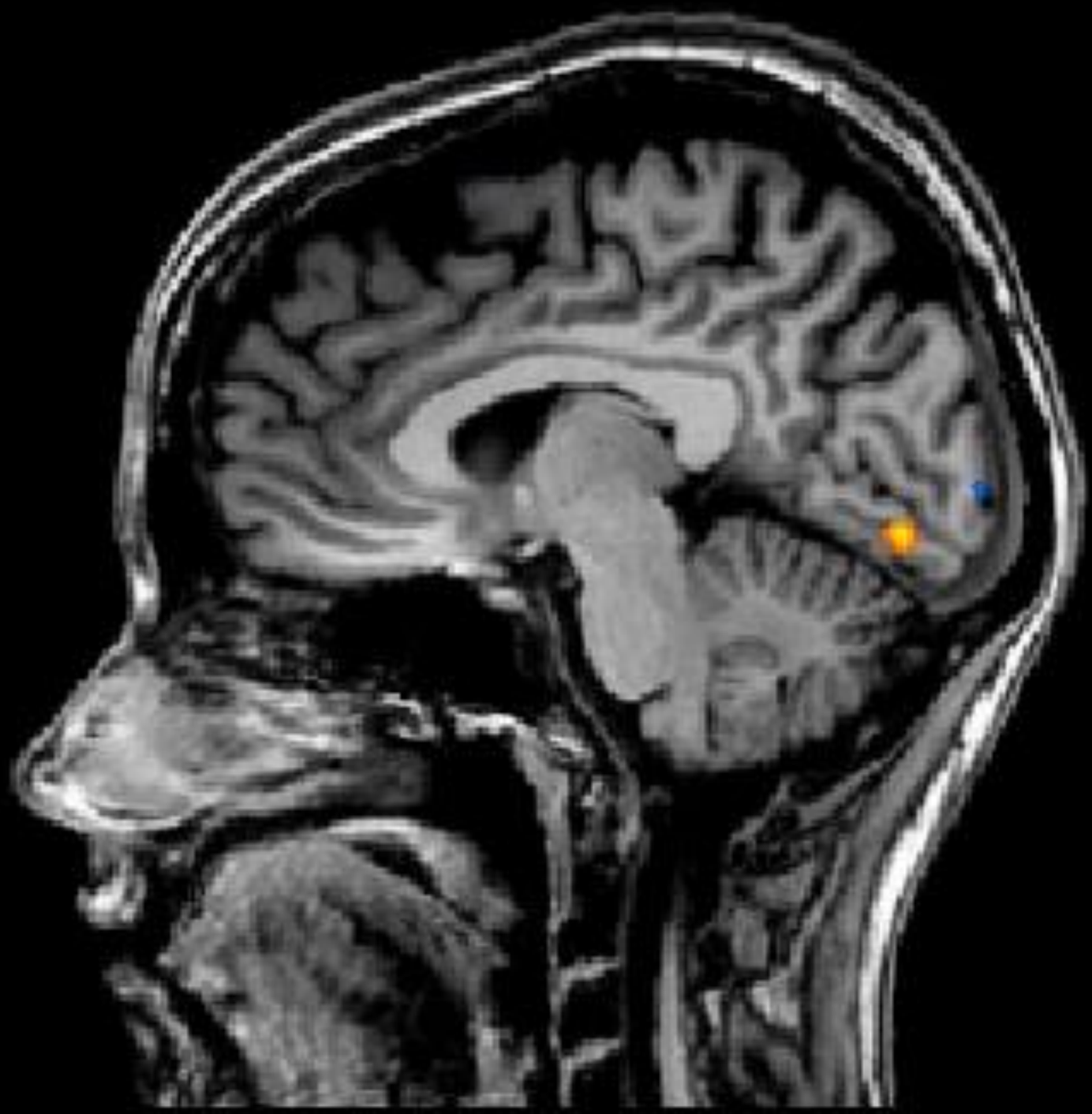
Computational neuroscience



What is the neural code?

-- techniques for recording from the brain

-- tools for discovering how the brain represents information

-- models that express our understanding of this representation

-- some methods for inferring what the brain is doing based on its activity *(week 3)*

-- using information theory to quantify neural representations *(week 4)*

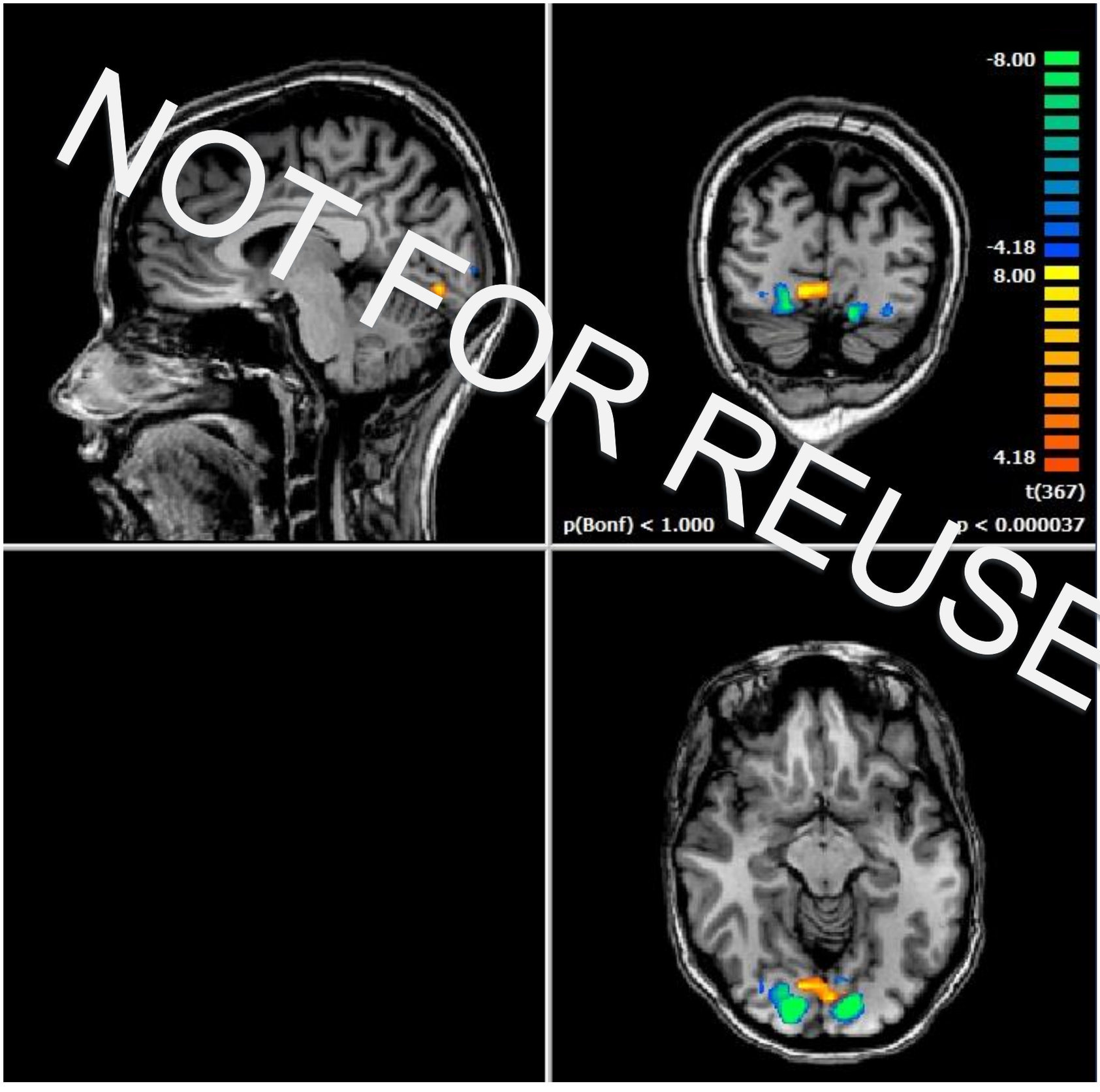
-- the biophysical basis of how the brain processes inputs and performs complex computations *(week 5)*

Recording from the brain

Recording from the brain: fMRI

Scott Murray

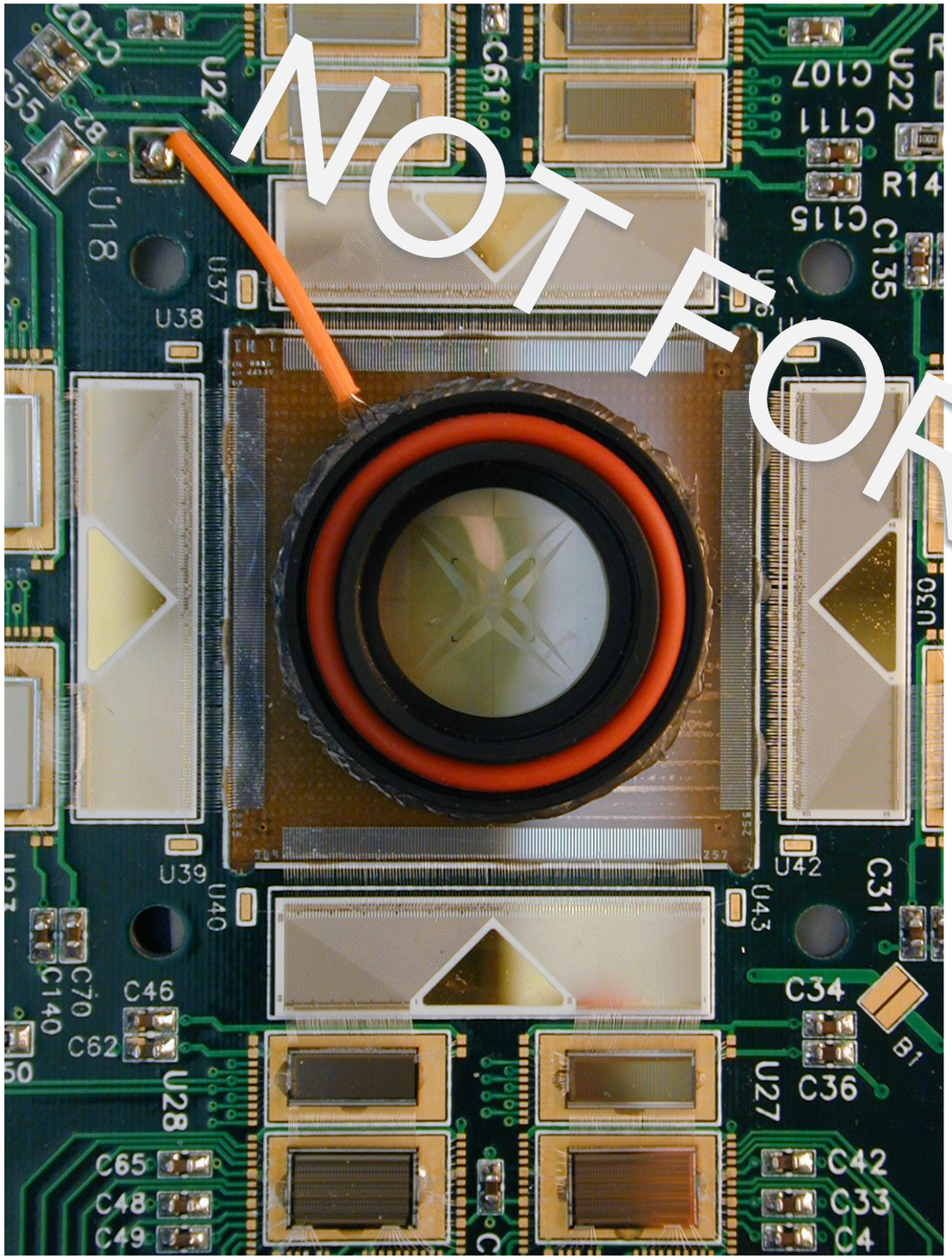
Recording from the brain: fMRI

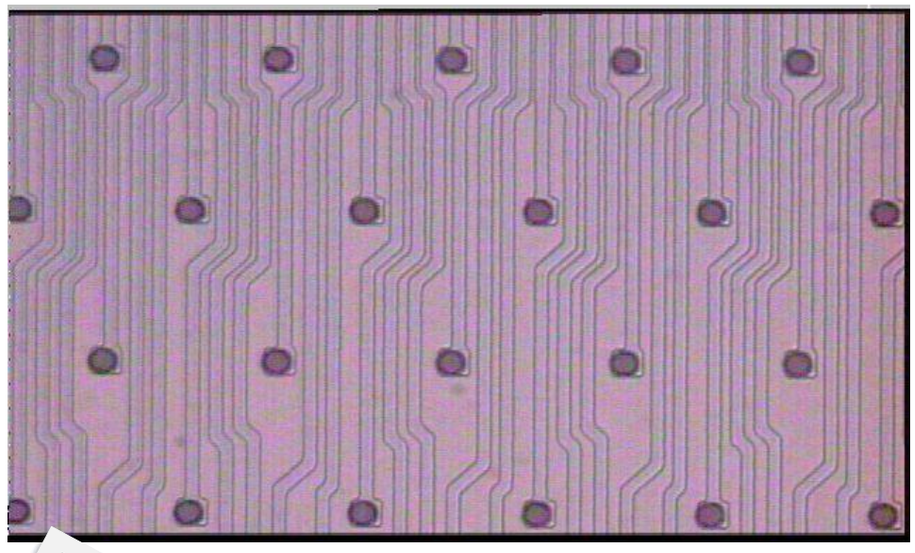


S. Murray

Recording from the brain: EEG

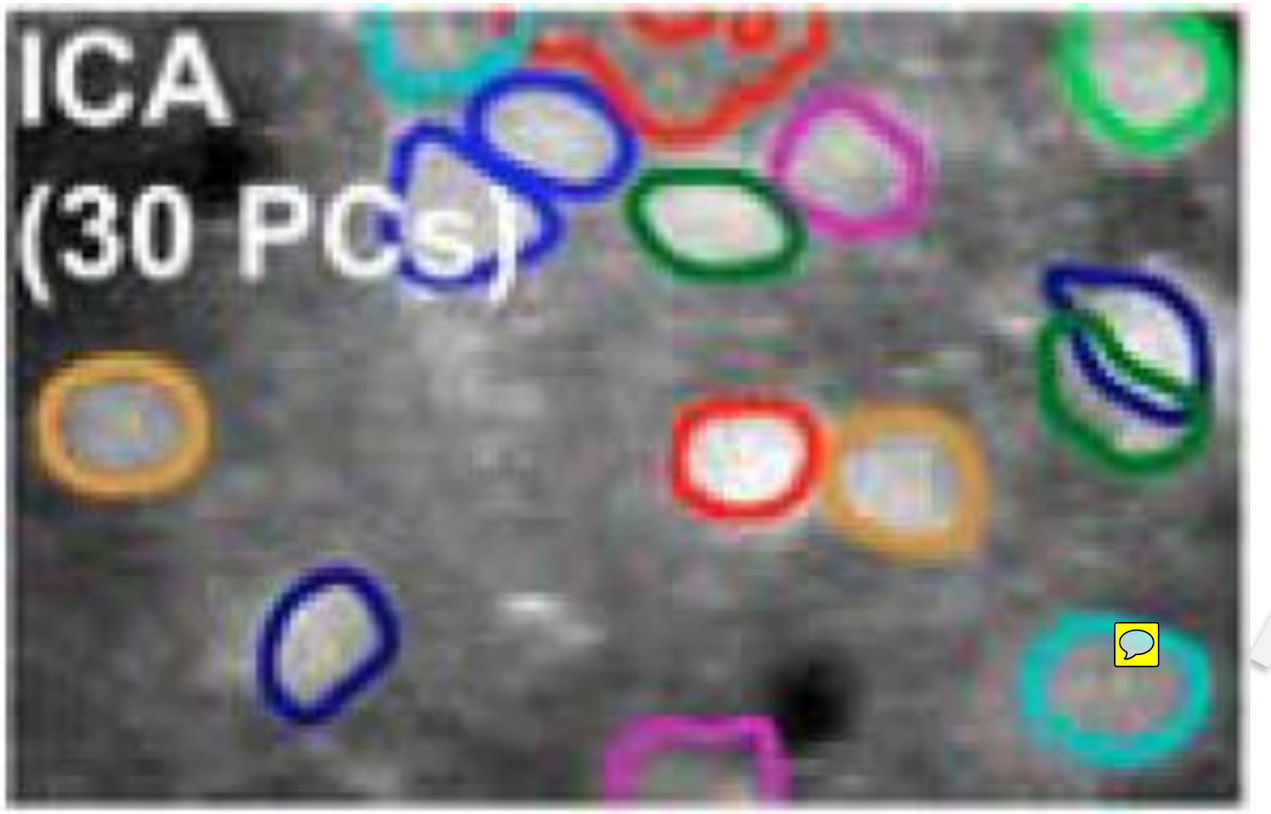
Reading out the neural code: electrode arrays

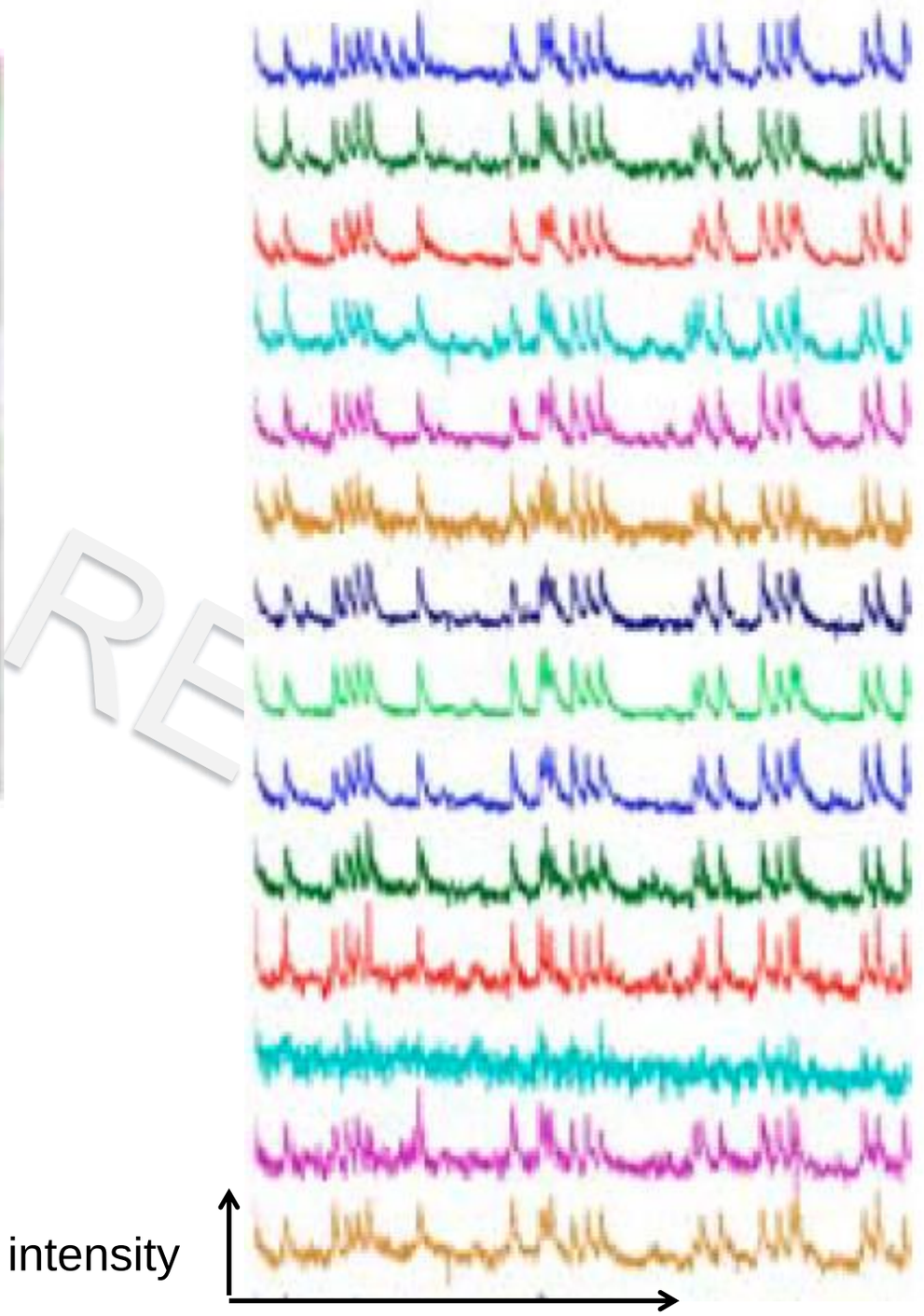




Reading out the neural code: electrode arrays

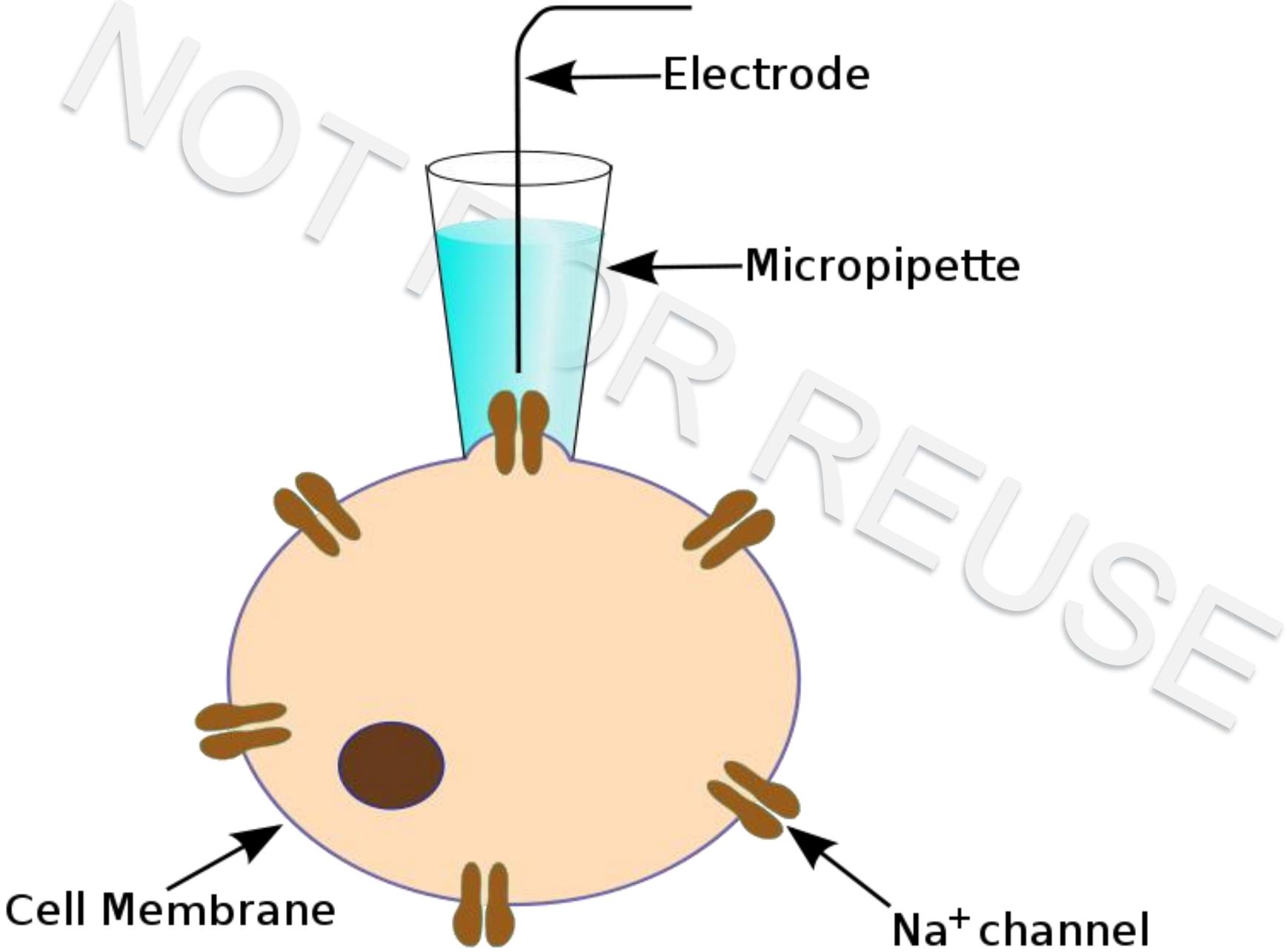
Reading out the neural code: calcium imaging





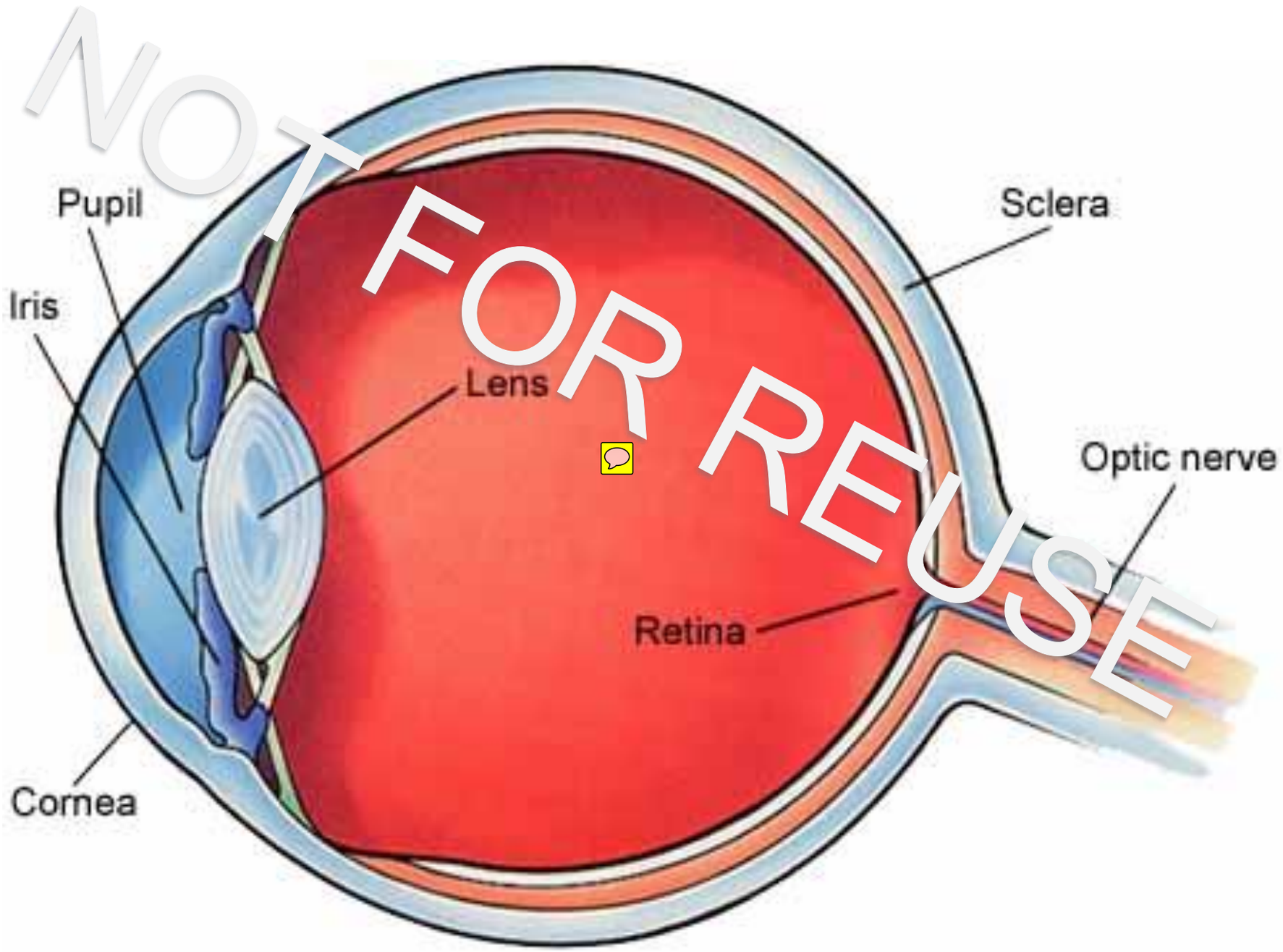
Alex Kwan

Looking inside single cells



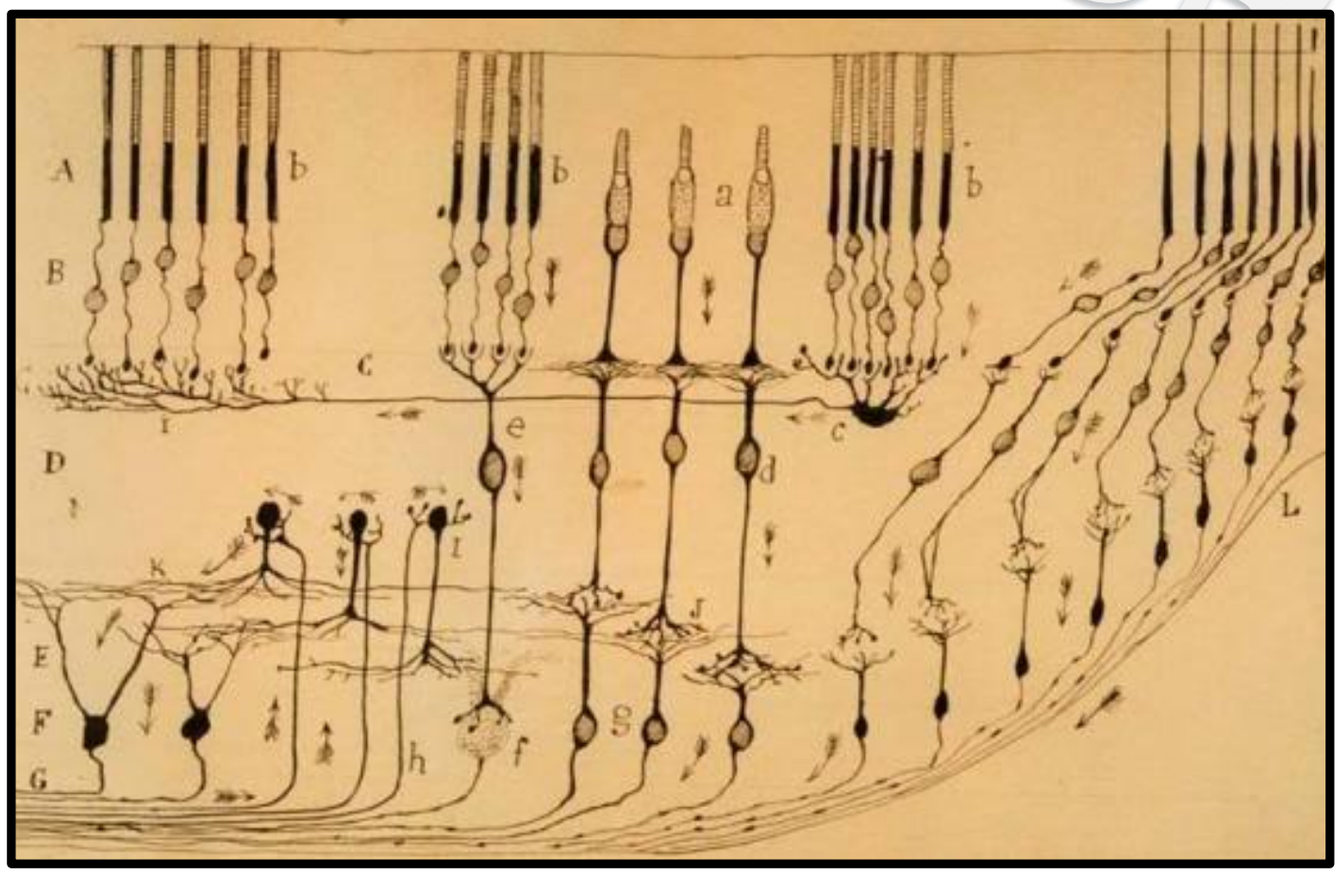
Theresa Knott, Creative Commons

What is the neural code?

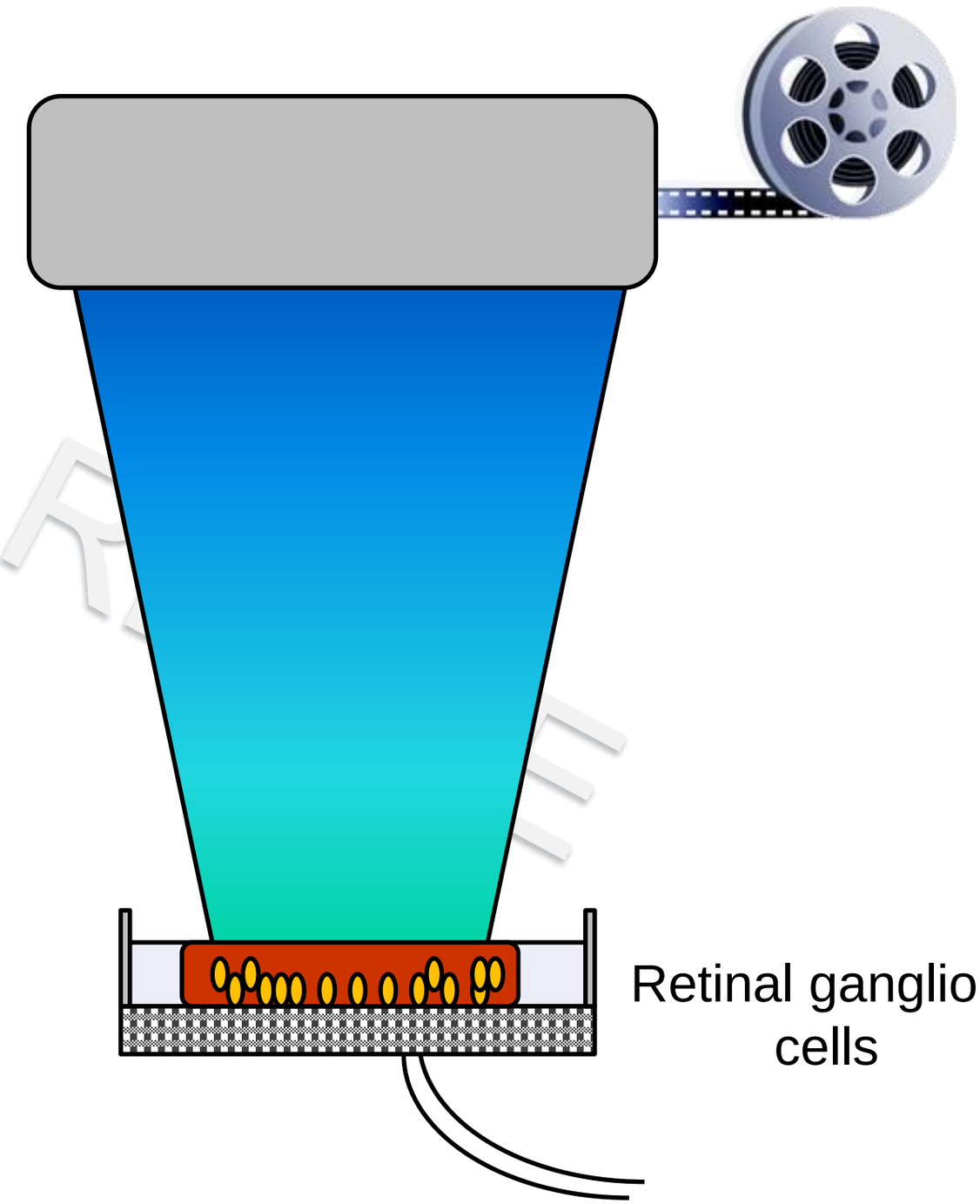


http://www.royles-opticians.co.uk

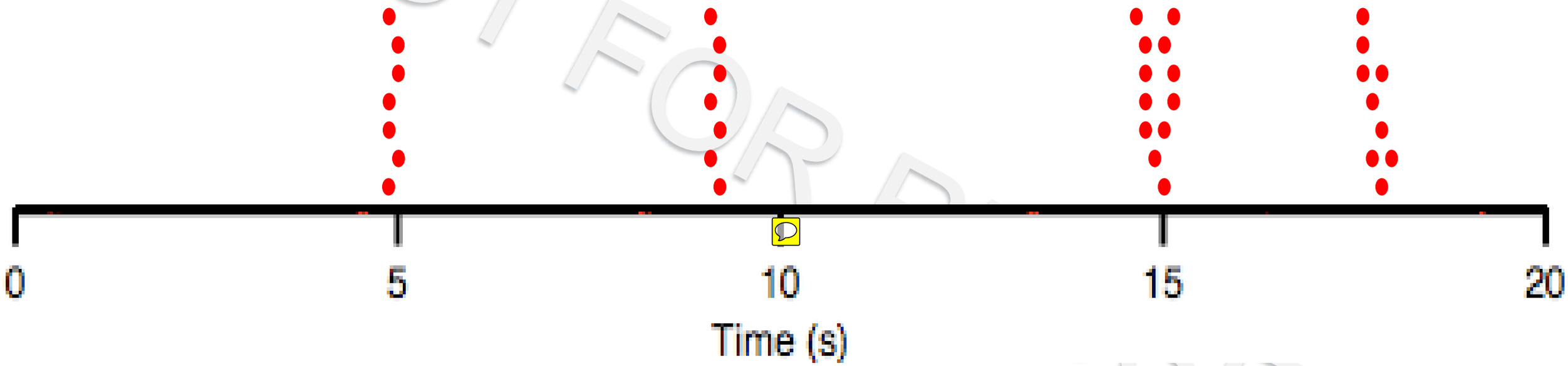
What is the neural code?



Ramon y Cajal, 1901

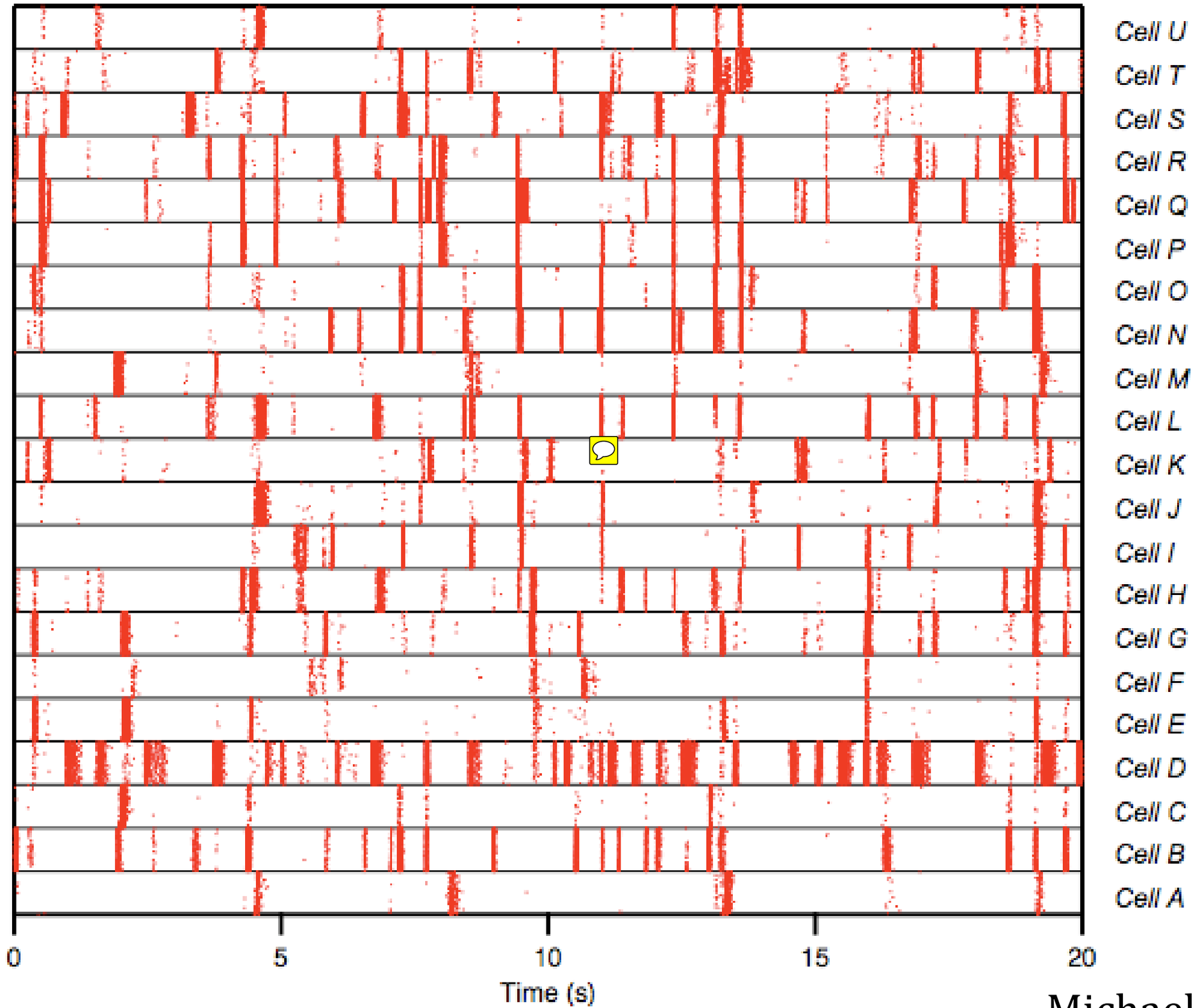


What is the neural code?



Michael J. Berry II

What is the neural code?



Michael J. Berry II

Encoding and decoding

Encoding: how does a stimulus cause a pattern of responses?

- building quasi-mechanistic models

Decoding: what do these responses tell us about the stimulus?

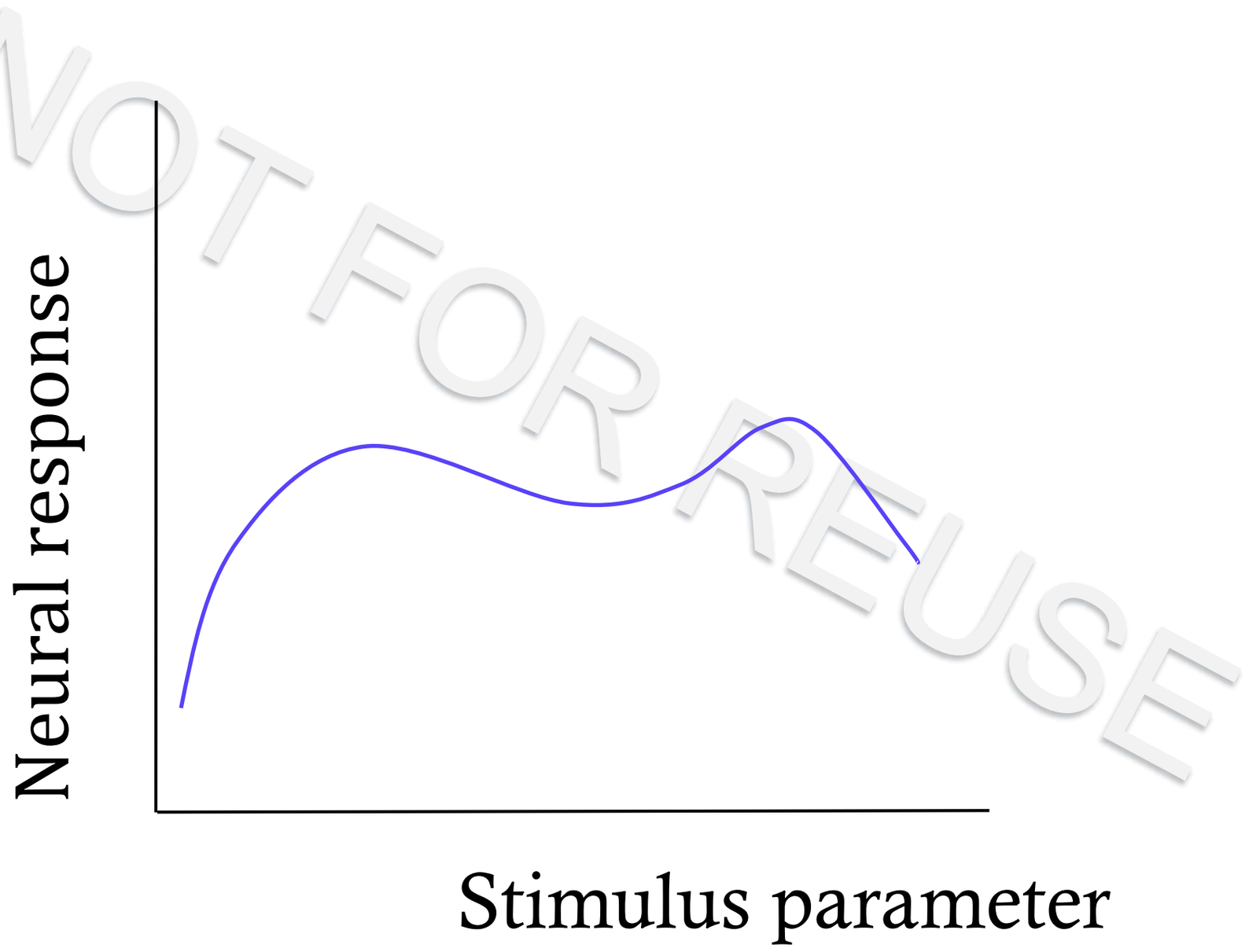
- how can we reconstruct what the brain is doing?

P(response | stimulus) *encoding*

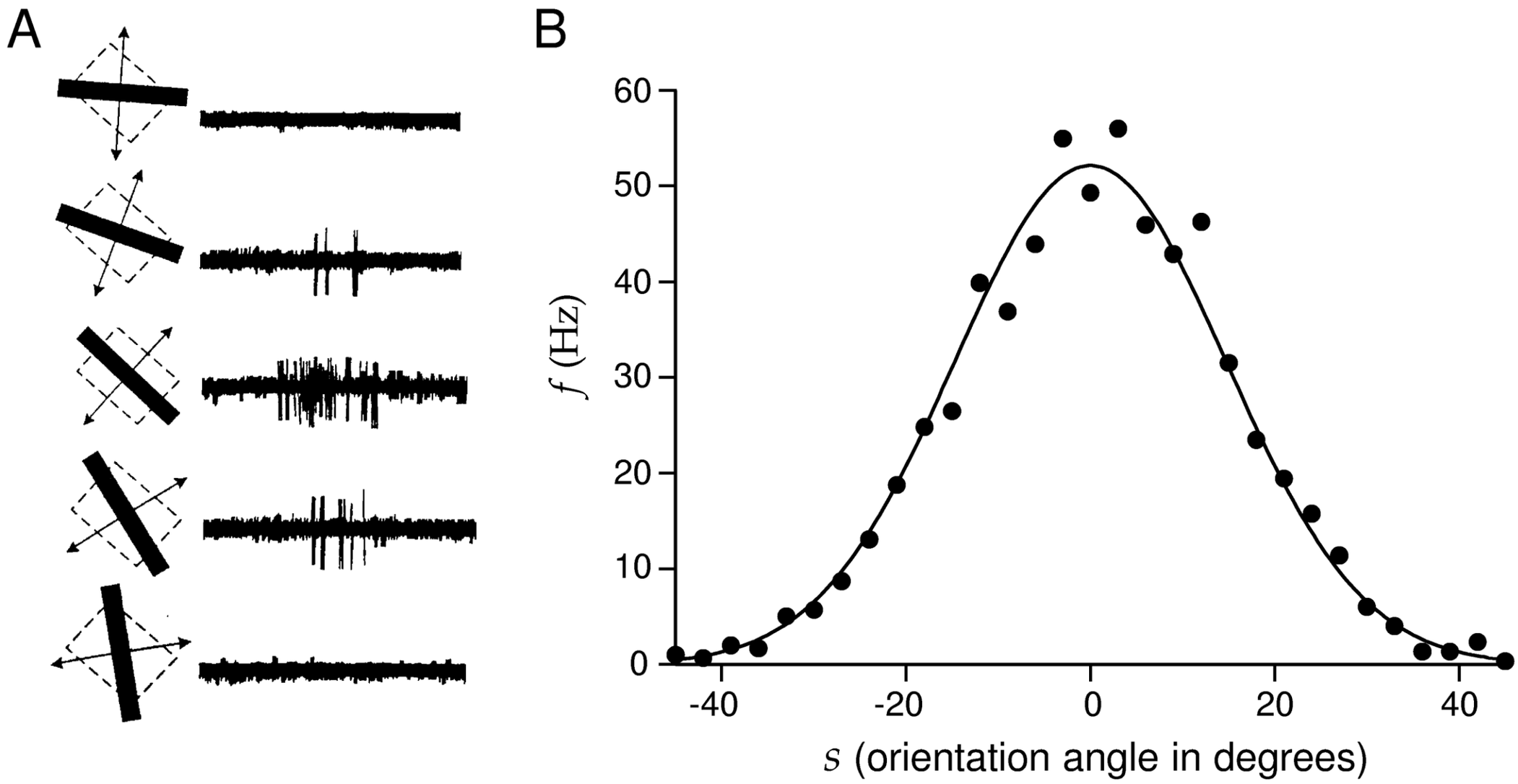
P(stimulus | response) *decoding*

What is the response? What is the stimulus?
What is the relationship between them?

Neural representation of information



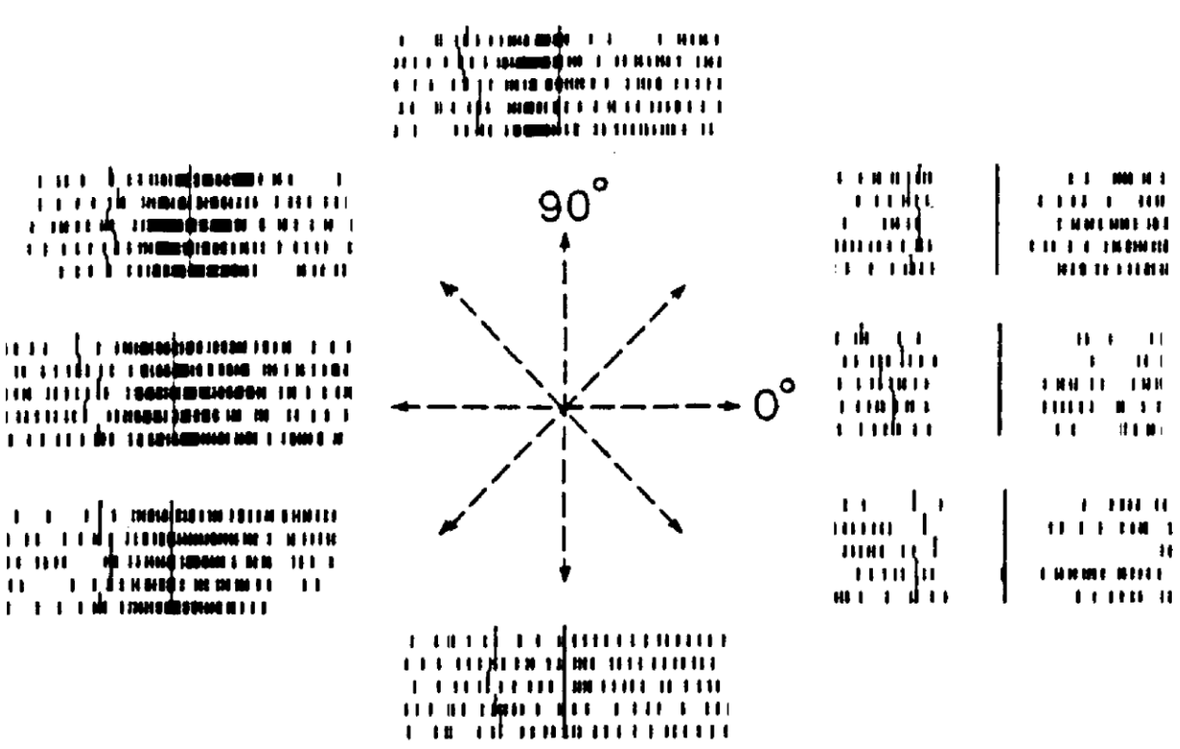
Tuning curves



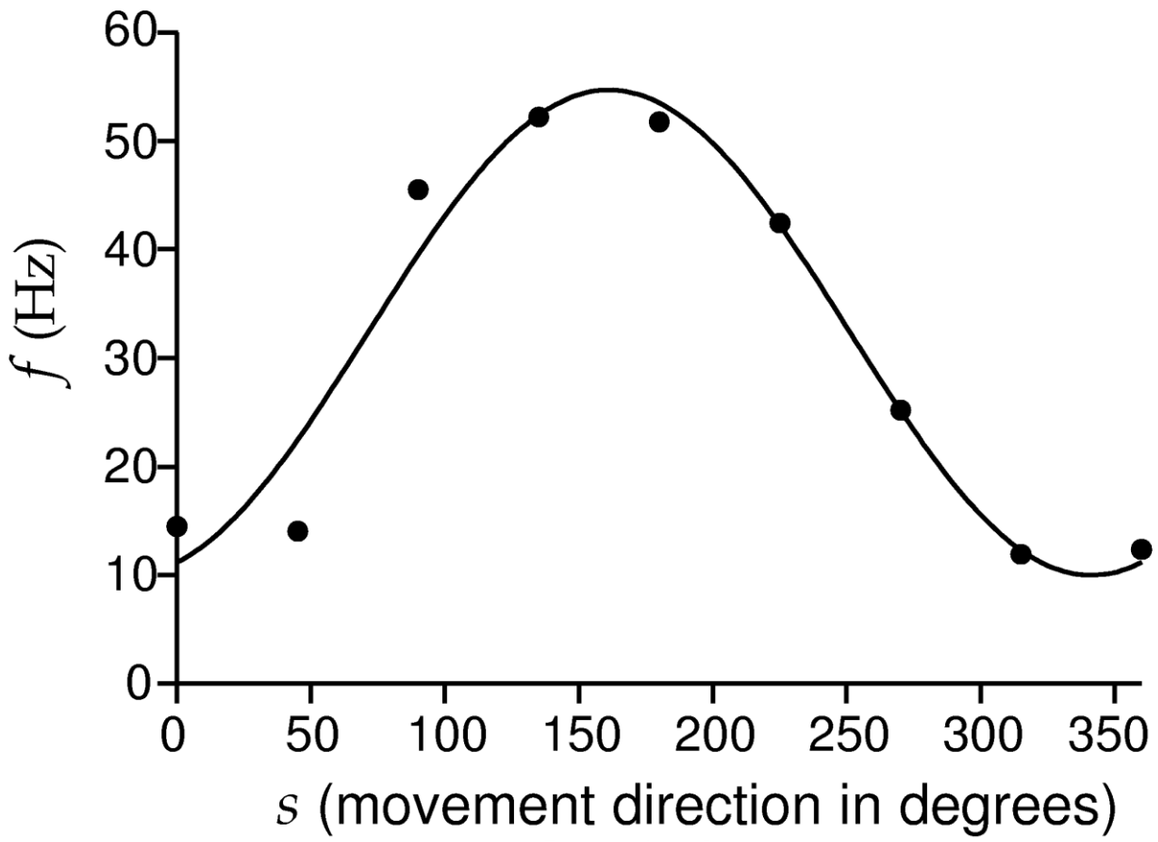
Gaussian tuning curve of a cortical (V1) neuron

from Dayan and Abbott, *Theoretical Neuroscience*:
adapted from Wandell ’95, Hubel and Wiesel ‘68; data from Henry et al., ‘74

Tuning curves



Hand reaching direction



Cosine tuning curve of a motor cortical neuron

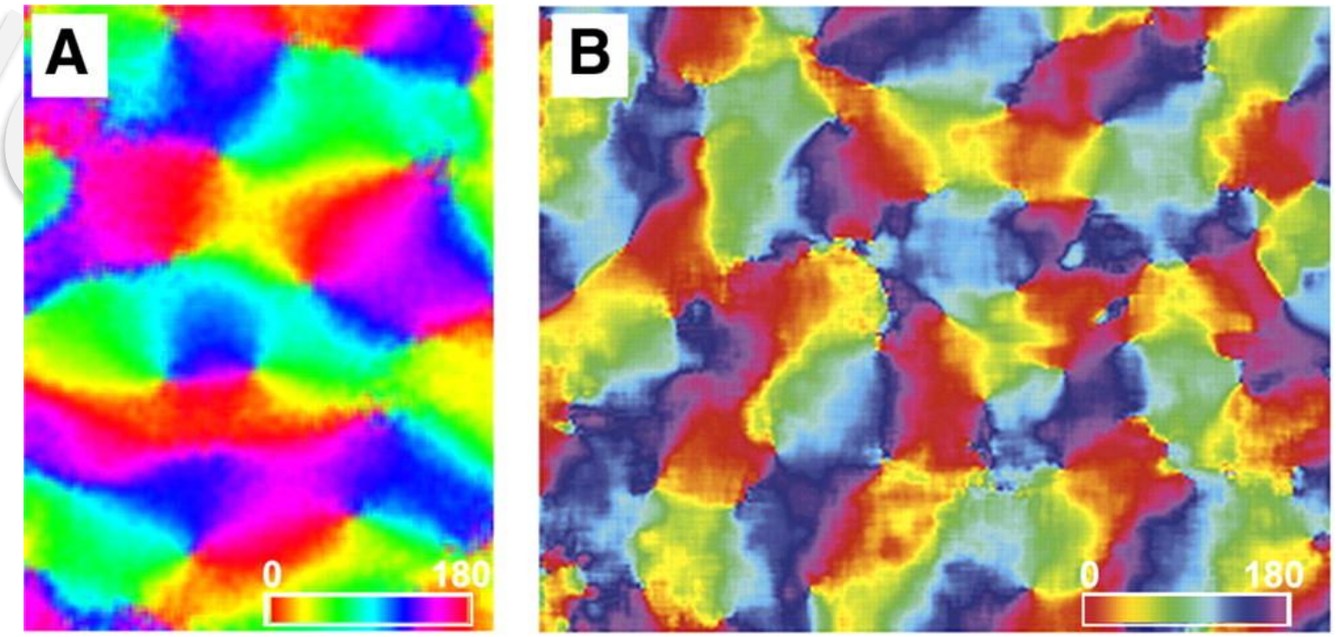
from Dayan and Abbott, *Theoretical Neuroscience*:
adapted from Georgopoulos et al. '92

Map of feature selectivity in primary visual cortex

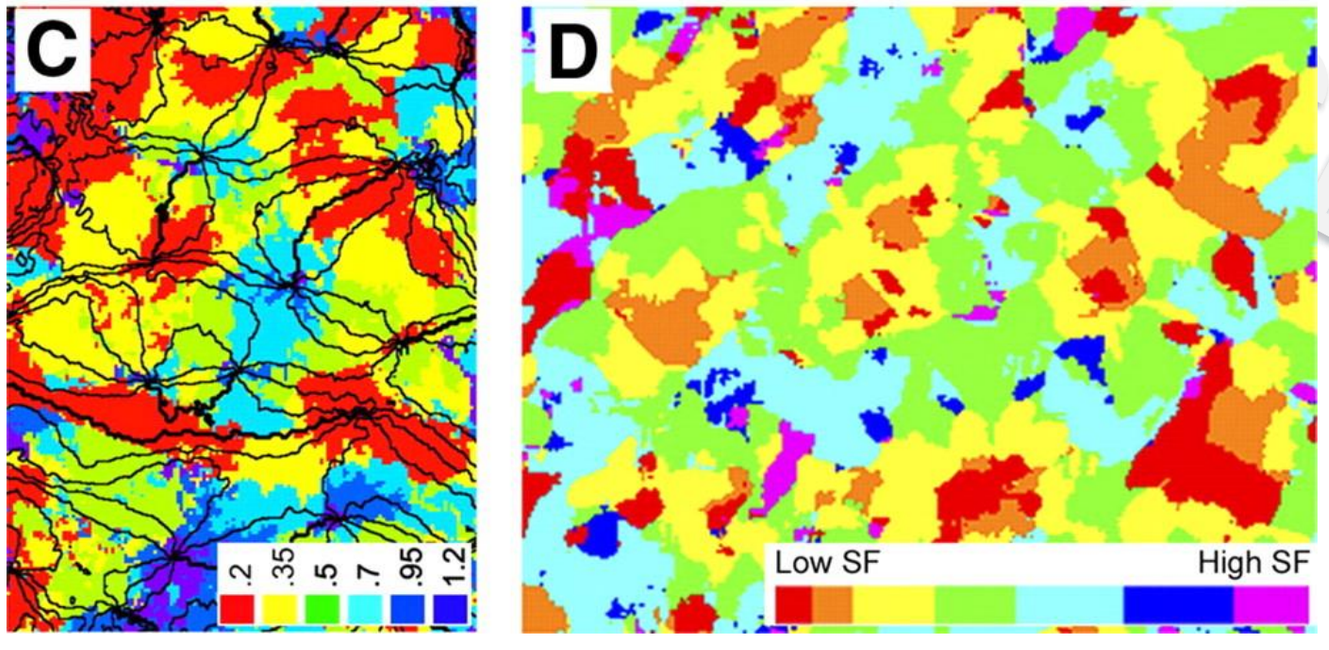
Cat

Bush baby

Orientation



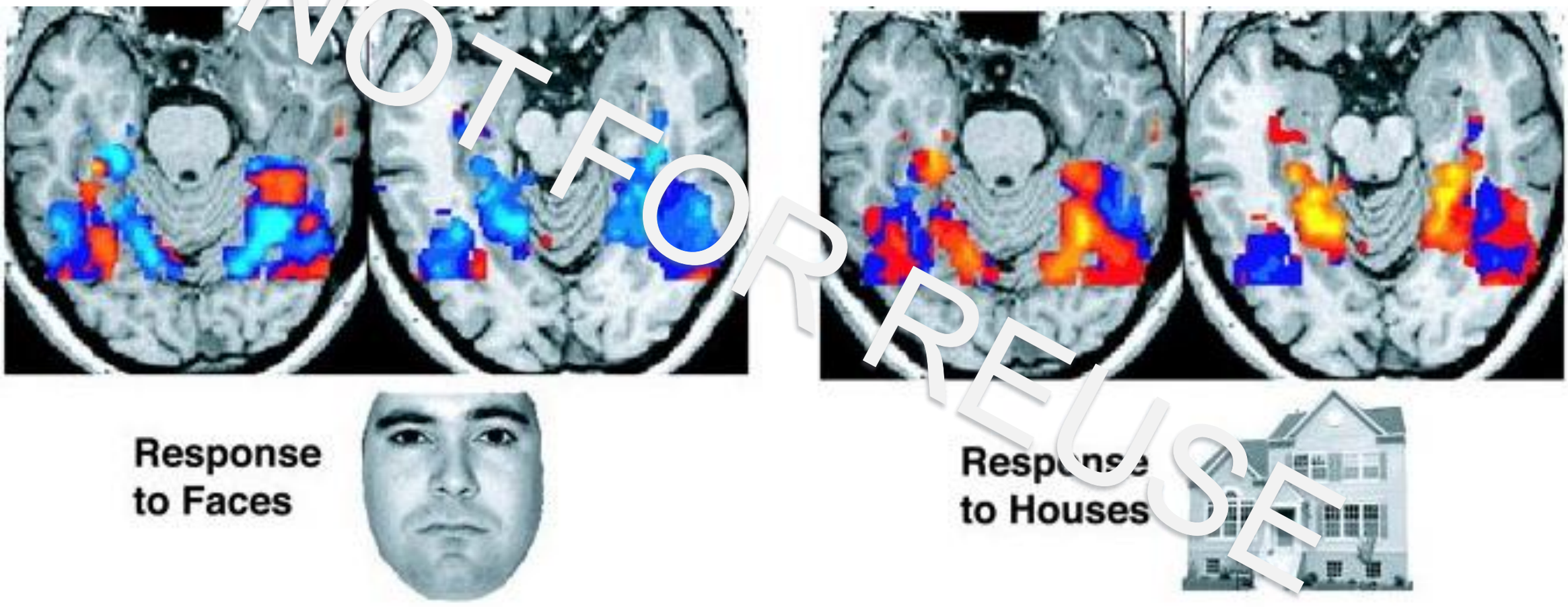
Spatial frequency



Issa N P et al. J Neurophysiol 2008;99:2745-2754

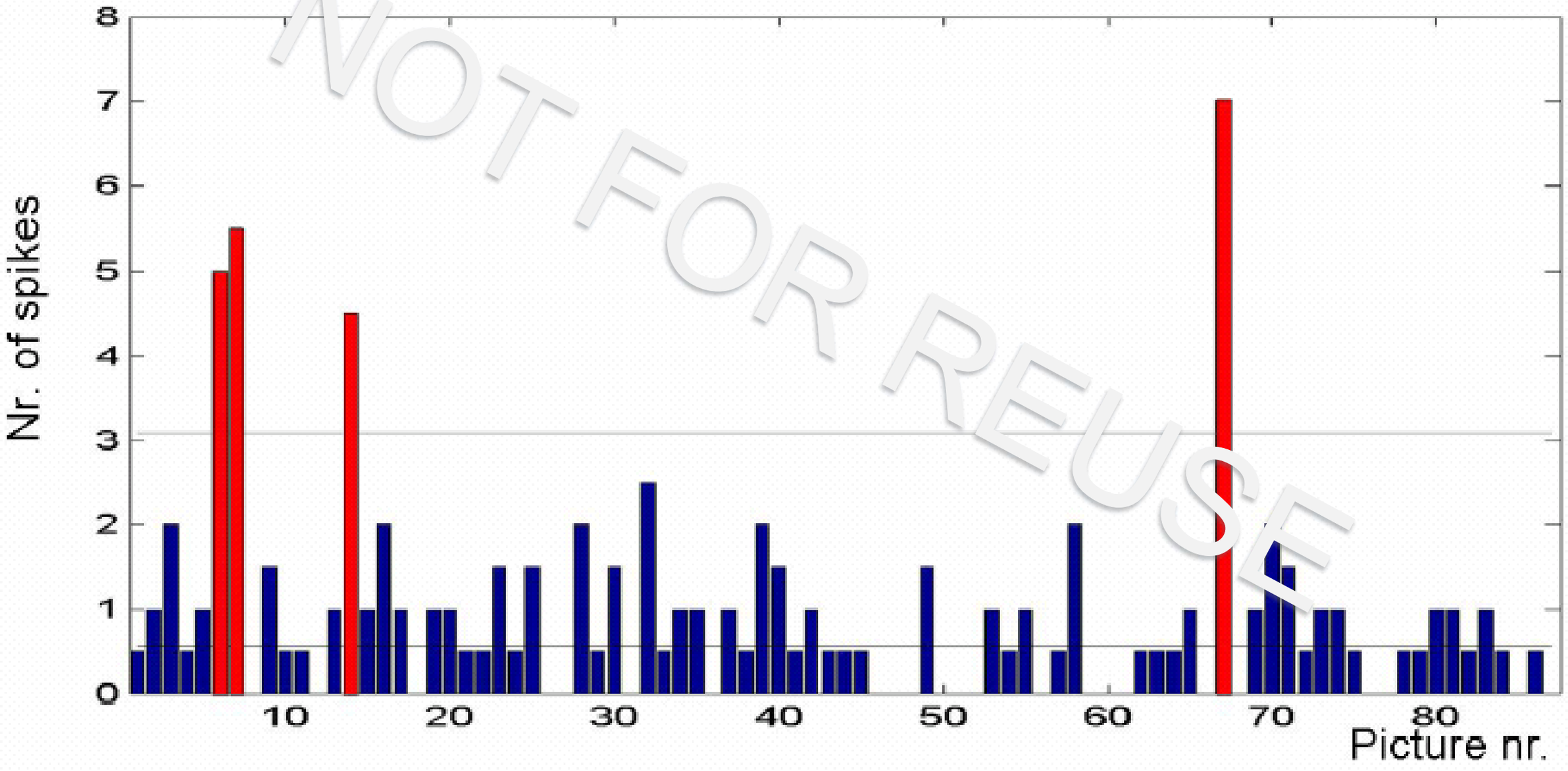
Journal of Neurophysiology

Higher order feature selectivity



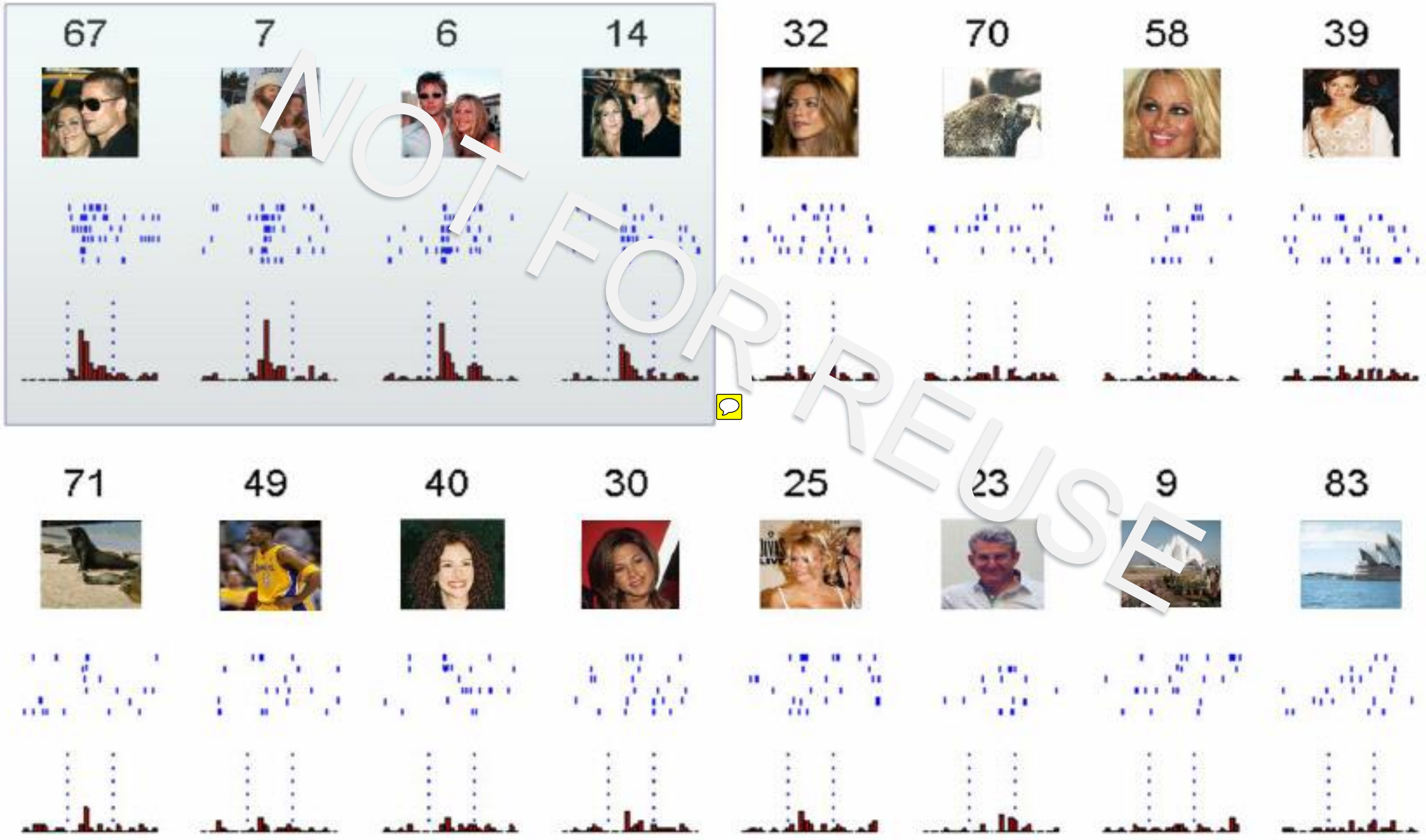
Haxby et al., *Science* (2001)

“Tuning curves”



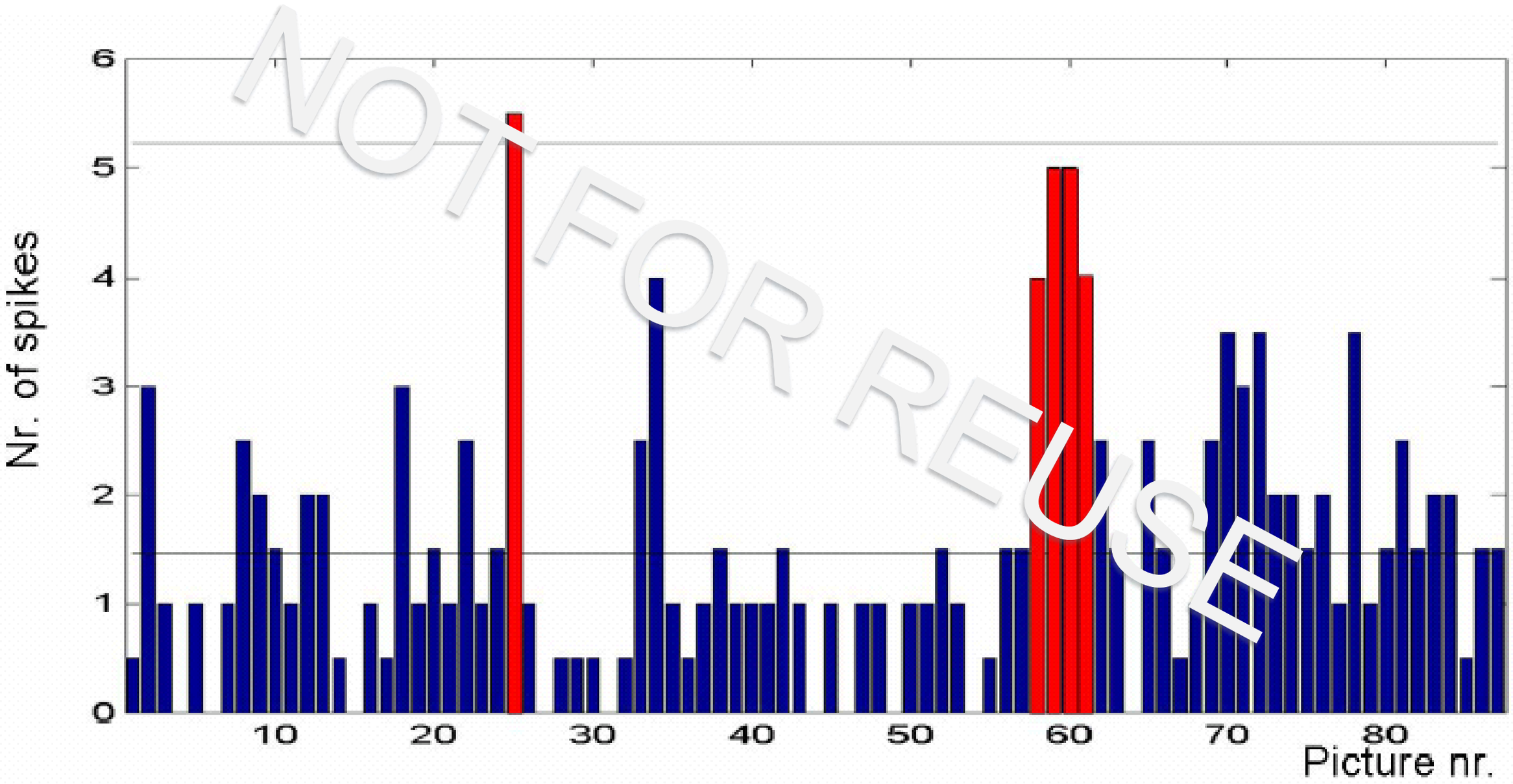
Quian Quiroga, Reddy, Kreiman, Koch and Fried, *Nature* (2005)

What is the stimulus *s*?



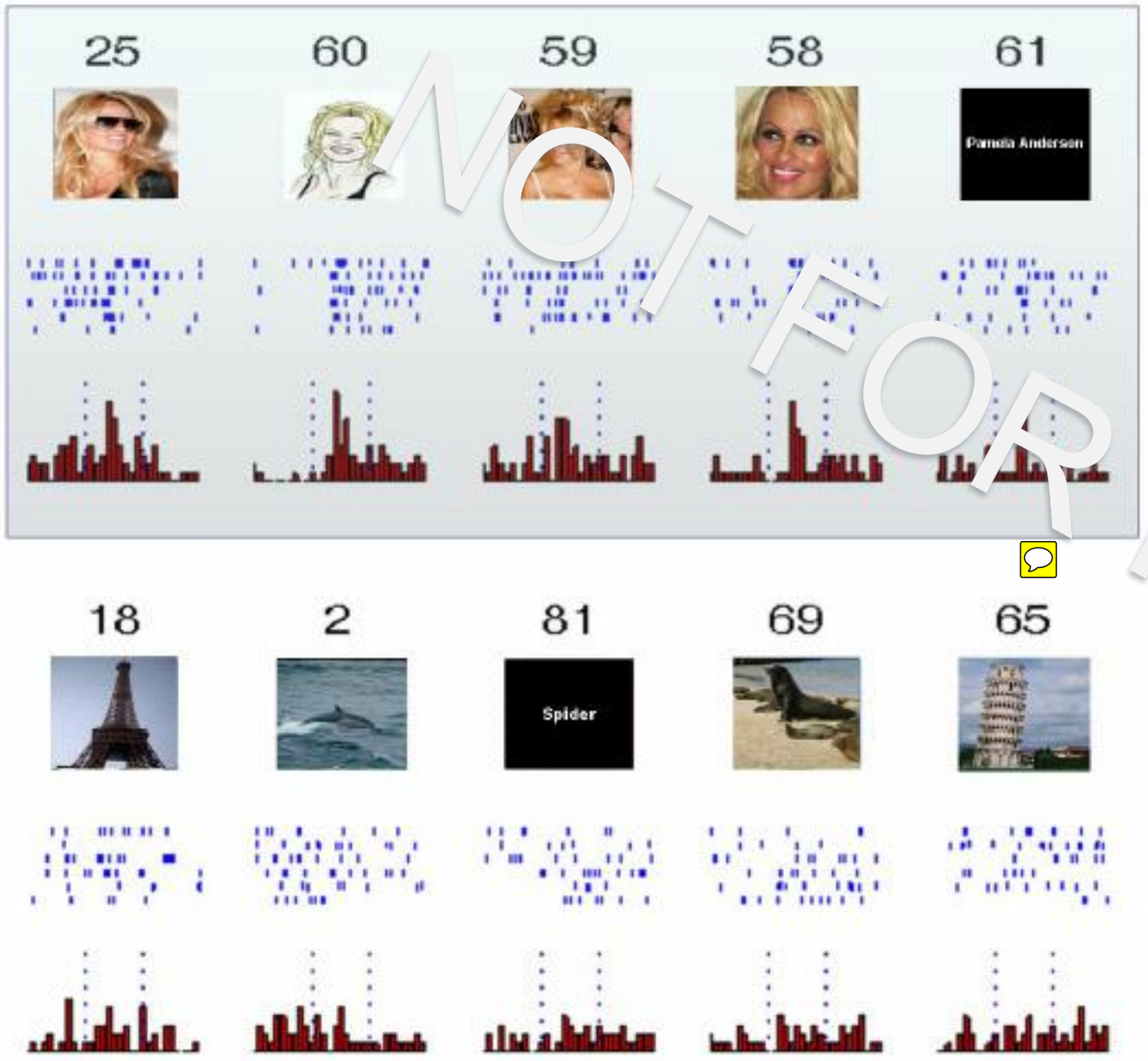
Quian Quiroga, Reddy, Kreiman, Koch and Fried, *Nature* (2005)

Tuning curves



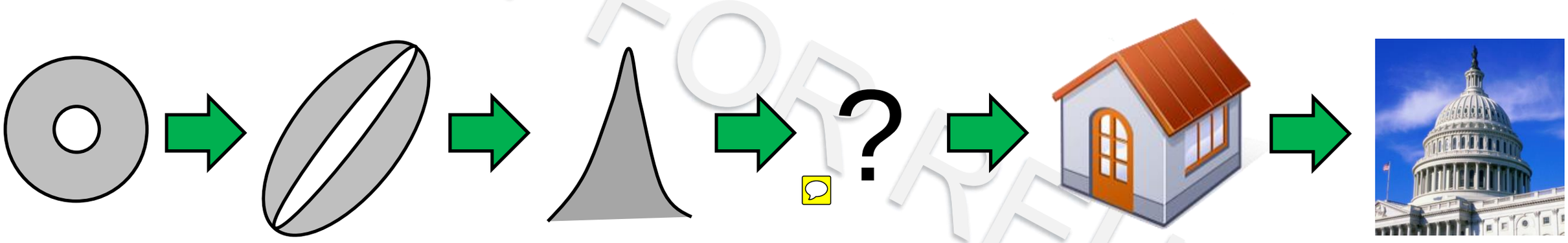
Quian Quiroga, Reddy, Kreiman, Koch and Fried, *Nature* (2005)

What is *s*?



Quian Quiroga, Reddy, Kreiman, Koch and Fried, *Nature* (2005)

Building up complex selectivity



Top-down effects

Next up: constructing response models

P(response | stimulus)