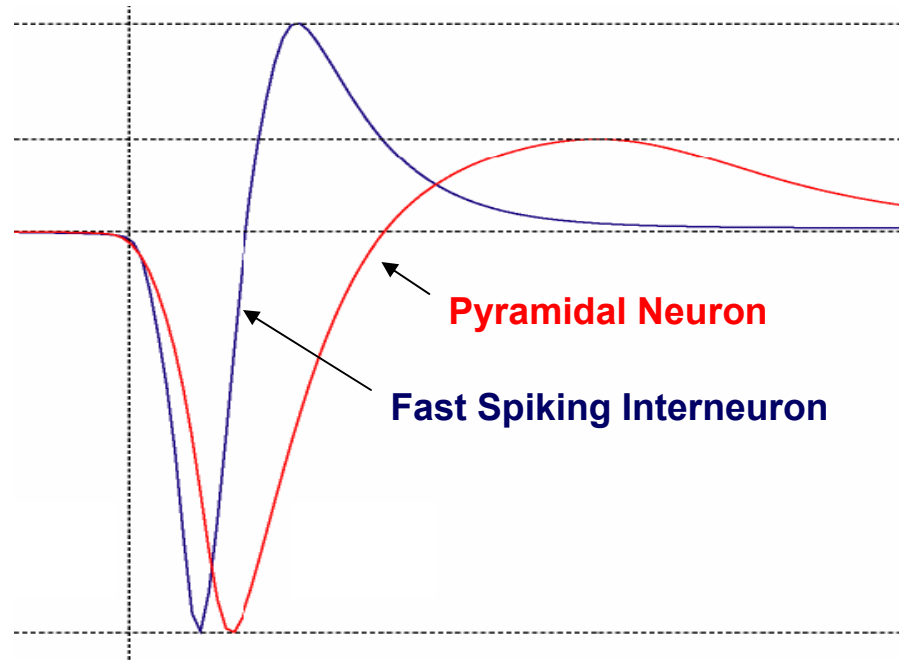


A   
B 



2 ms

Extracellular action potential

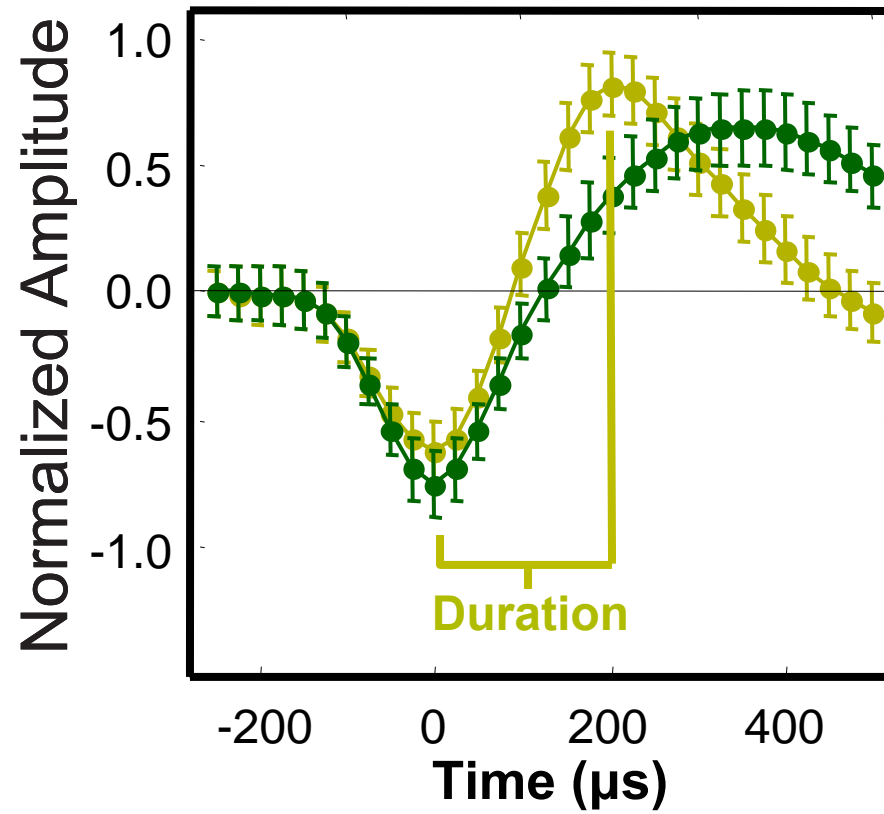


A   
B 

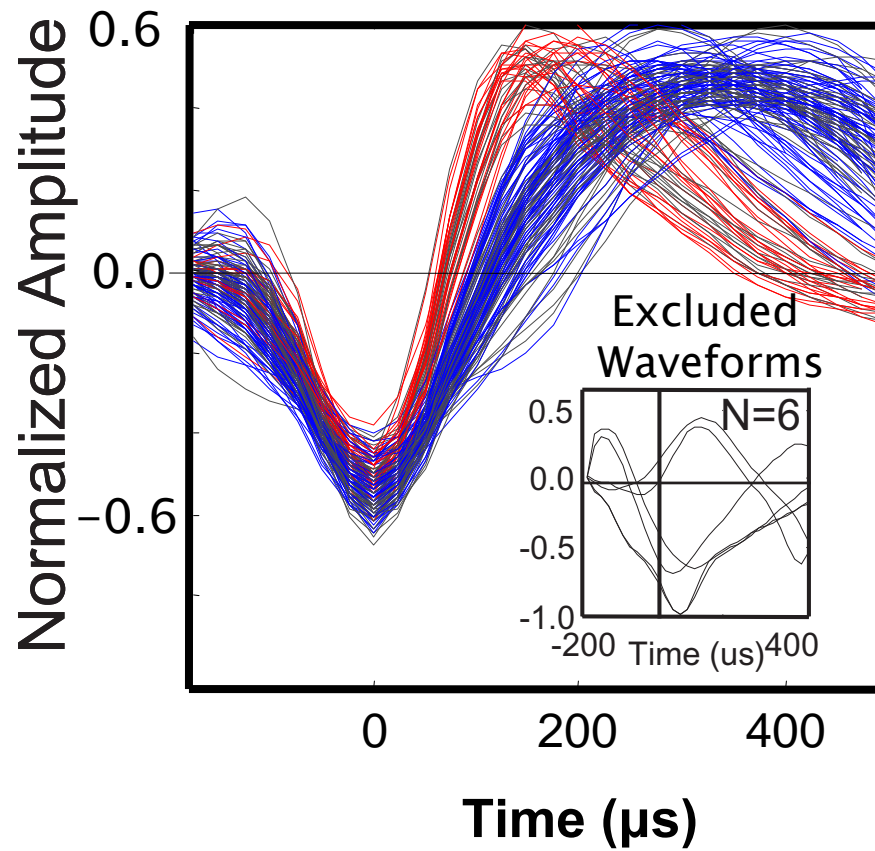
Hasenstaub et al., 2005  
c.f. Henze et al., 1999  
Goldman-Rakic et al.



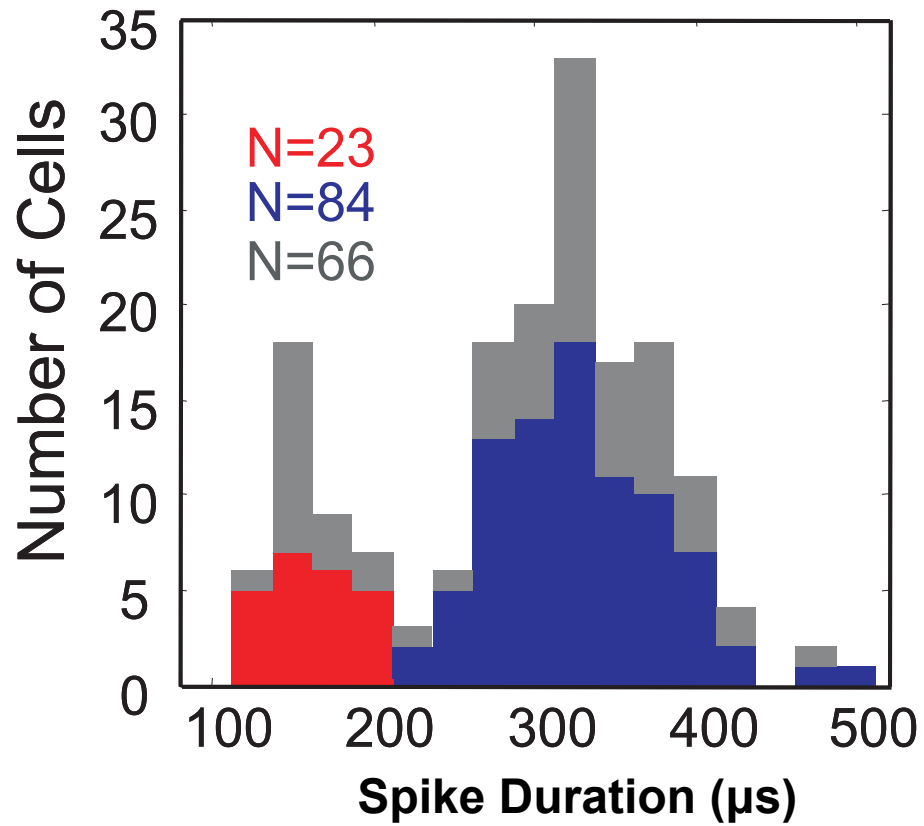
## Two Mean Neuronal Waveforms (+/- one standard deviation)



# All Mean Waveforms (N=179)

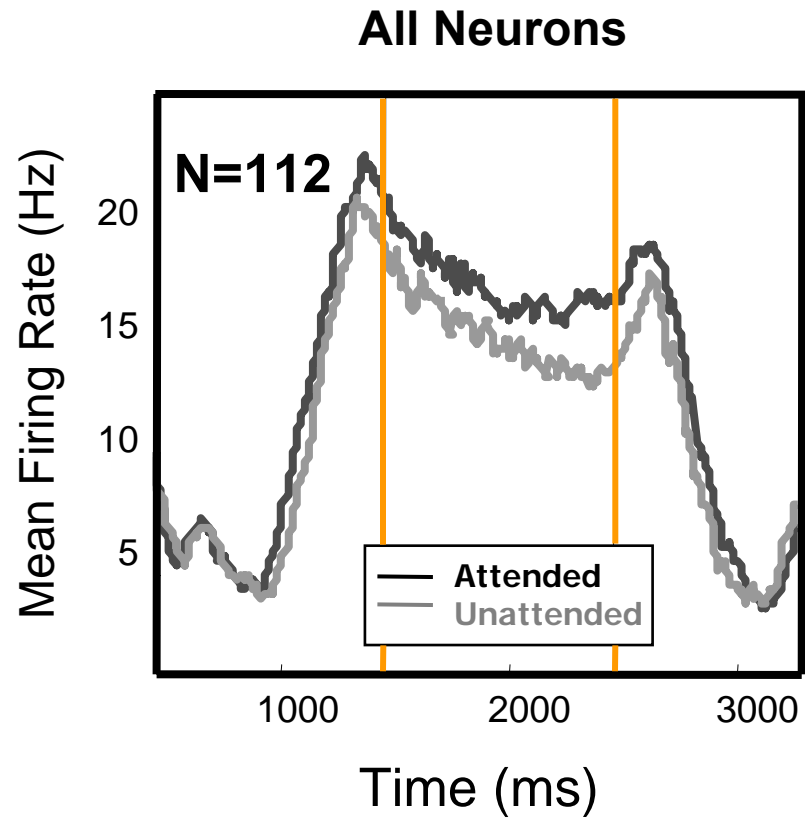


## Distribution of Waveform Durations



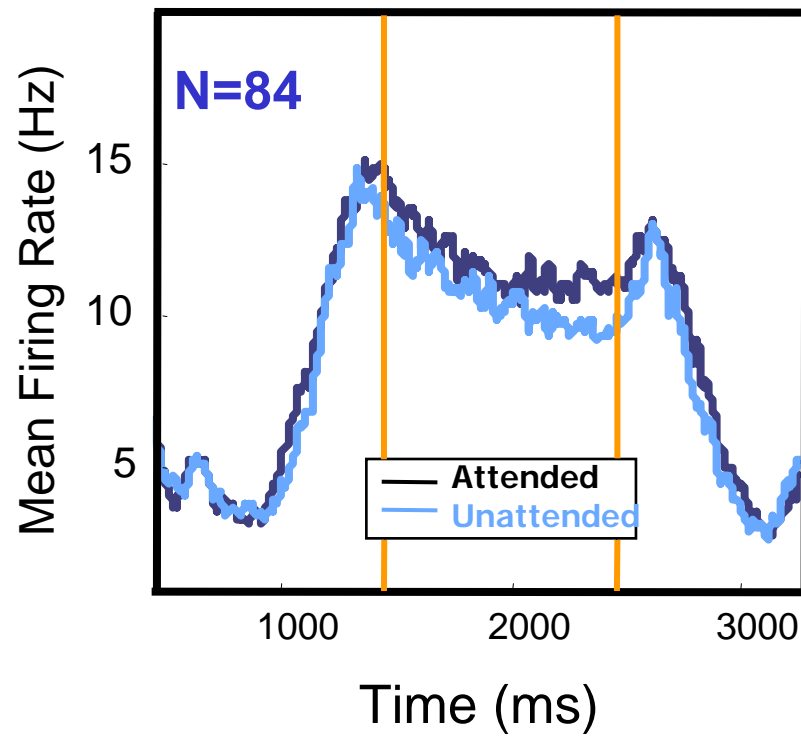
Hartigan's Dip test  $p=0.015$

# Attention-dependent modulation of firing rate



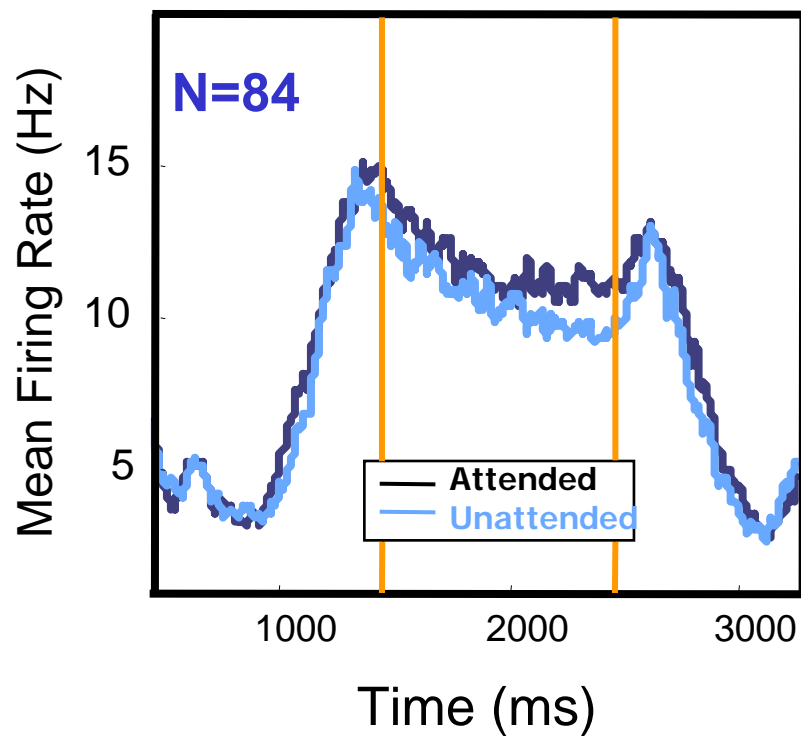
# Attention-dependent modulation of firing rate

## Broad Spiking Neurons

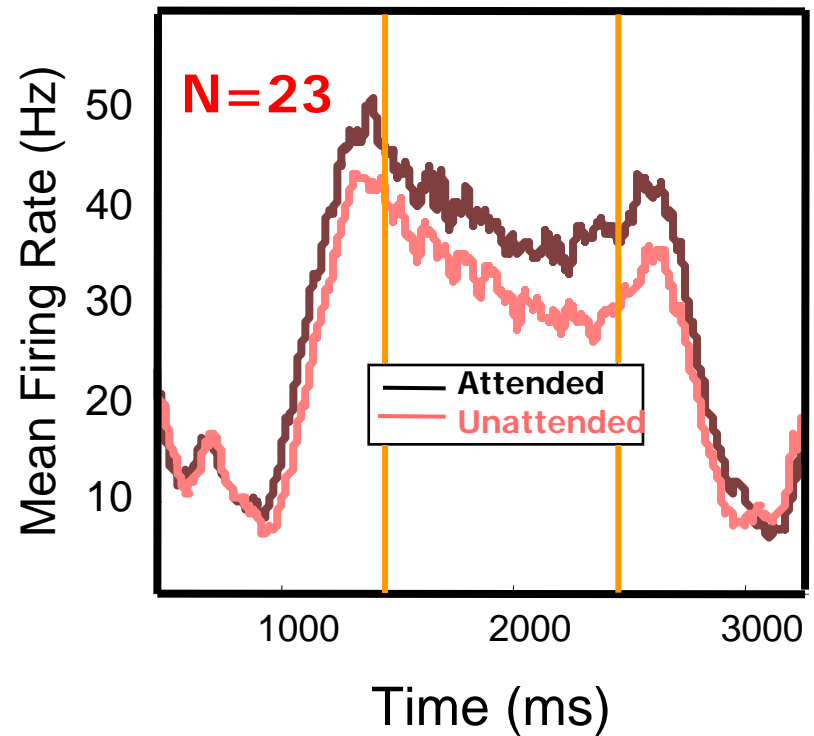


# Attention-dependent modulation of firing rate

## Broad Spiking Neurons

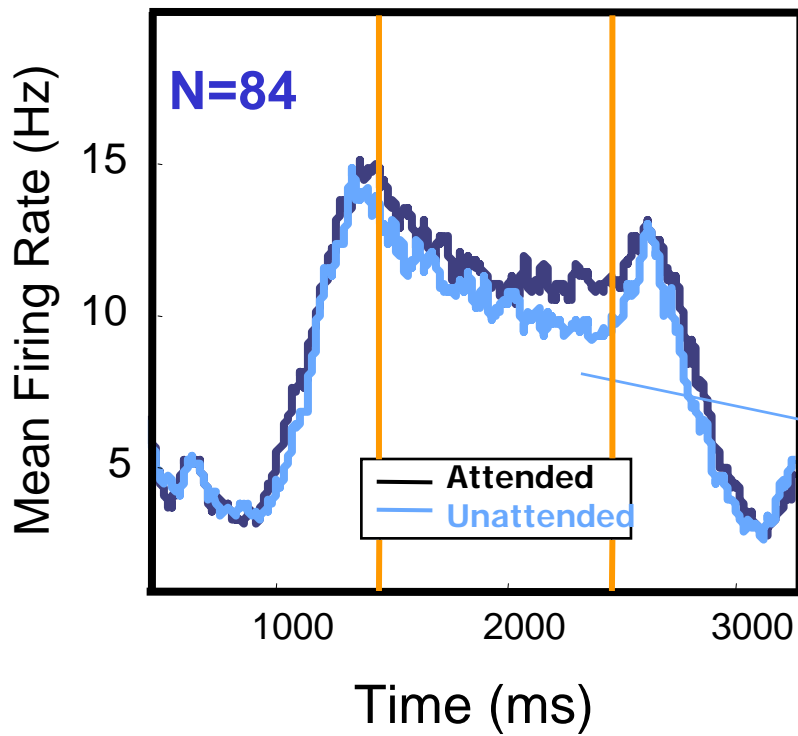


## Narrow Spiking Neurons

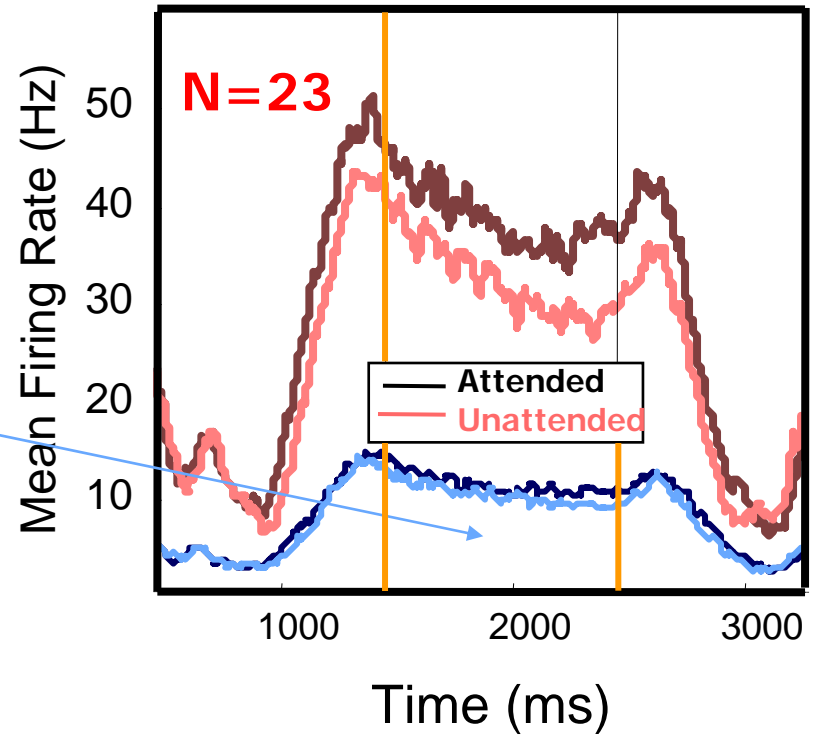


# Attention-dependent modulation of firing rate

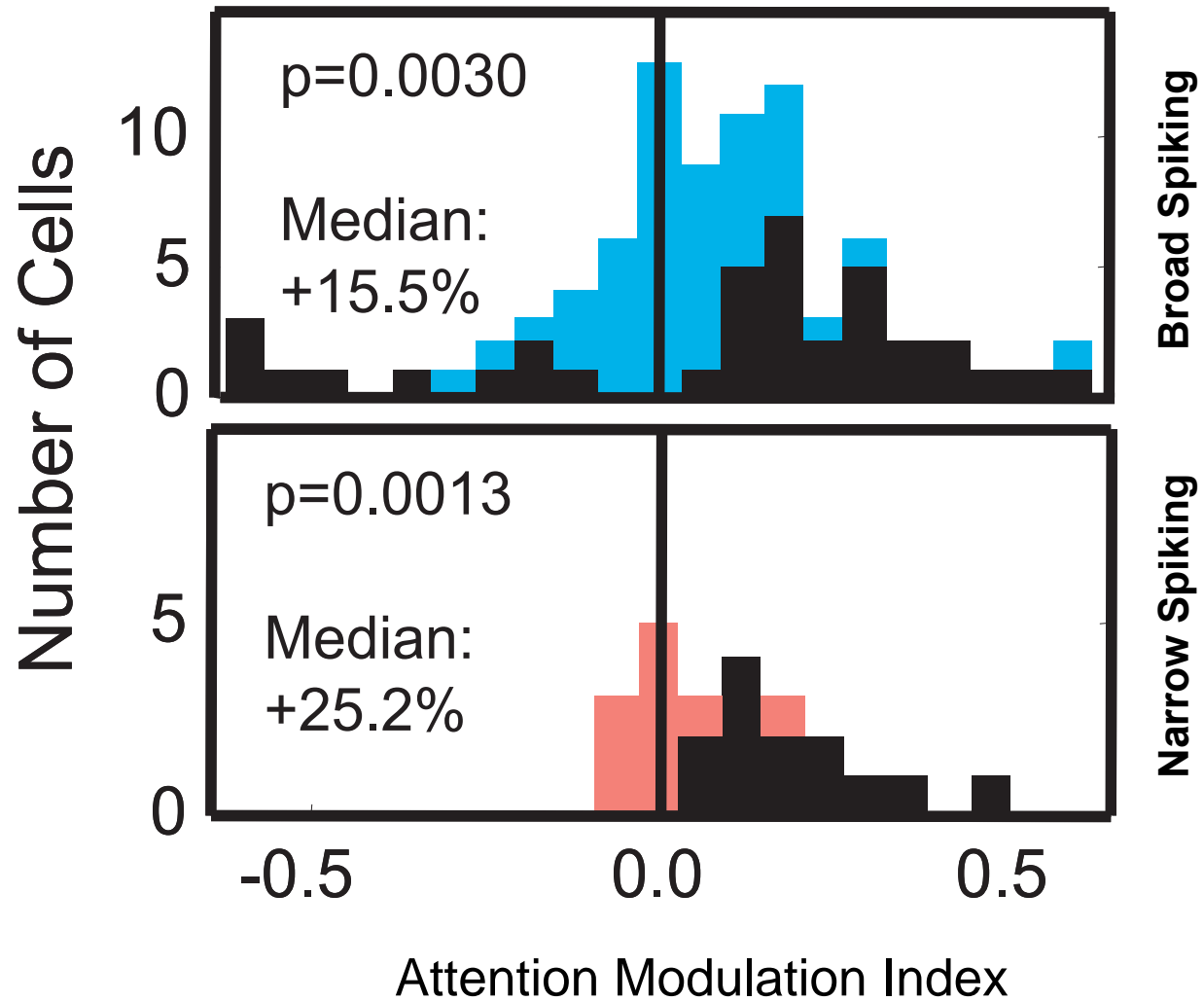
## Broad Spiking Neurons



## Narrow Spiking Neurons

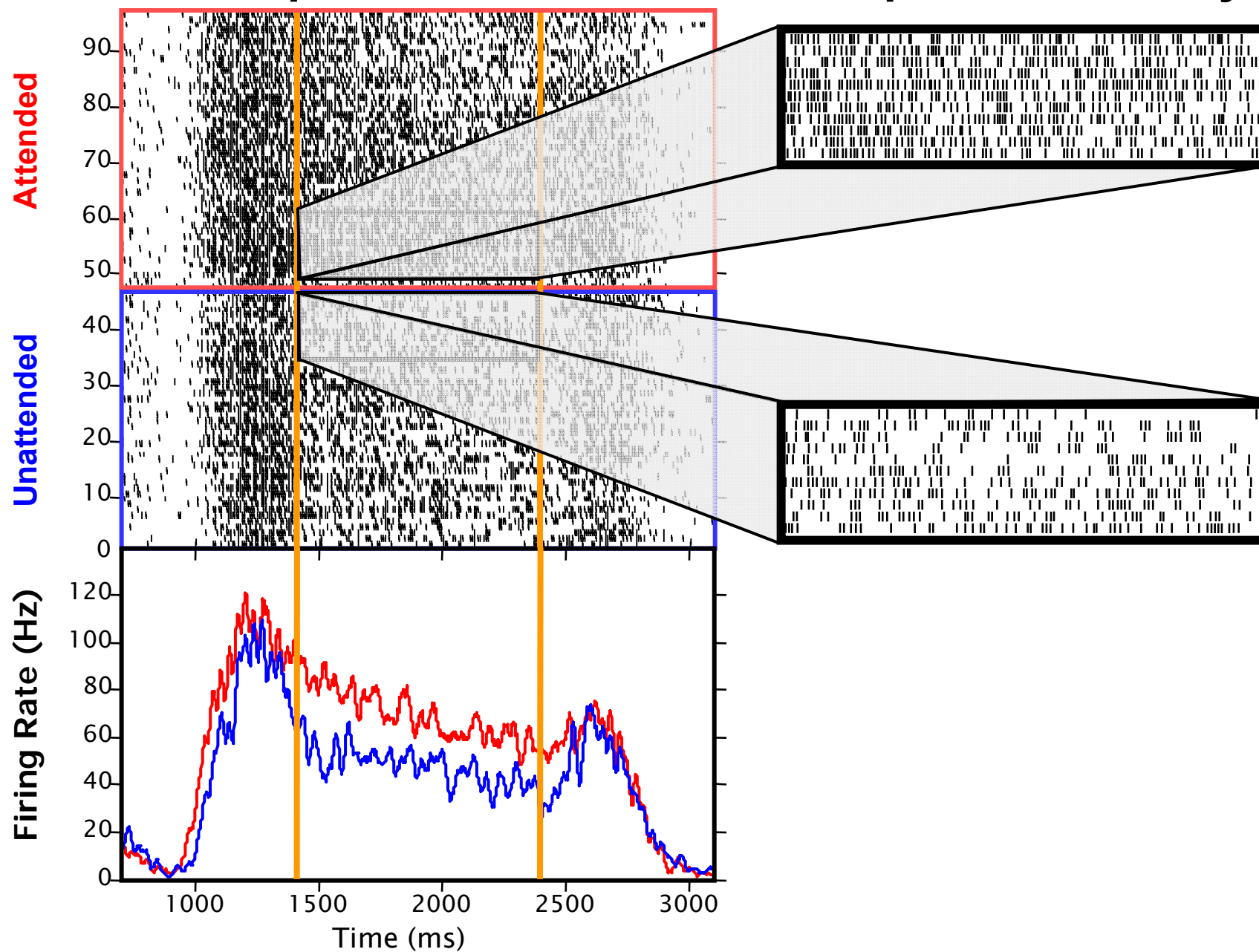


# Attentional Modulation of Firing Rate

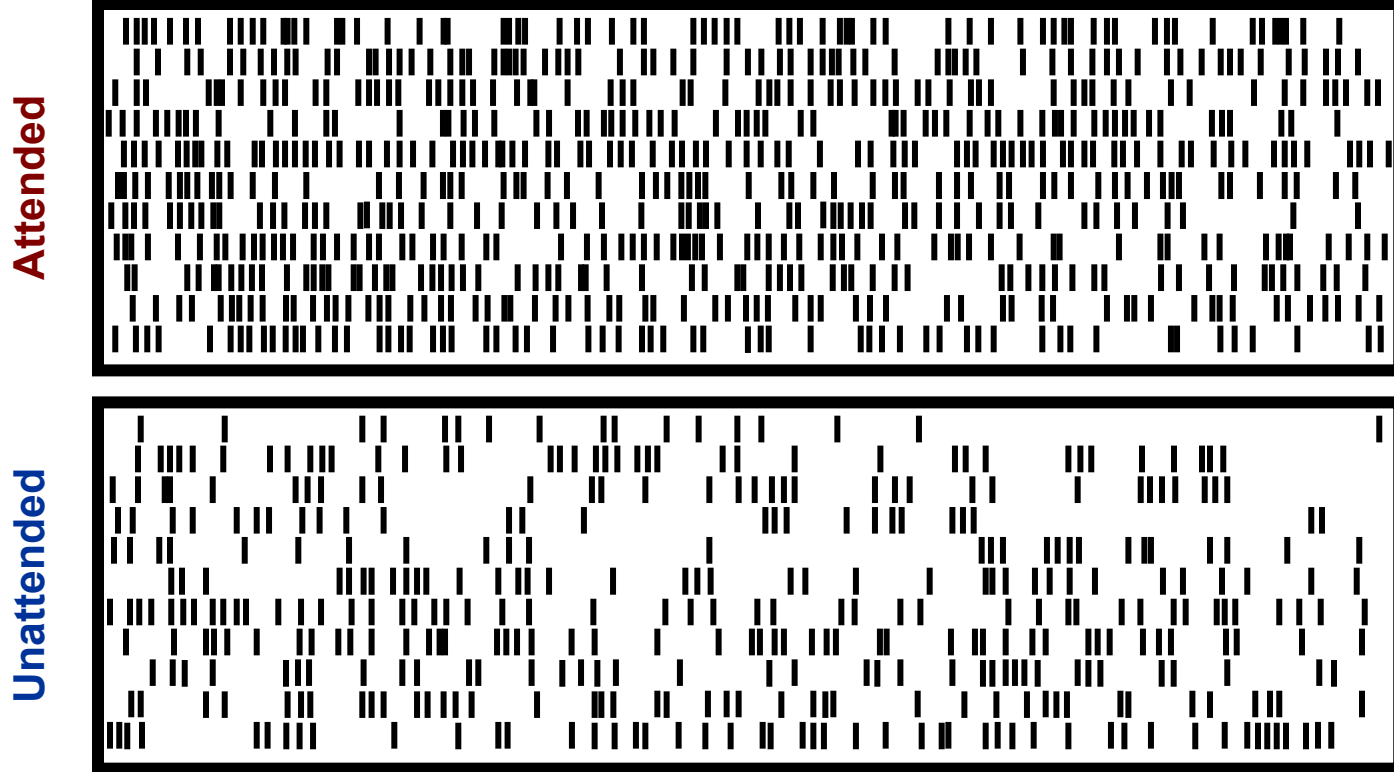




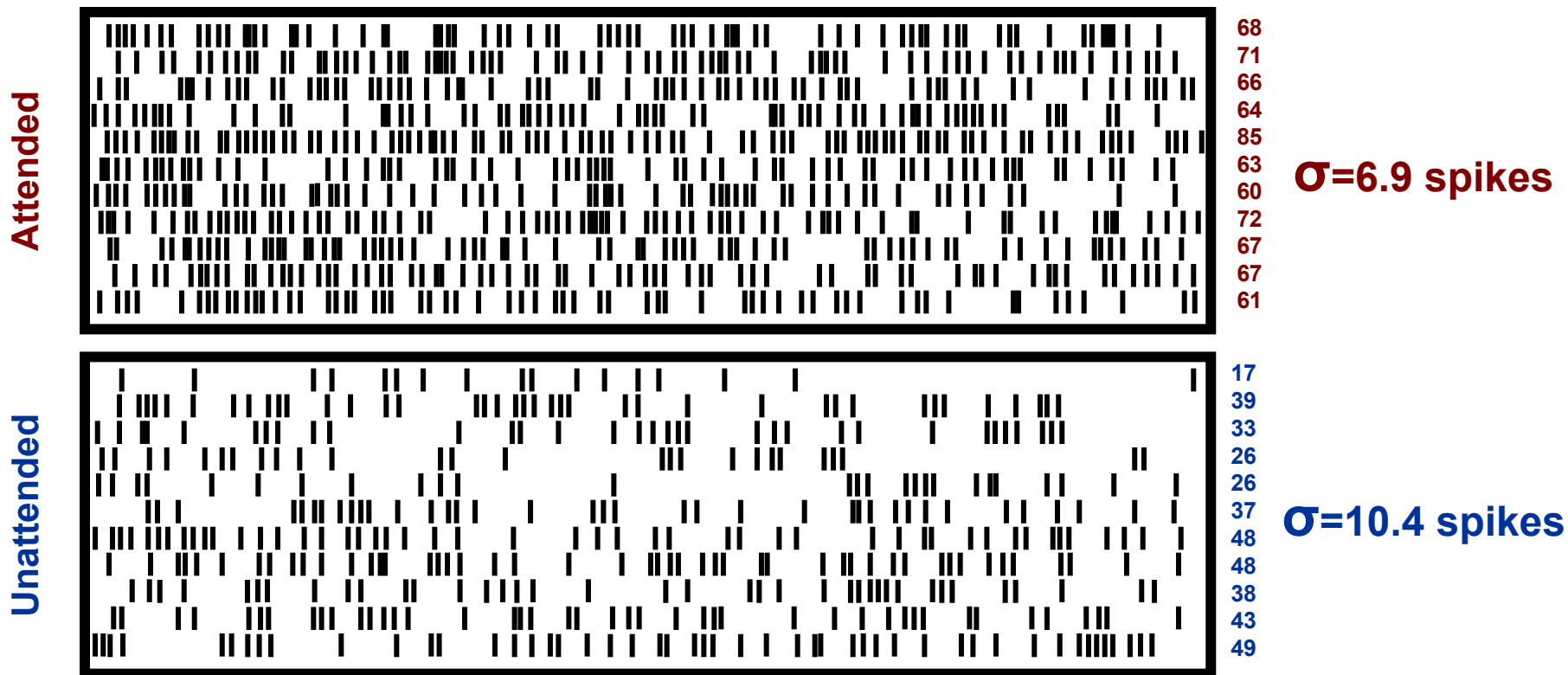
# Attention-dependent modulation of response reliability



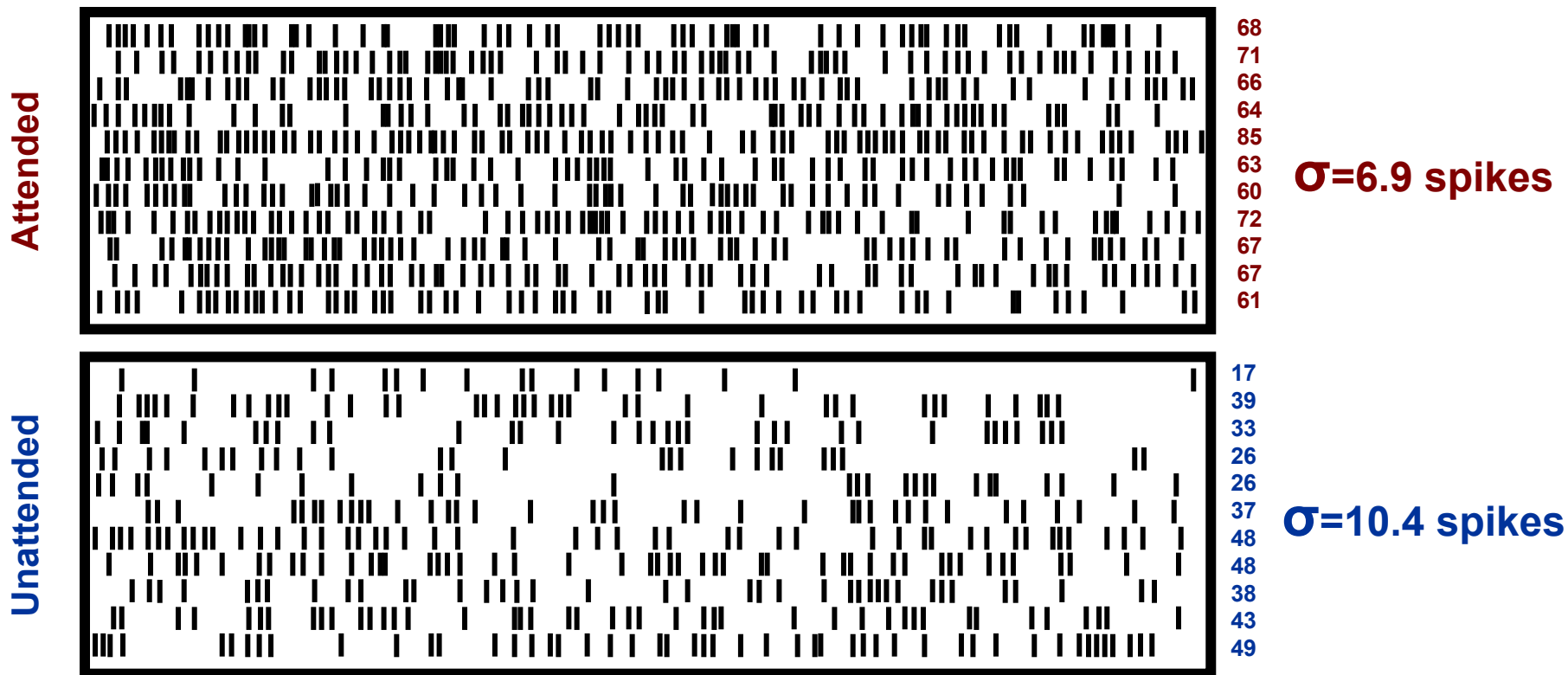
# Attention-dependent modulation of response reliability



# Attention-dependent modulation of response reliability



# Attention-dependent modulation of response reliability

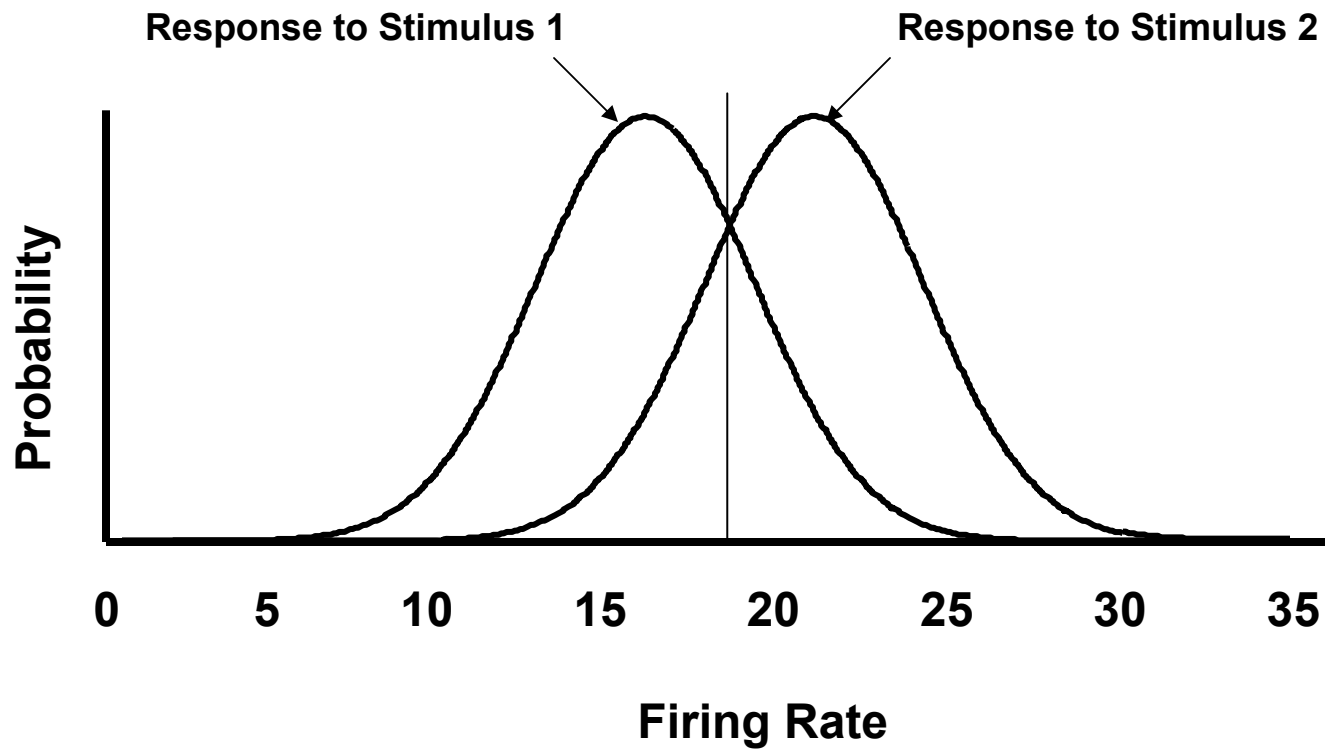


$$\text{Fano Factor} = \frac{\sigma^2}{\mu}$$

Note: Model of Tiesinga et al (2004) J. Physiol (Paris) 98: 296-314 predicted attention-dependent reduction in Fano Factor.

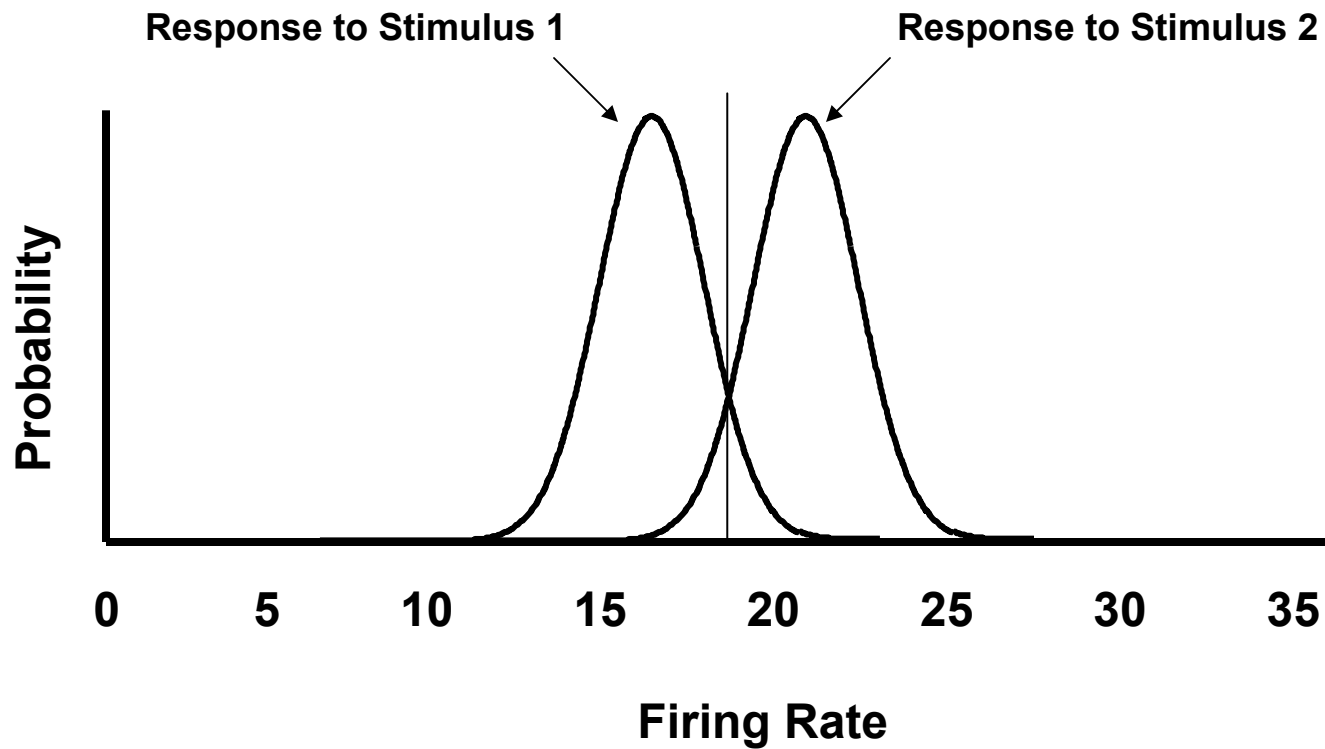
# Fano factor

$d'=1$  (lots of overlap)



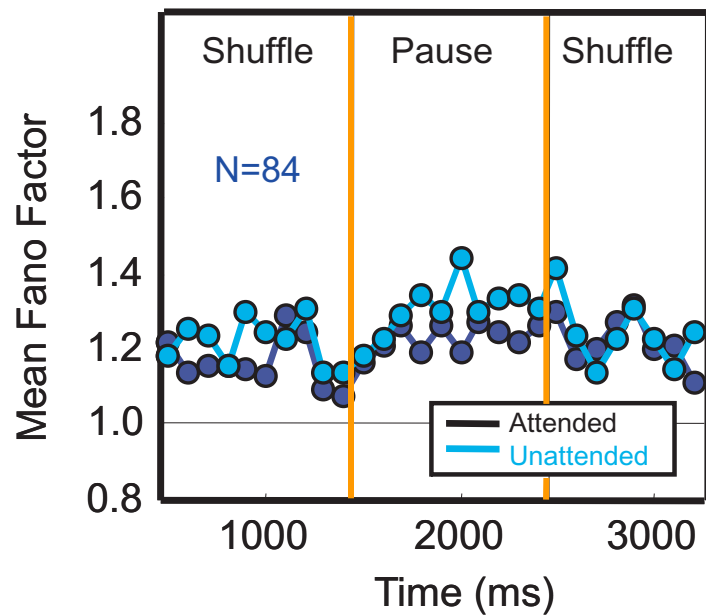
# Fano factor

$d'=3$  (not much overlap)



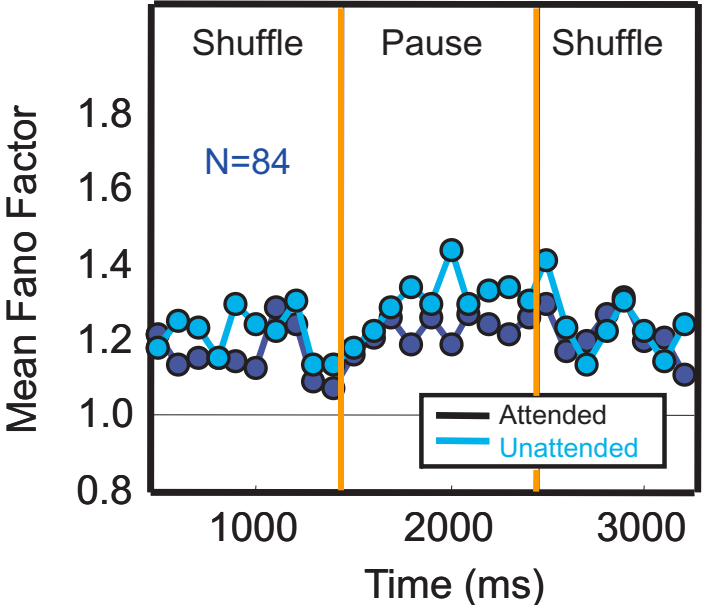
# Attention-dependent modulation of response variability

## Broad Spiking Neurons

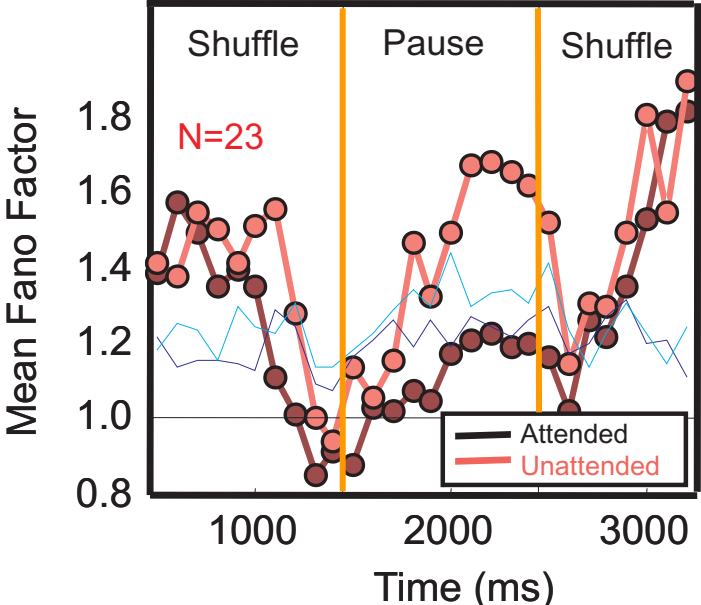


# Attention-dependent modulation of response variability

## Broad Spiking Neurons

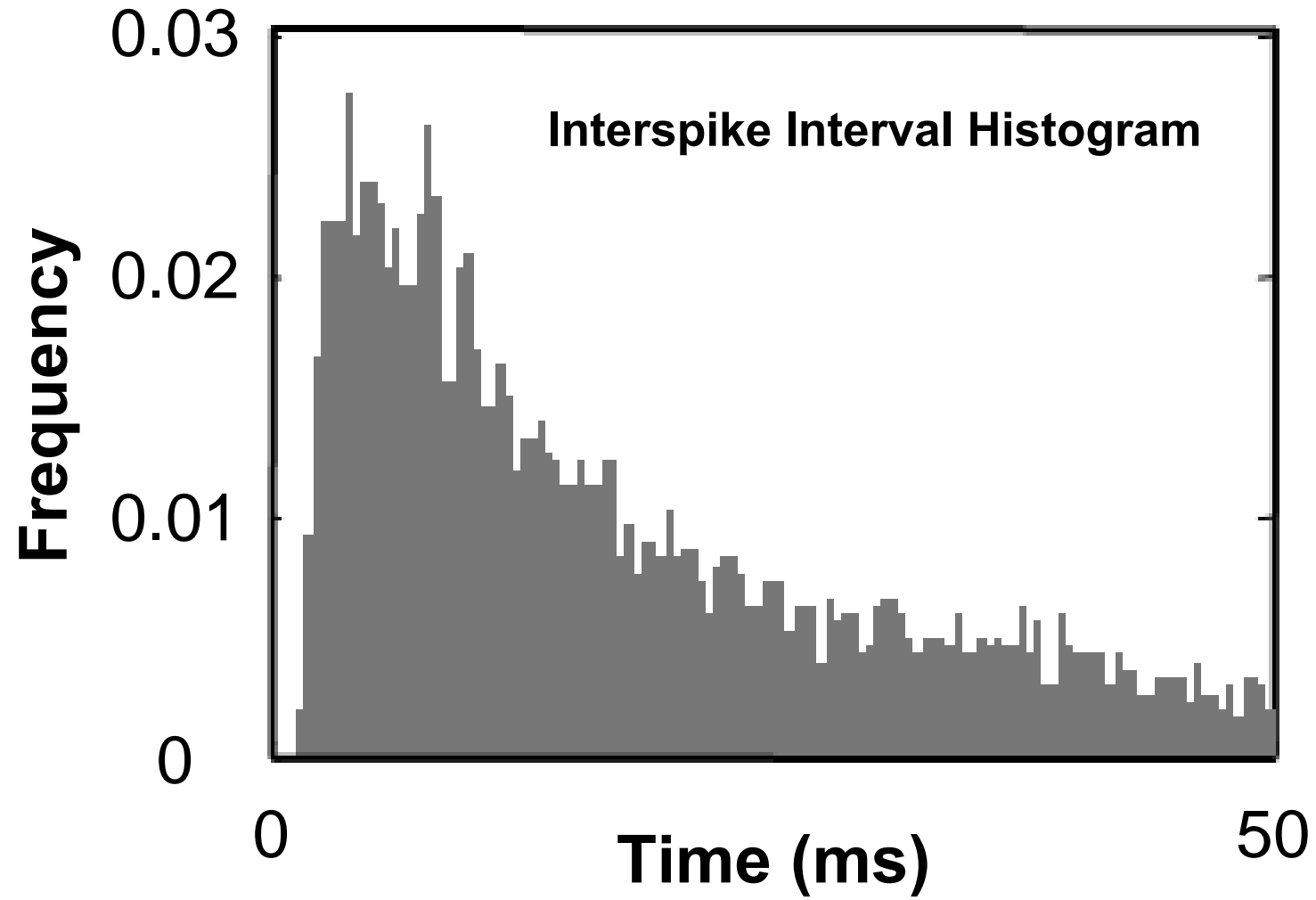


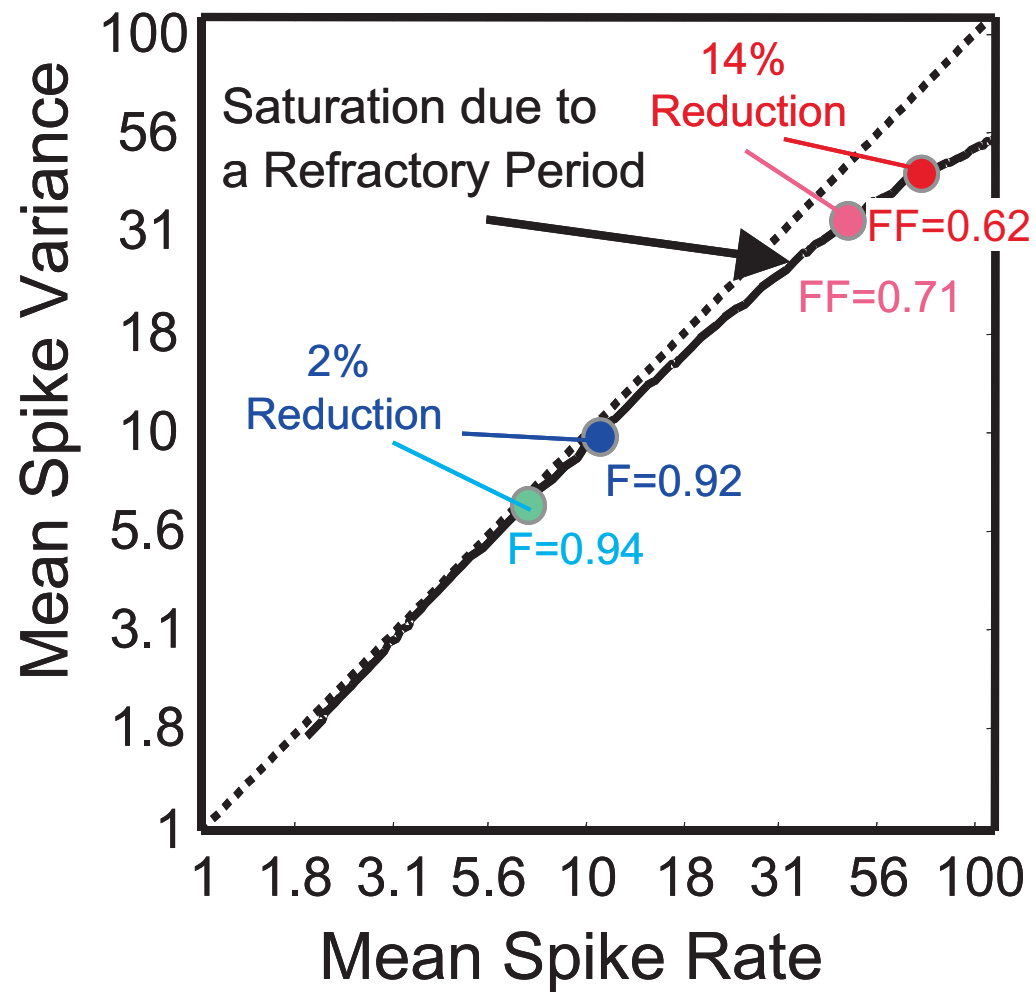
## Narrow Spiking Neurons

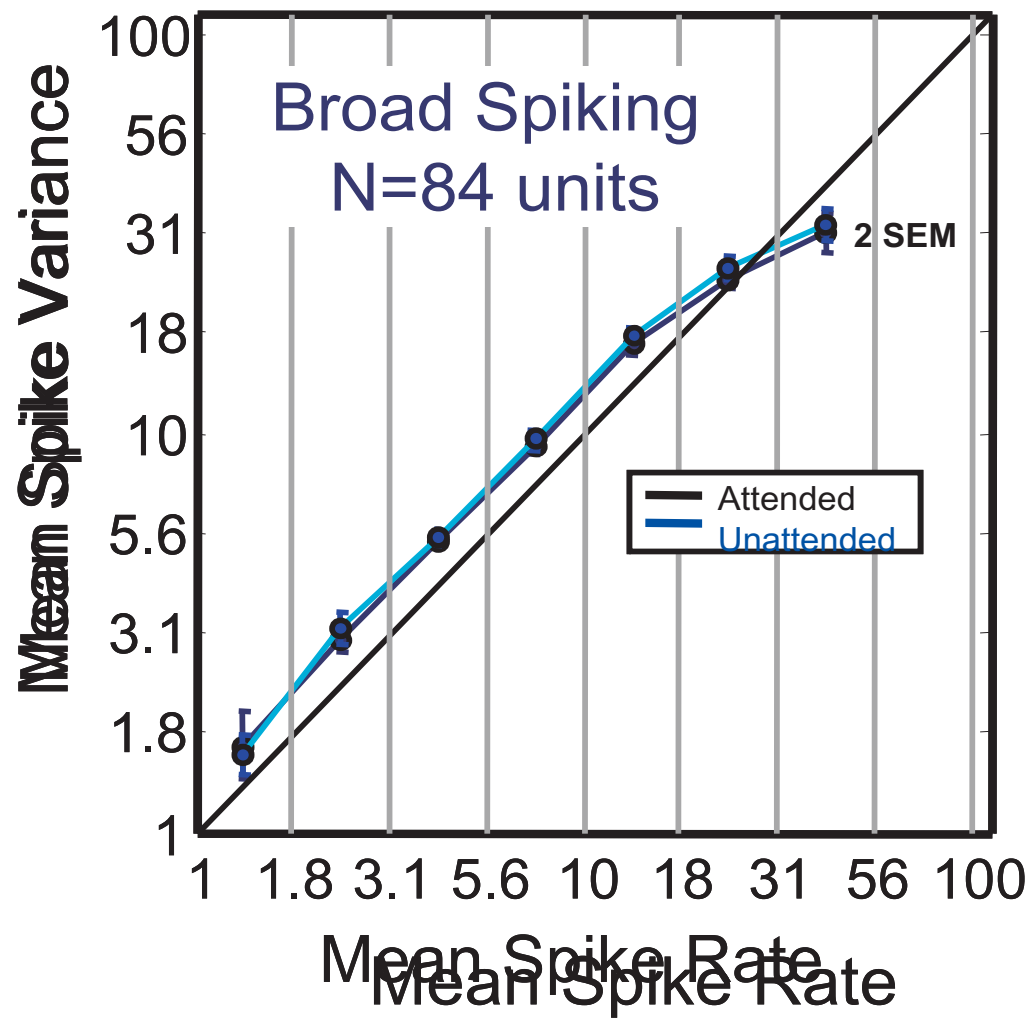


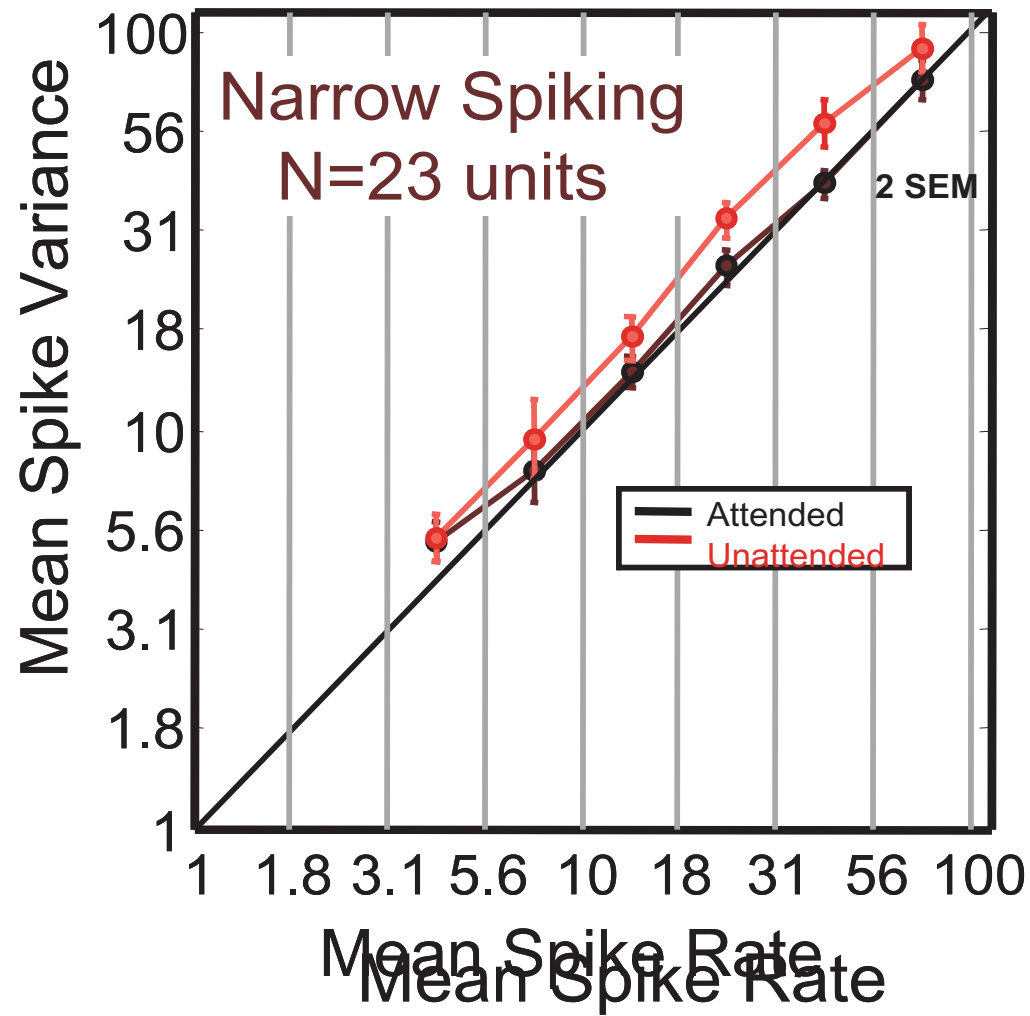


**The relative refractory period could limit response variance**



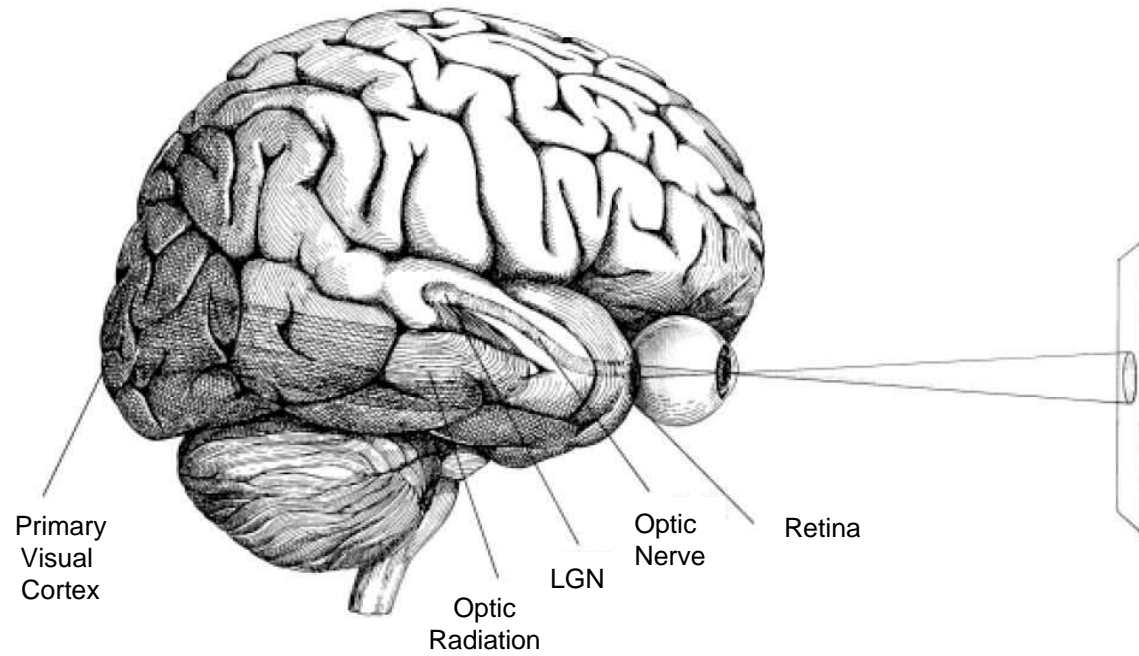




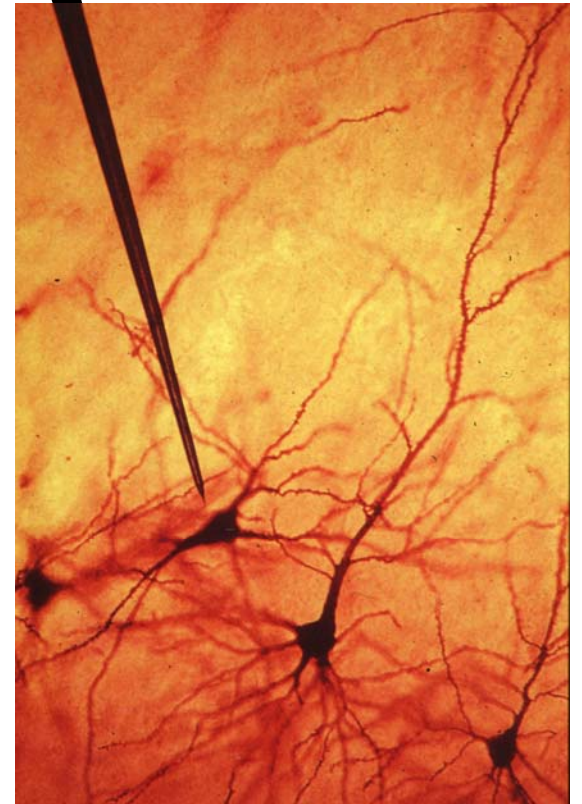
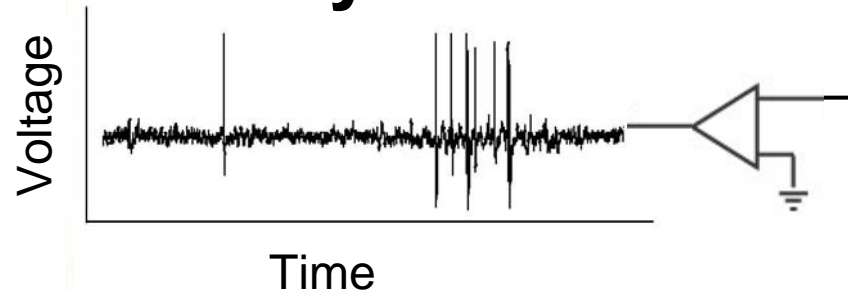


# Summary/Conclusions

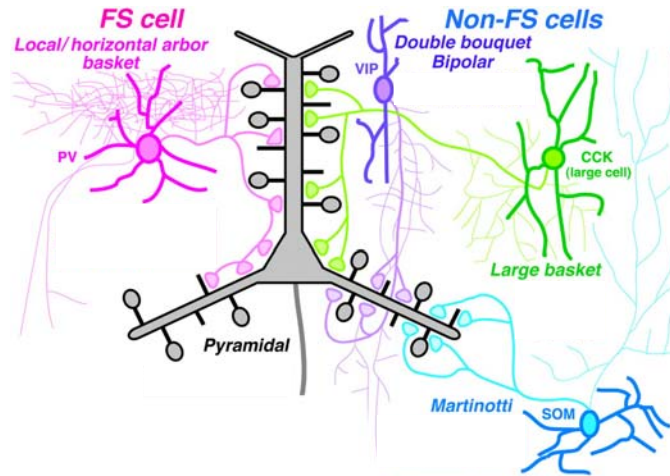
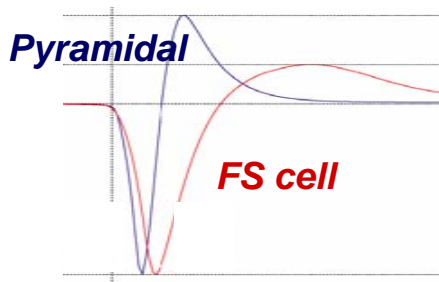
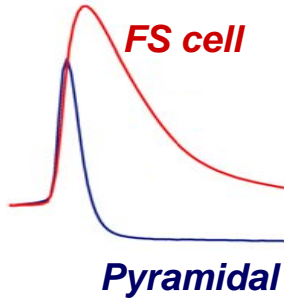
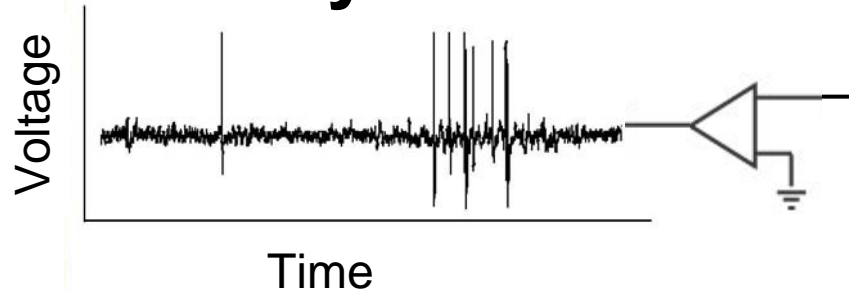
# Summary/Conclusions



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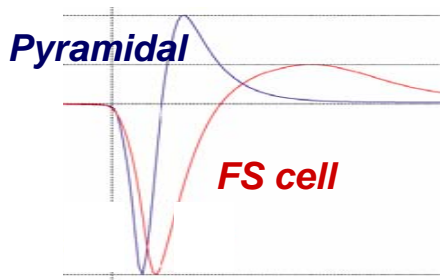
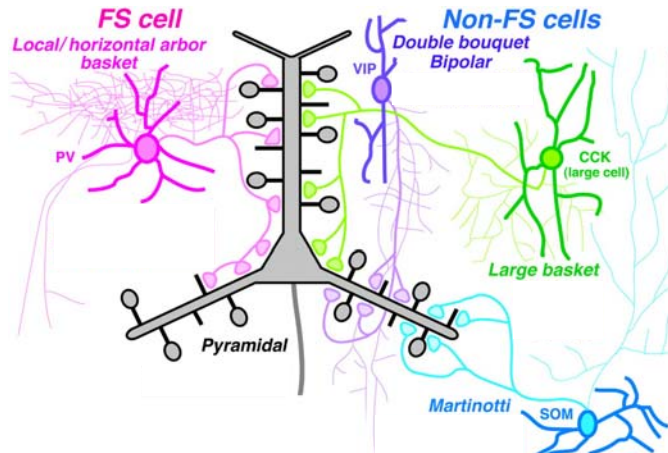
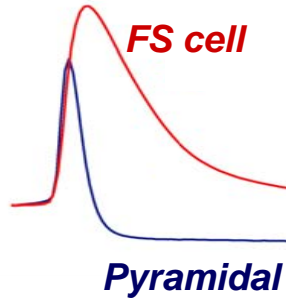
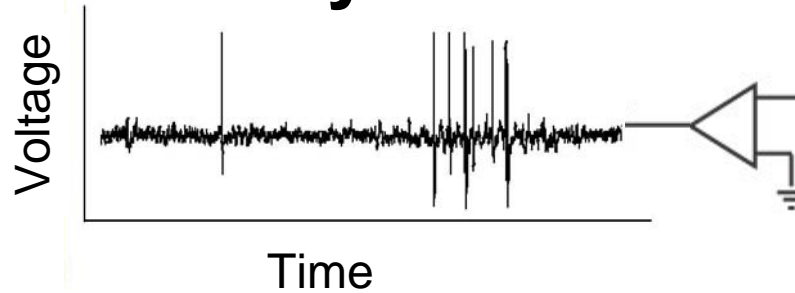


# Summary/Conclusions





# Summary/Conclusions



**Narrow Spiking Neurons**  
**Firing Rate**  
**Reliability**

