

# Adaptation-induced plasticity in neurons of visual cortex: do neurons remain loyal to selective properties established after critical period?

Stéphane Molotchnikoff

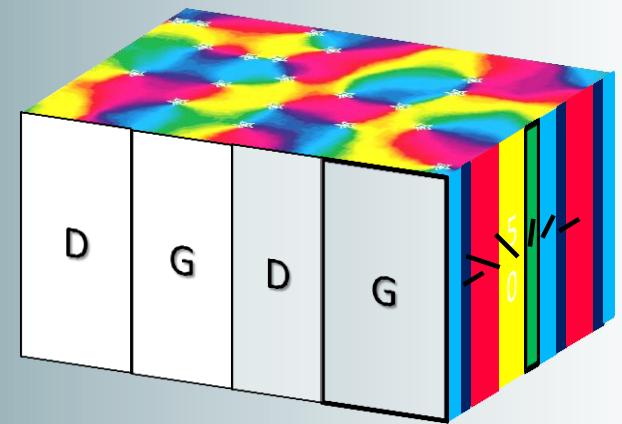
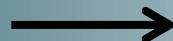
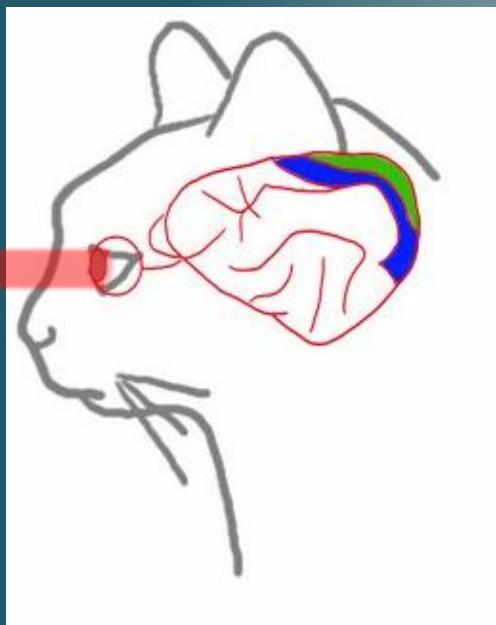
Dépt. Sciences Biologiques

Université de Montréal

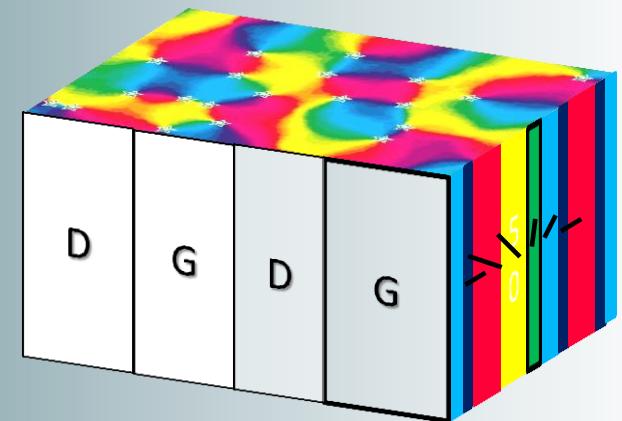
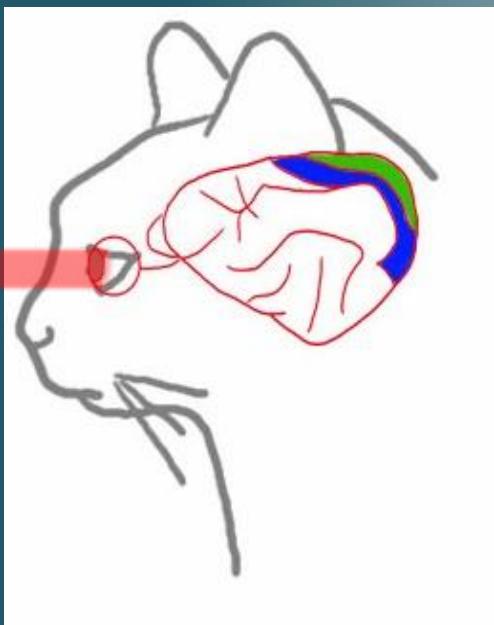
Dépt. Génie électrique et informatique

Université de Sherbrooke

# Architecture of the visual cortex

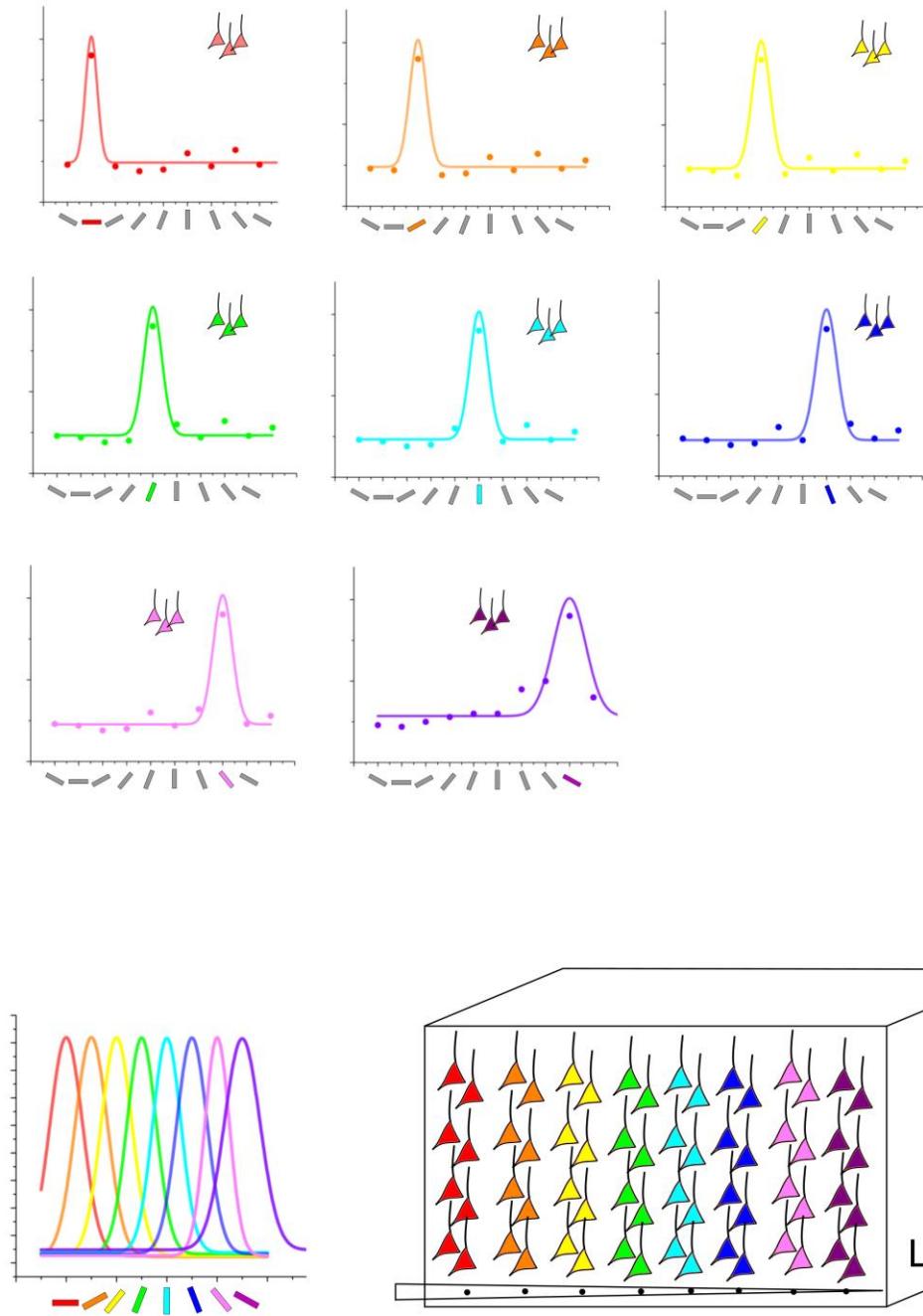
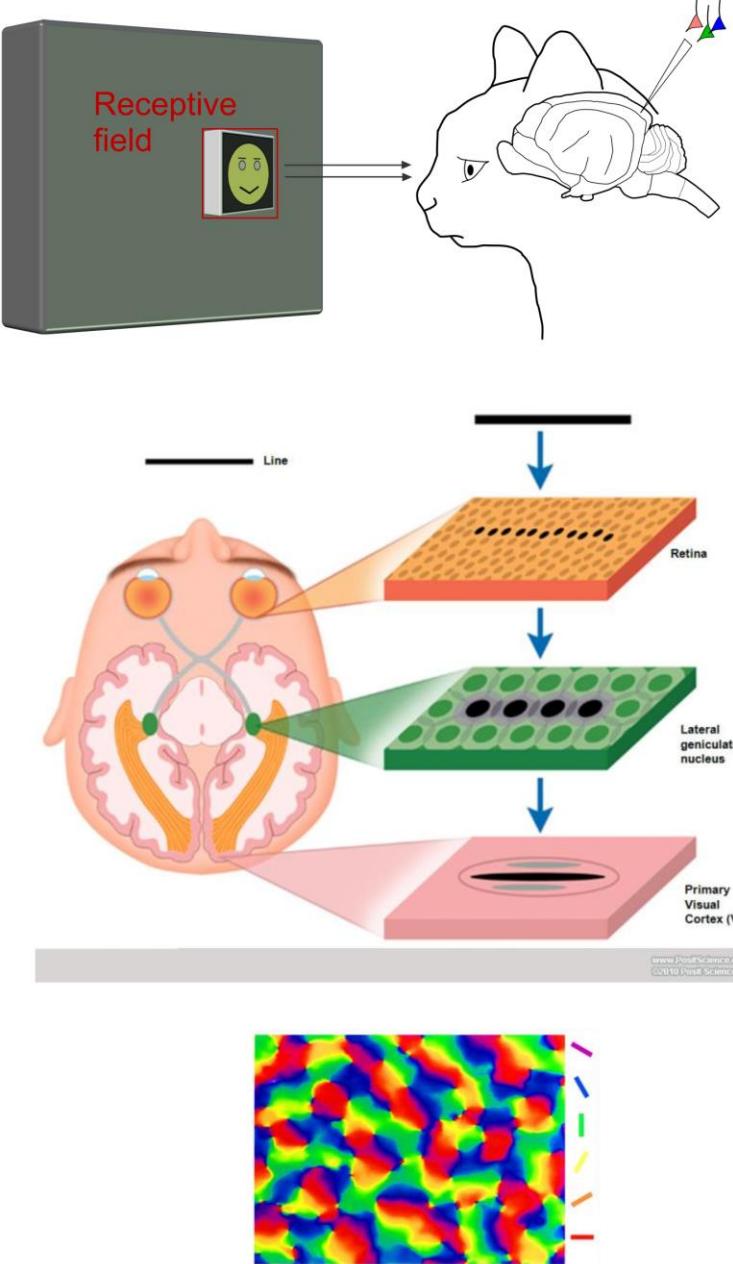


# Architecture of the visual cortex



How does the brain process ?

From retina to the visual cortex



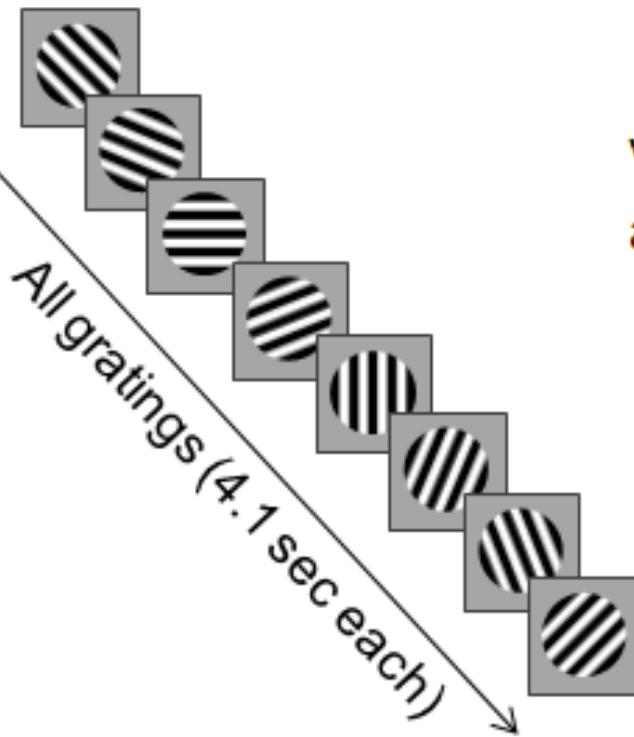
Orientation map

Cortical module

- The selectivity of various neuronal properties acquired following the critical period after birth may be changed
  - Protocol
  - Orientation
  - Spatial frequency
  - Animals

Control

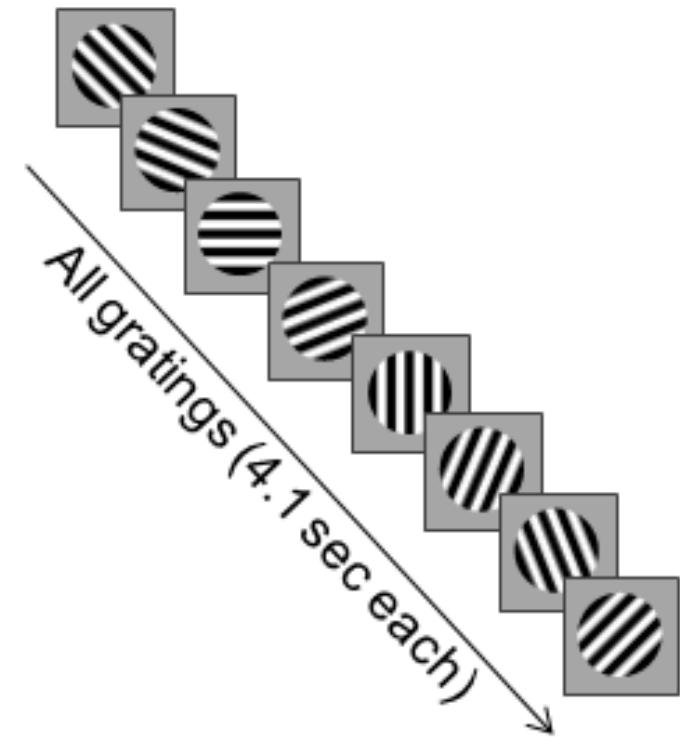
Post-adaptation



Visual  
adaptation

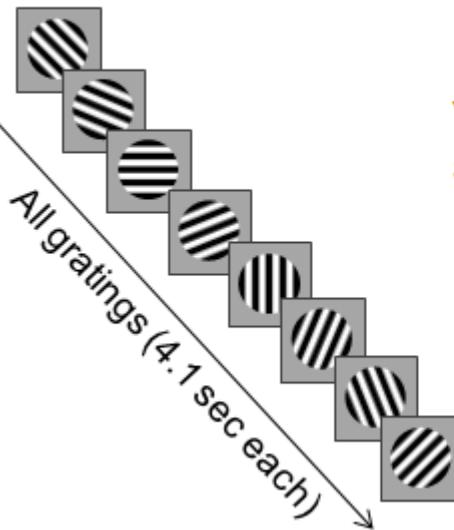


1 grating  
(12 min)

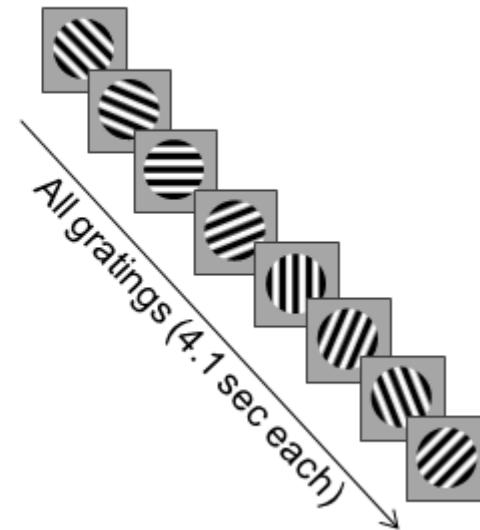


Same protocol for spatial frequencies and  
for both mouse and cat

Control



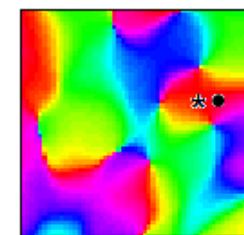
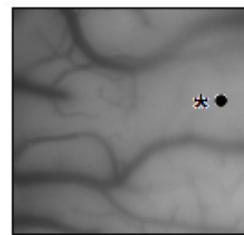
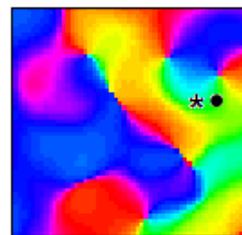
Post-adaptation



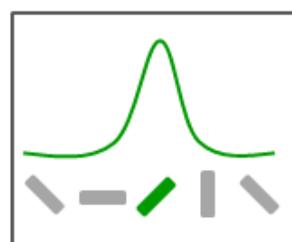
Visual  
adaptation



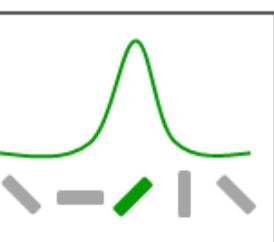
1 grating  
(12 min)



Control

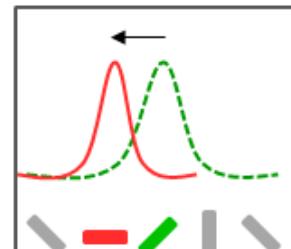


Neuron 1\*

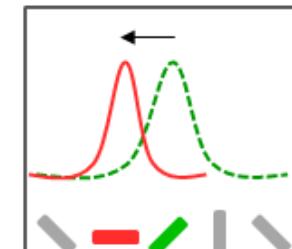


Neuron 2\*

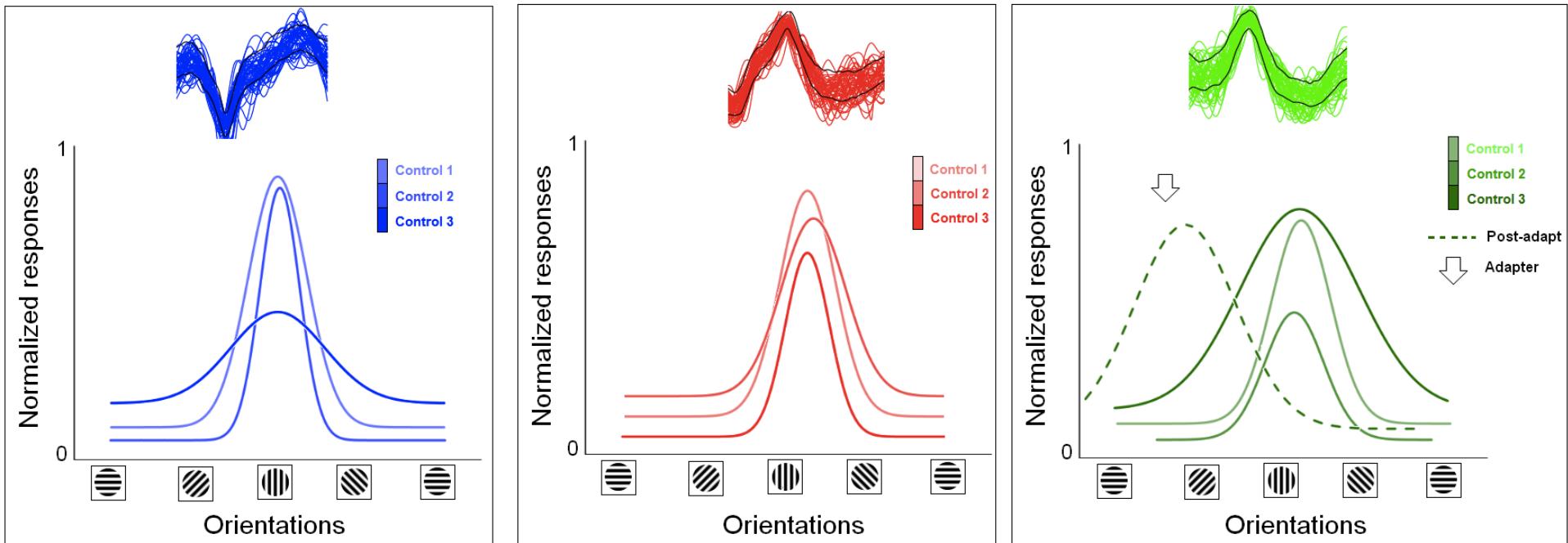
Post-adaptation



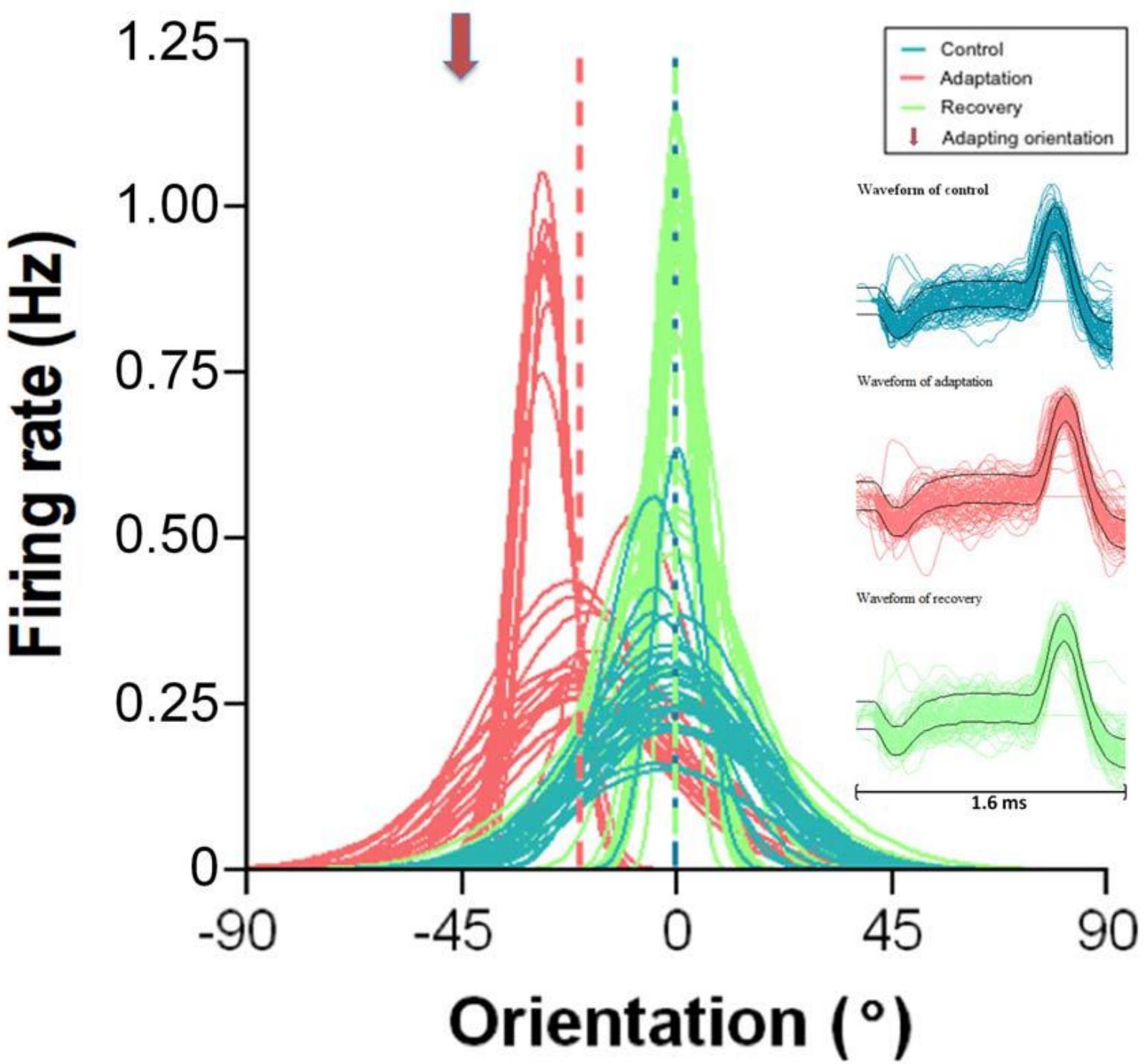
Neuron 1\*



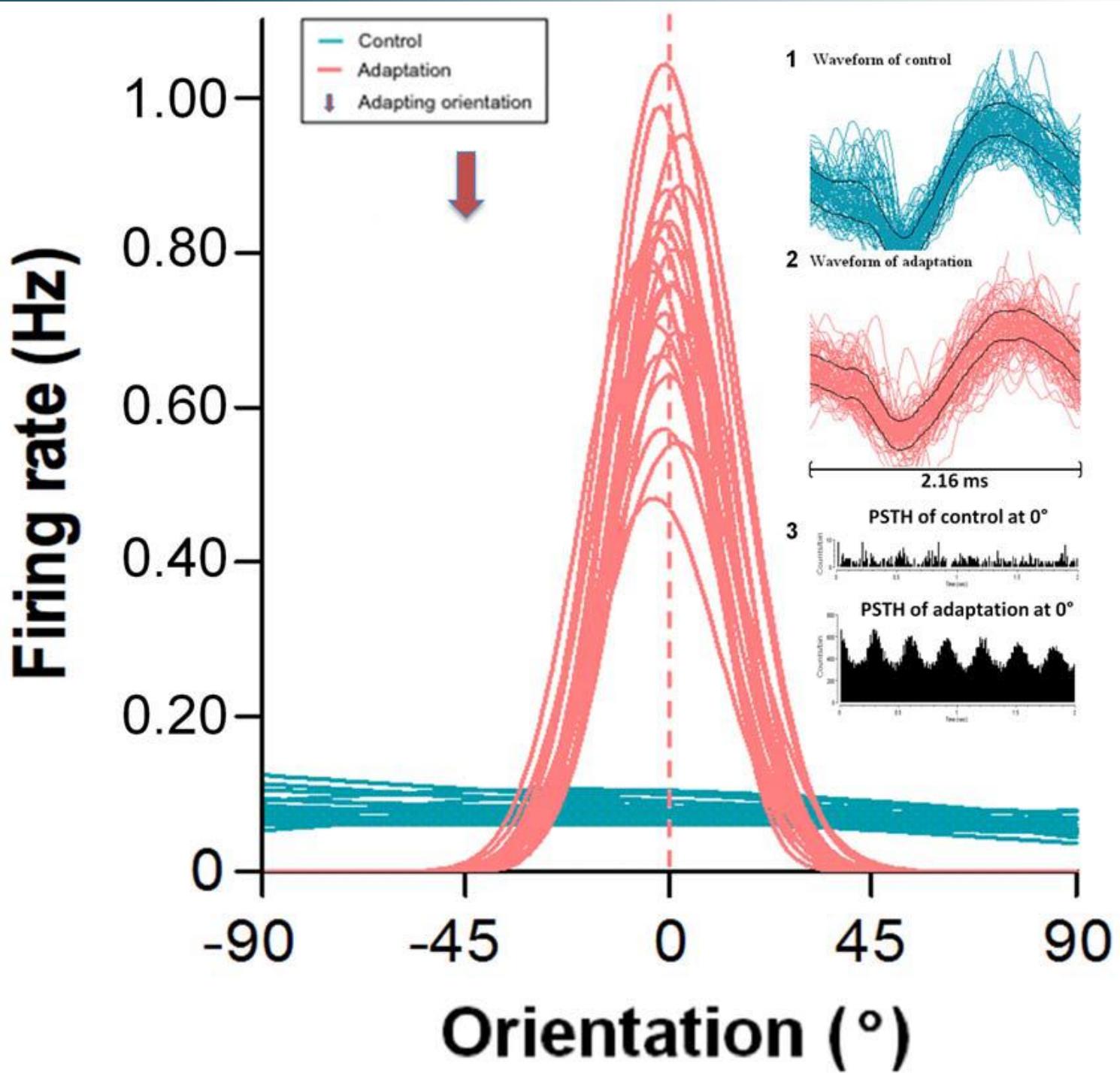
Neuron 2\*

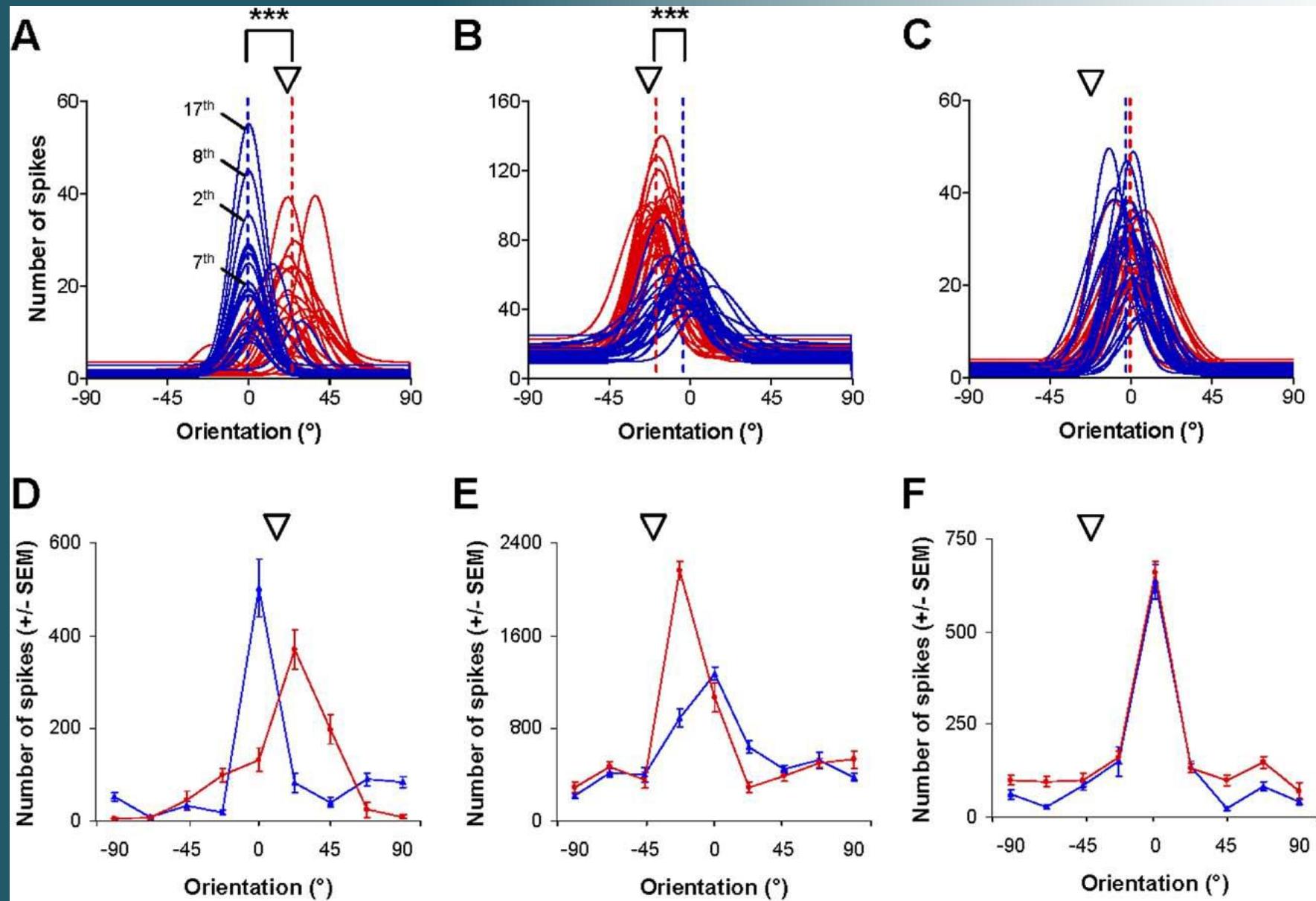
**A**

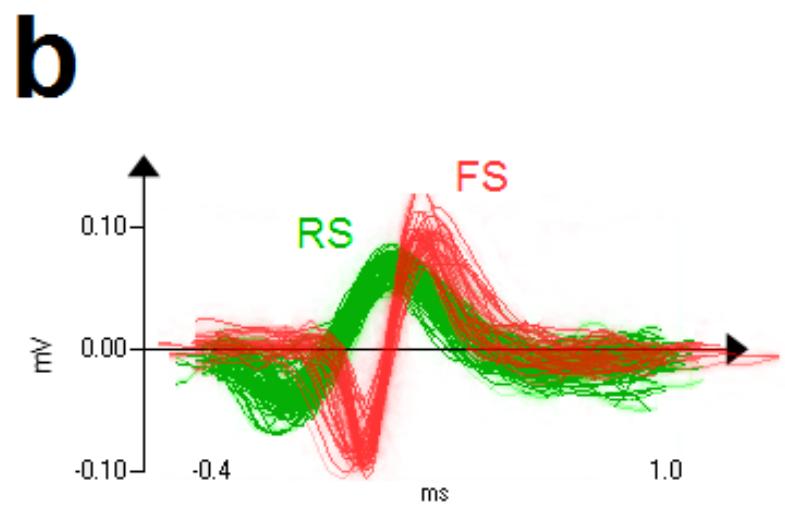
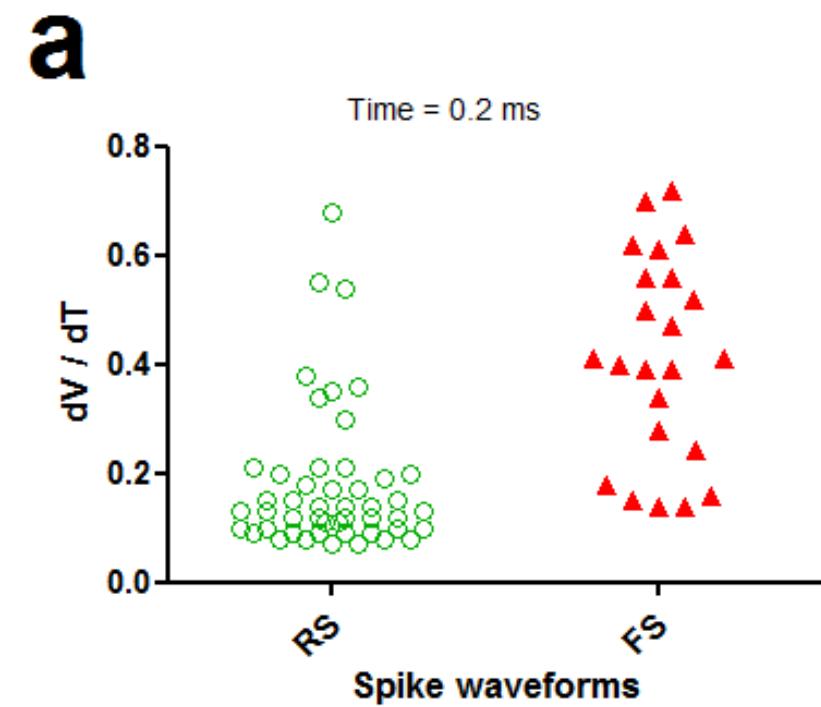
Mouse



## Mouse

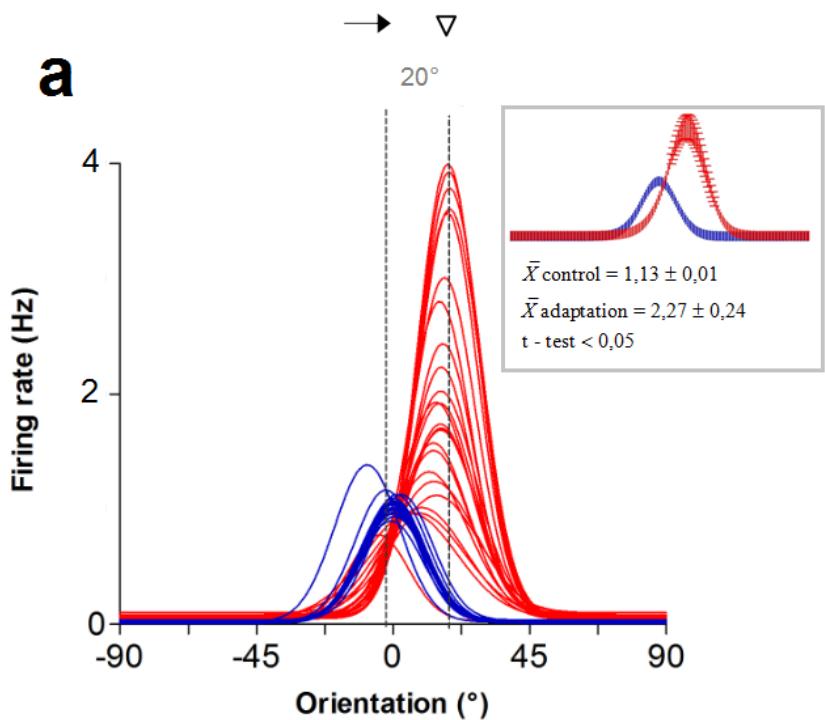
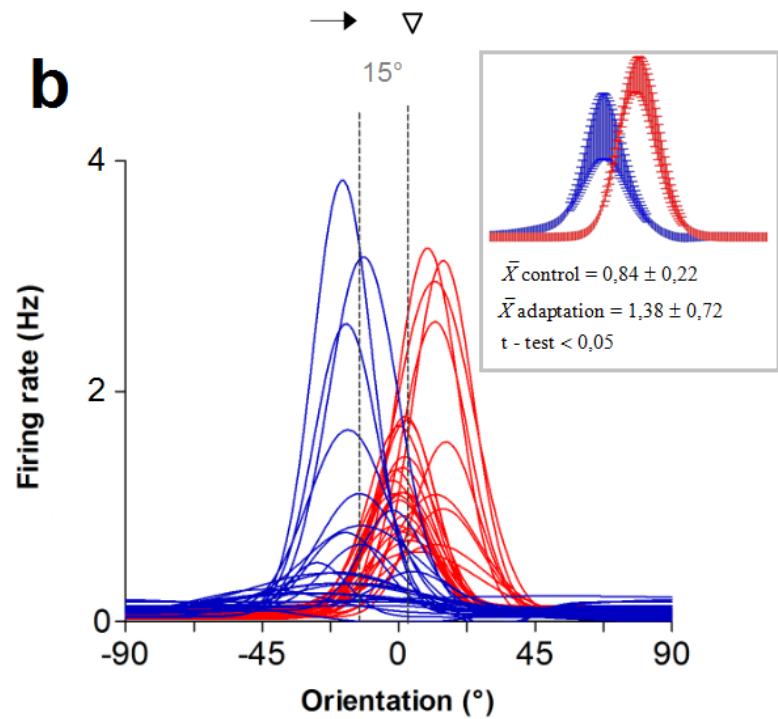
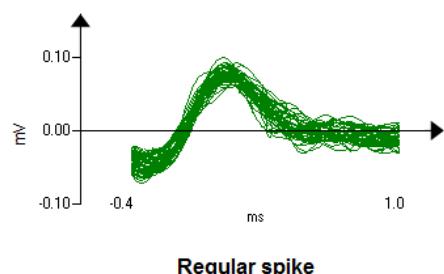
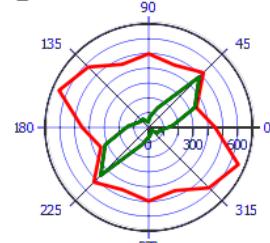
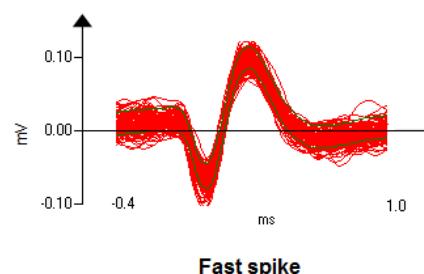


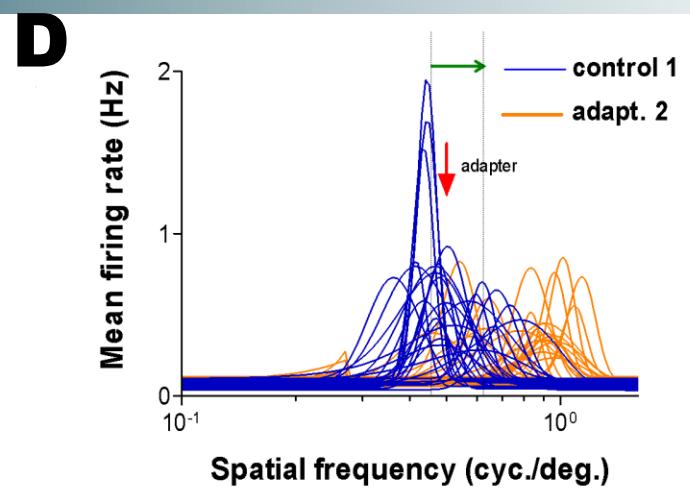
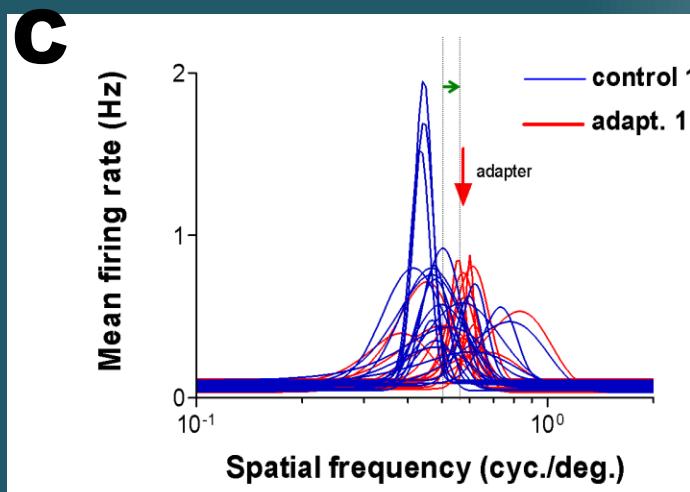
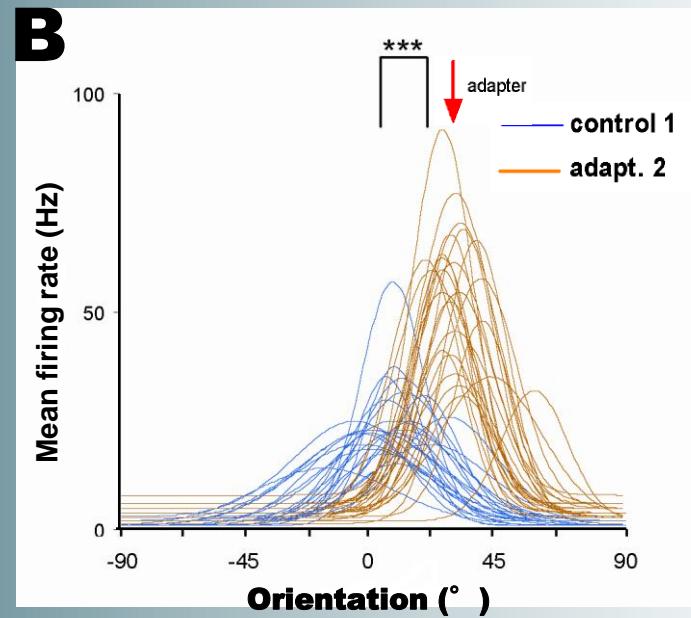
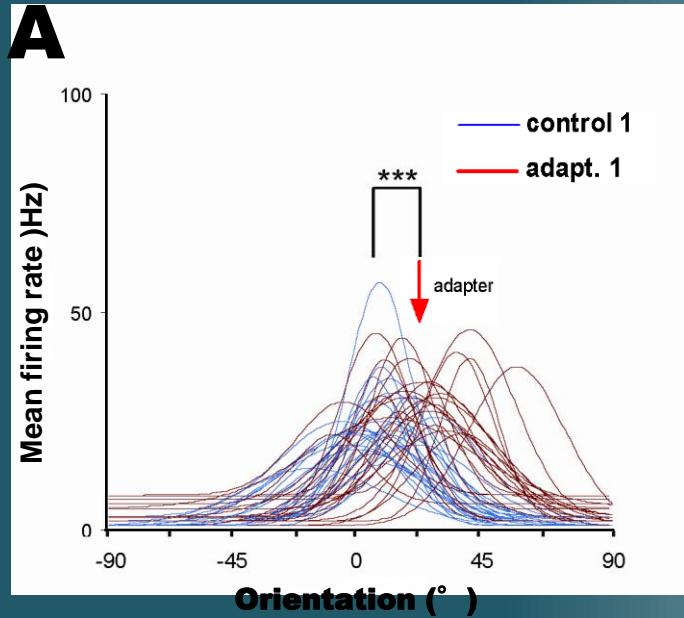




**ATTRACTIVE (RS)**

Control  
Adaptation

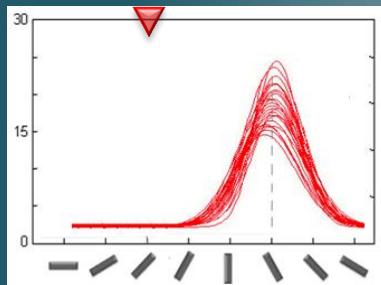
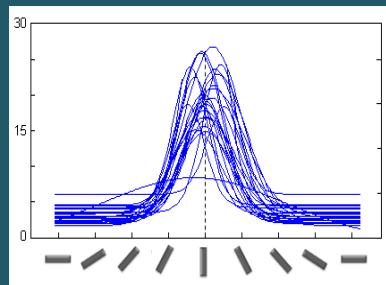
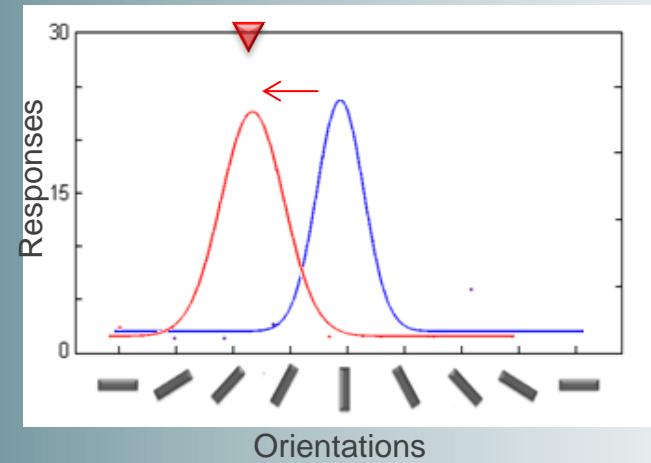
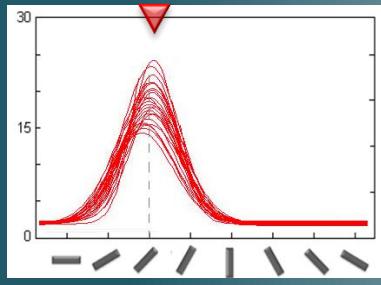
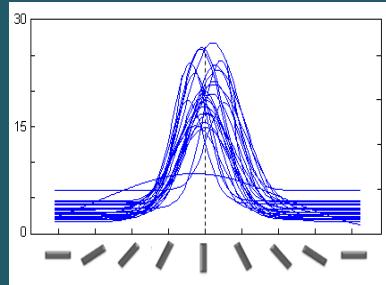
**a****ATTRACTIVE (FS)****b****c****e****d**



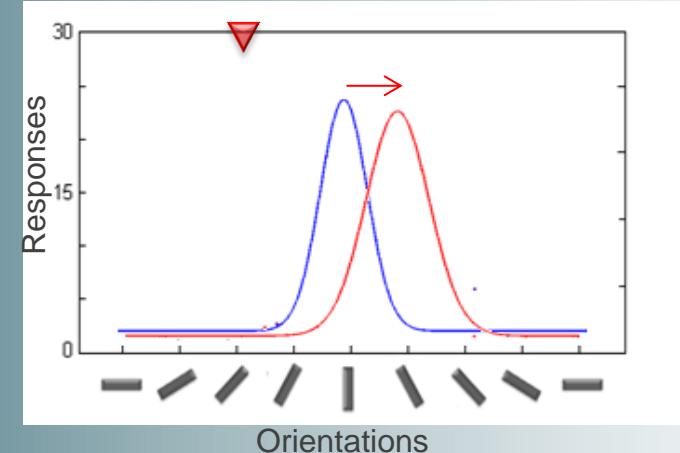
The second adaptation improves responses and augments shifts magnitude

## Displacement of the orientation tuning curve

### **Attractive Shift**

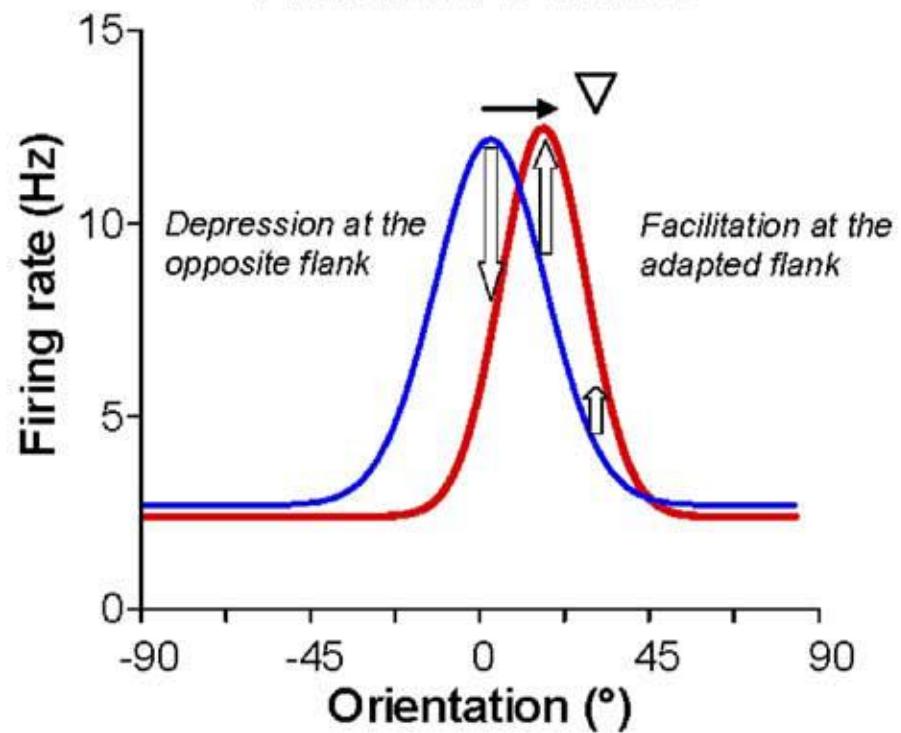


### **Repulsive Shift**

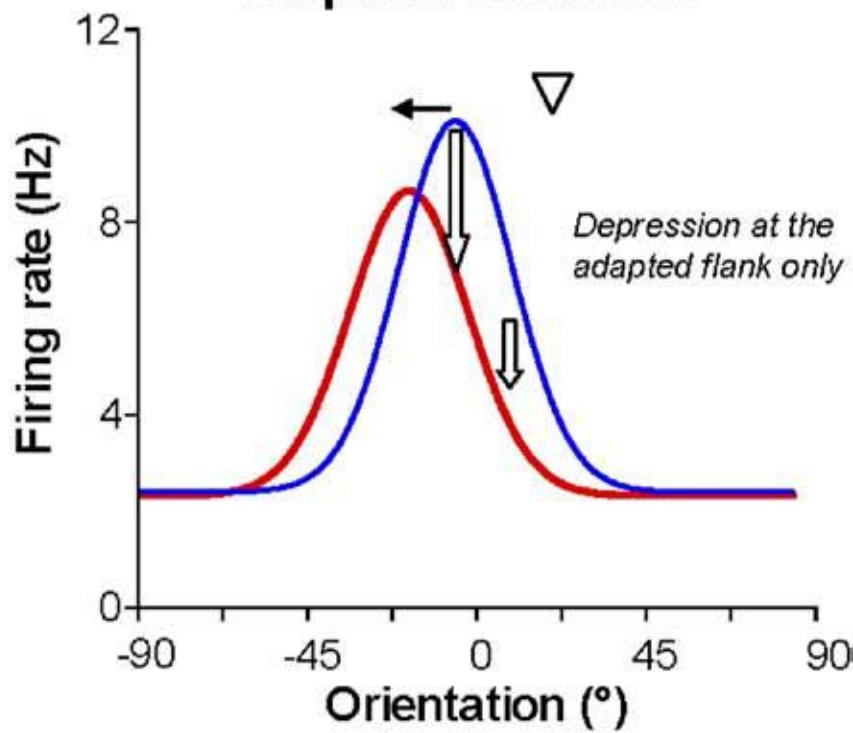


**A**

### Attractive shifts

**B**

### Repulsive shifts



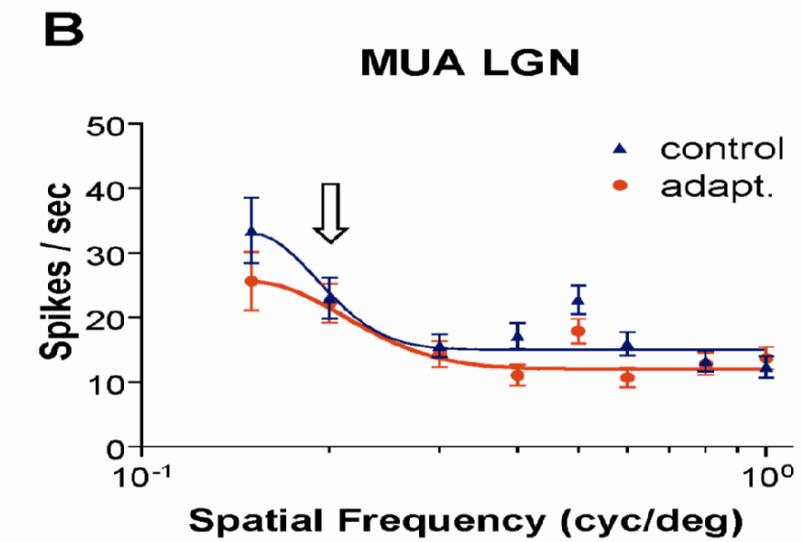
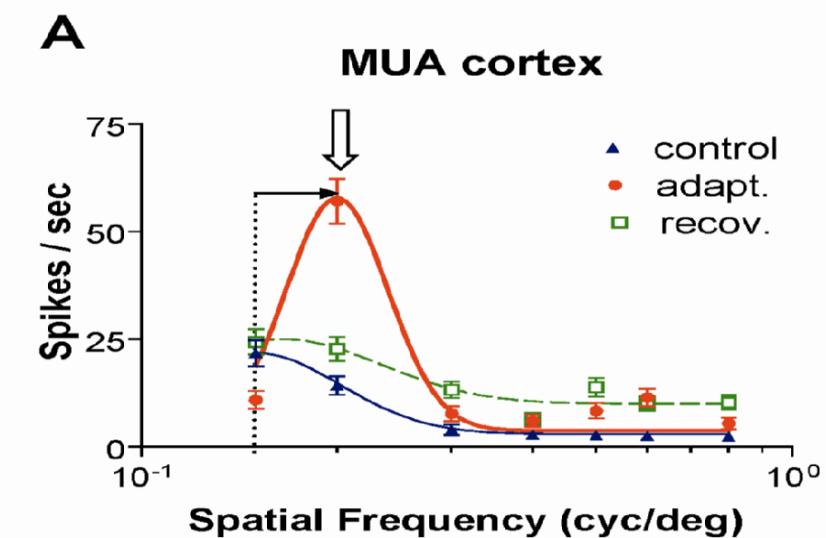
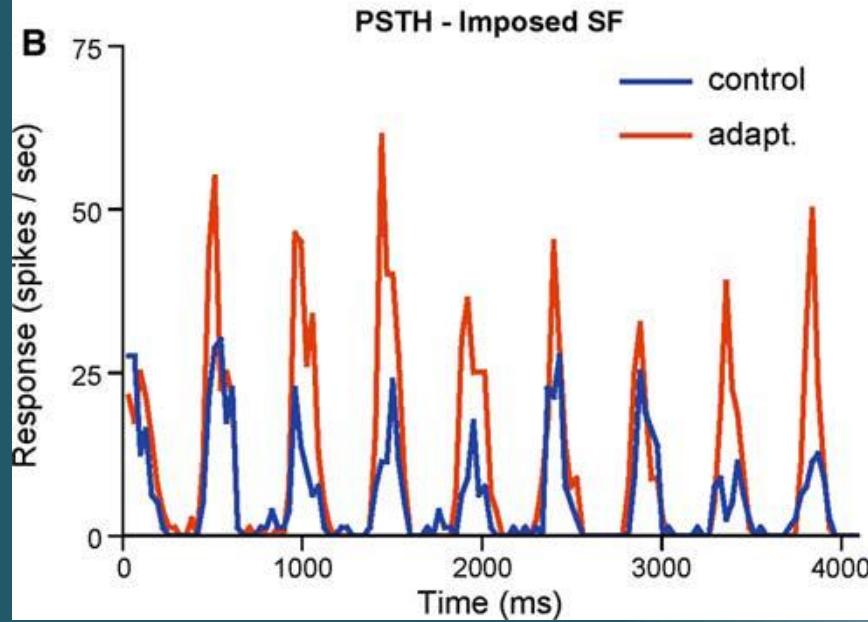
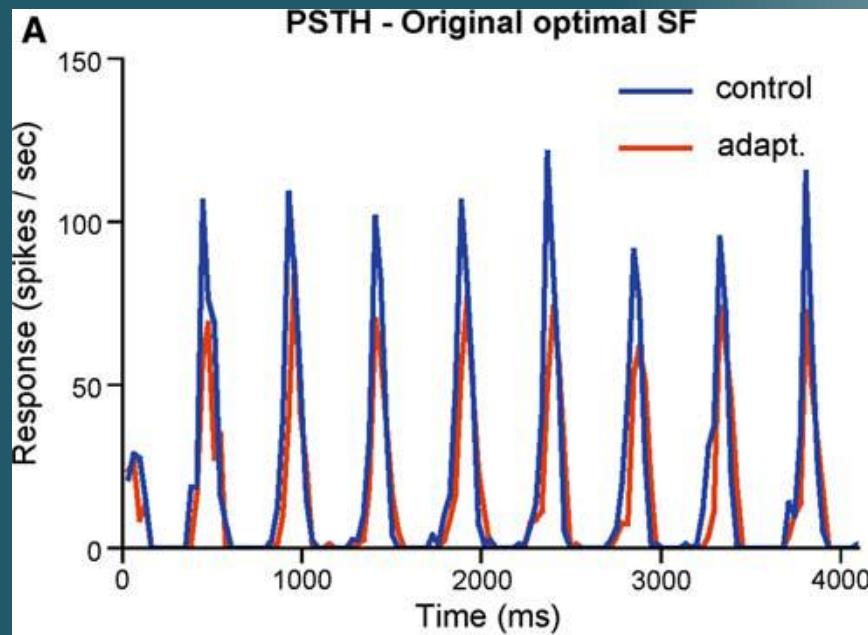
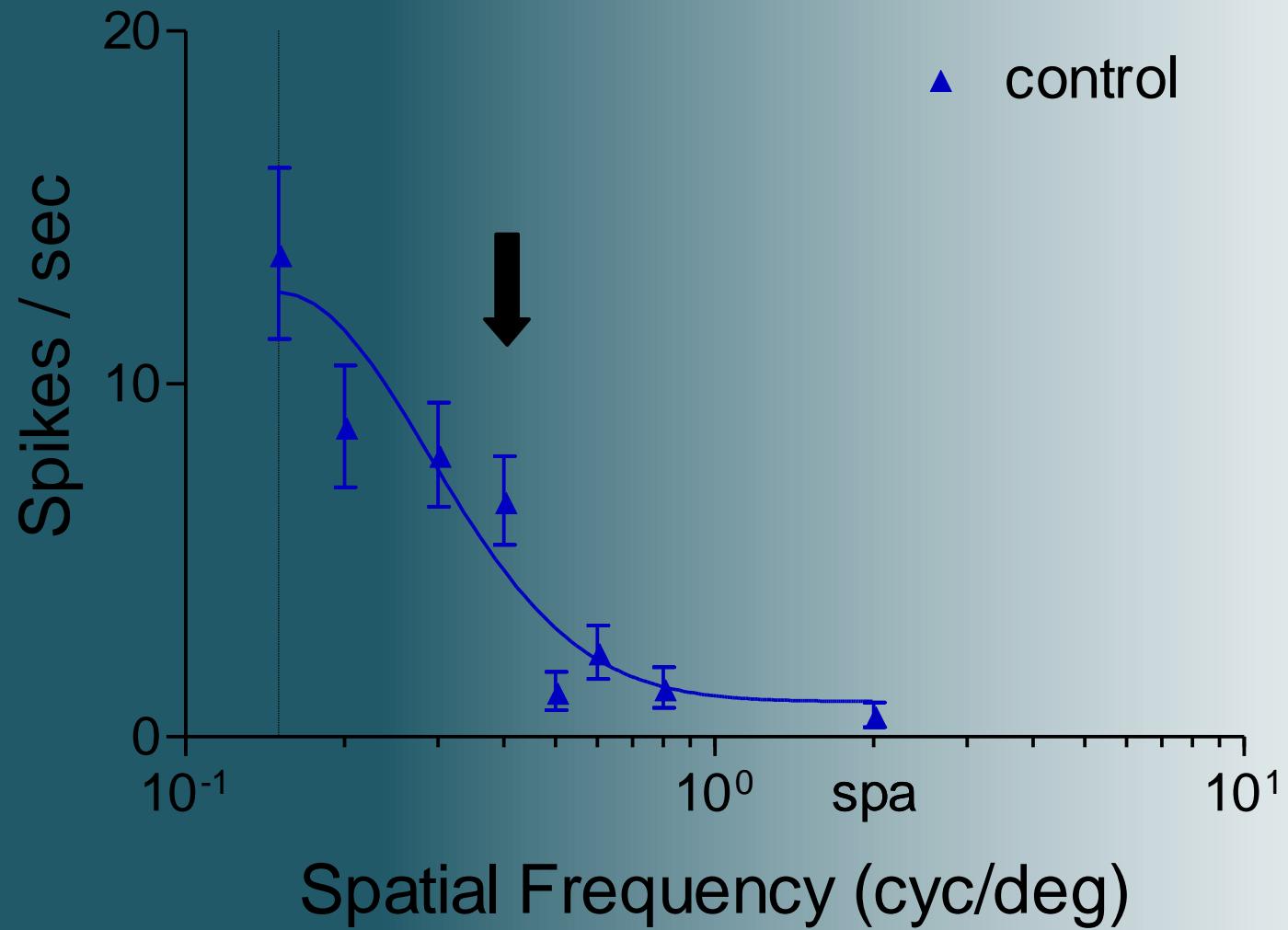
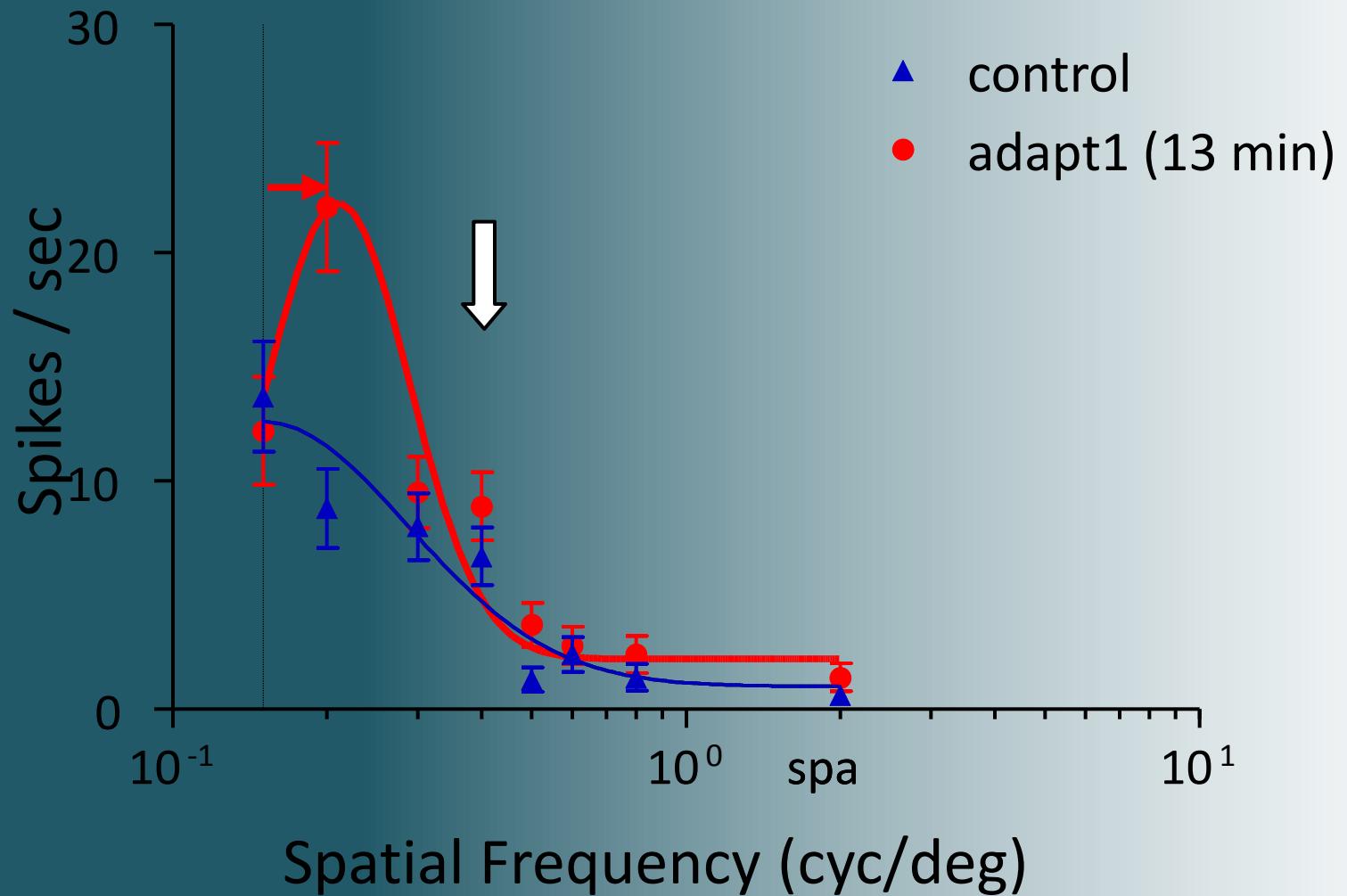
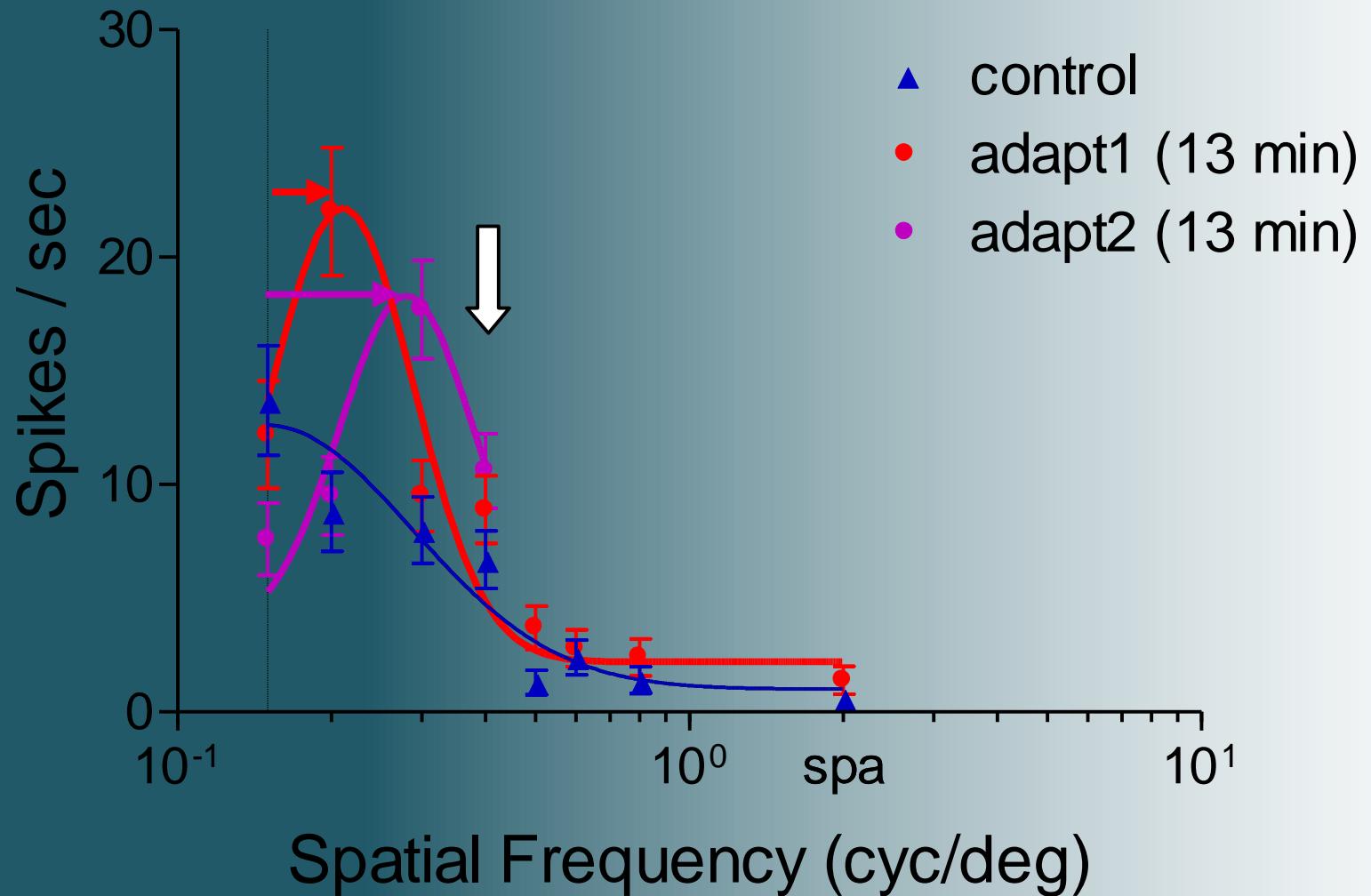
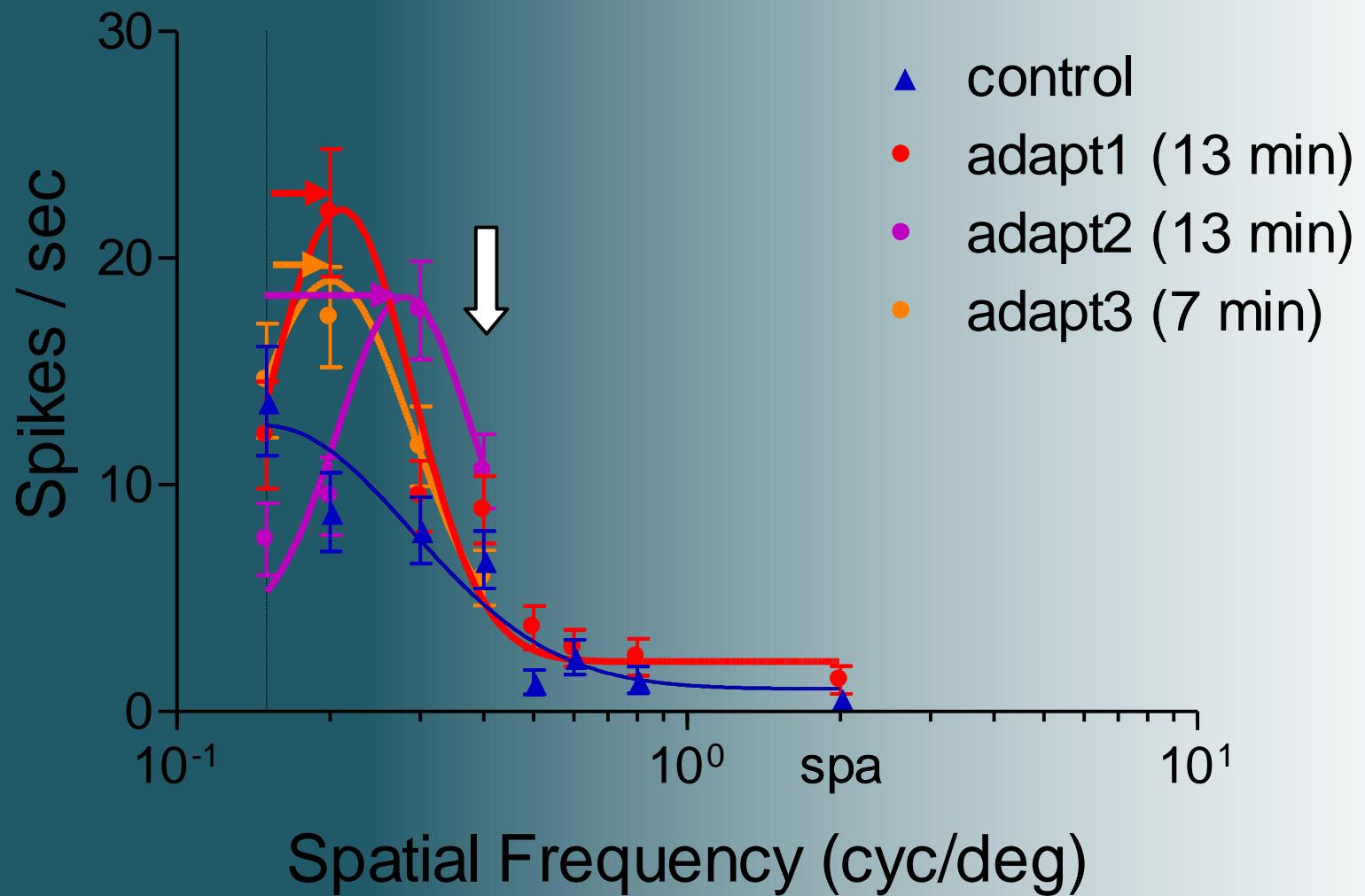


Fig. 3





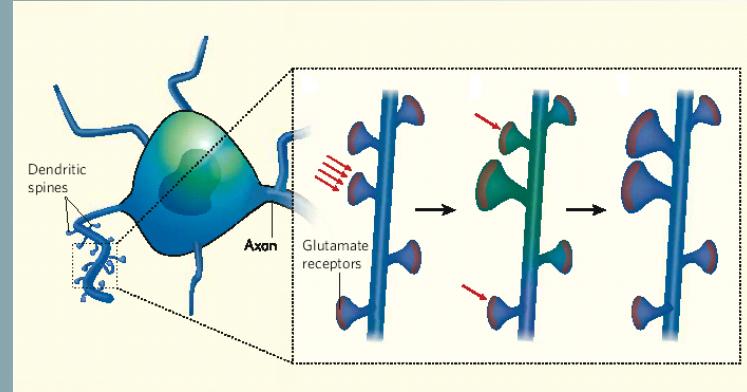
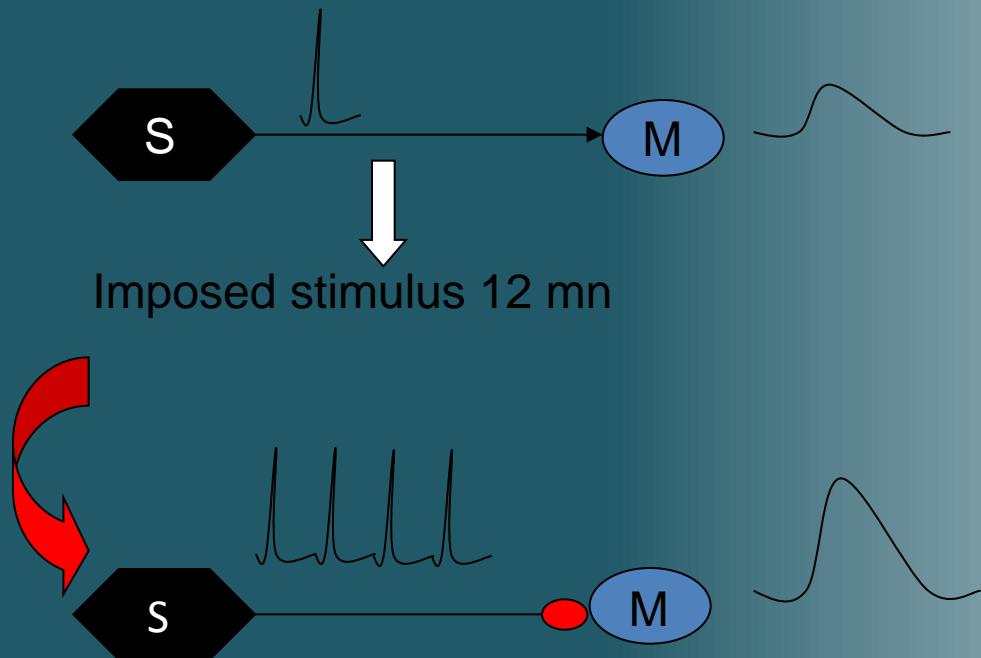




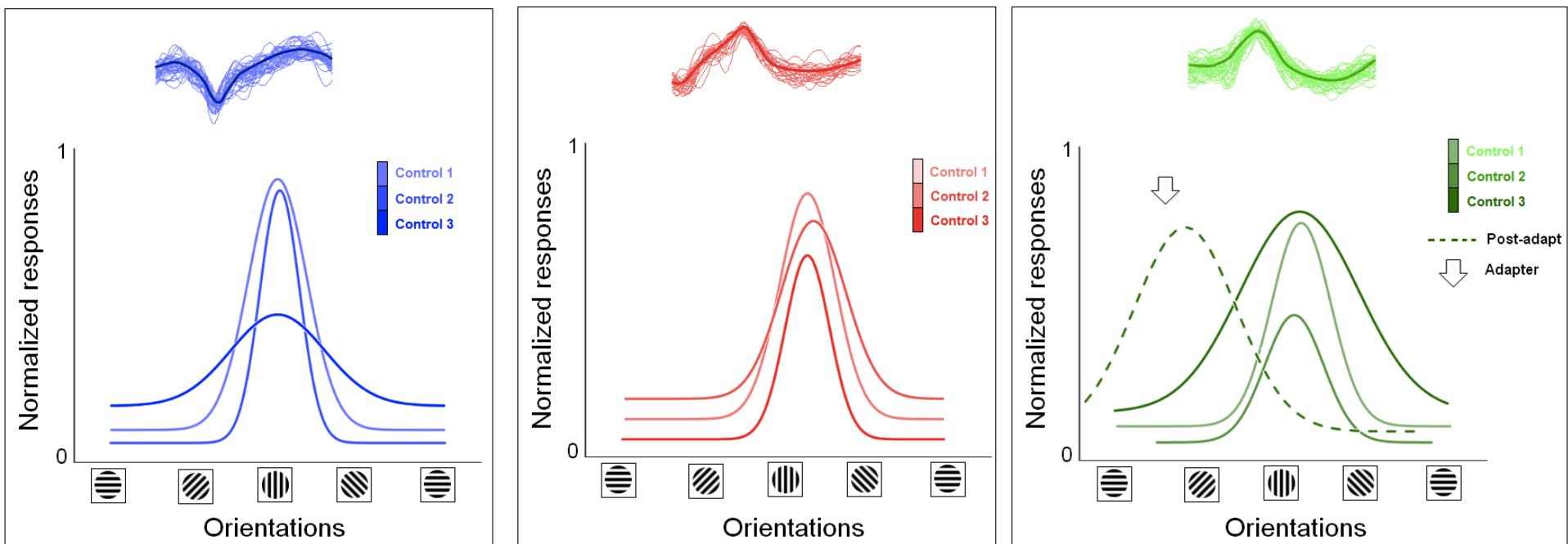
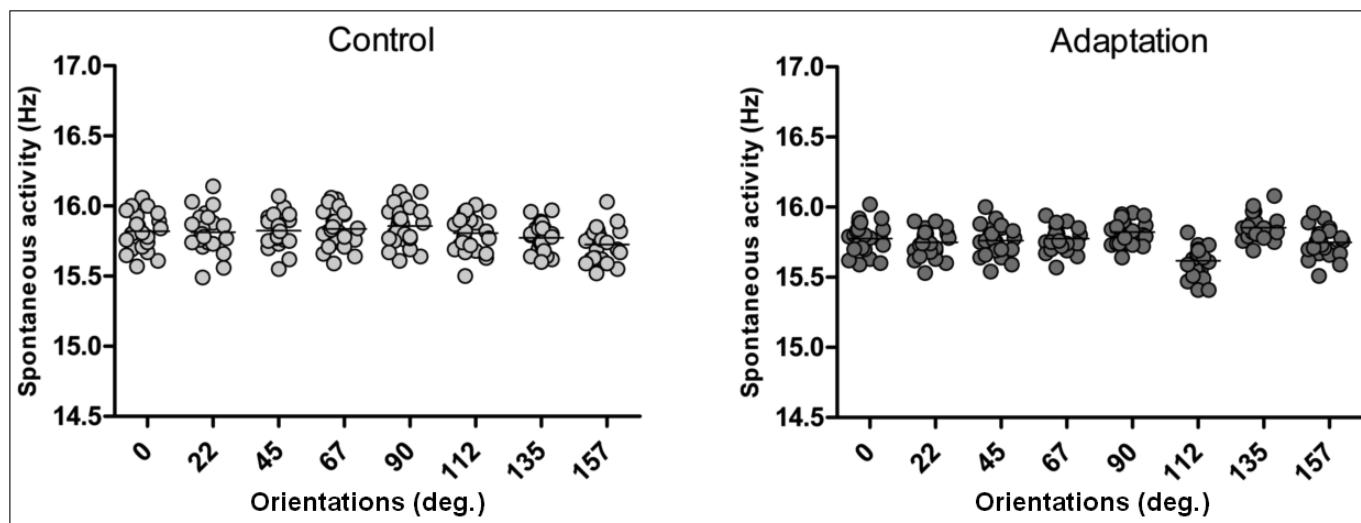
# Explanation attempts (2) synaptic microstructure

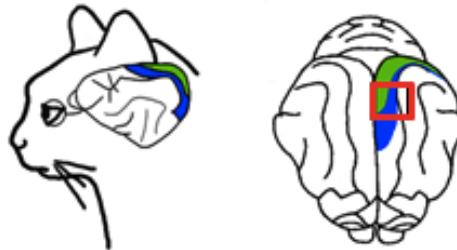
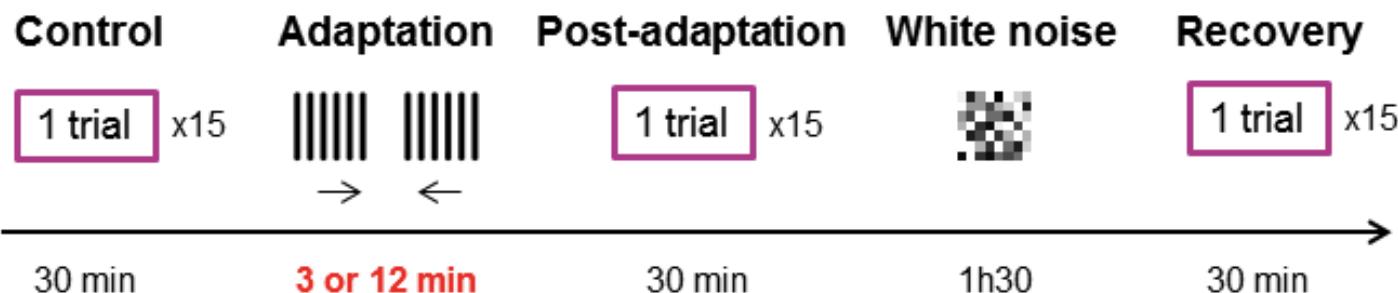
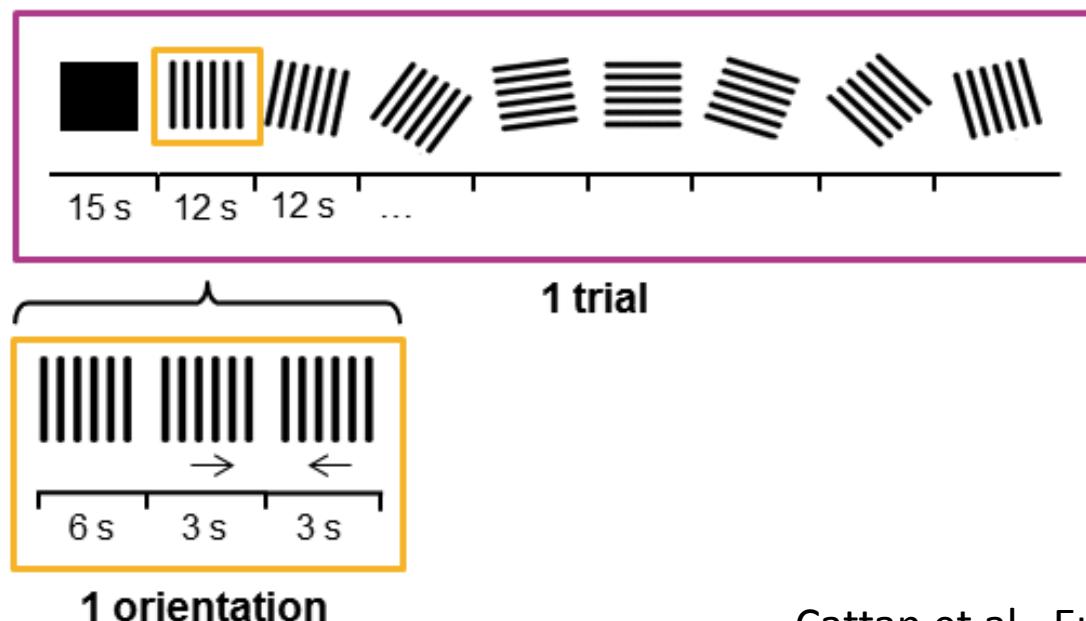
Hebb 1949

If neuron S repeatedly participates in firing cell M the efficiency of cell S as one of the neurons firing cell M is increased

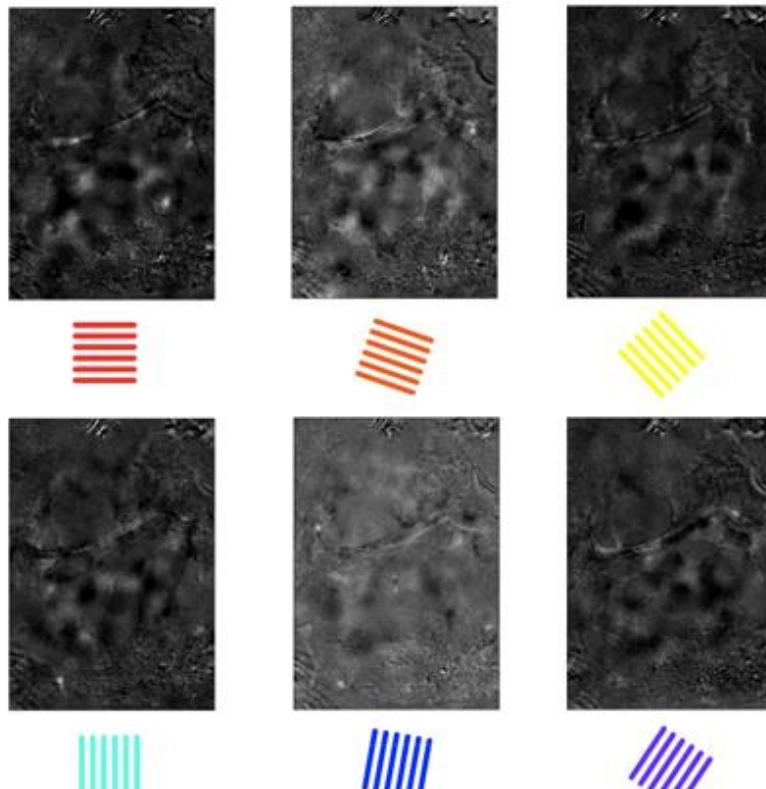


Sabatini et al, 2008

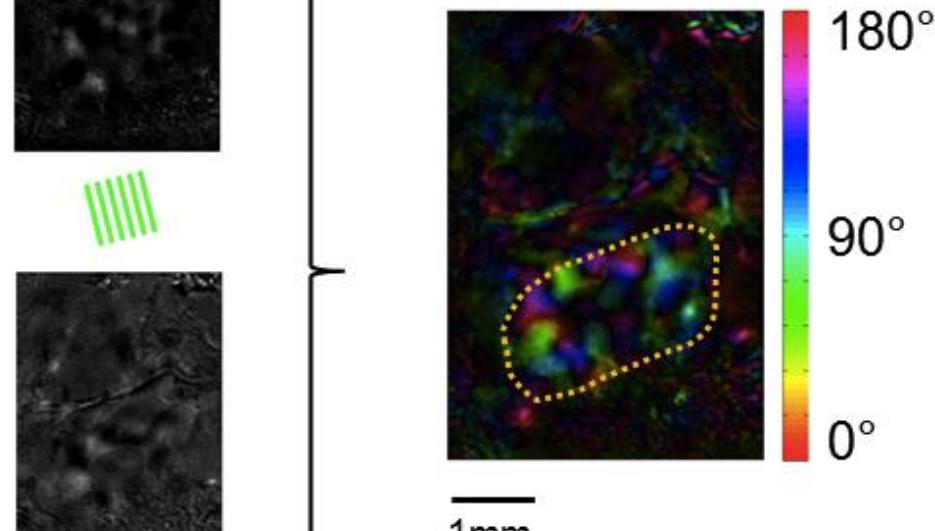
**A****B**

**A****B****C**

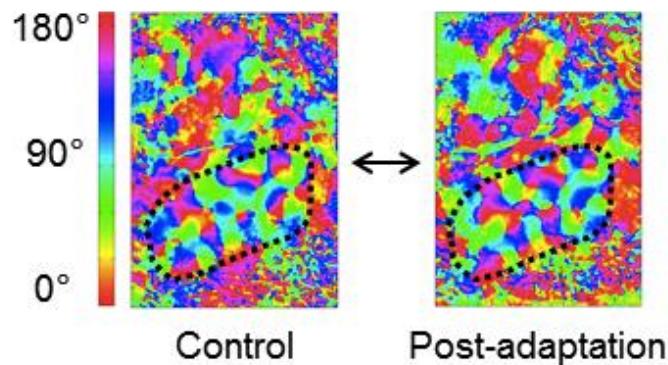
A



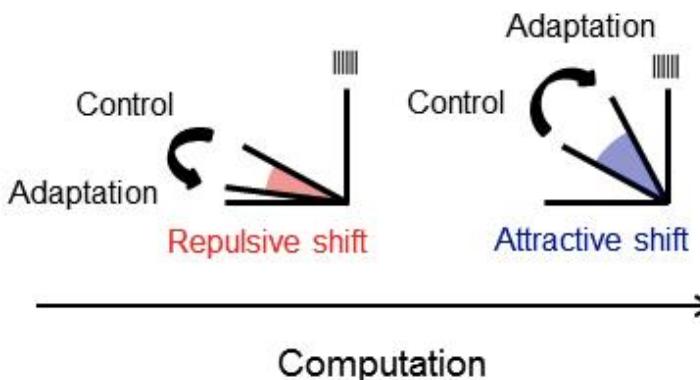
B



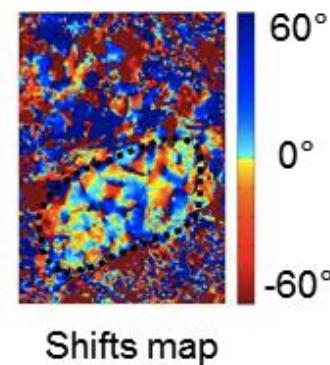
C

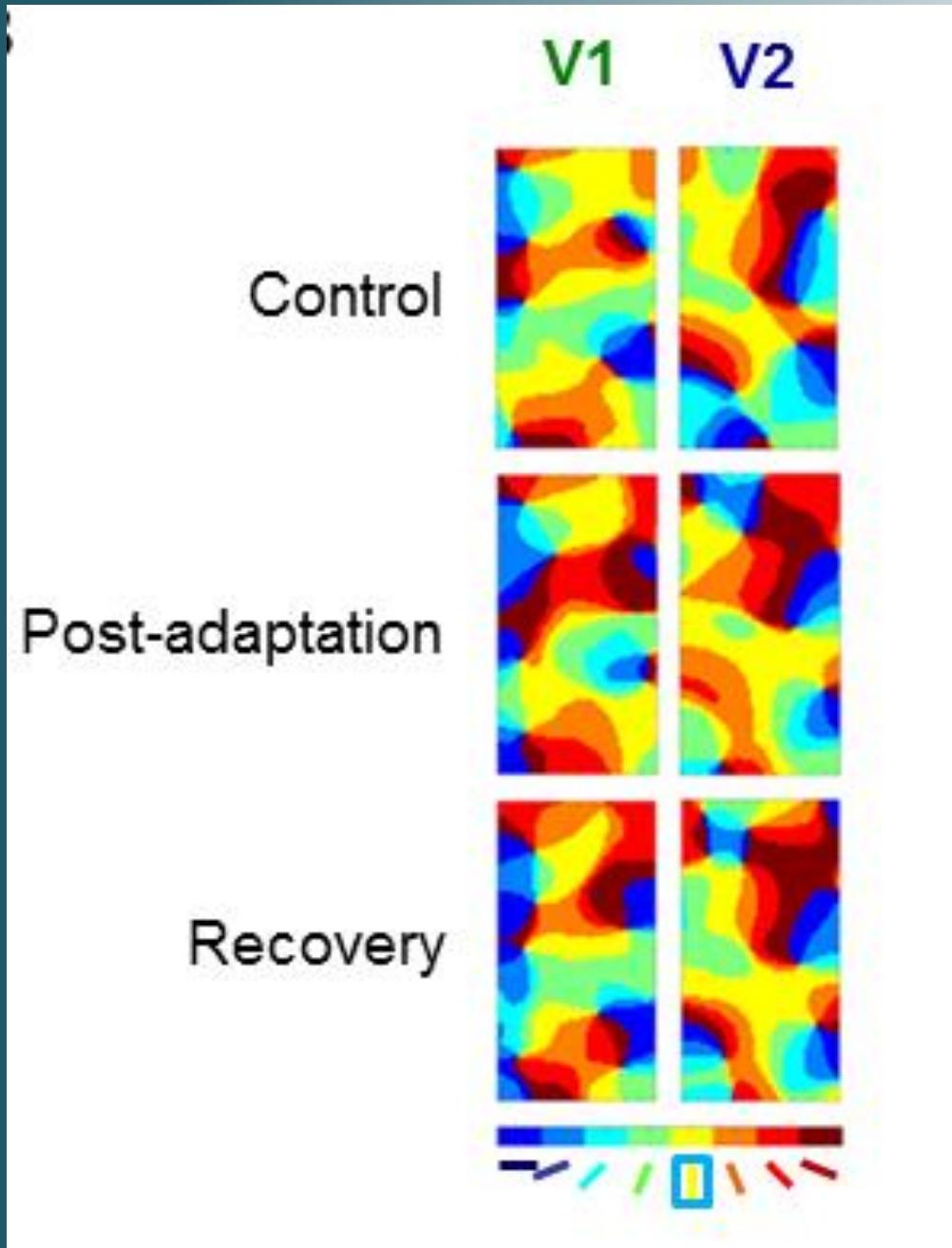


D

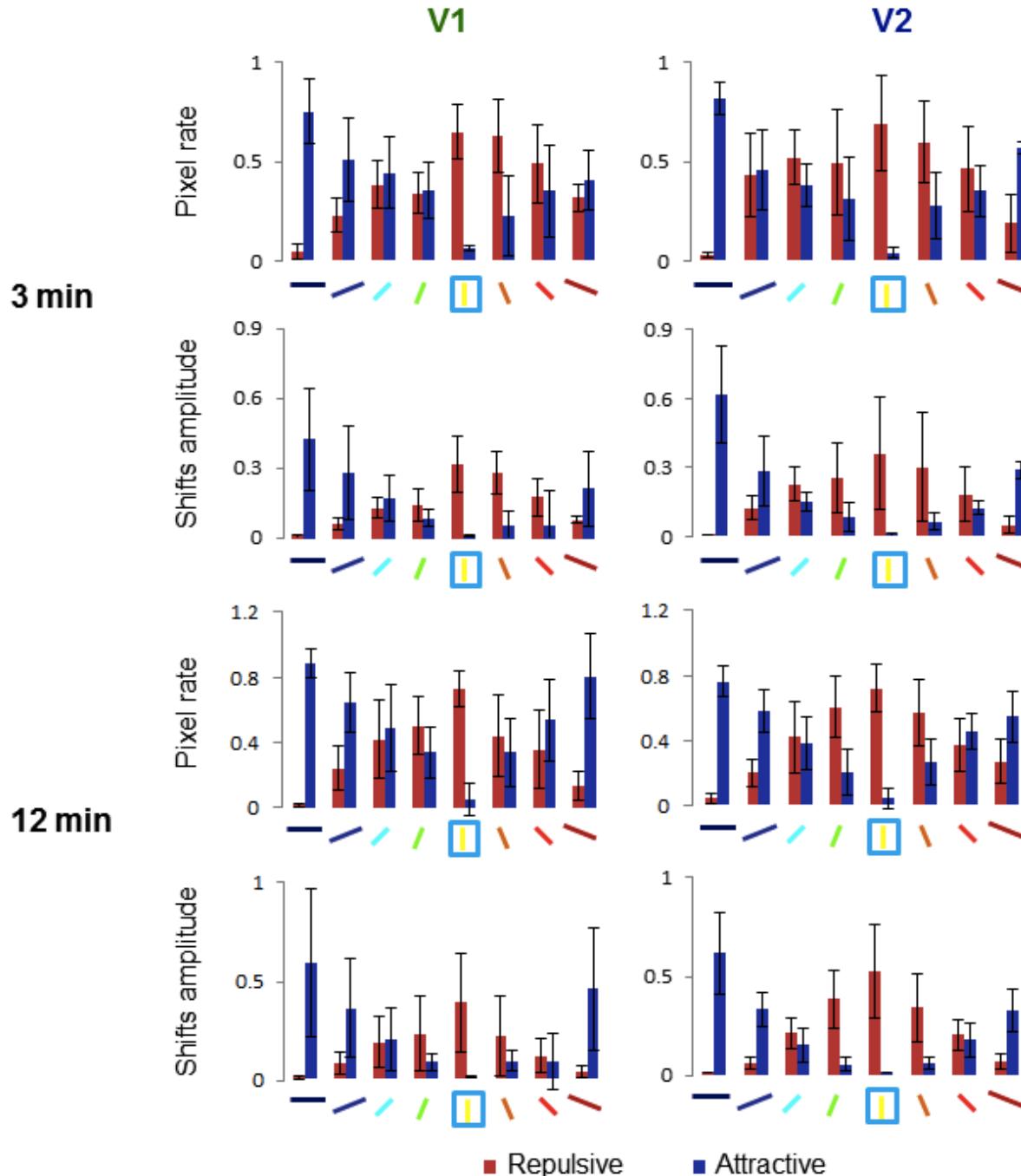


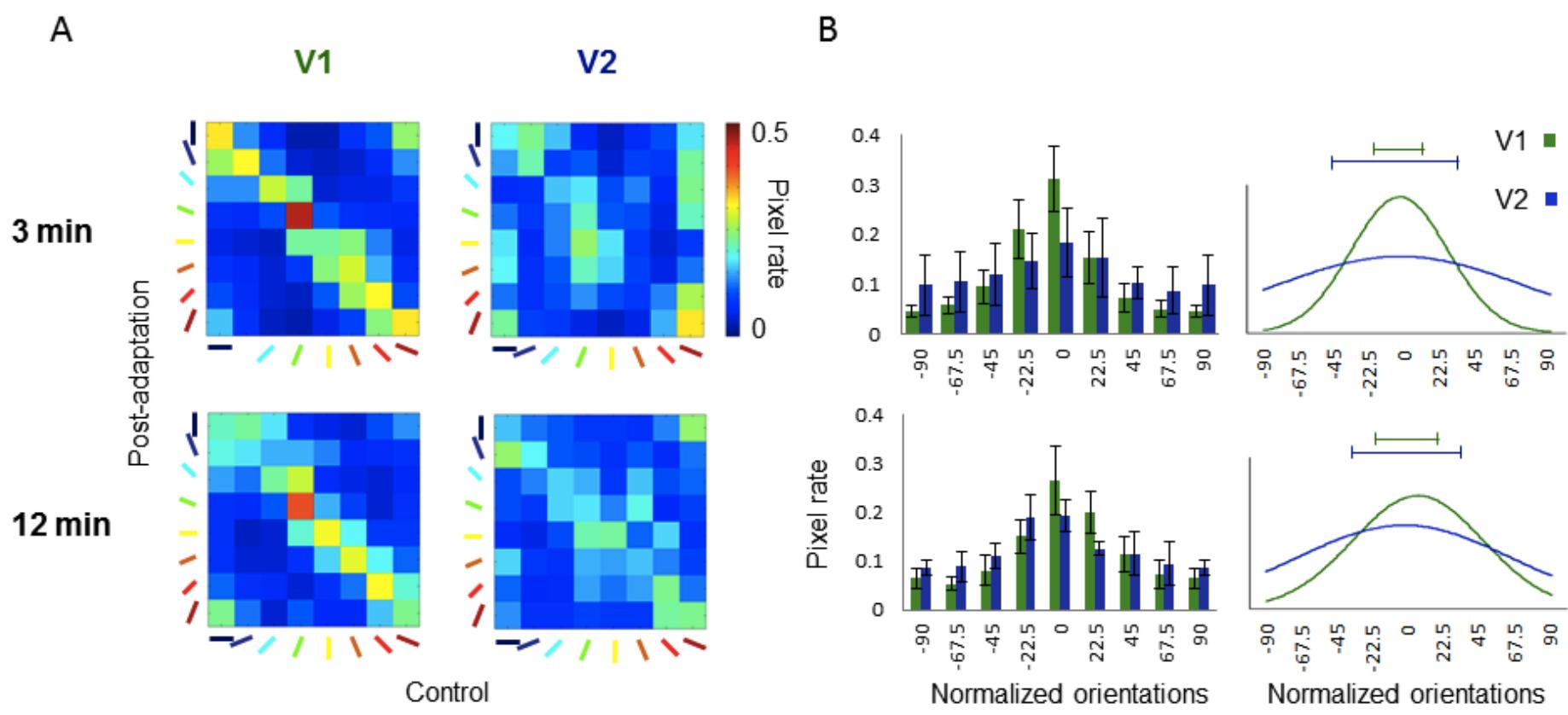
E





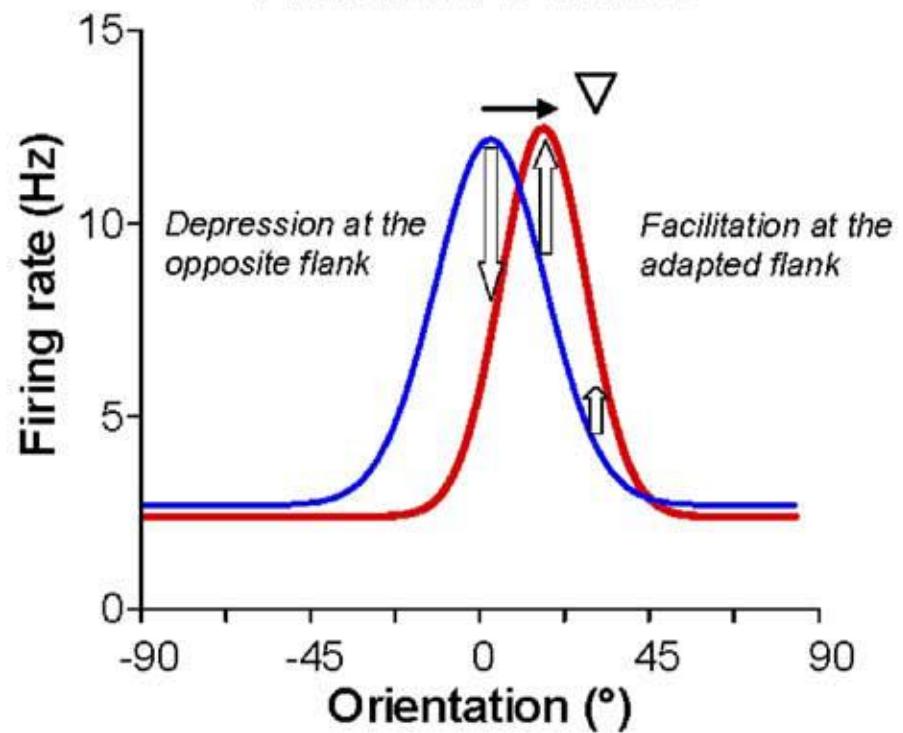
A



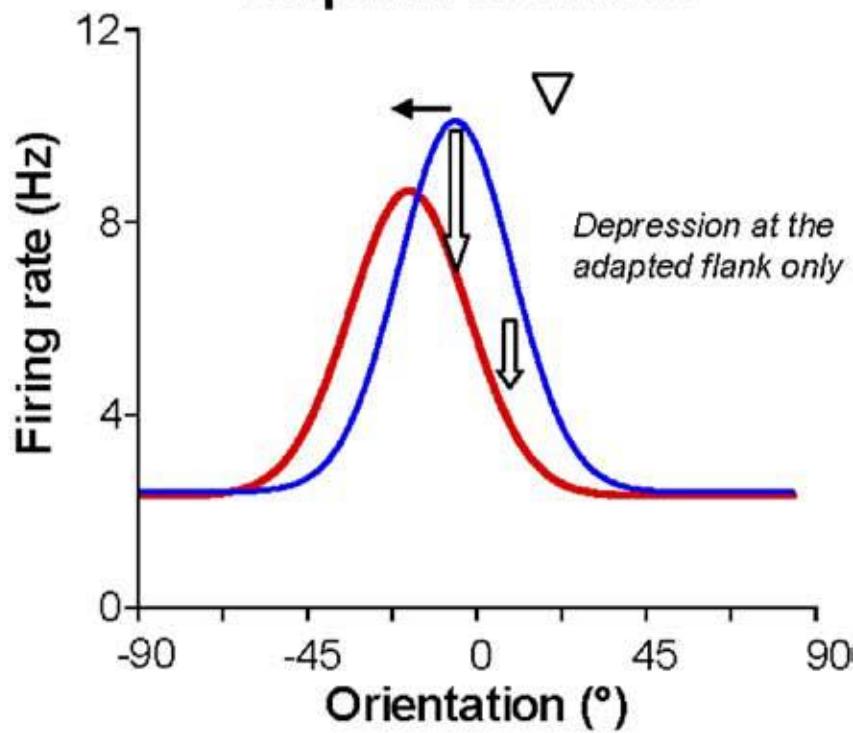


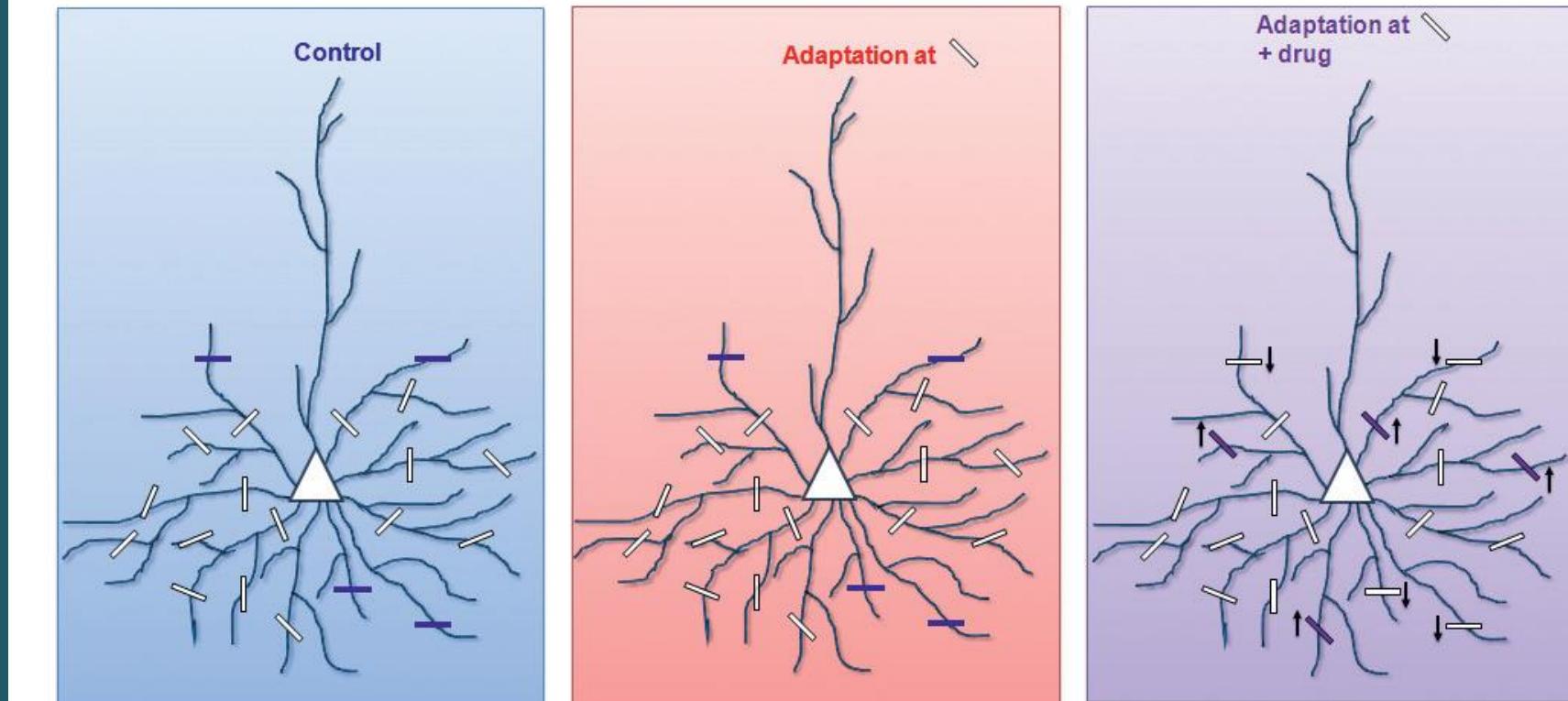
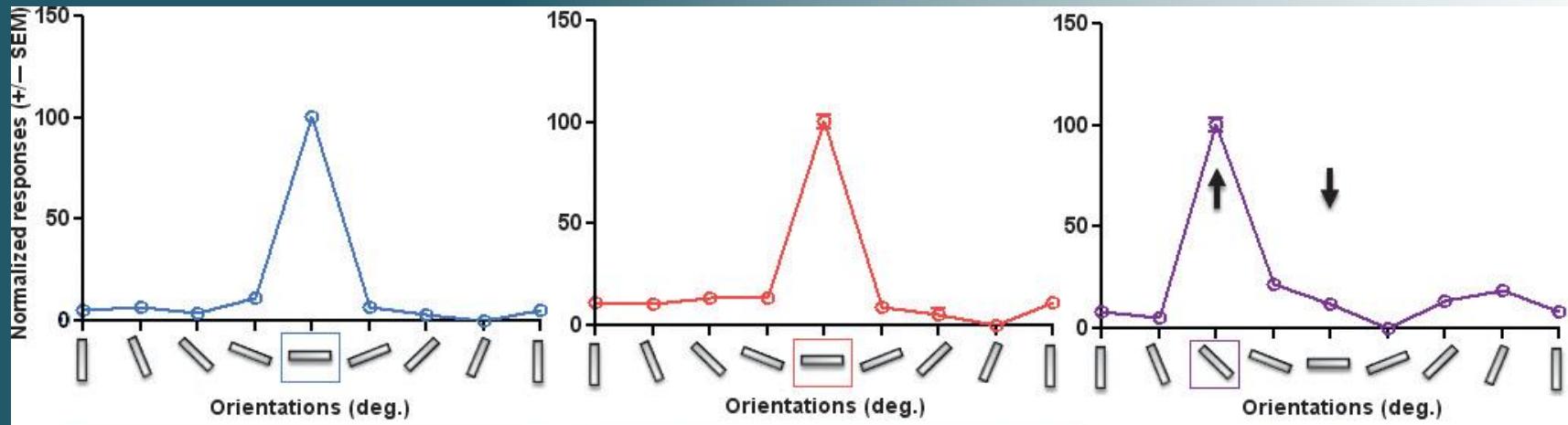
**A**

### Attractive shifts

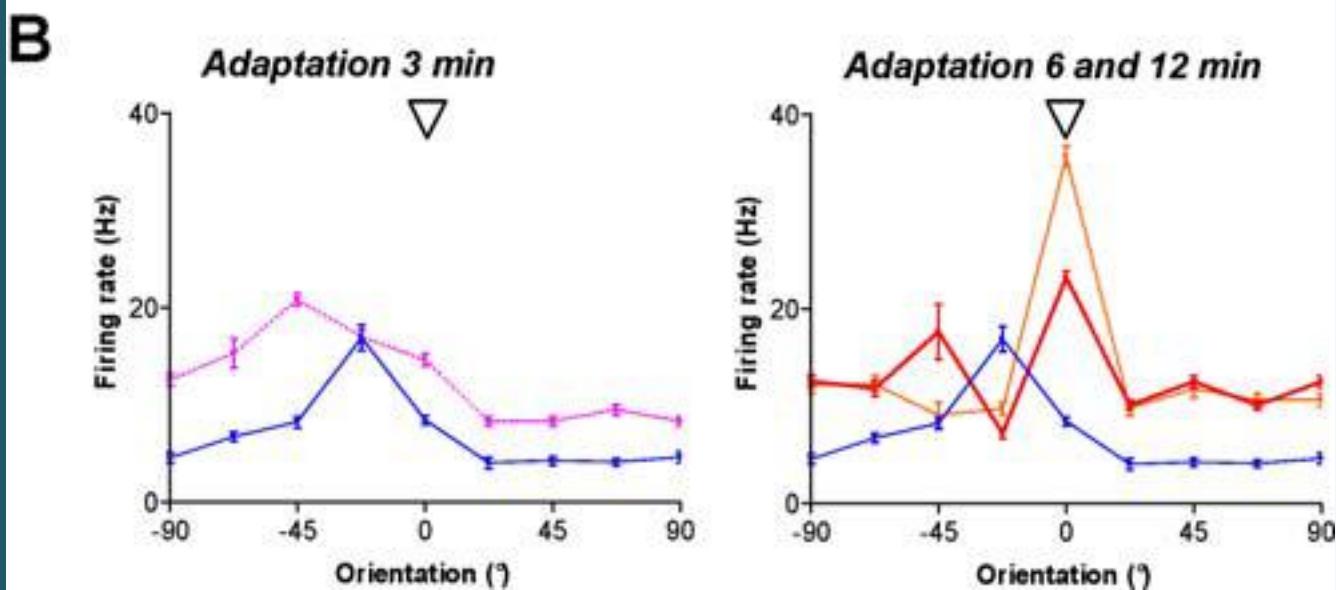
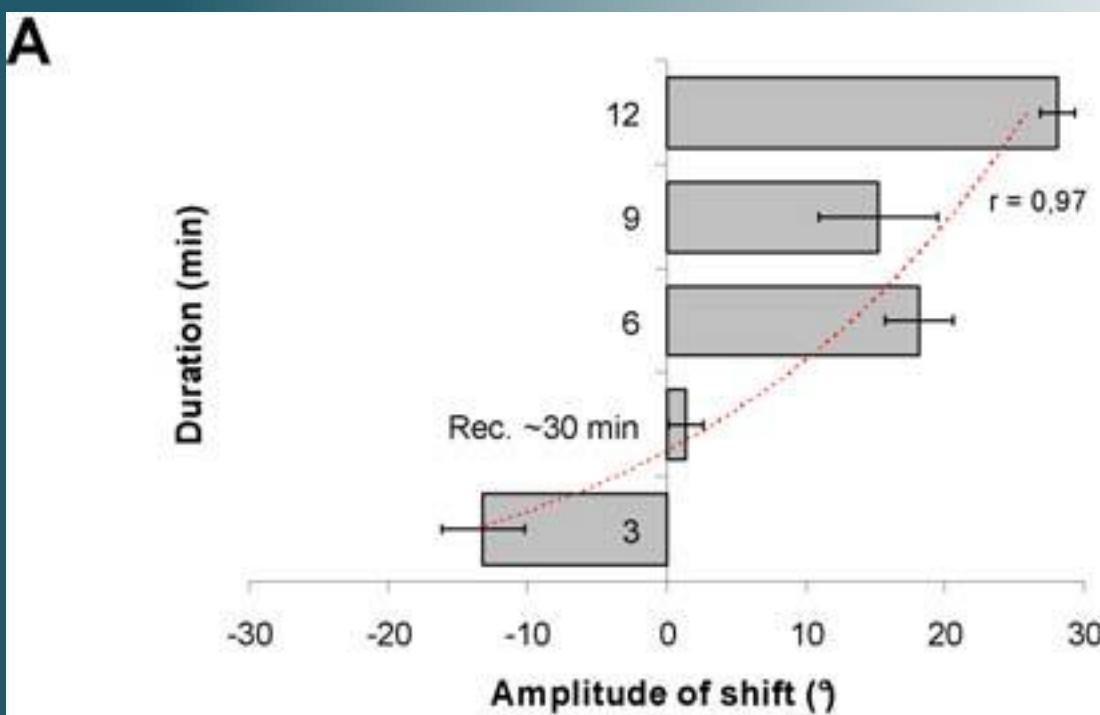
**B**

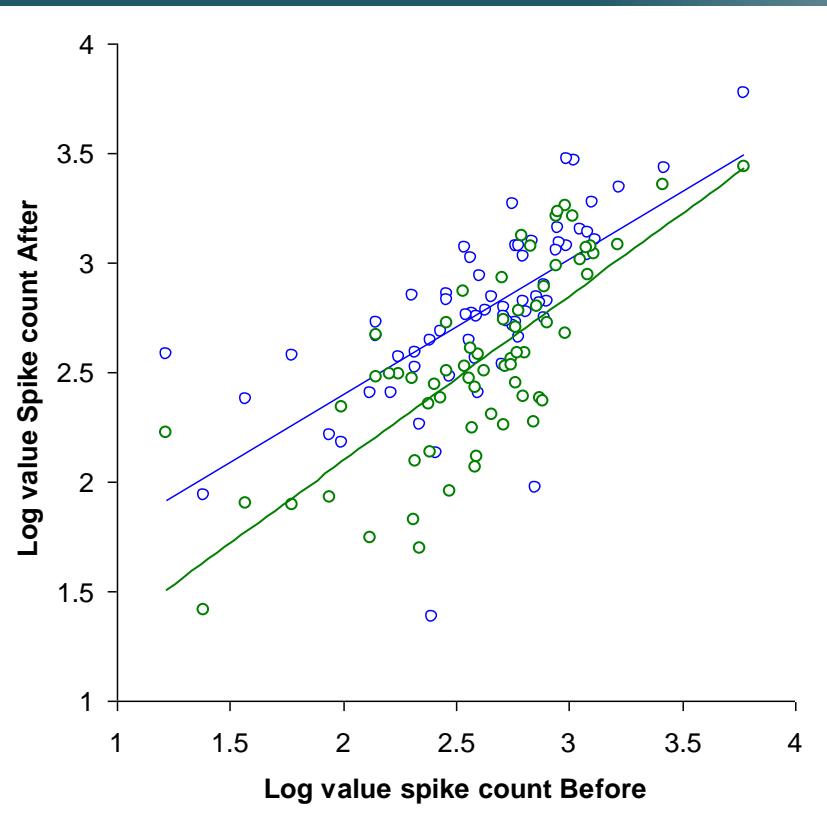
### Repulsive shifts



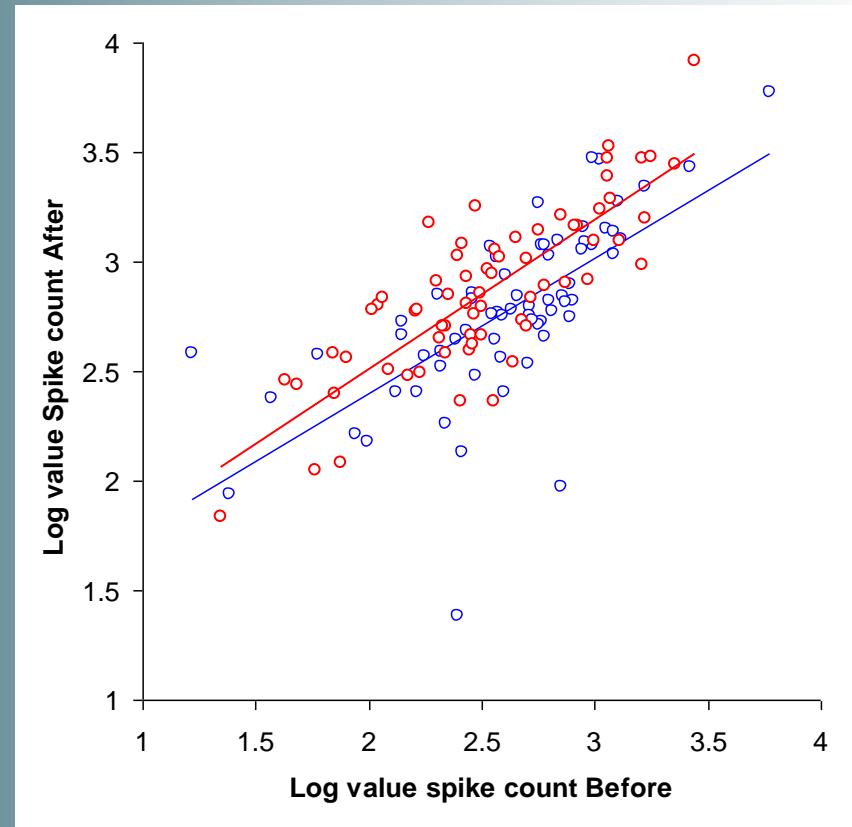


Cells remember the adapter!





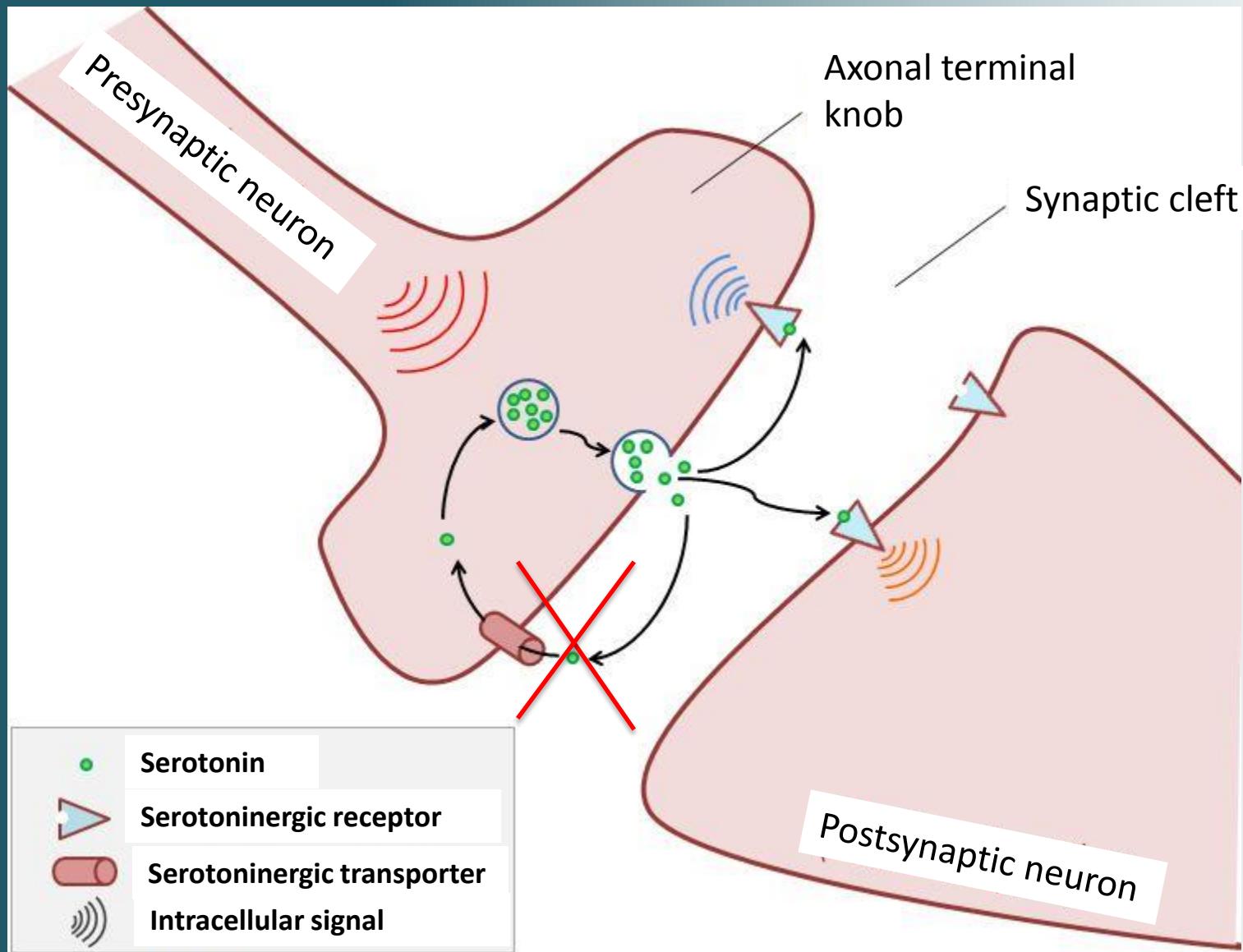
Orientation tested:  
New preferred orientation

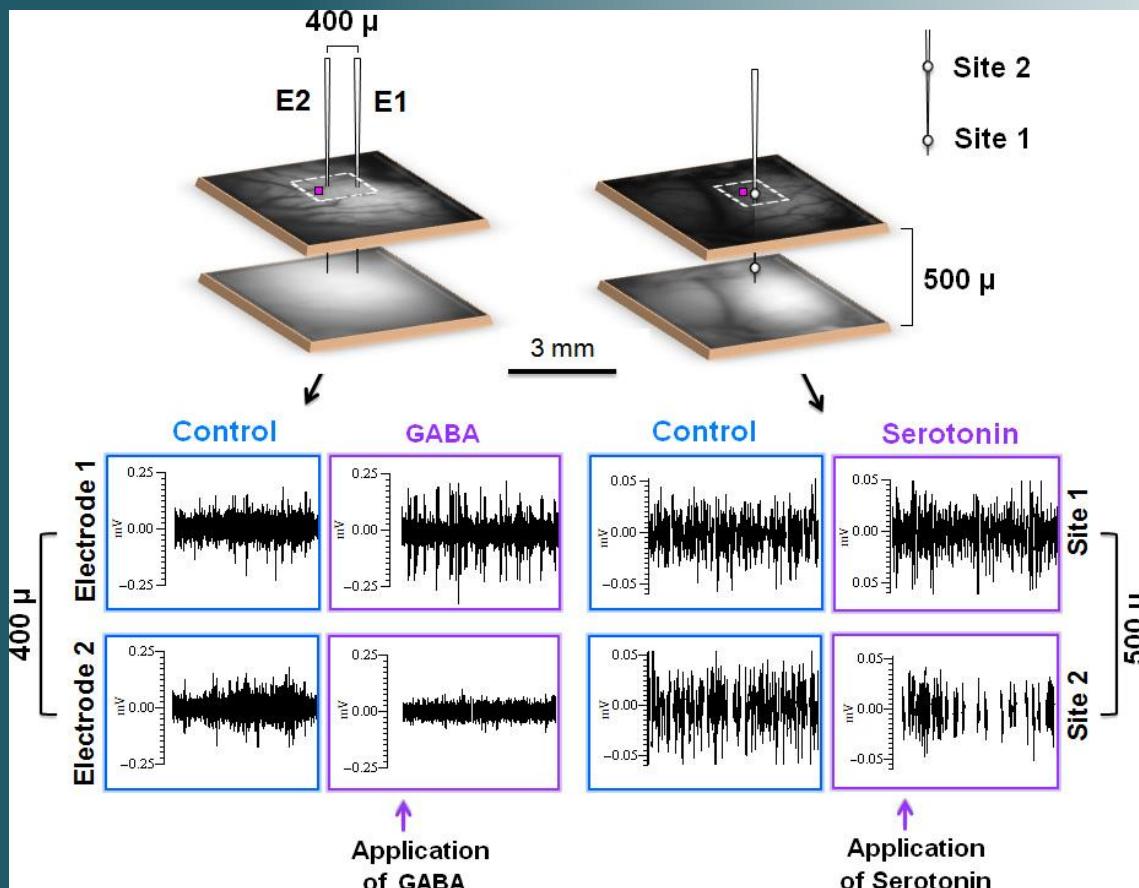
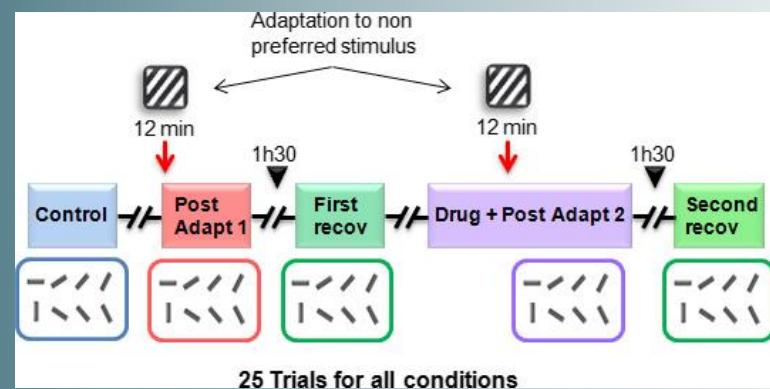
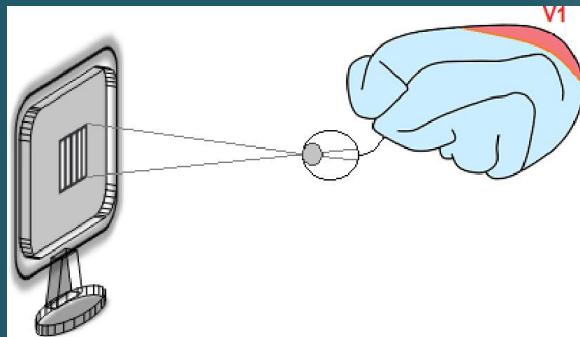


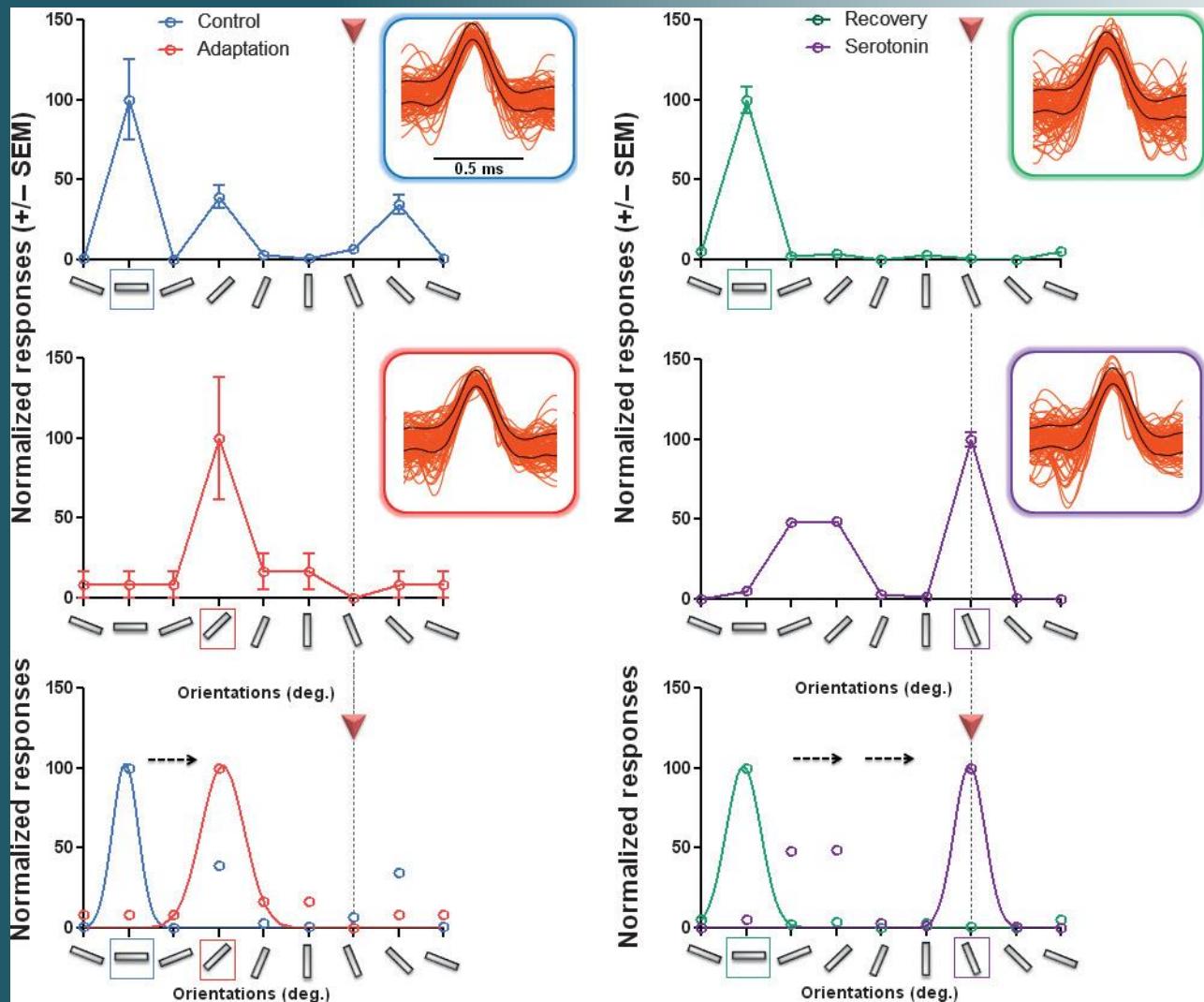
Green = prior to adaptation  
Blue = after **first** adaptation  
Red = after **second** adaptation

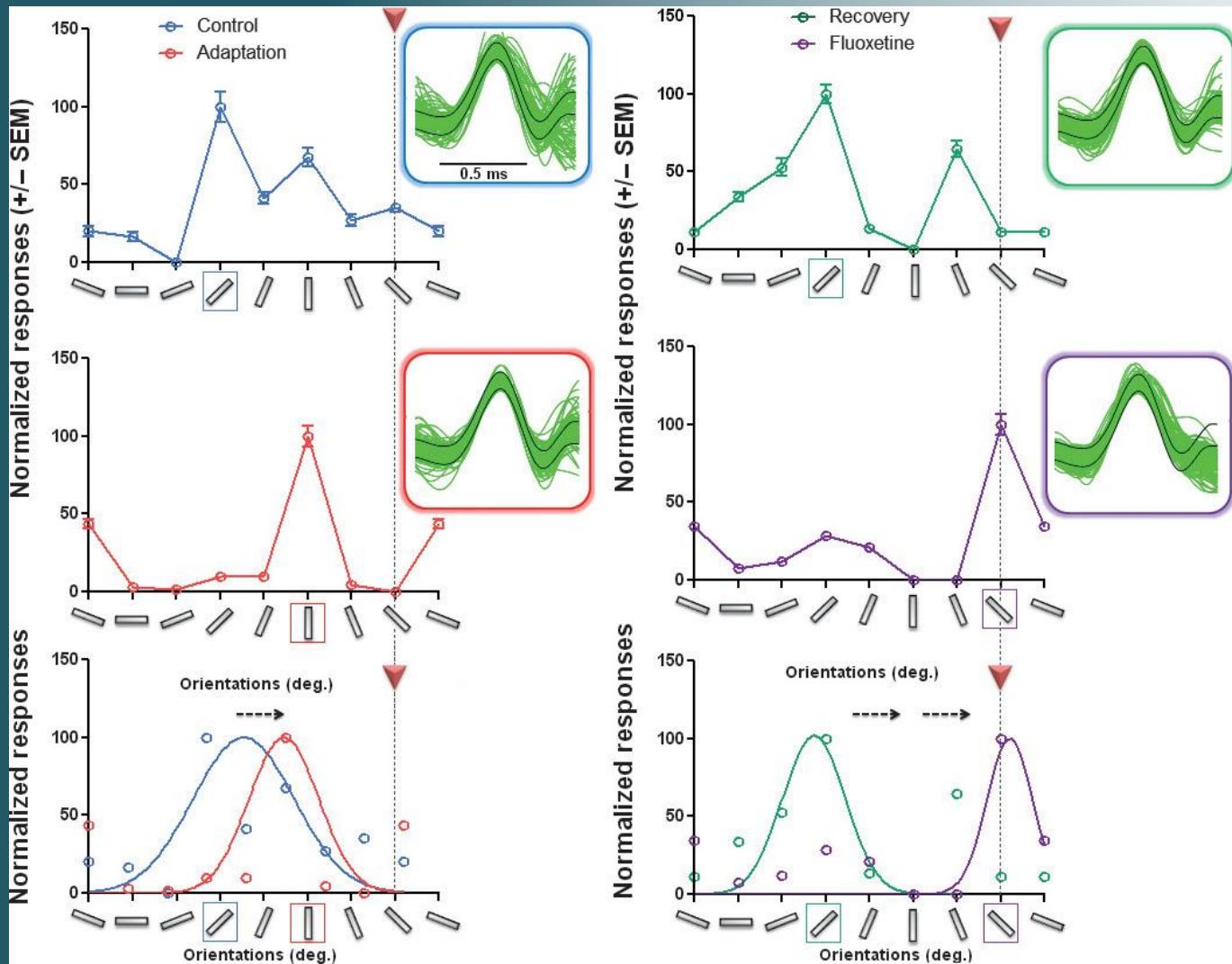
Is serotonin involved in this kind of  
plasticity

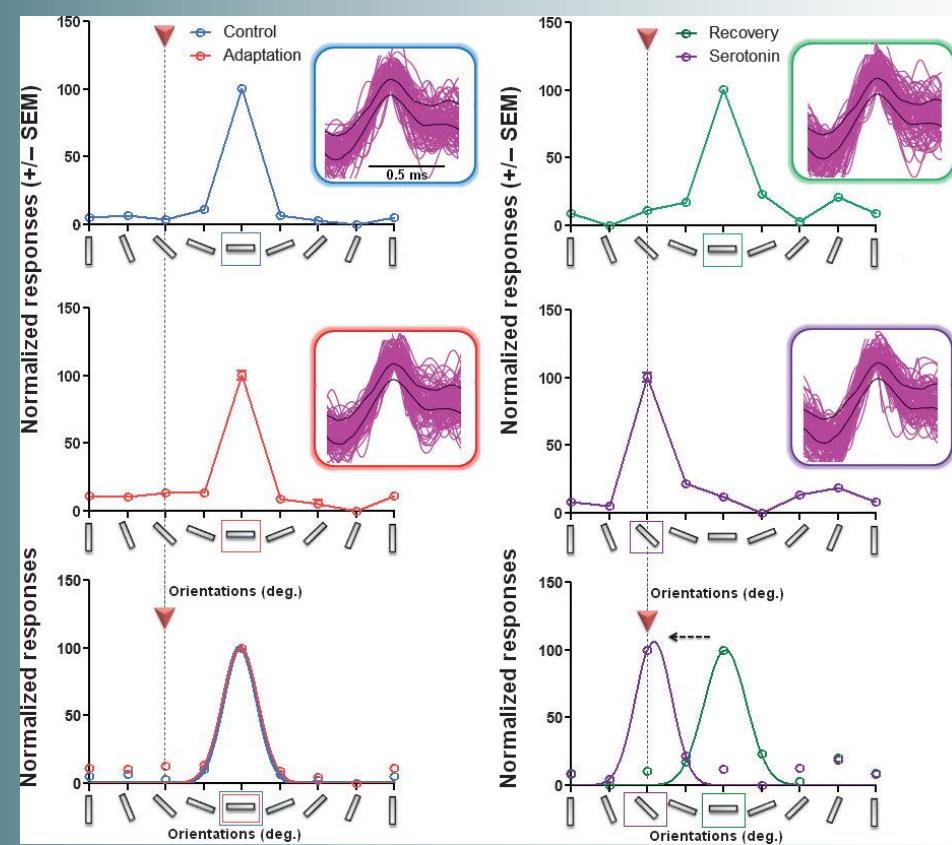
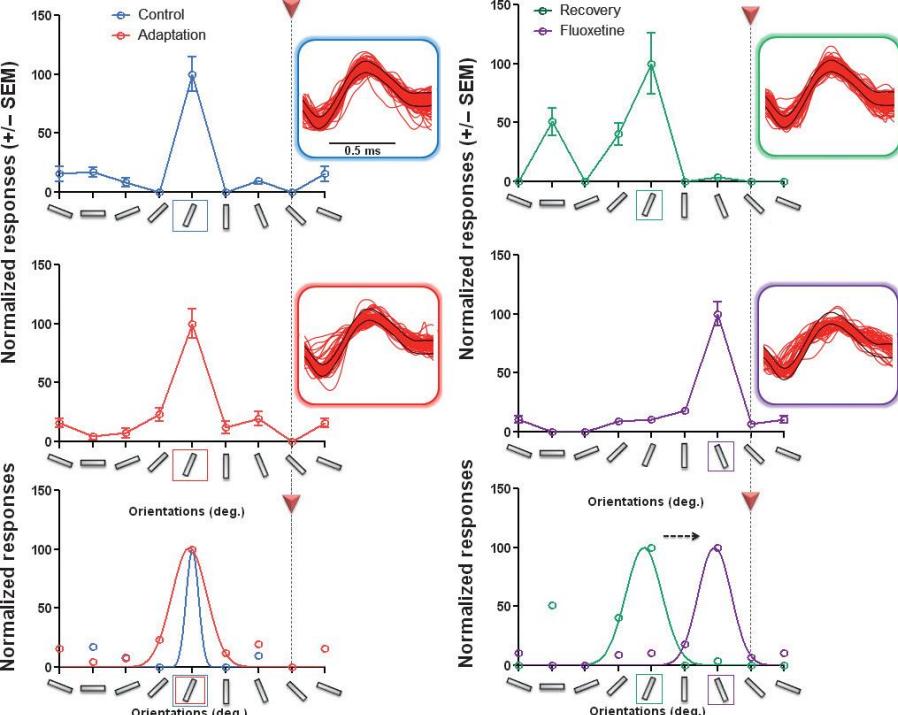
Pharmacological mechanism

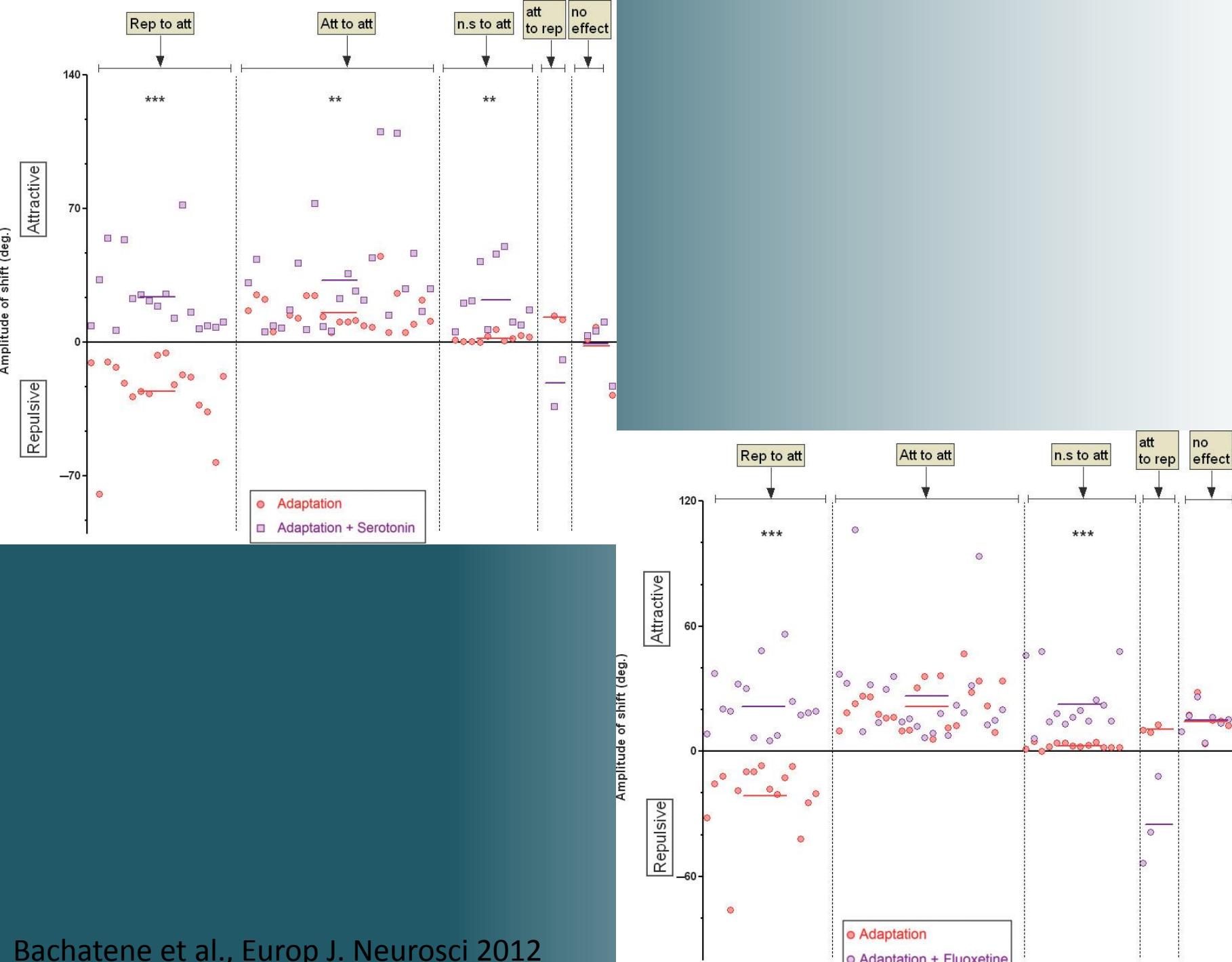


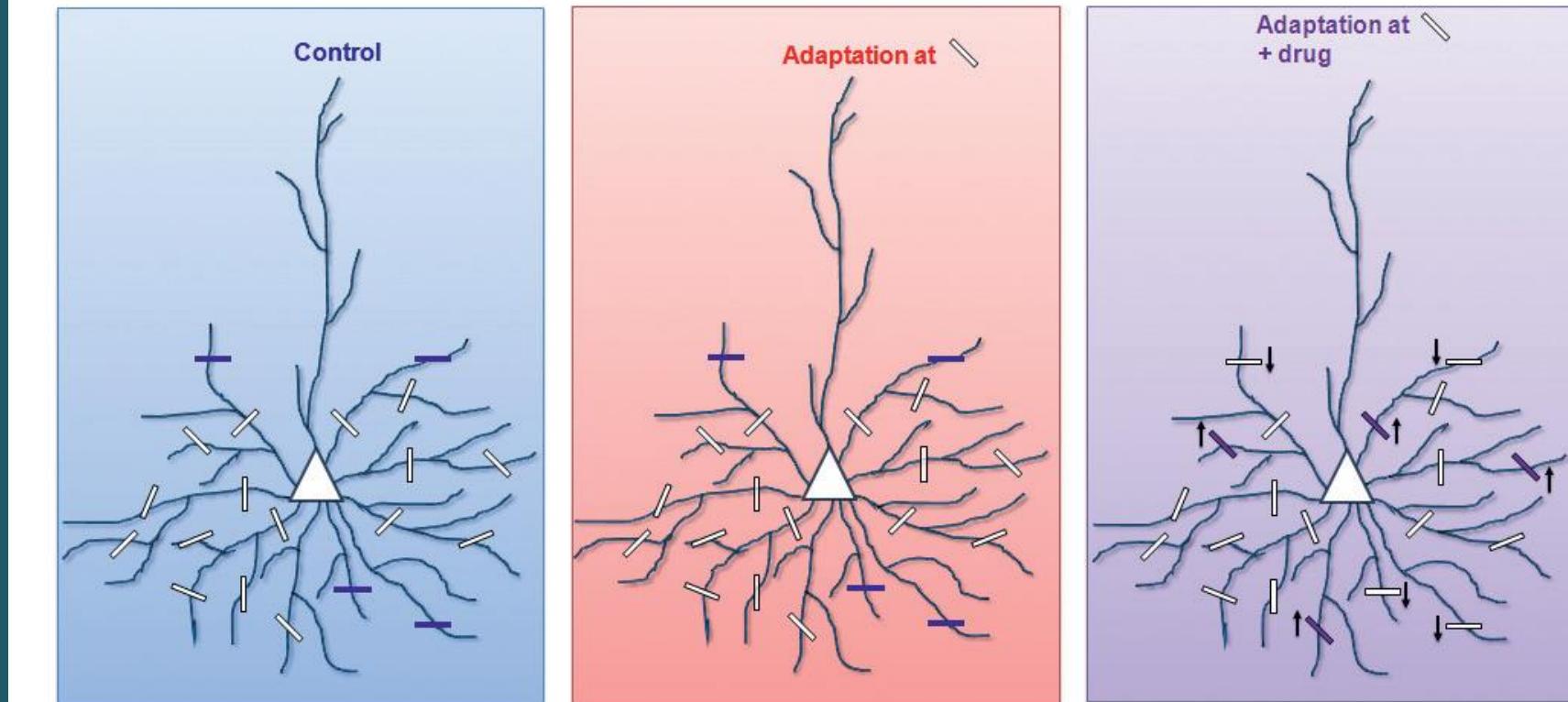
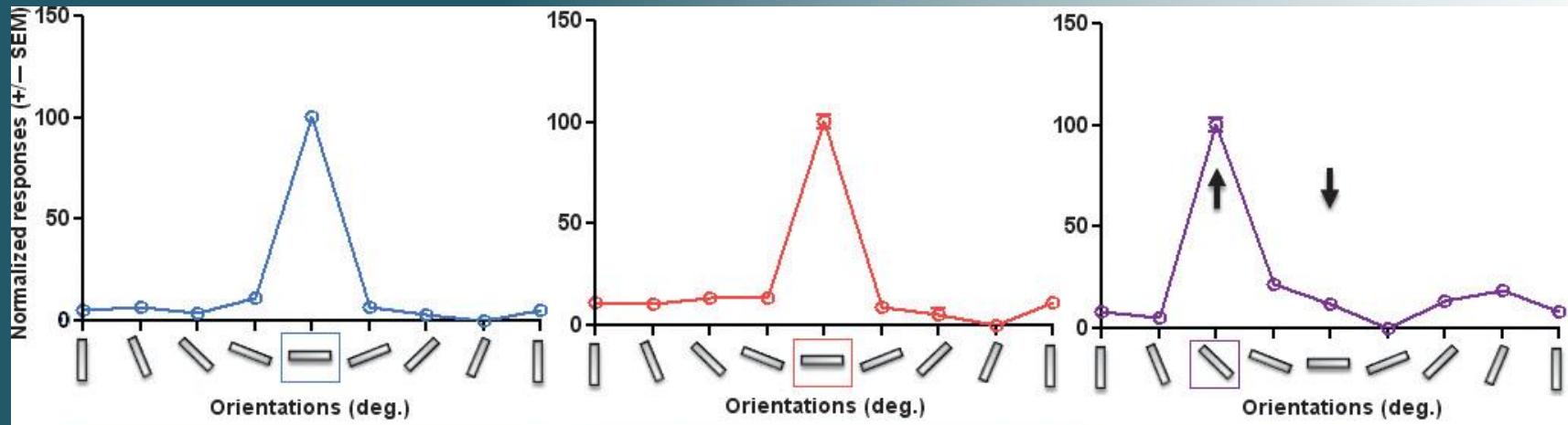






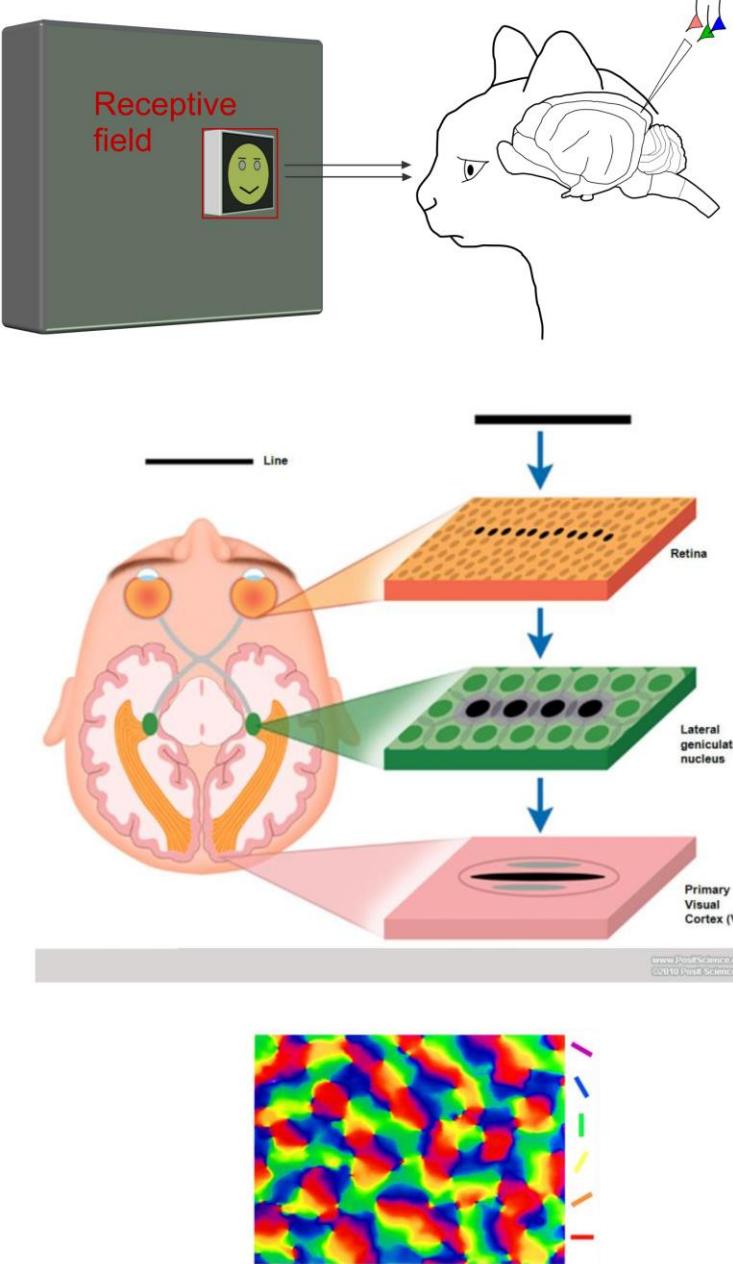




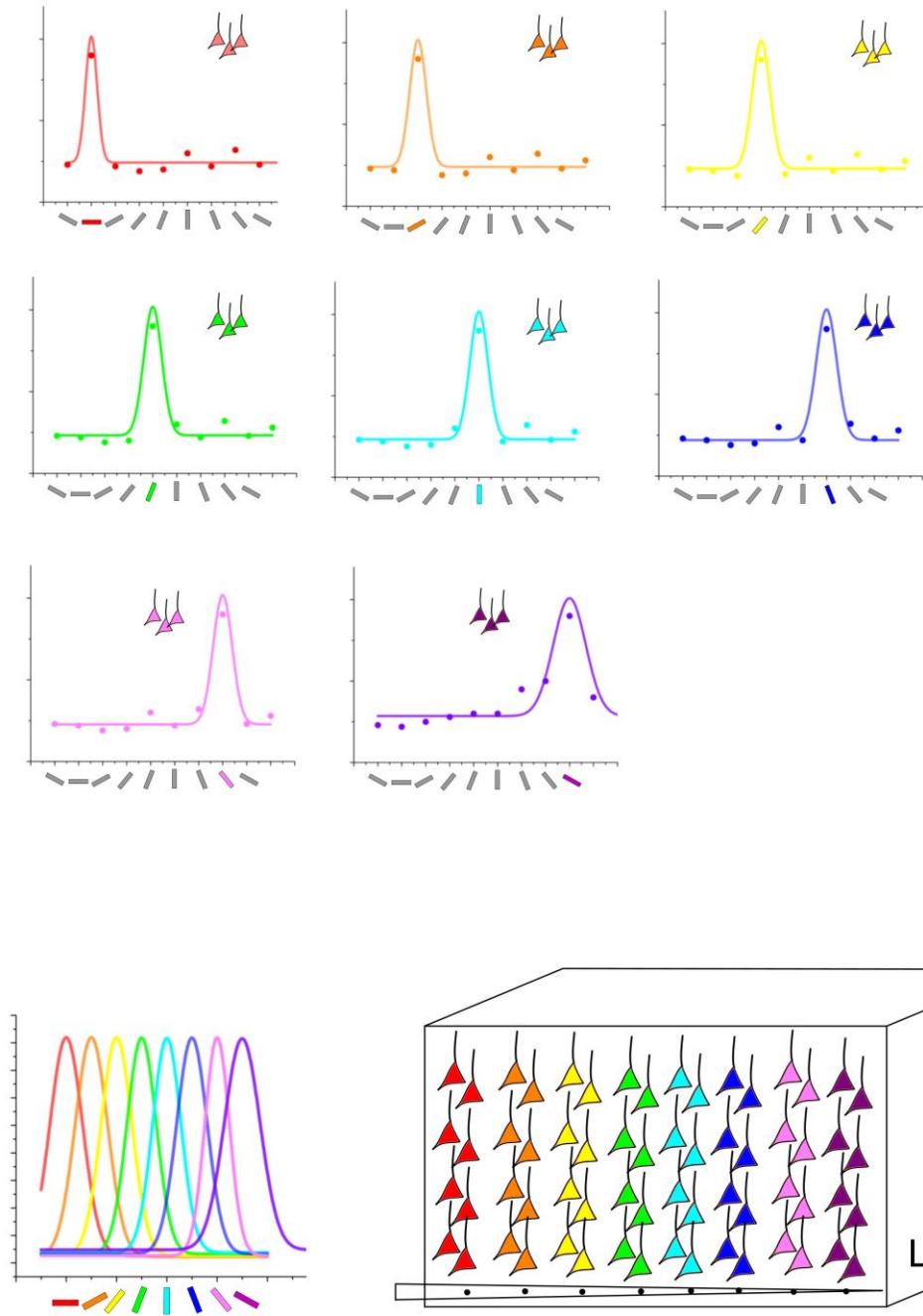


How does the brain process ?

From retina to the visual cortex



Orientation map



Cortical module

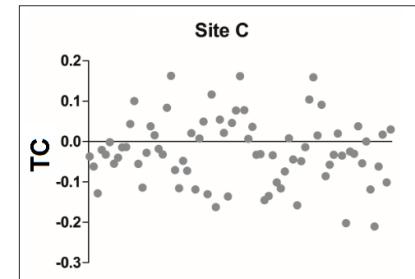
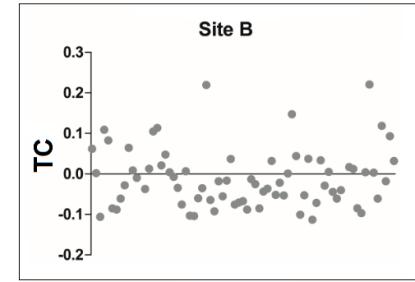
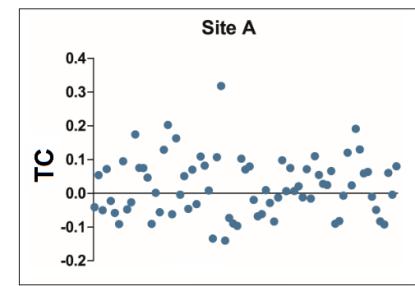
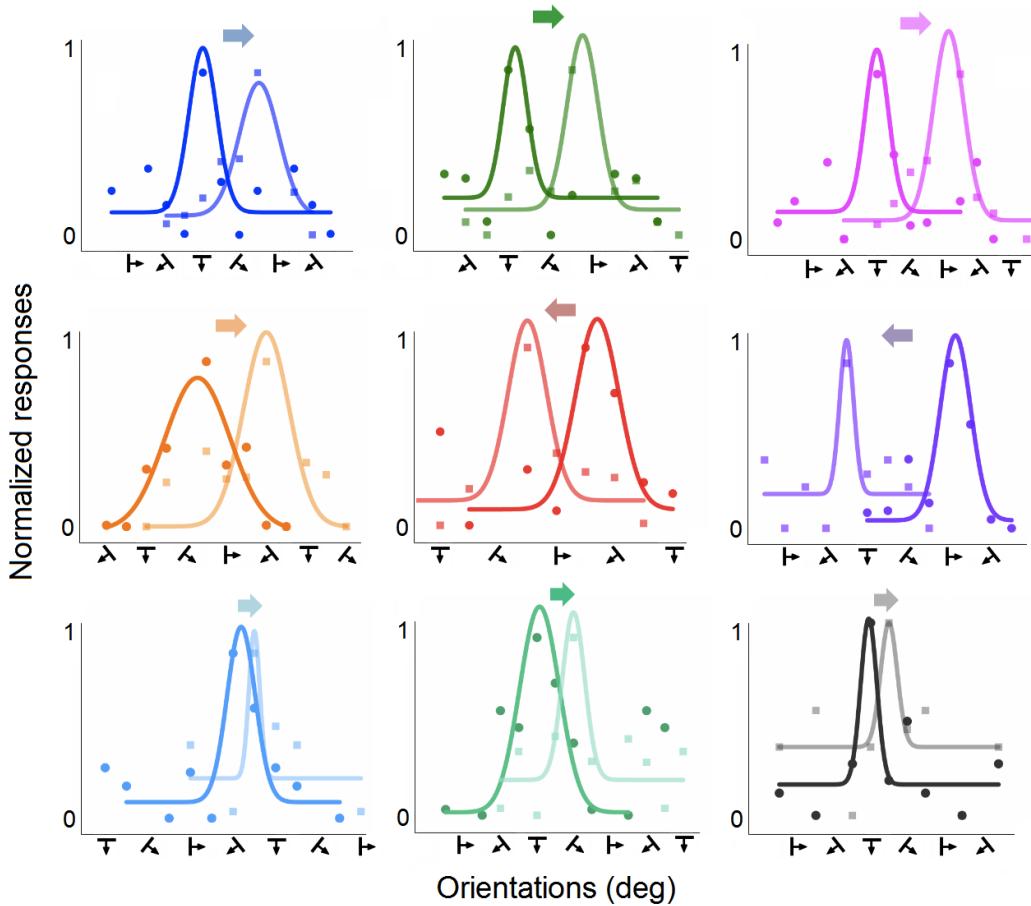
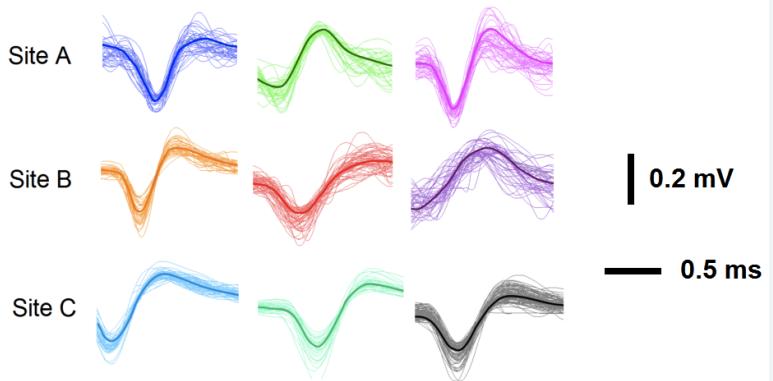
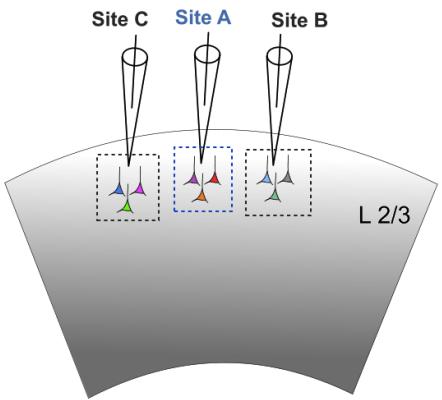
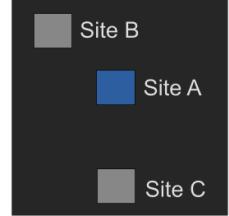
- If orientation changes
- does that imply that brain (visual areas ) has an orientation hole and become blind to one specific orientation?
- Or do we have a full reorganization of orientation domains

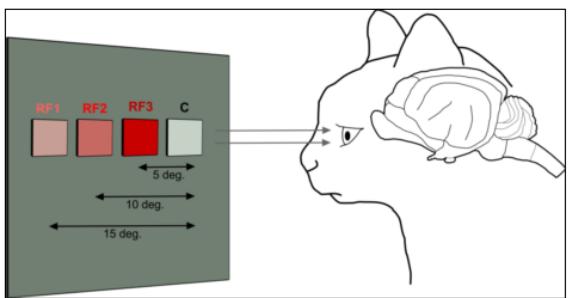
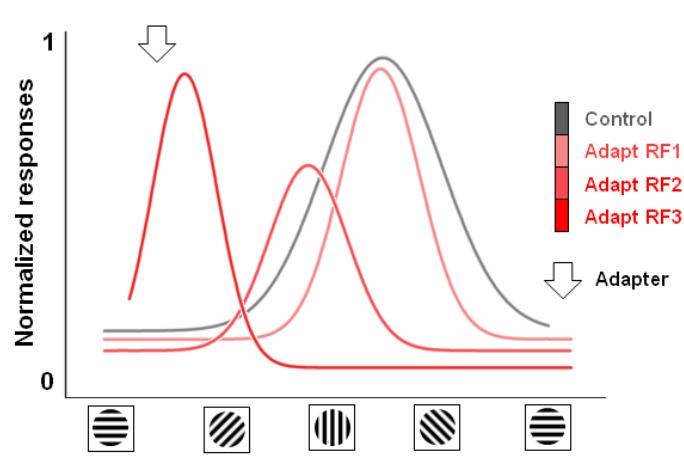
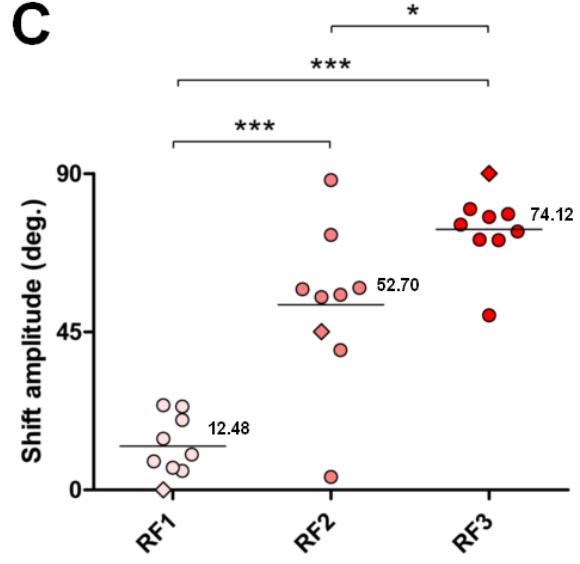
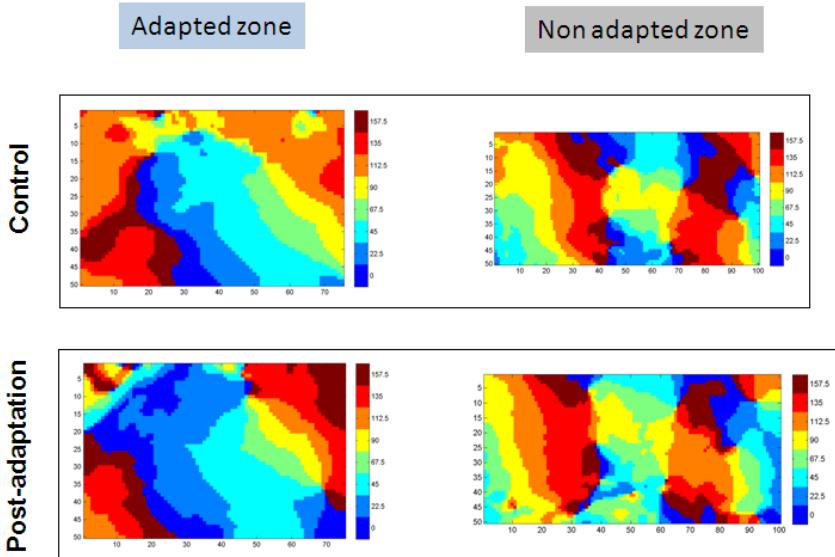
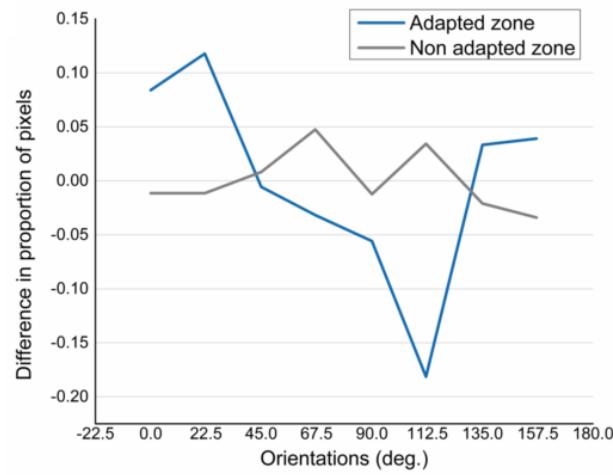
# Three circumscribed sites

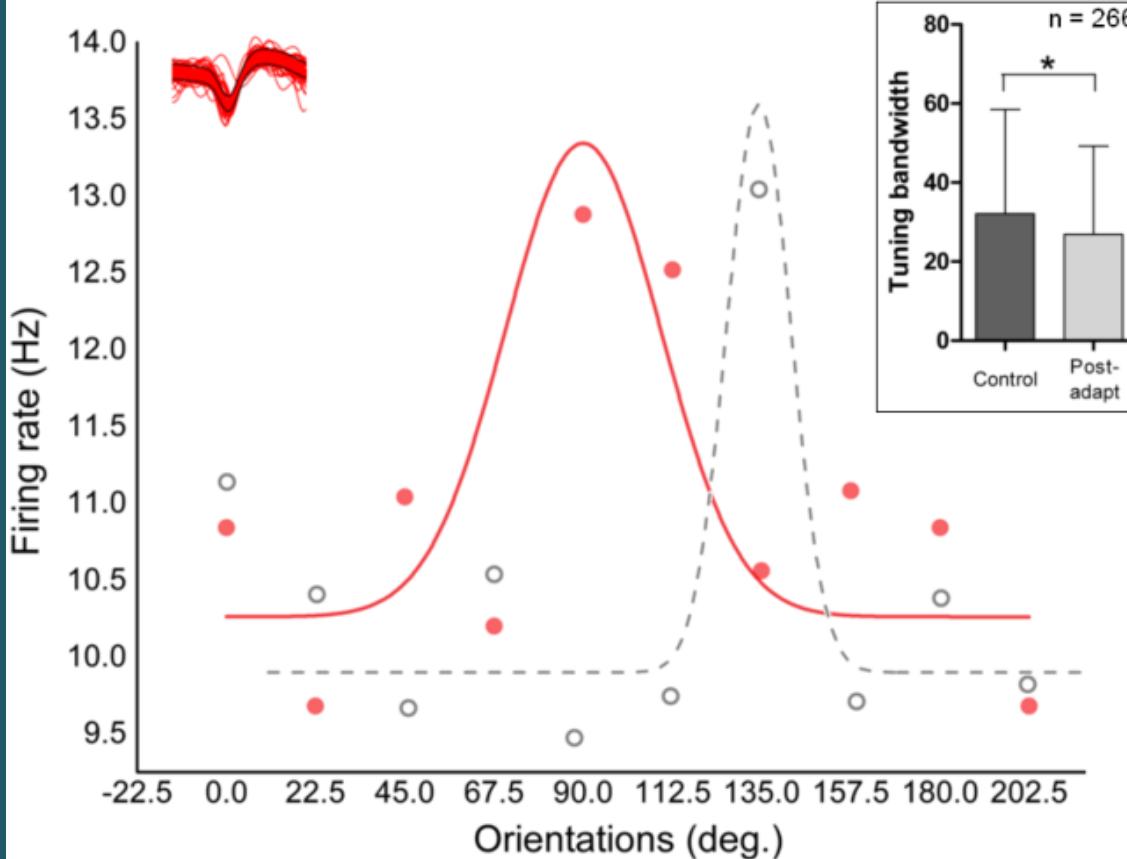
A = adapted

B and C = unadapted



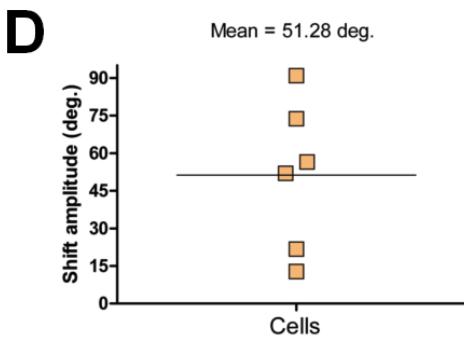
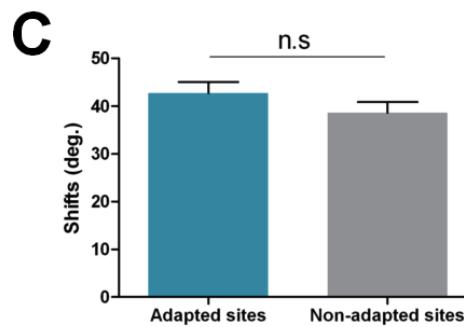
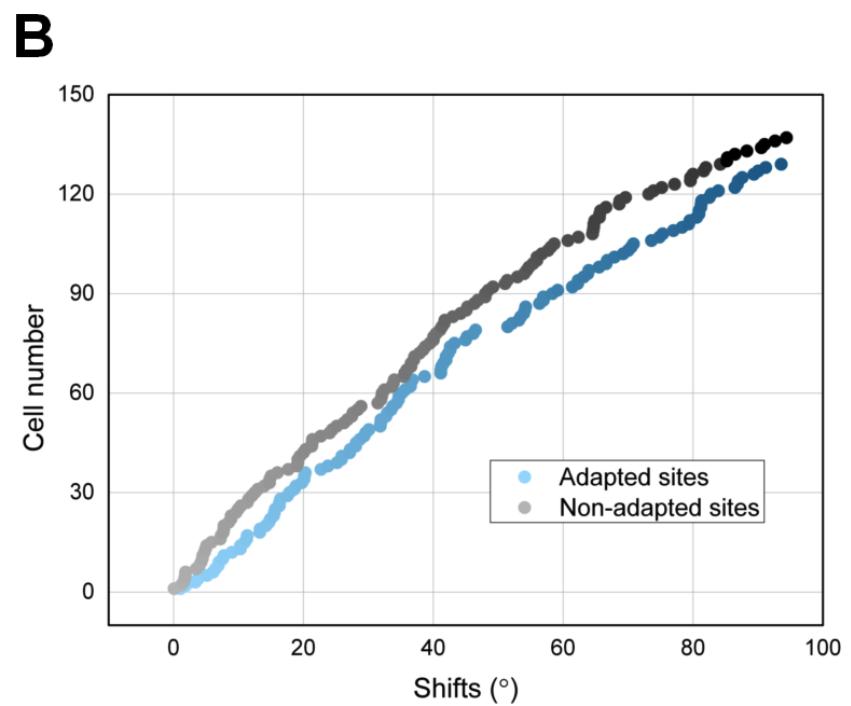
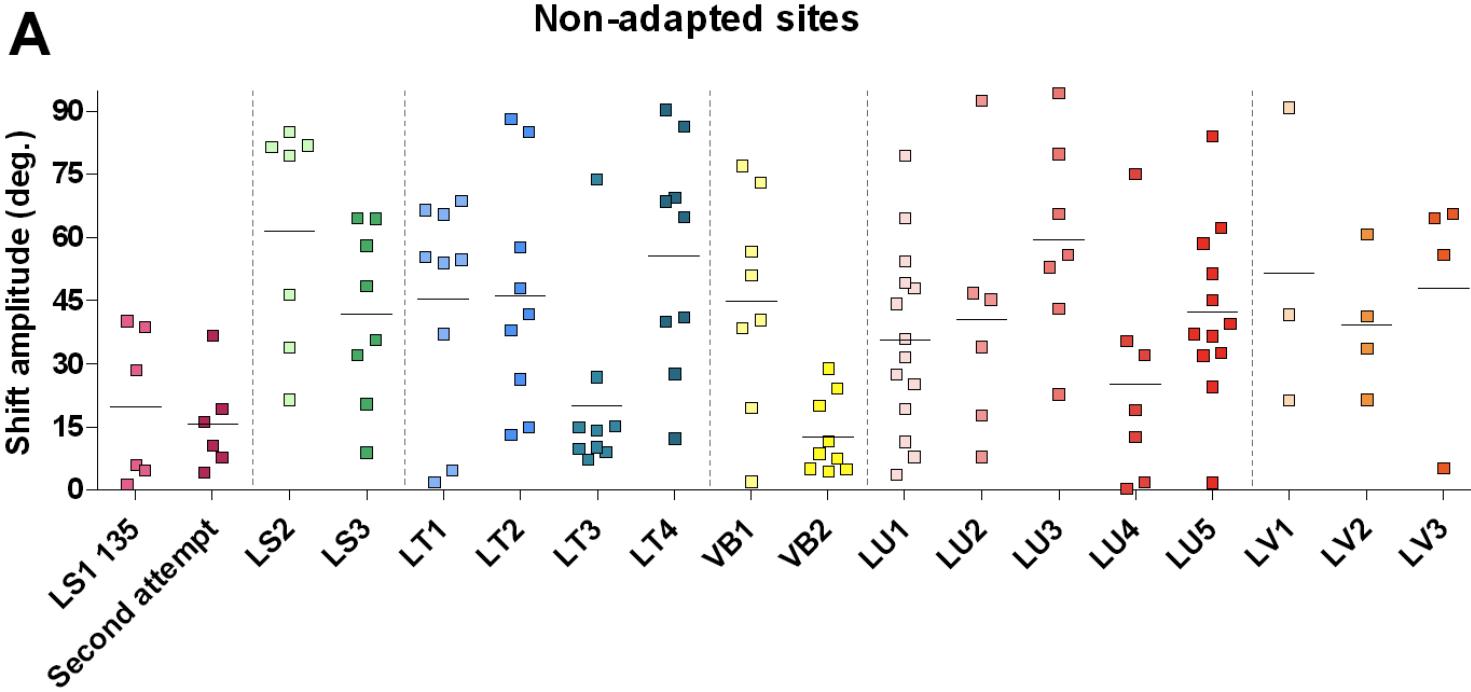


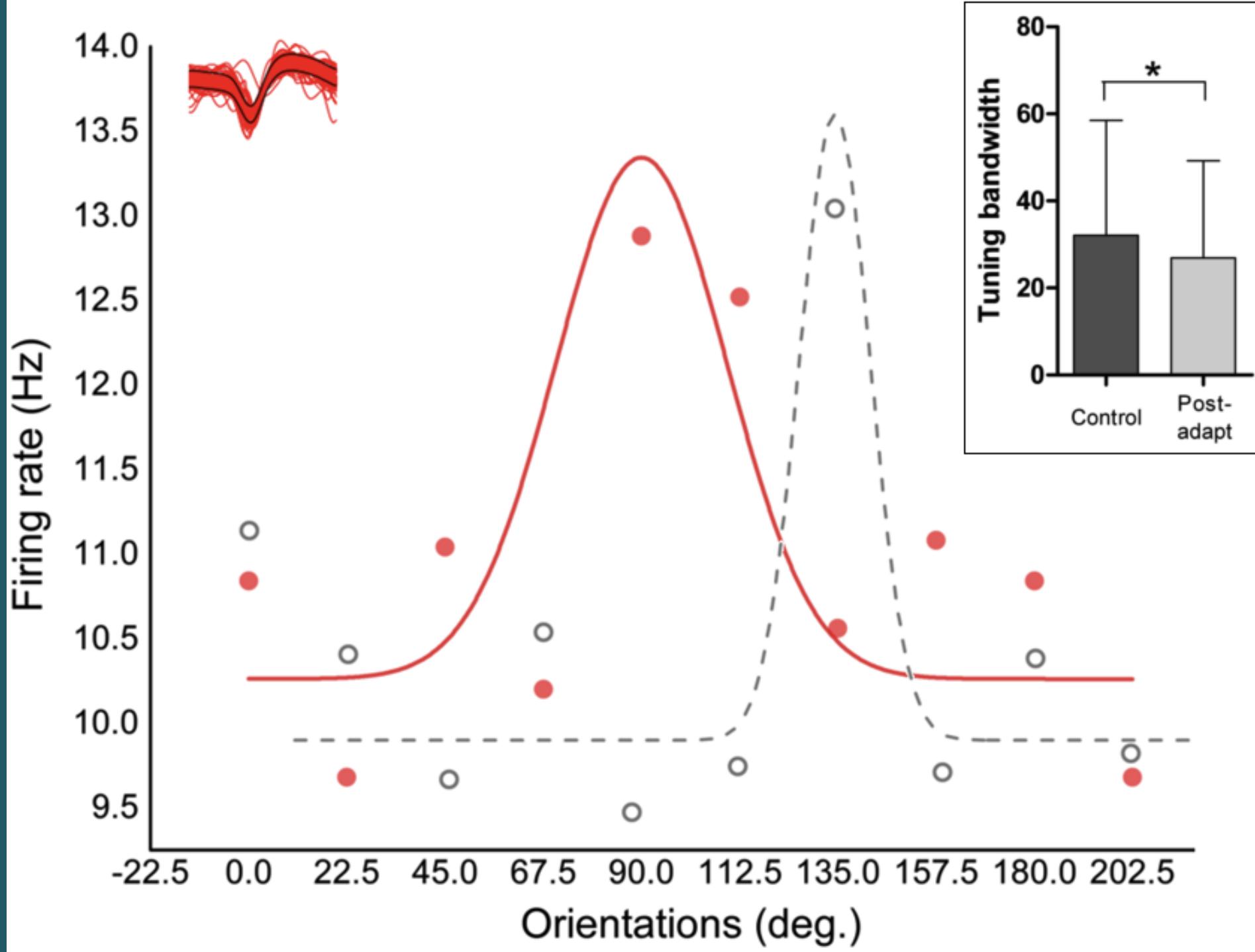
**A****B****C****D****E**



Enhanced neuronal selectivity = enhanced neuronal discrimination

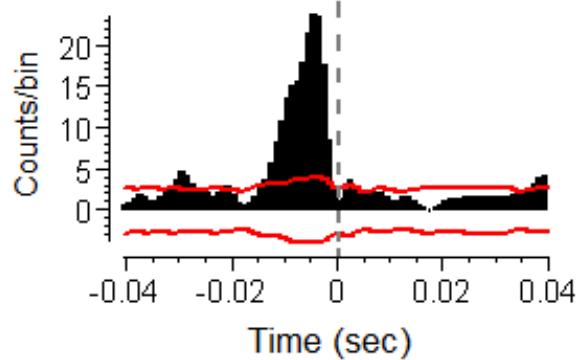
A → A





- The neuronal network is modified following adaptation

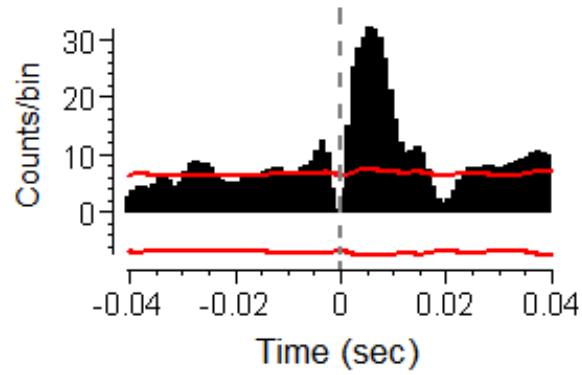
a) Reference cell = cell 1  
Target cell = cell 2



Target projects on reference

Cell 2  $\xrightarrow{\hspace{1cm}}$  Cell 1

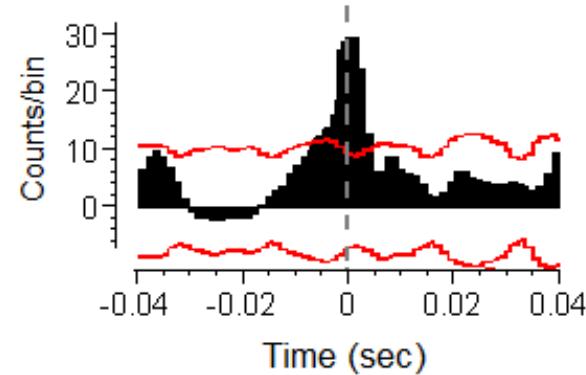
b) Reference cell = cell 1  
Target cell = cell 2



Reference projects on target

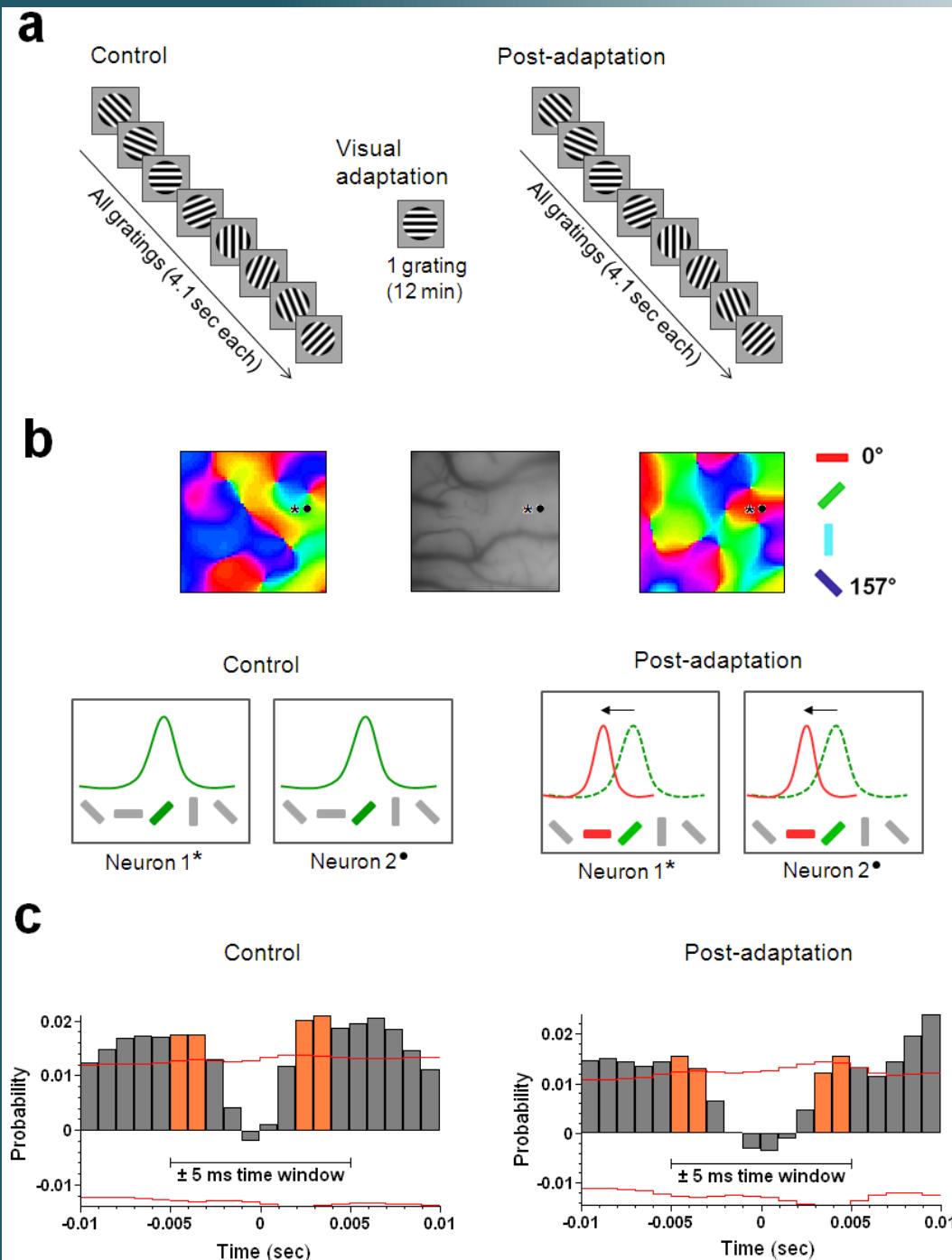
Cell 1  $\xrightarrow{\hspace{1cm}}$  Cell 2

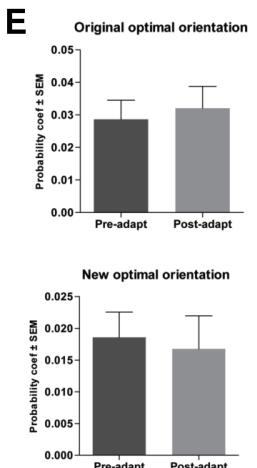
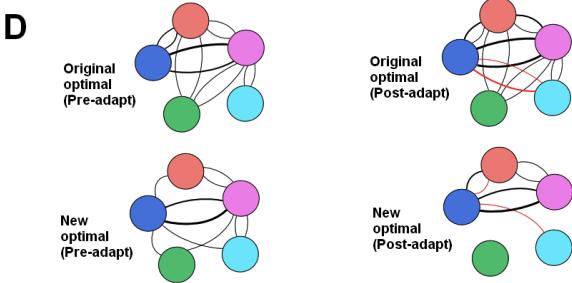
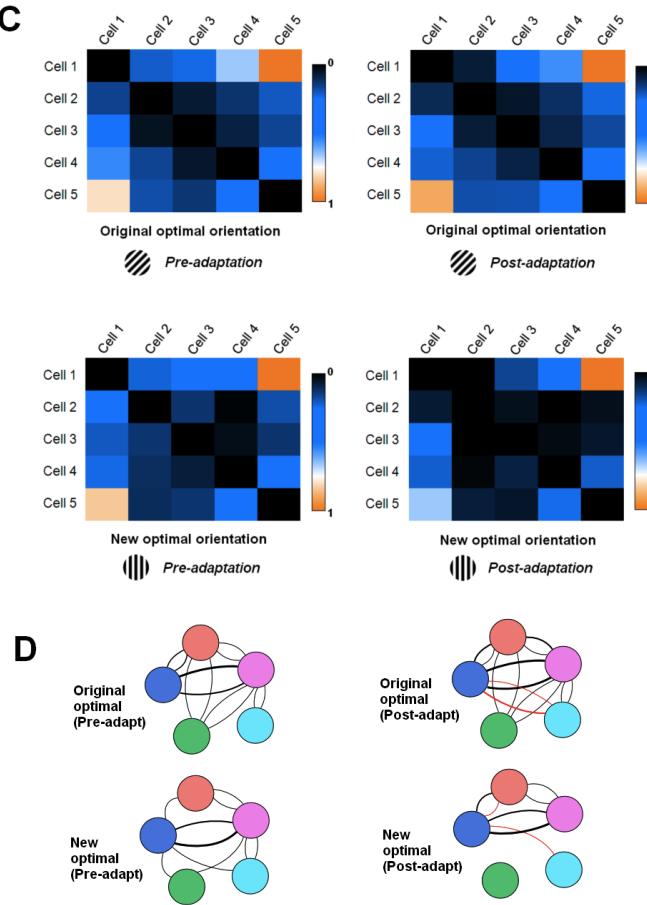
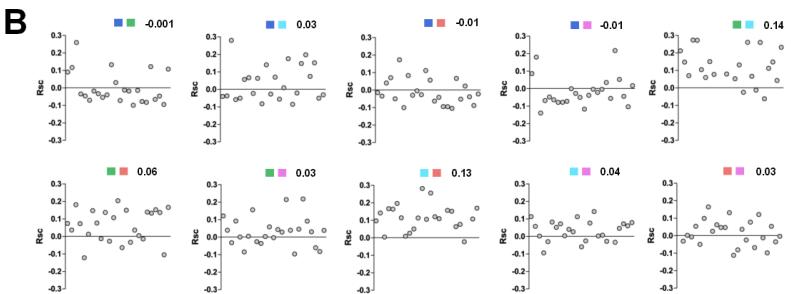
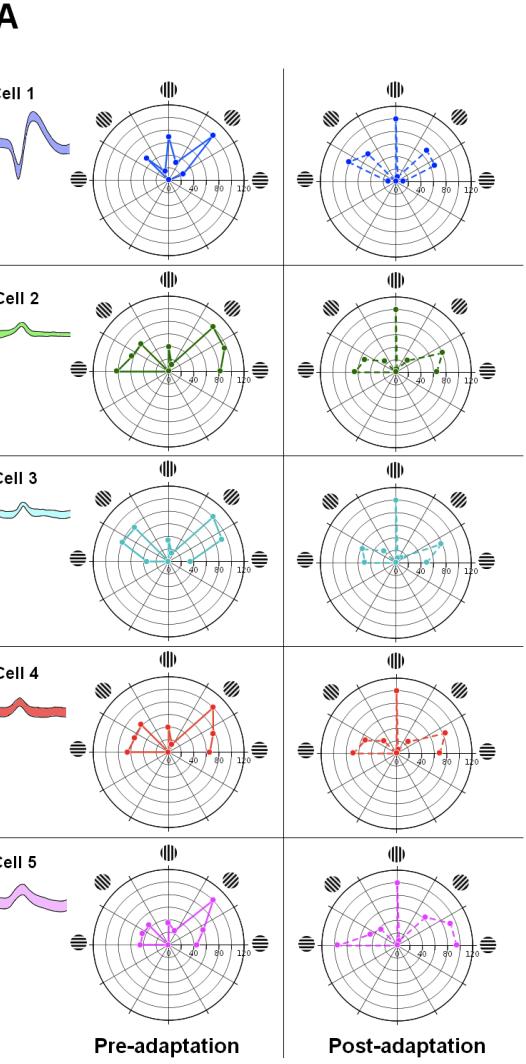
c) Reference cell = cell 1  
Target cell = cell 2



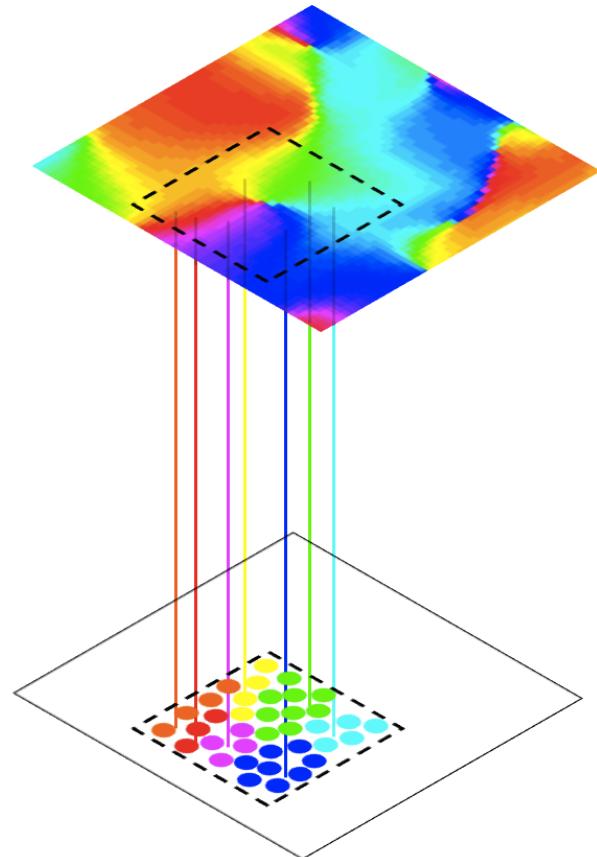
Common input



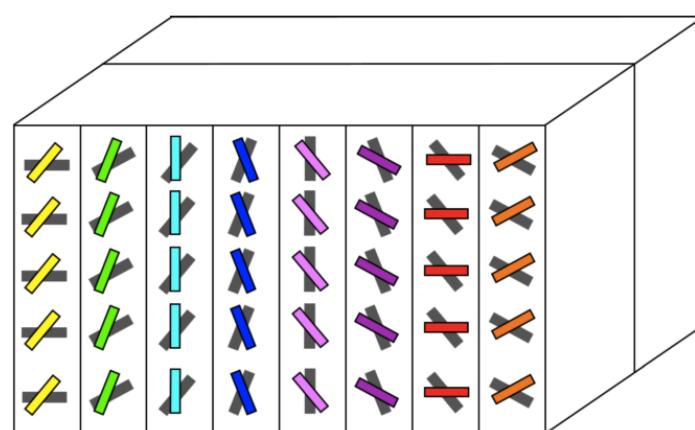
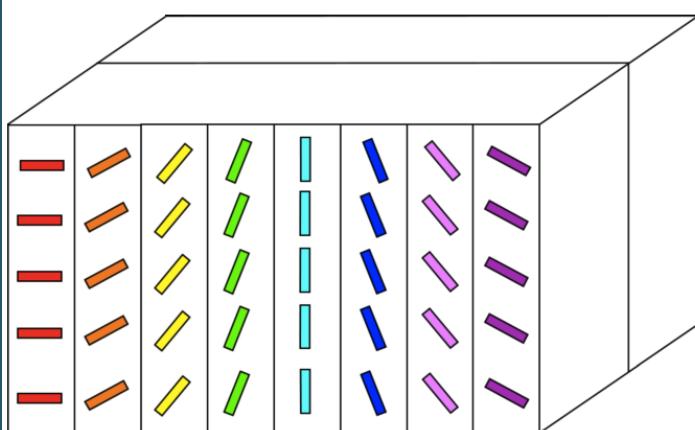
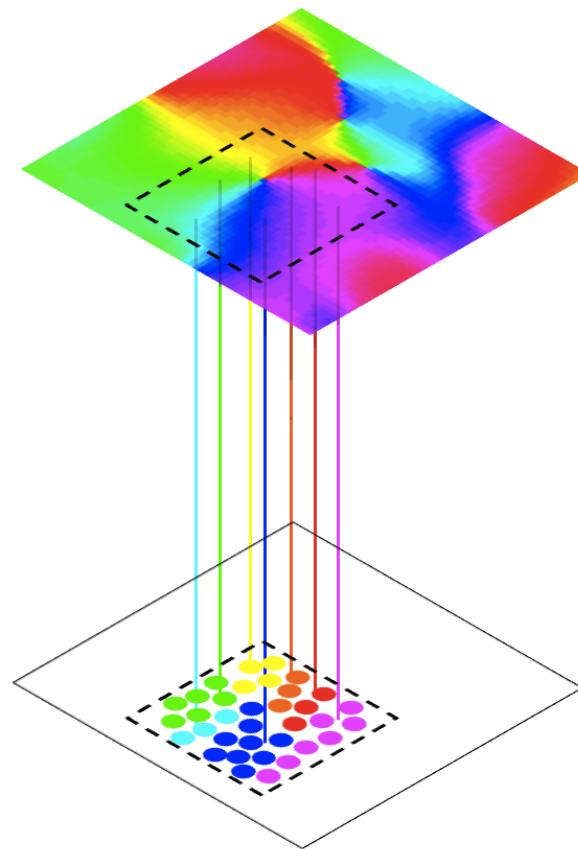




**Pre-adaptation**



**Post-adaptation**



# Thank you

## Acknowledgements to the team



Dr. J Rouat



L. Bachatene



Bhamauria V



S. Cattan



Nayan Chanauria



J.  
Jeyabalaratnam

