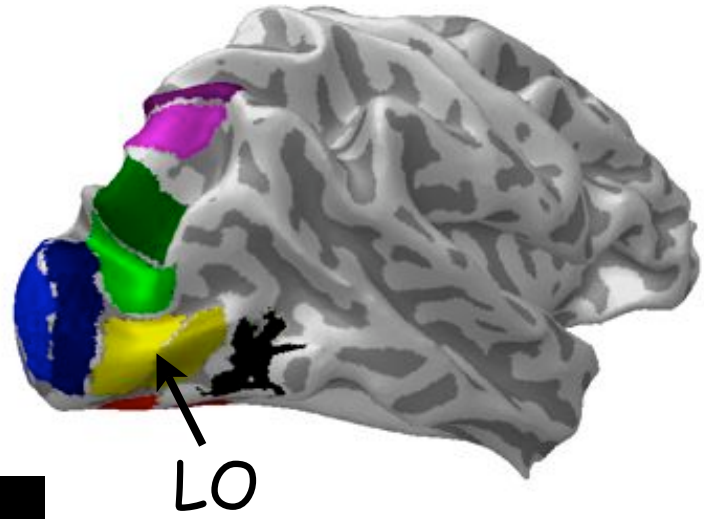
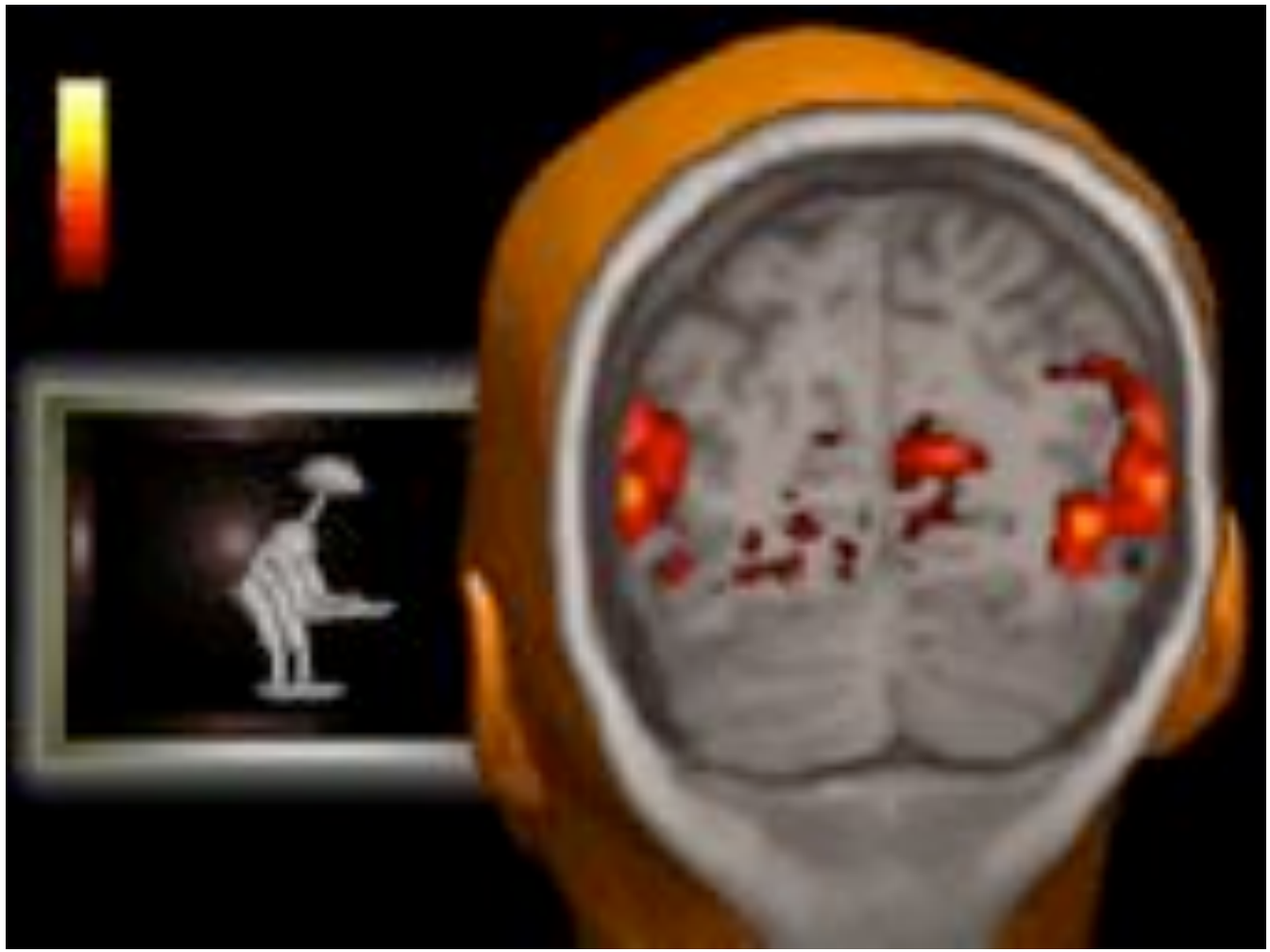
Functional Specialization

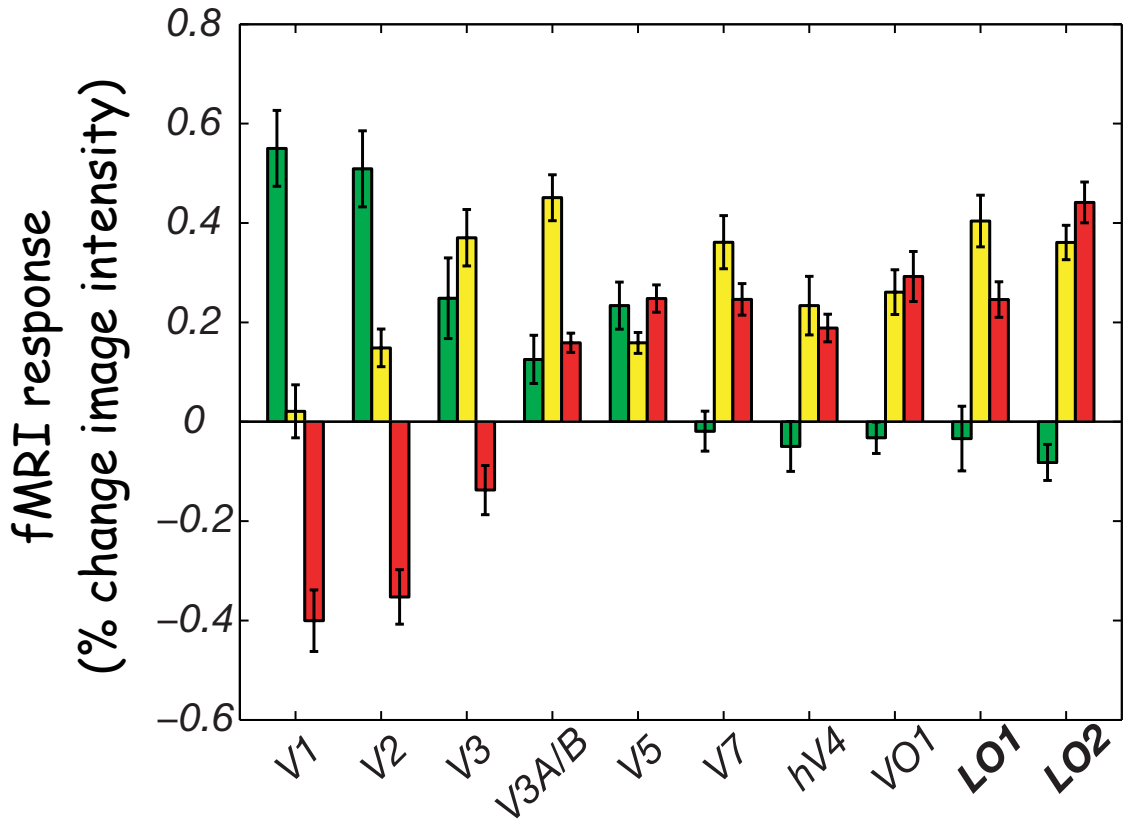
Functional specialization: shape perception

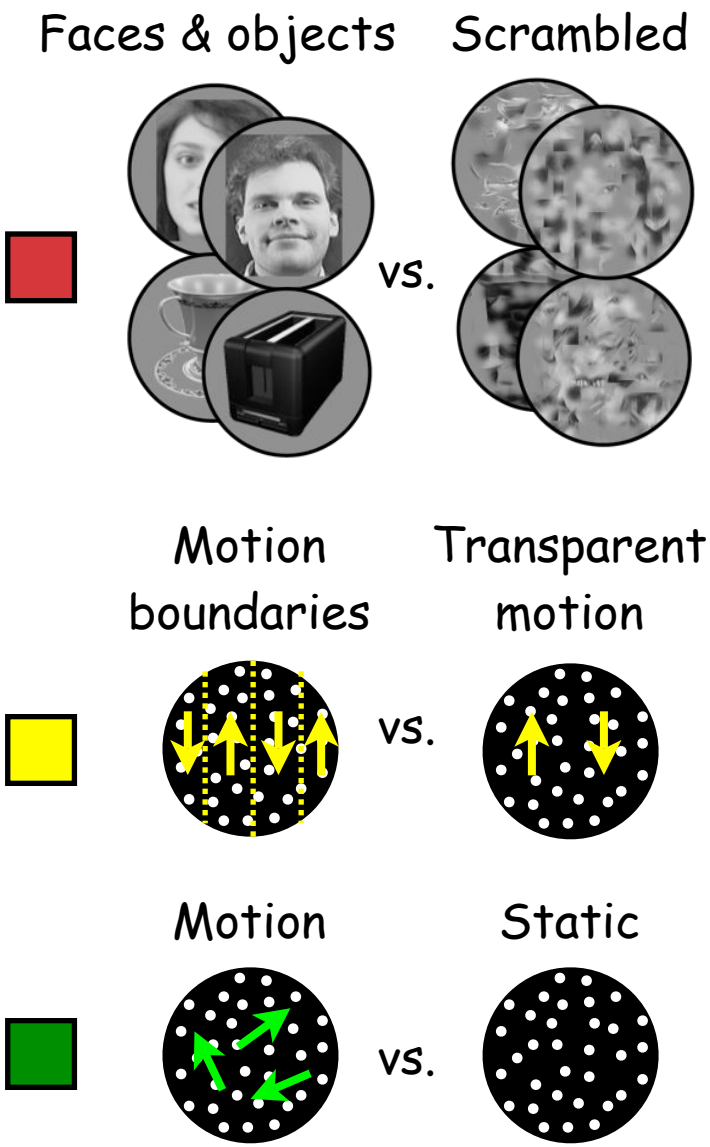




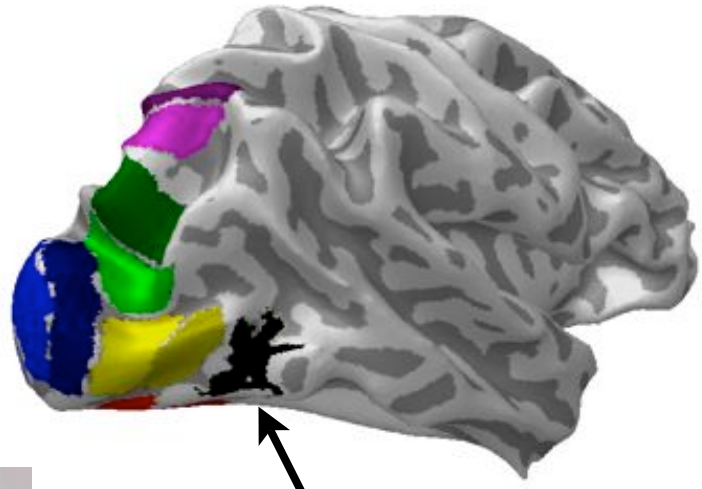
Malach et al.

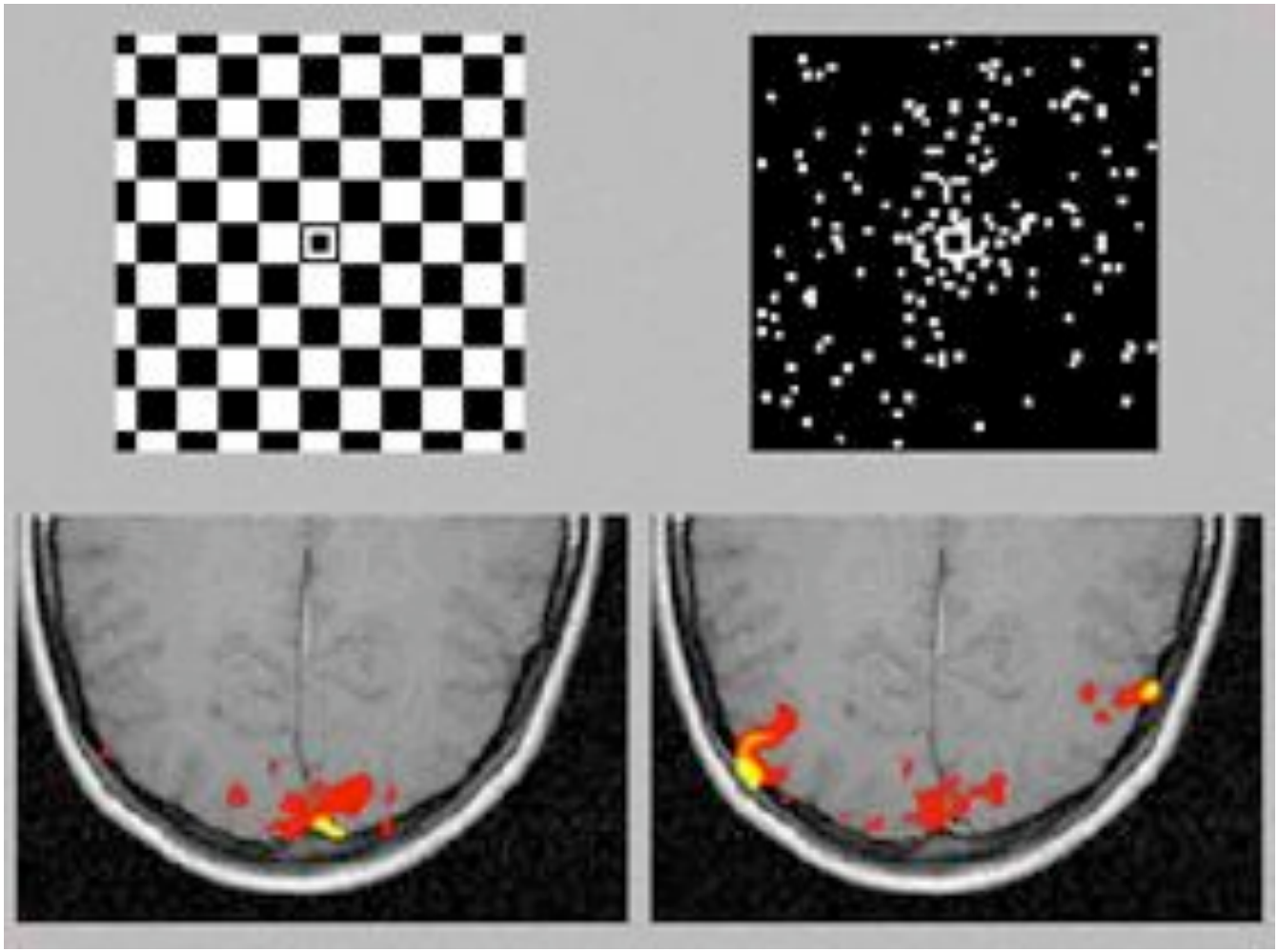
Functional properties of LO1 & LO2





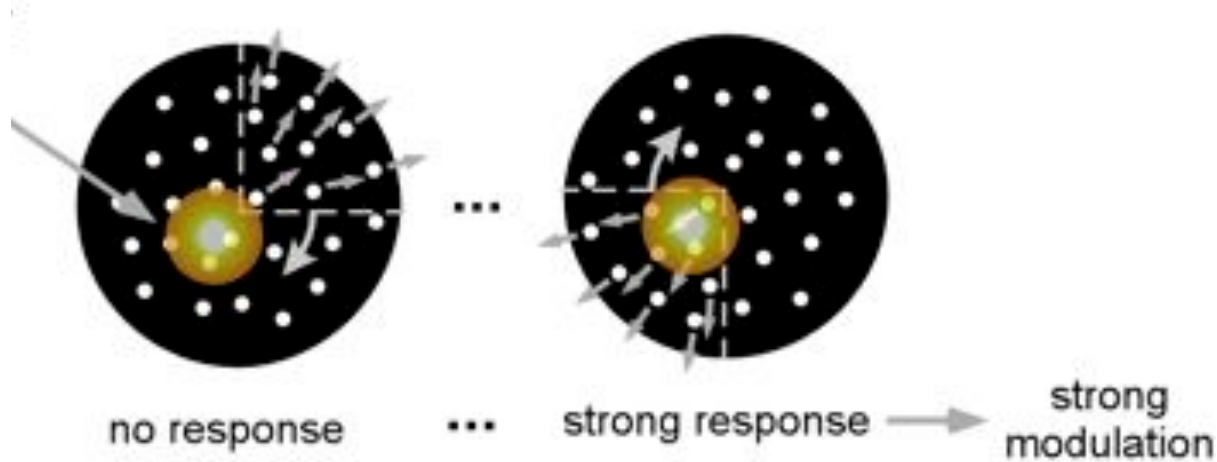
Functional specialization: motion perception



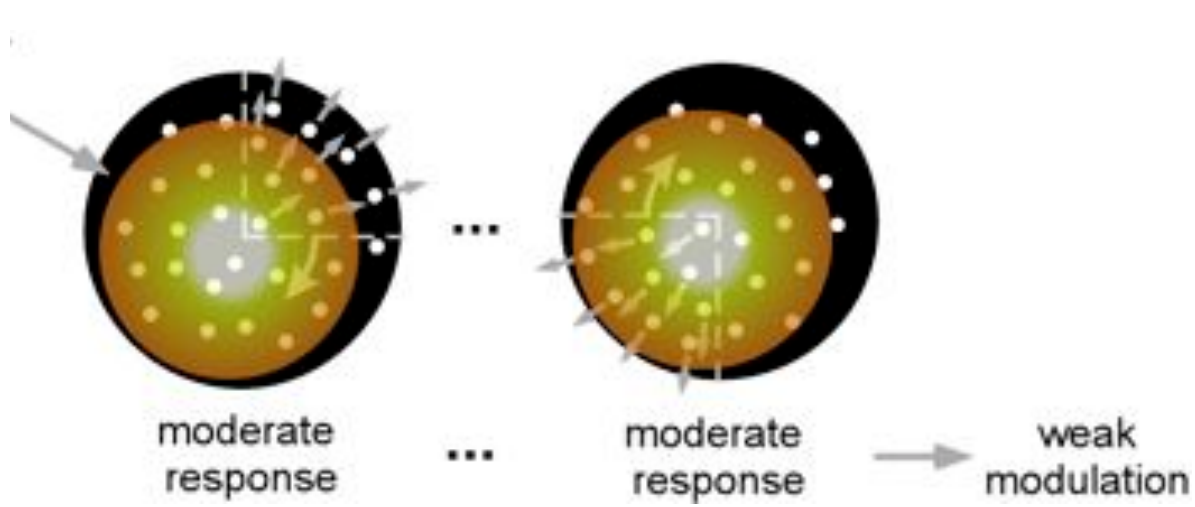


Subdividing MT+ (retinotopy)

small RF
(MT)

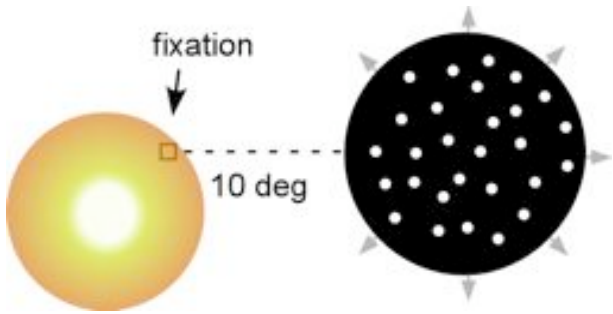


large RF
(MST)

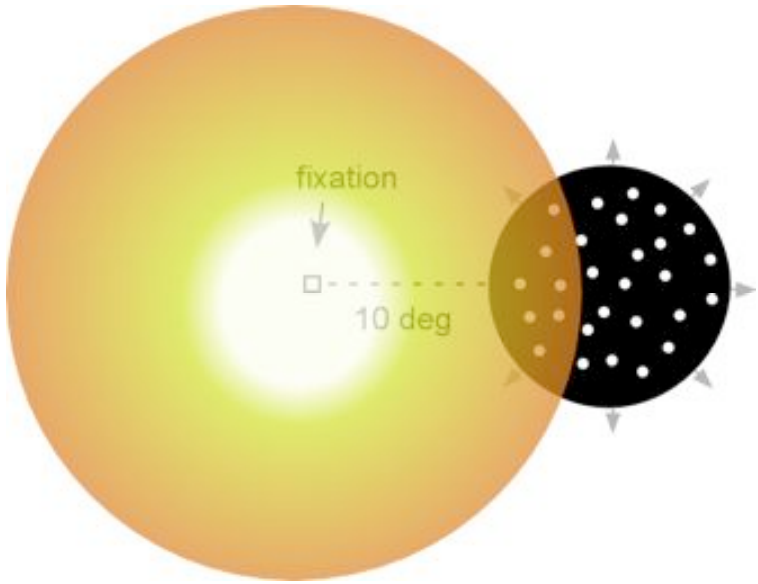


Subdividing MT+ (ipsilateral stimulation)

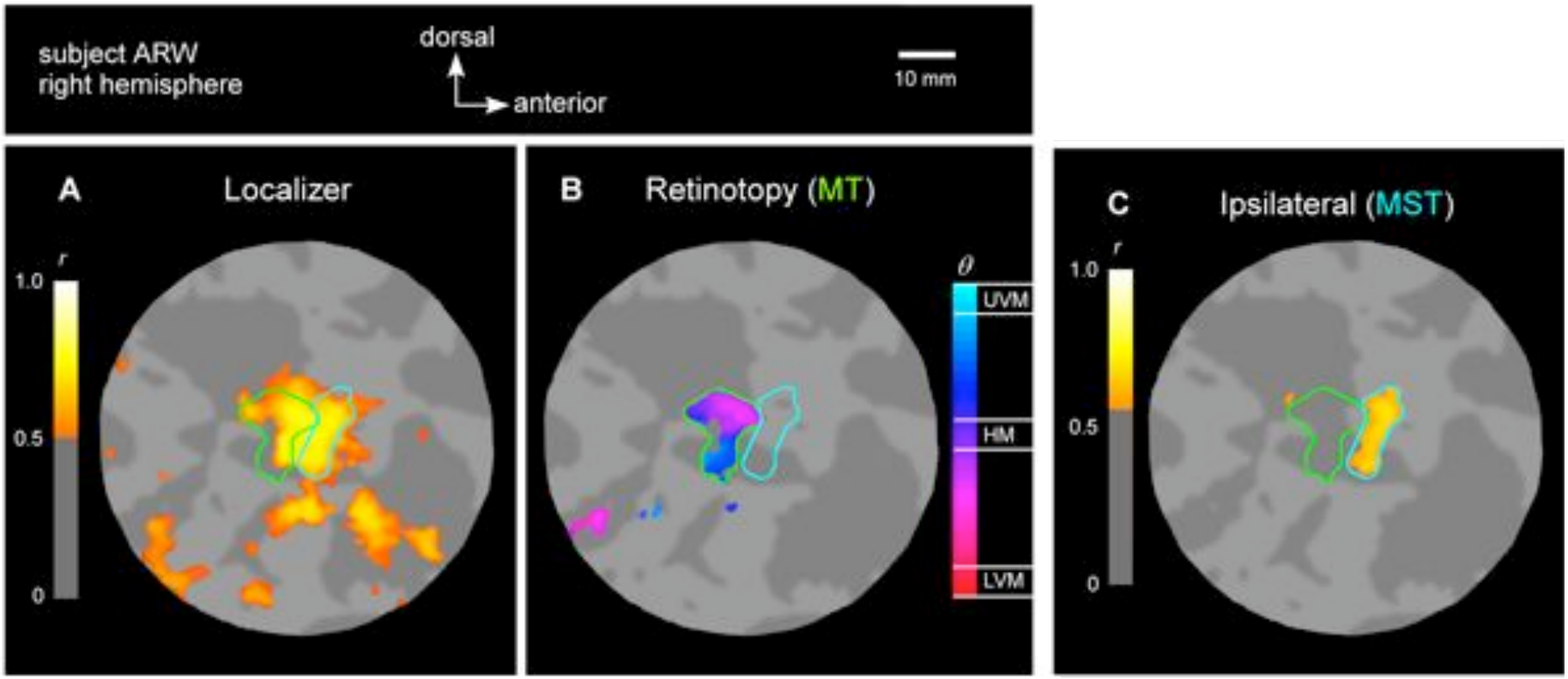
small RF
(MT)



large RF
(MST)

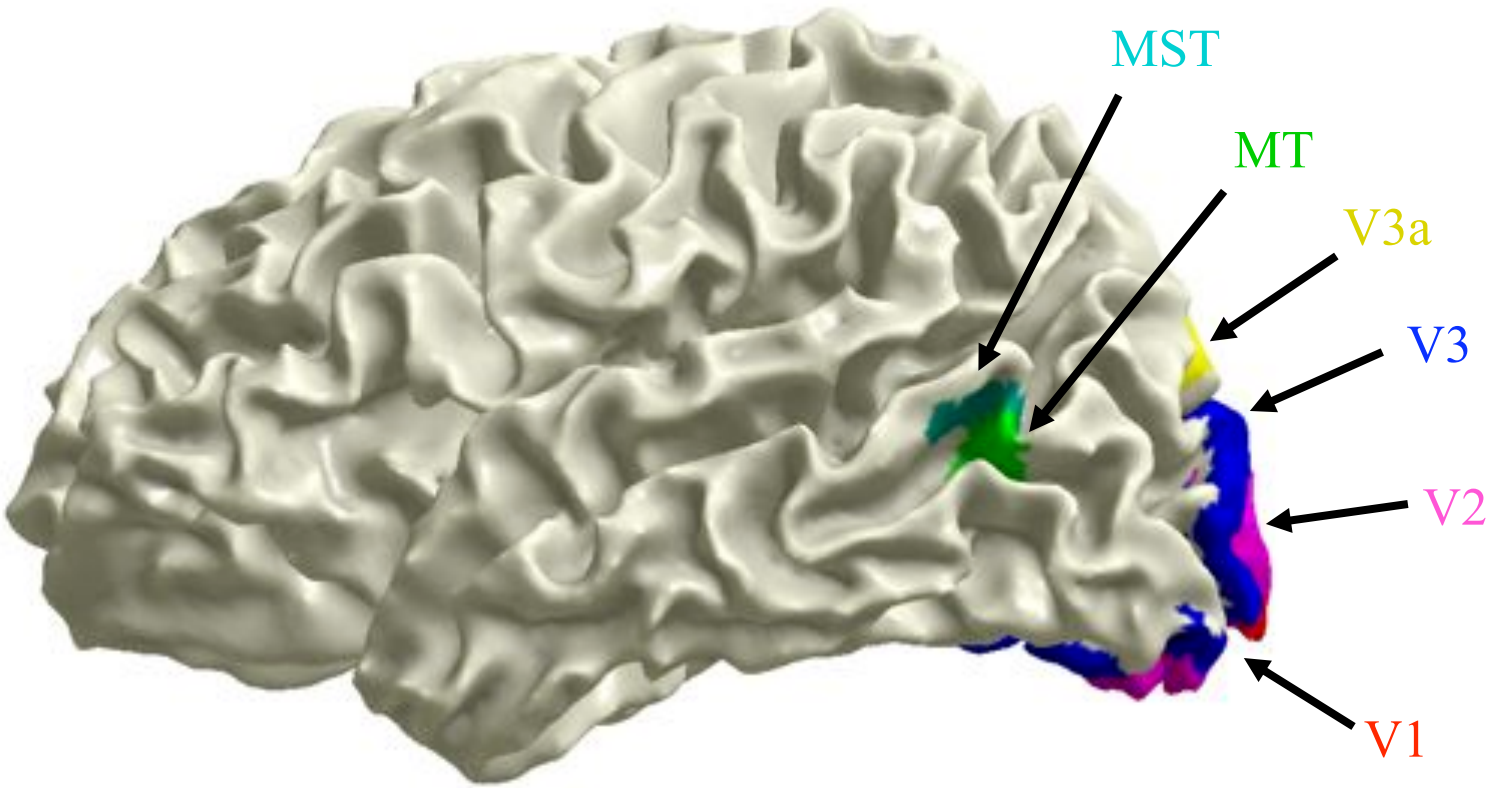


Subdividing MT+



Huk, Dougherty, & Heeger, J Neurosci, 22:7195-7205, 2002

Human MT and MST



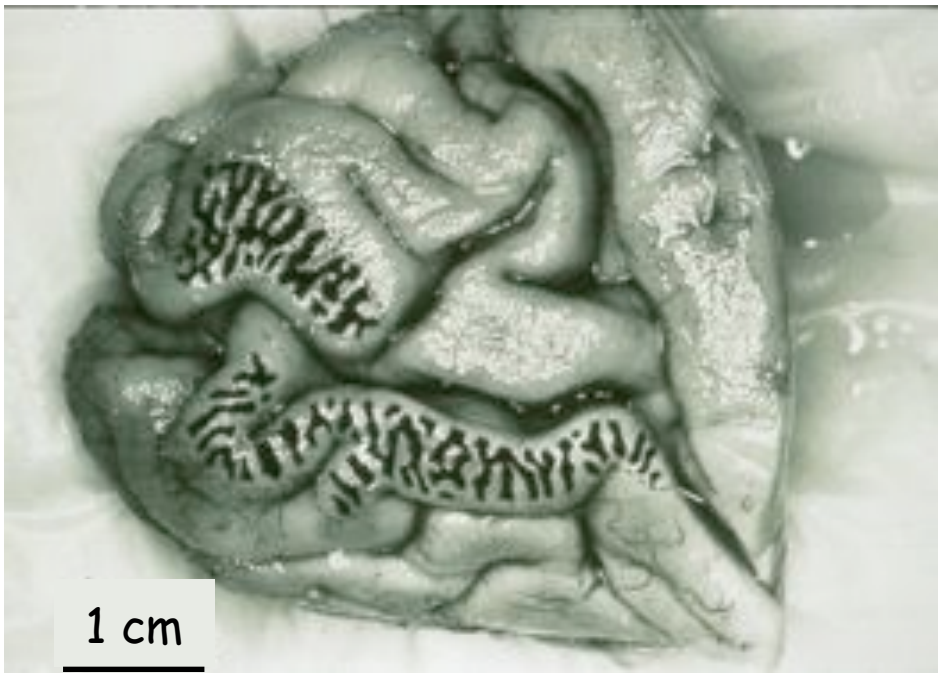
Functional specialization

Match each cortical area to its corresponding function:

V1	Motion
V2	Stereo
V3	Color
V3A	Texture
V3B	Segmentation, grouping
V4	Recognition
V5	Attention
V7	Working memory
V9	Mental imagery
IPS1	Decision-making
IPS2	Sensorimotor integration
Etc.	Etc.

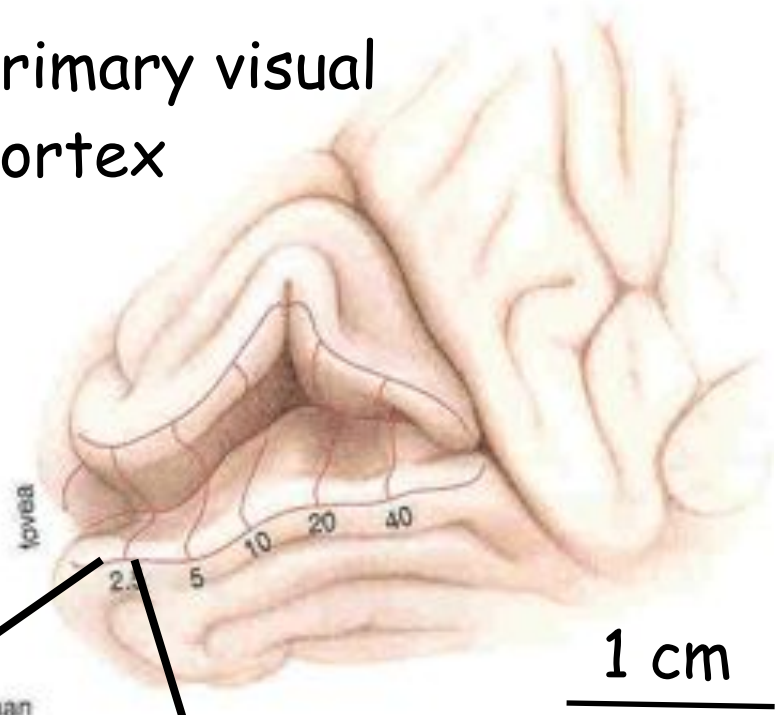
Selectivity

Columnar architecture

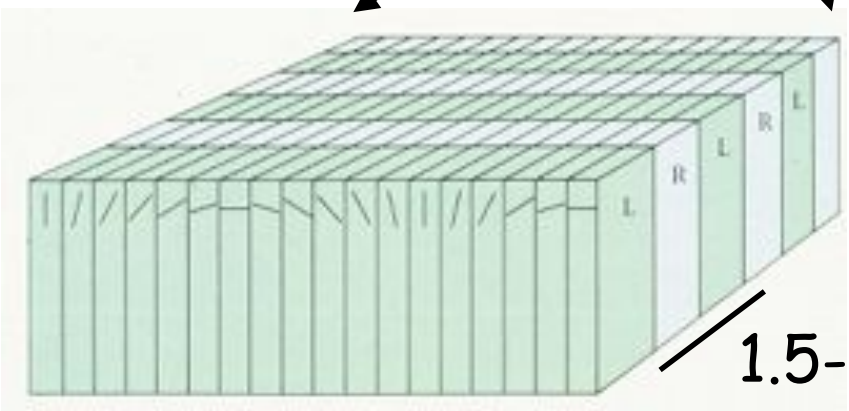


Horton & Hedley-Whyte, Philos Trans R Soc Lond B (1984)

Primary visual cortex

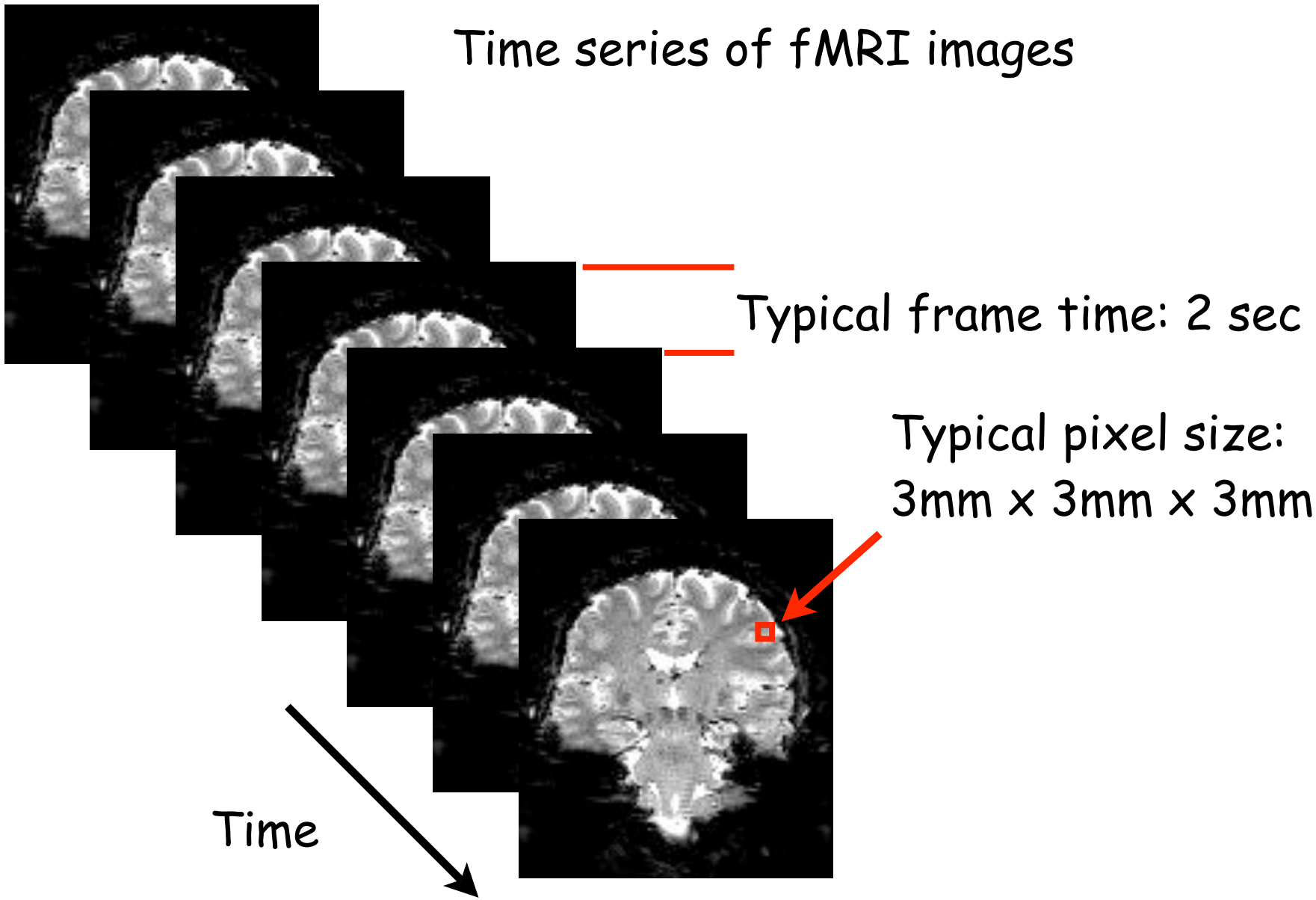


Hubel & Wiesel

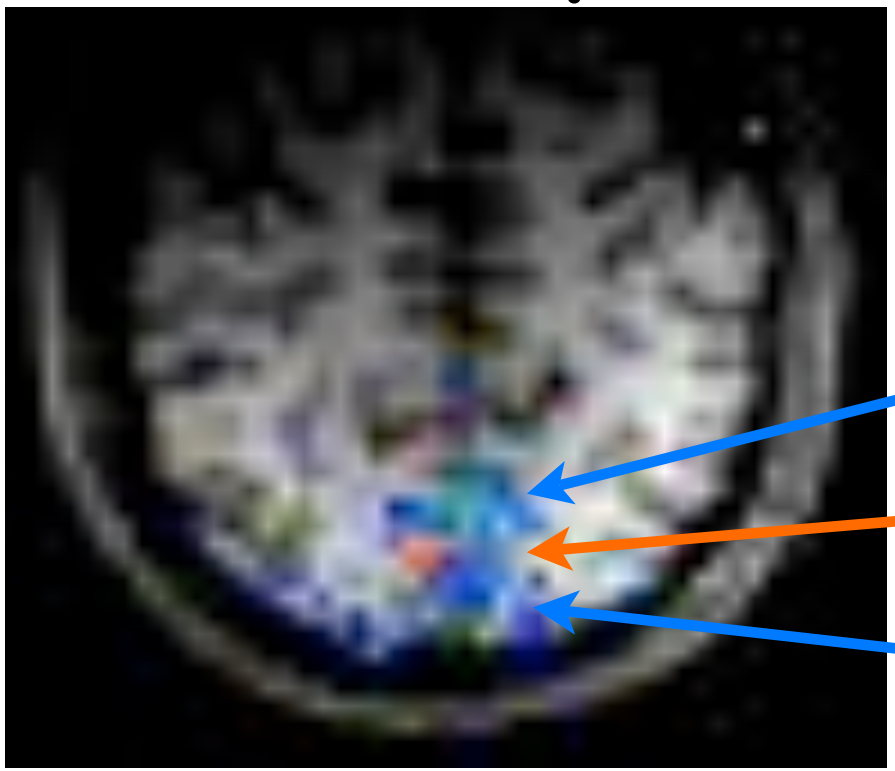


Columnar architecture

fMRI spatial and temporal resolution



Convention spatial resolution



Voxel size: 3 x 3 x 3 mm^3

FOV: 192 x 192 x 72 mm^3

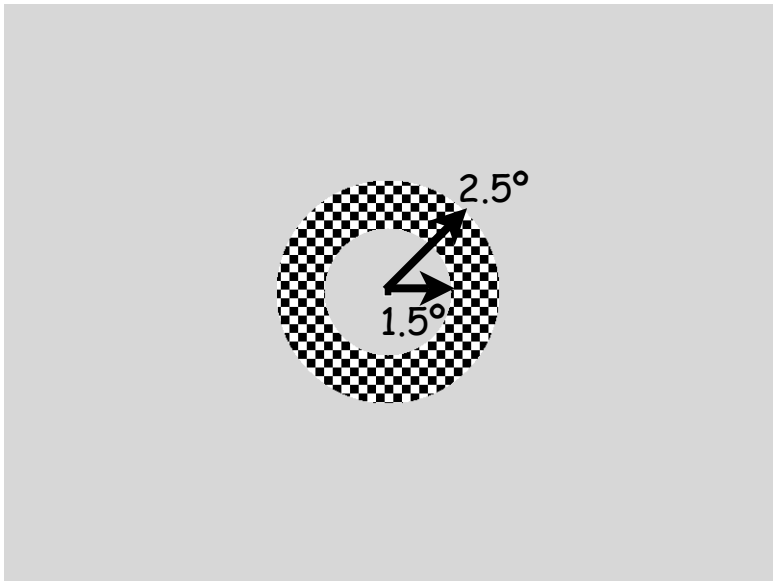
24 slices in 1.5 sec

Response to periphery

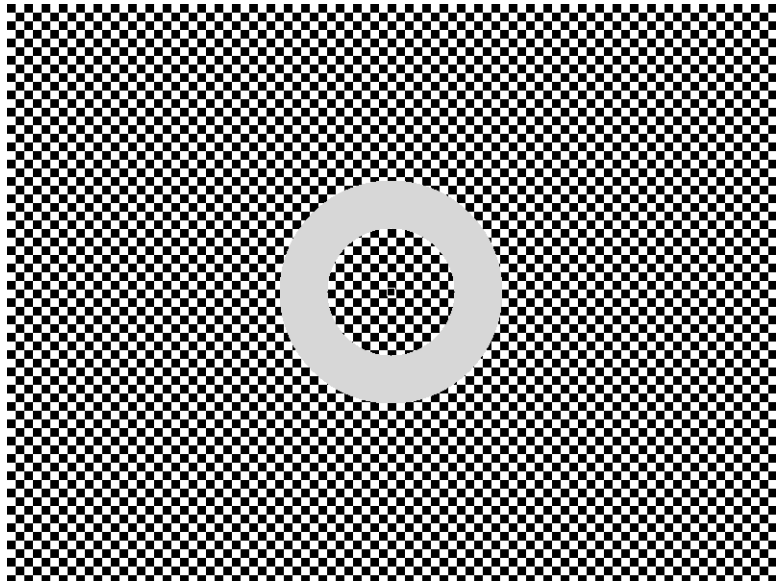
Response to annulus

Response to center

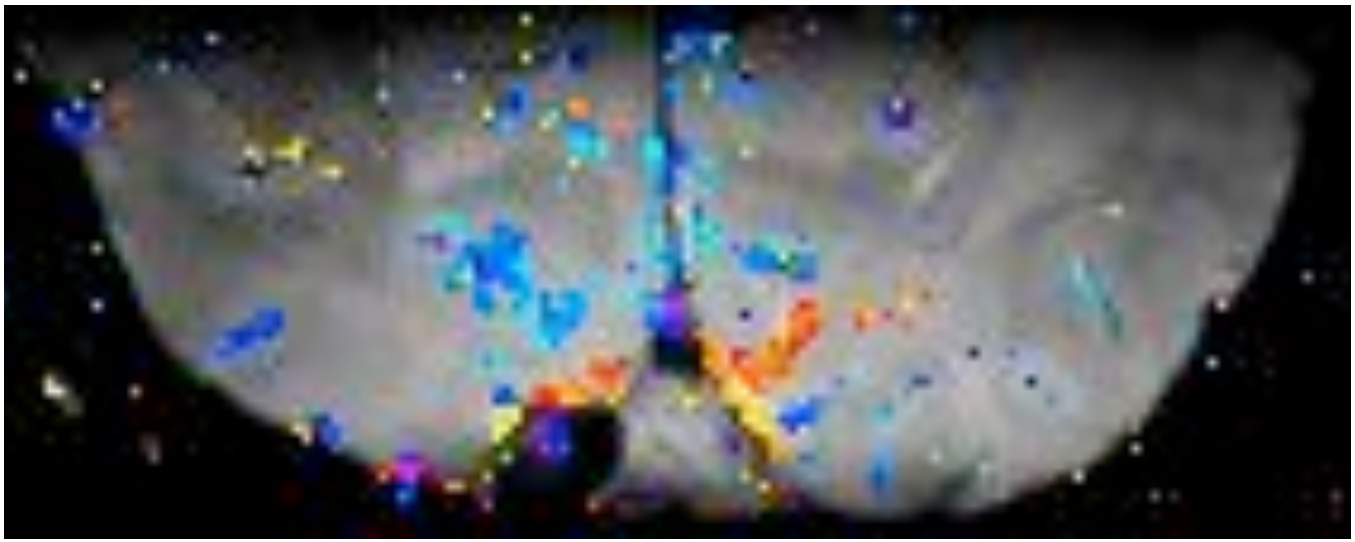
Stimulus:



vs.



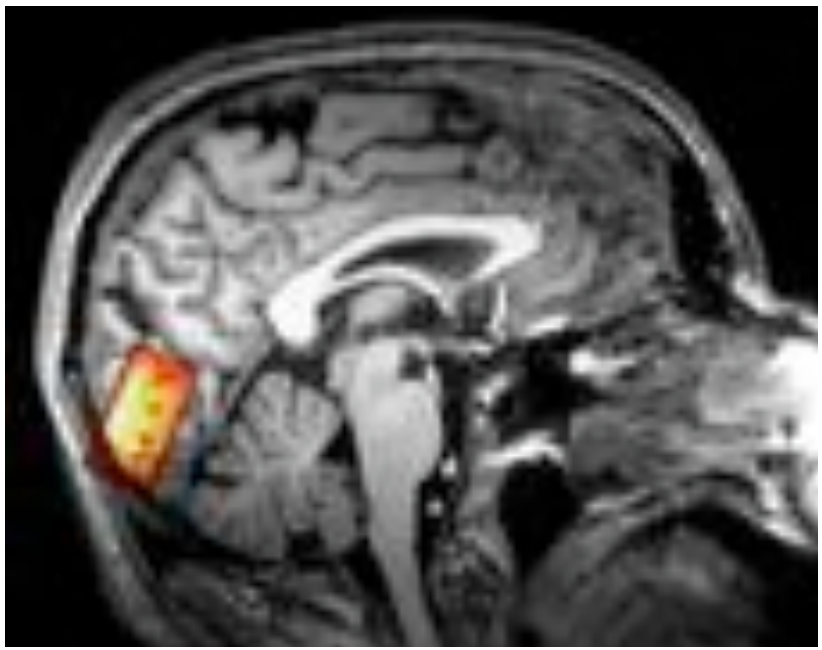
High spatial resolution fMRI (3D zoomed EPI with OVS)



Voxel size: 0.7 x 0.7 x 0.7 mm^3

FOV: 157 x 39 x 21 mm^3

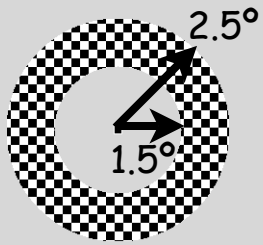
30 slices in 3 sec



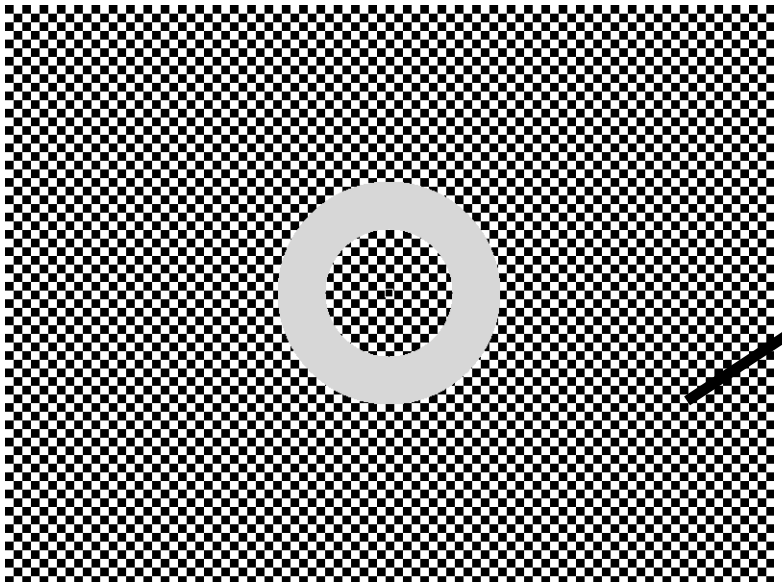
Zoomed field of view

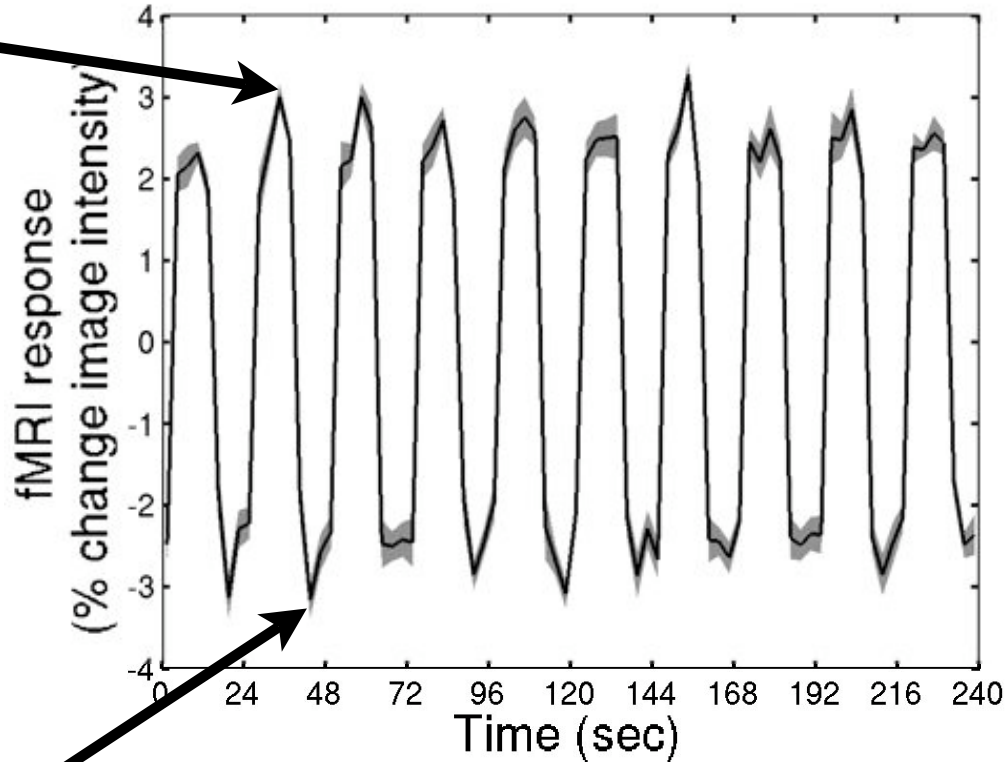
Reliability

Annulus

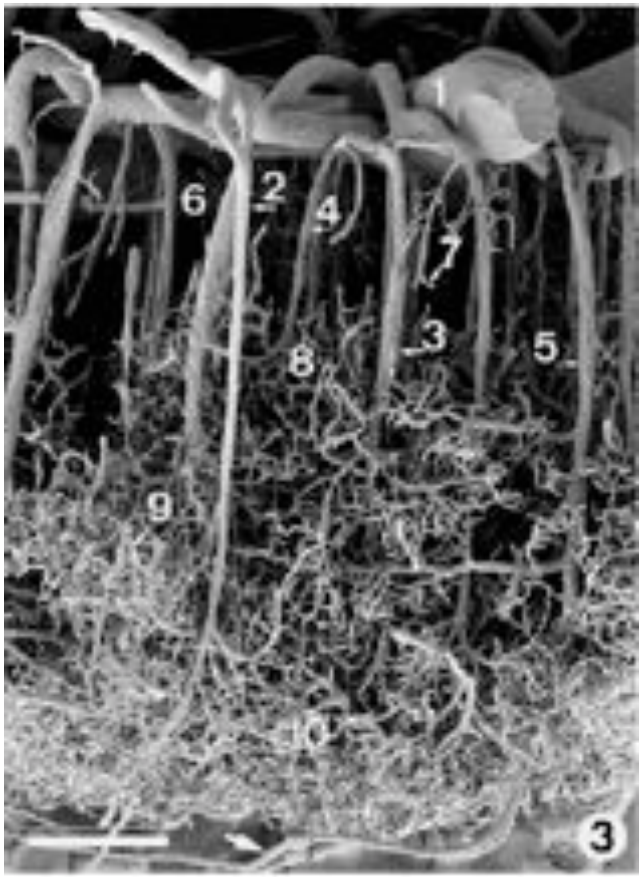


Center & periphery



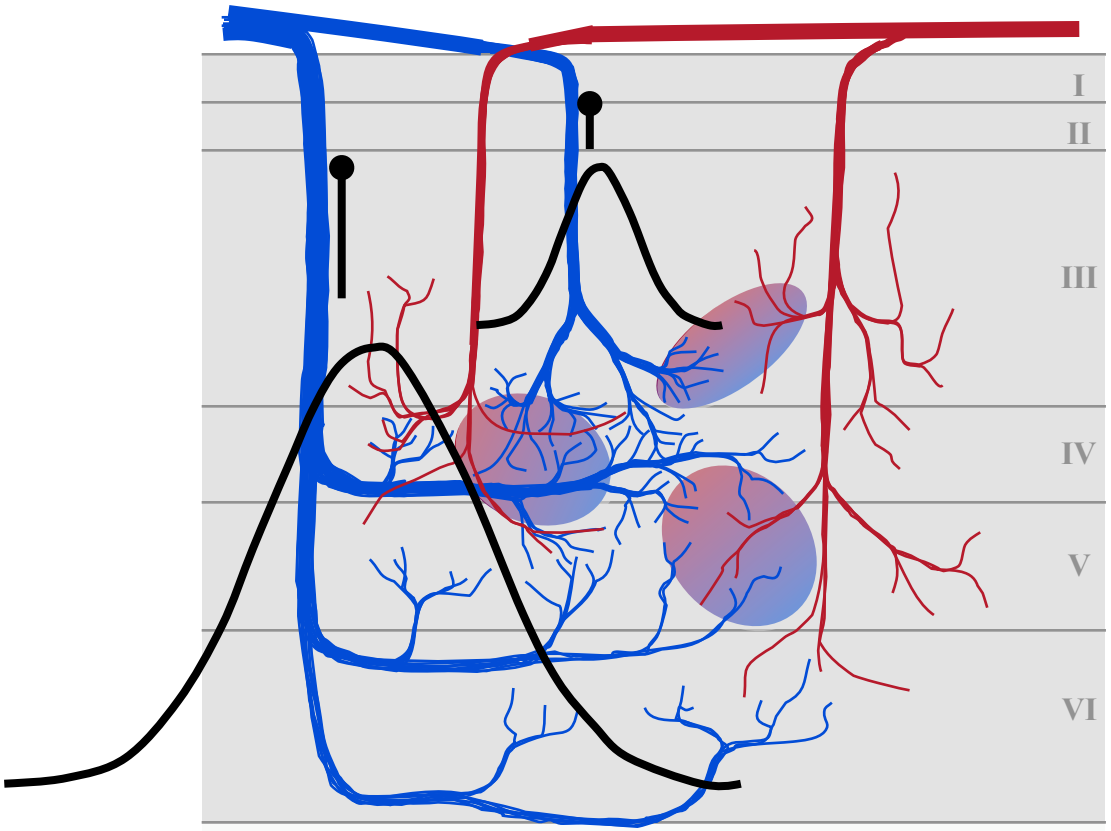


Neurovascular coupling limits spatial specificity



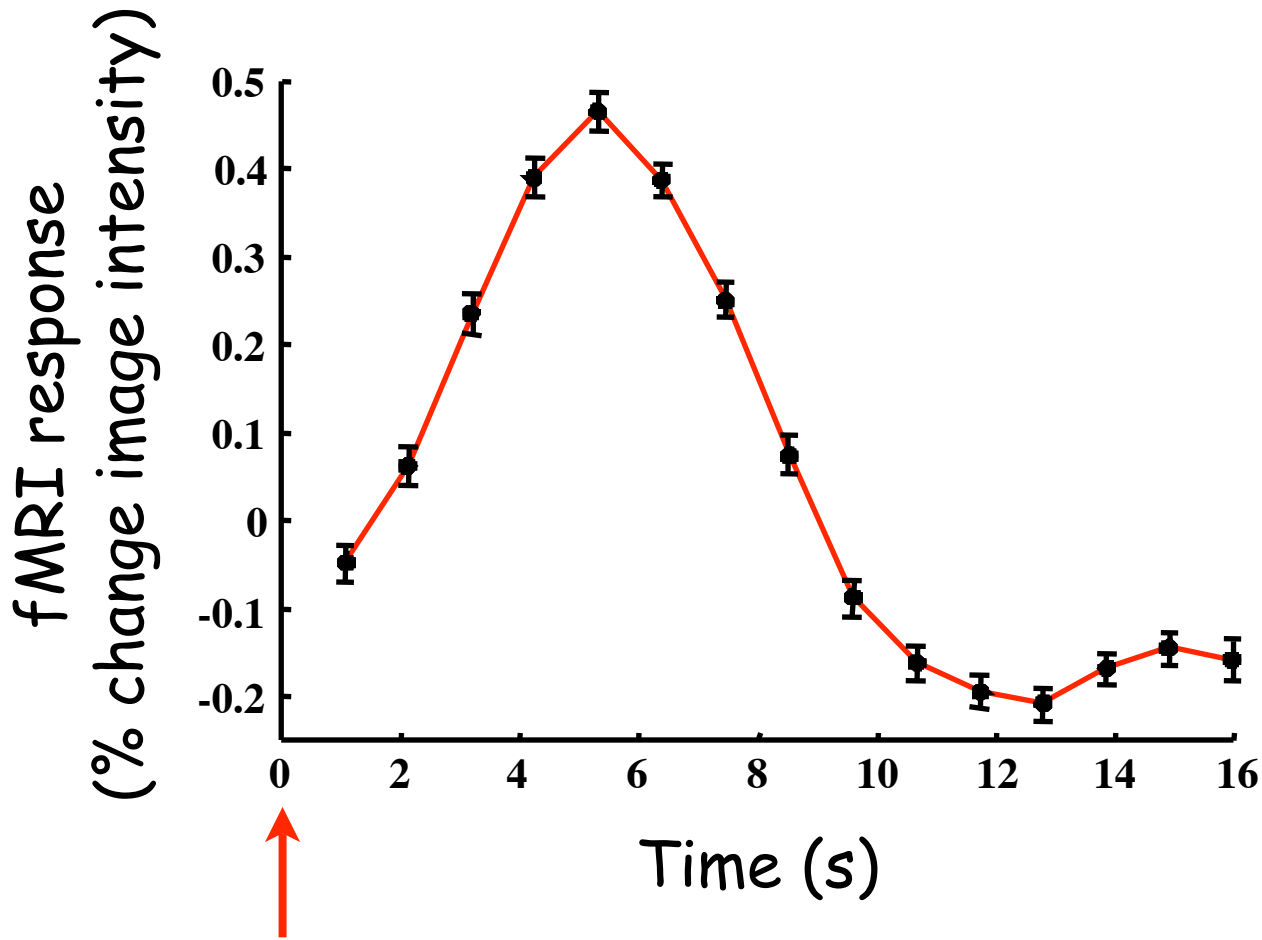
Reina de la Torre et al
Anatomical Record (1998)

3.5 mm full-width at half-max
(Engel el et al., 1997)

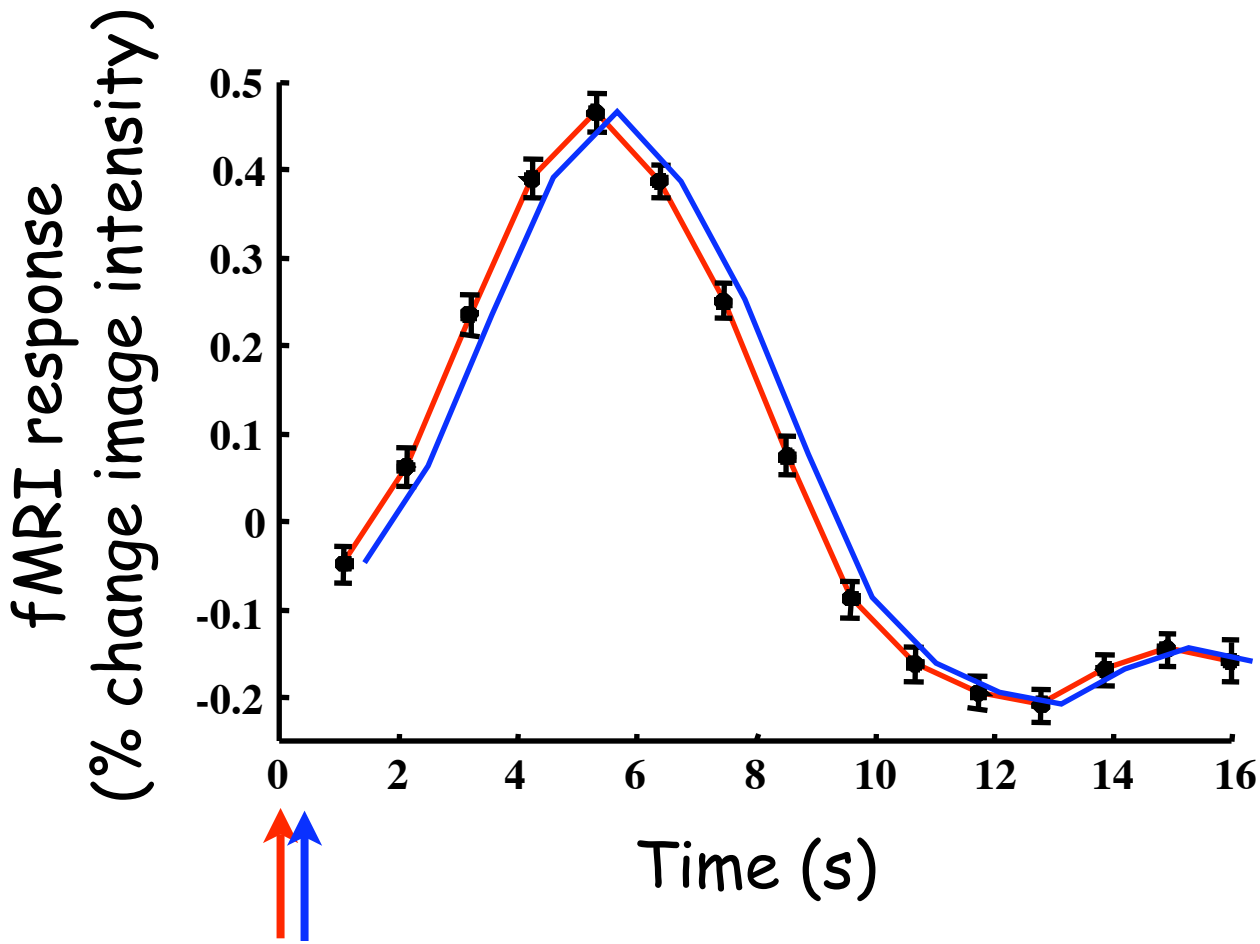


Spatial specificity (spread and mislocalization) depends on vein size.

Sluggishness of hemodynamics limits temporal specificity

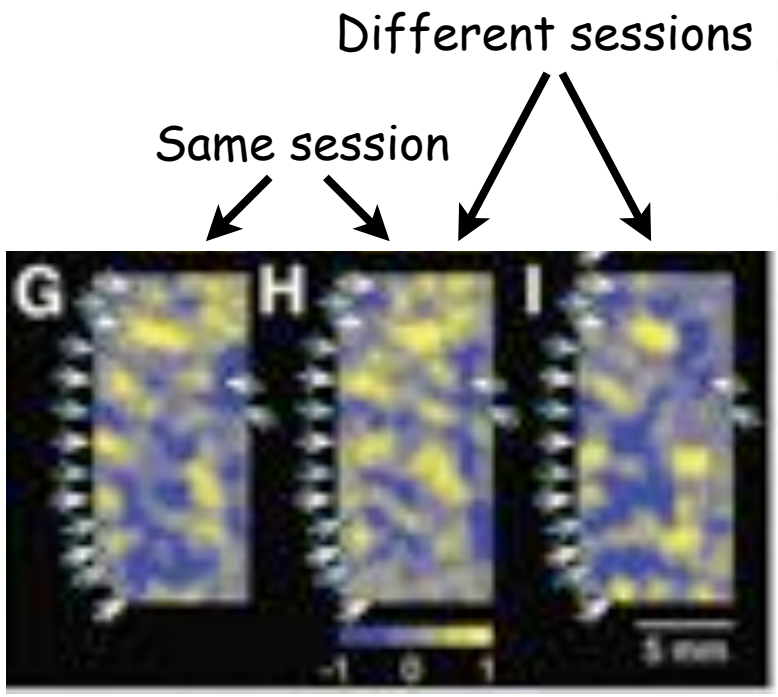


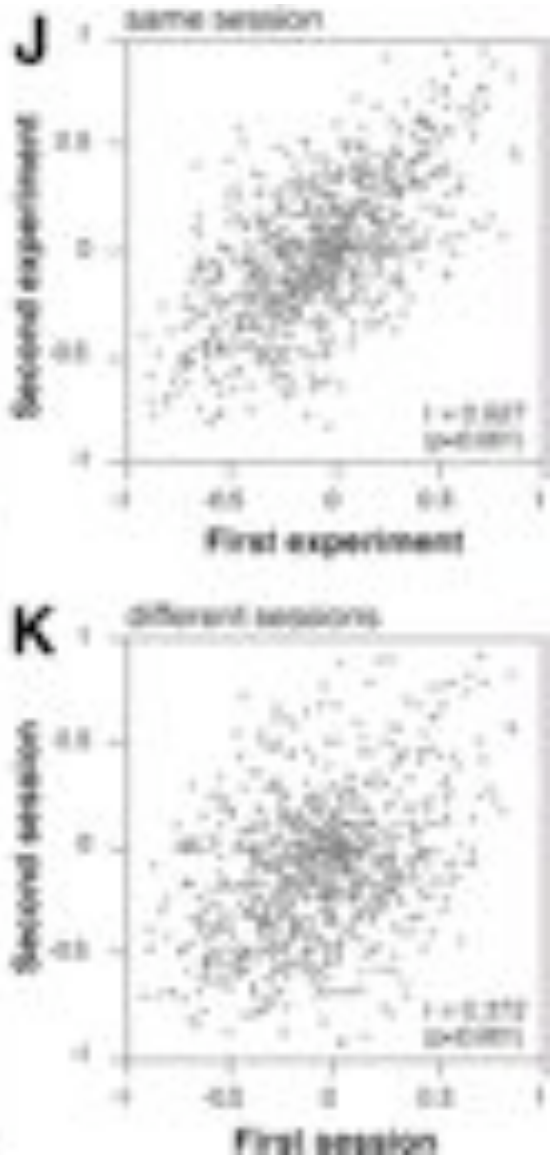
Sluggishness of hemodynamics limits temporal specificity



Columns with fMRI: proof of principle

Voxel size: 0.5 x 0.5 x 3 mm^3
FOV: 240 x 240 x 9 mm^3
3 slices in 9.6 sec



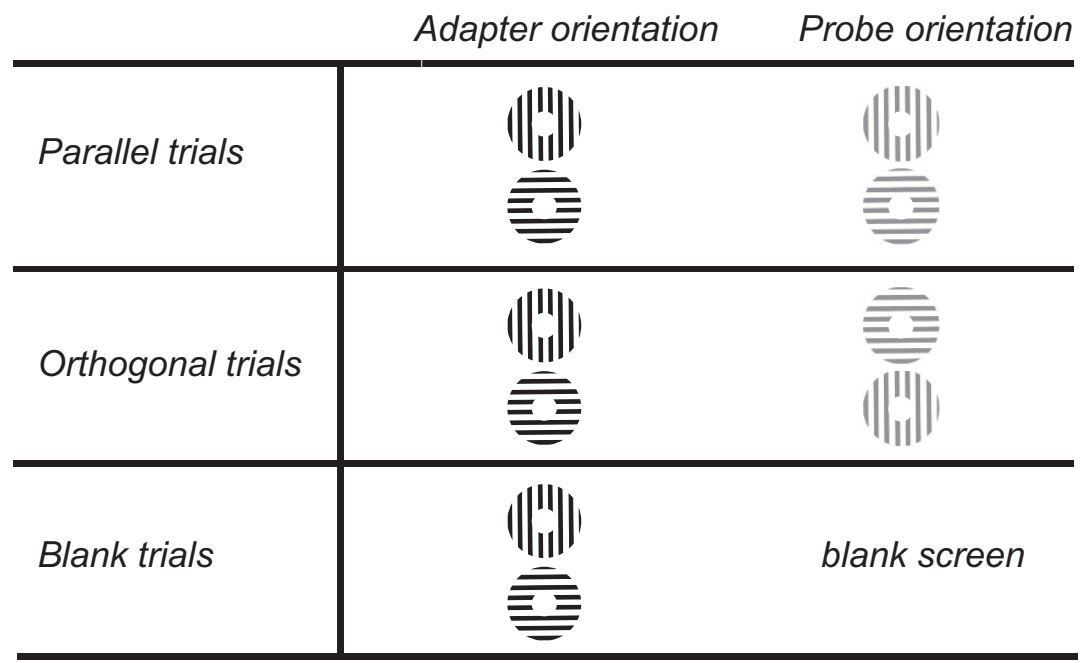


Cheng, Waggoner, & Tanaka, Neuron (2001)

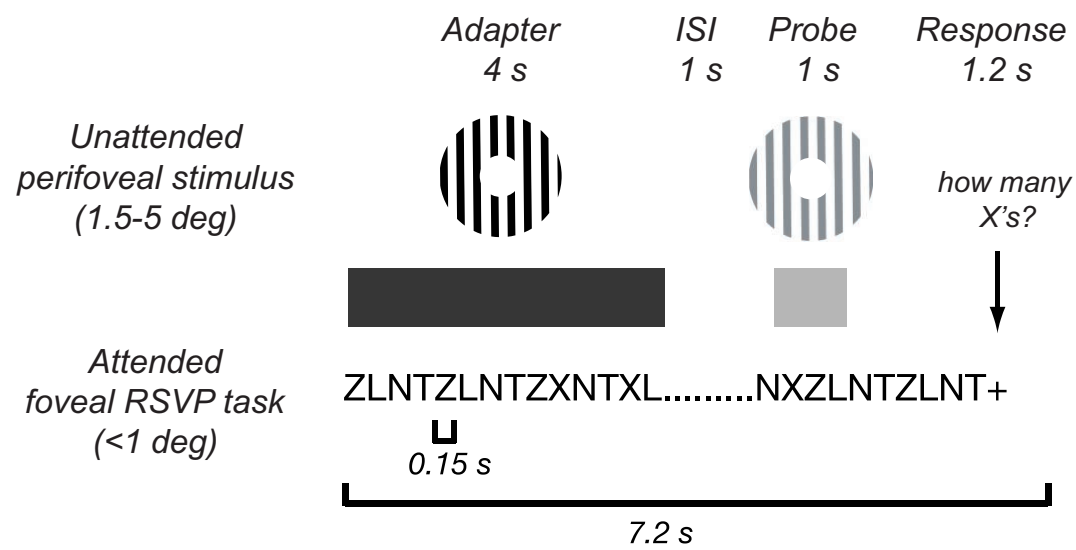
Adaptation

Orientation-selective adaptation protocol

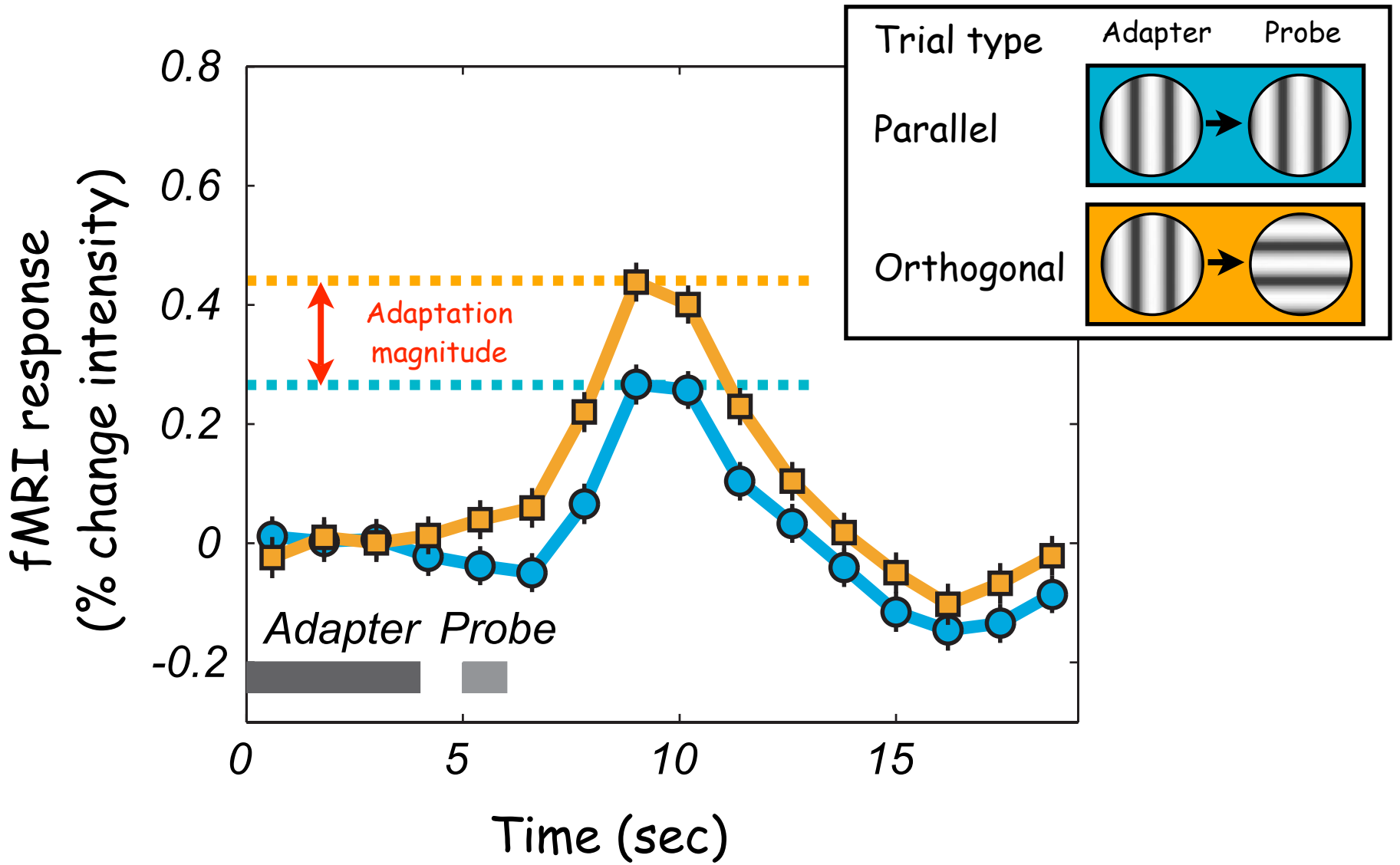
Trial types



Trial structure

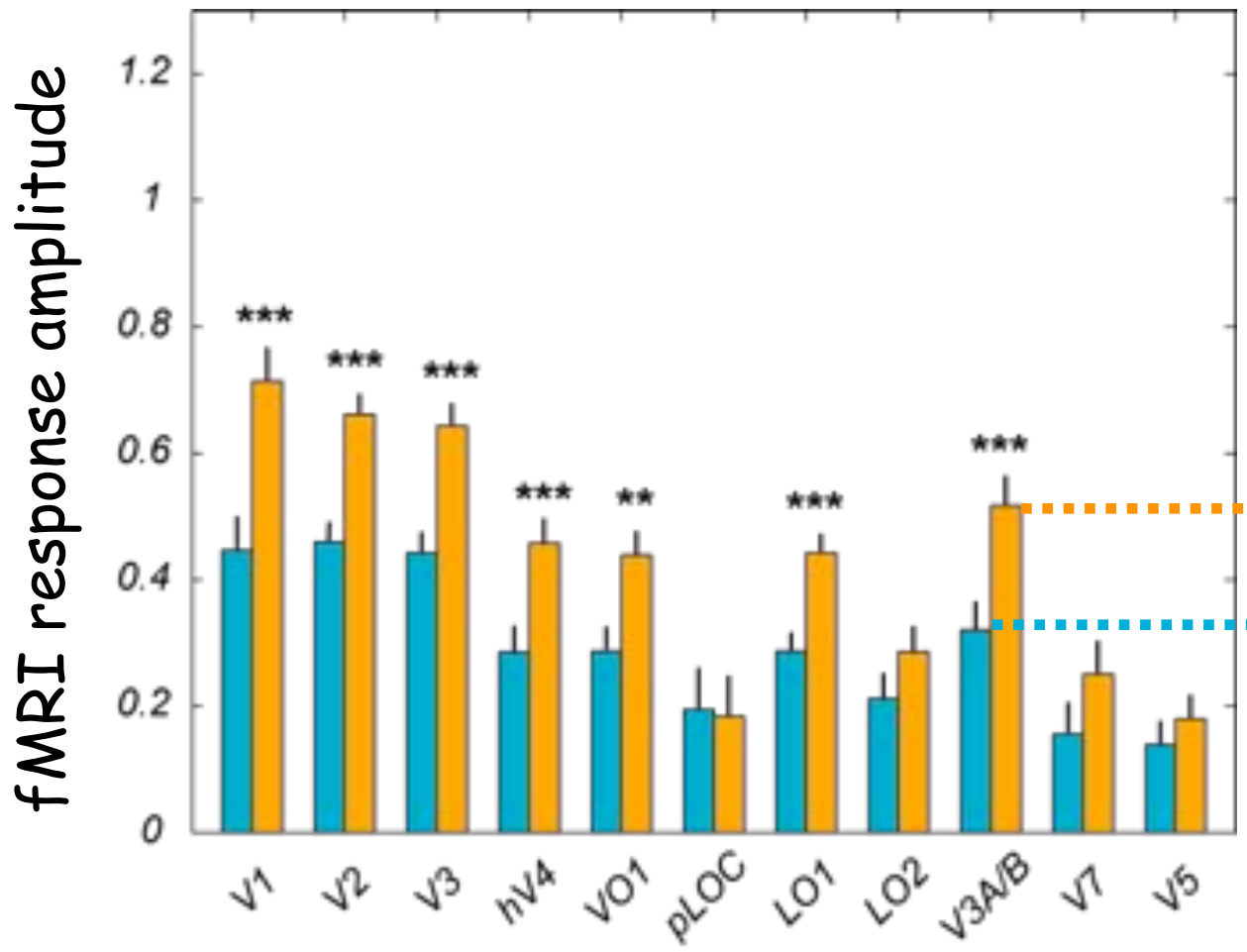


Orientation-selectivity in human V1



Larsson, Landy, & Heeger, J Neurophysiol (2006)

Orientation-selective adaptation



Adaptation index:

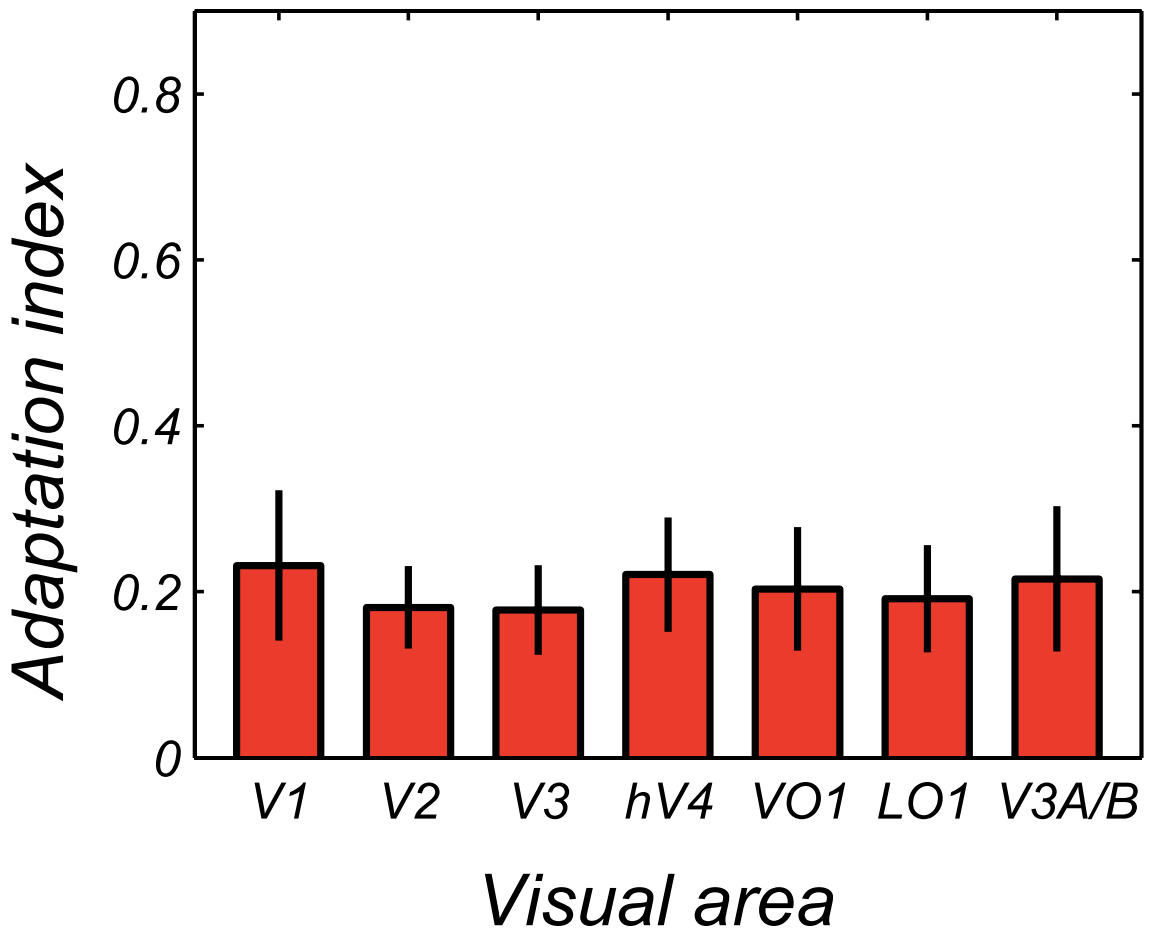
$$I_A = \frac{A_\perp - A_\parallel}{|A_\perp| + |A_\parallel|}$$

$A_\perp$

$A_\parallel$

Larsson, Landy, & Heeger, J Neurophysiol (2006)

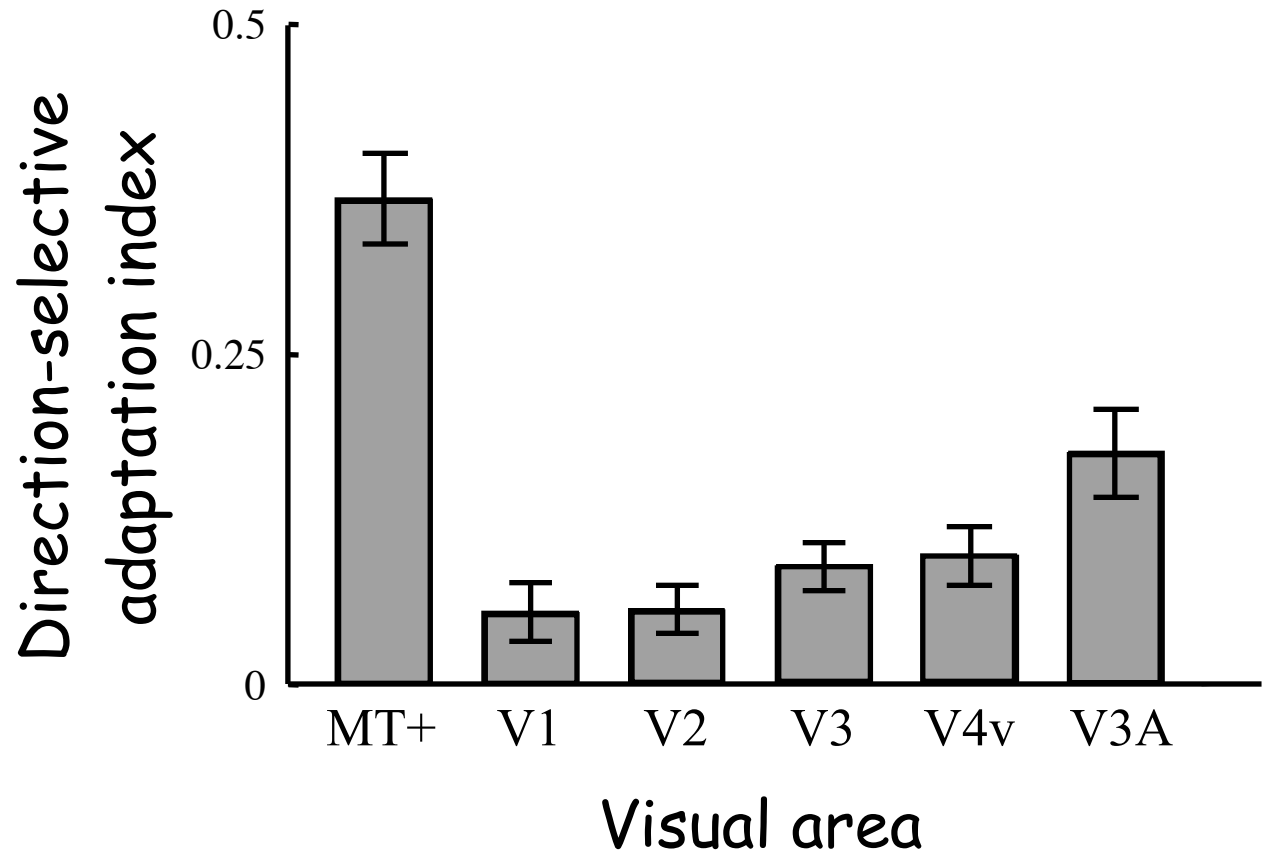
Adaptation index



- Adaptation indices constant across visual areas
- No significant differences between V1 and extrastriate visual areas
- Adaptation in V1 can account for adaptation in extrastriate visual areas

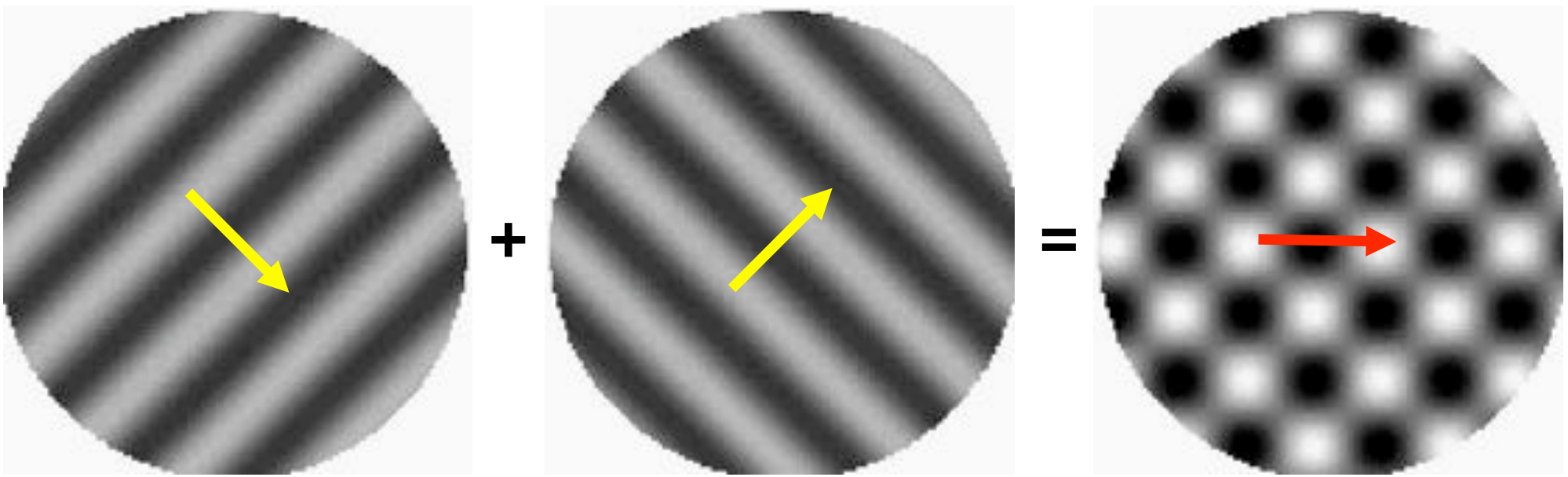
Larsson, Landy, & Heeger,
J Neurophysiol (2006)

Direction-selective adaptation



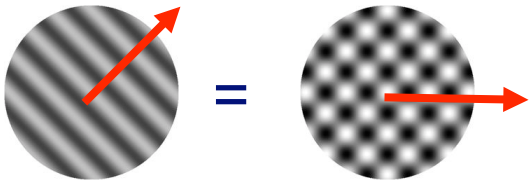
Huk, Ress, & Heeger (2001) Neuron, 32:161-

Pattern motion



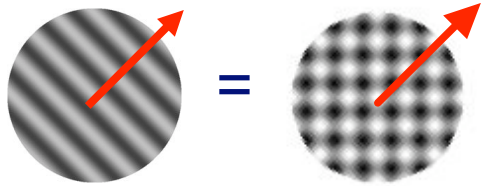
Component vs. pattern motion selectivity

component-motion cell

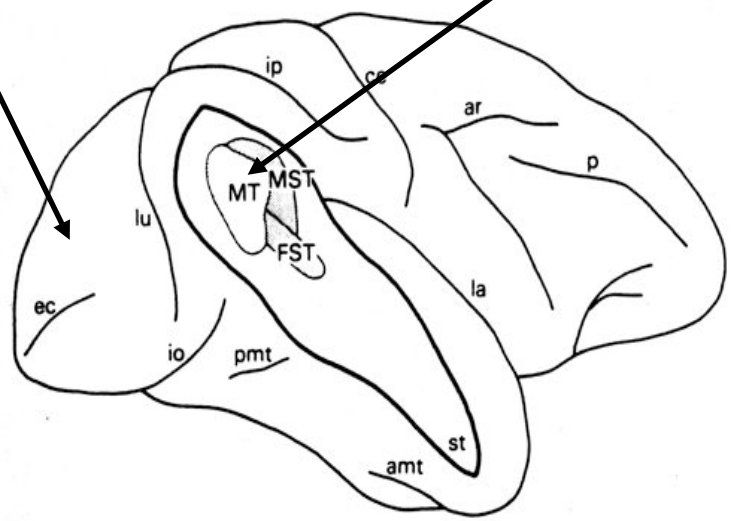


grating component moving up-right => strong response

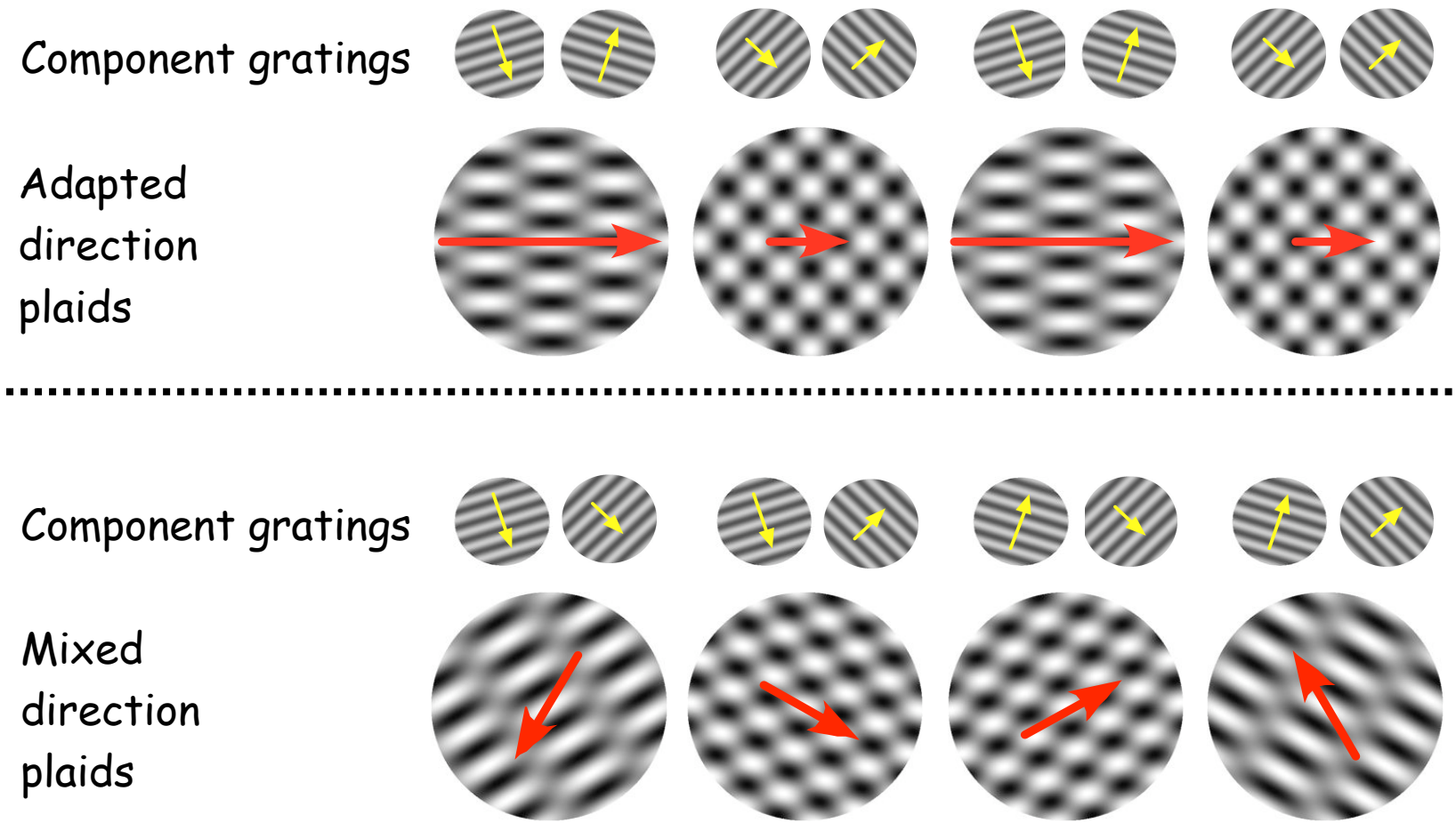
pattern-motion cell



pattern moving up-right strong response

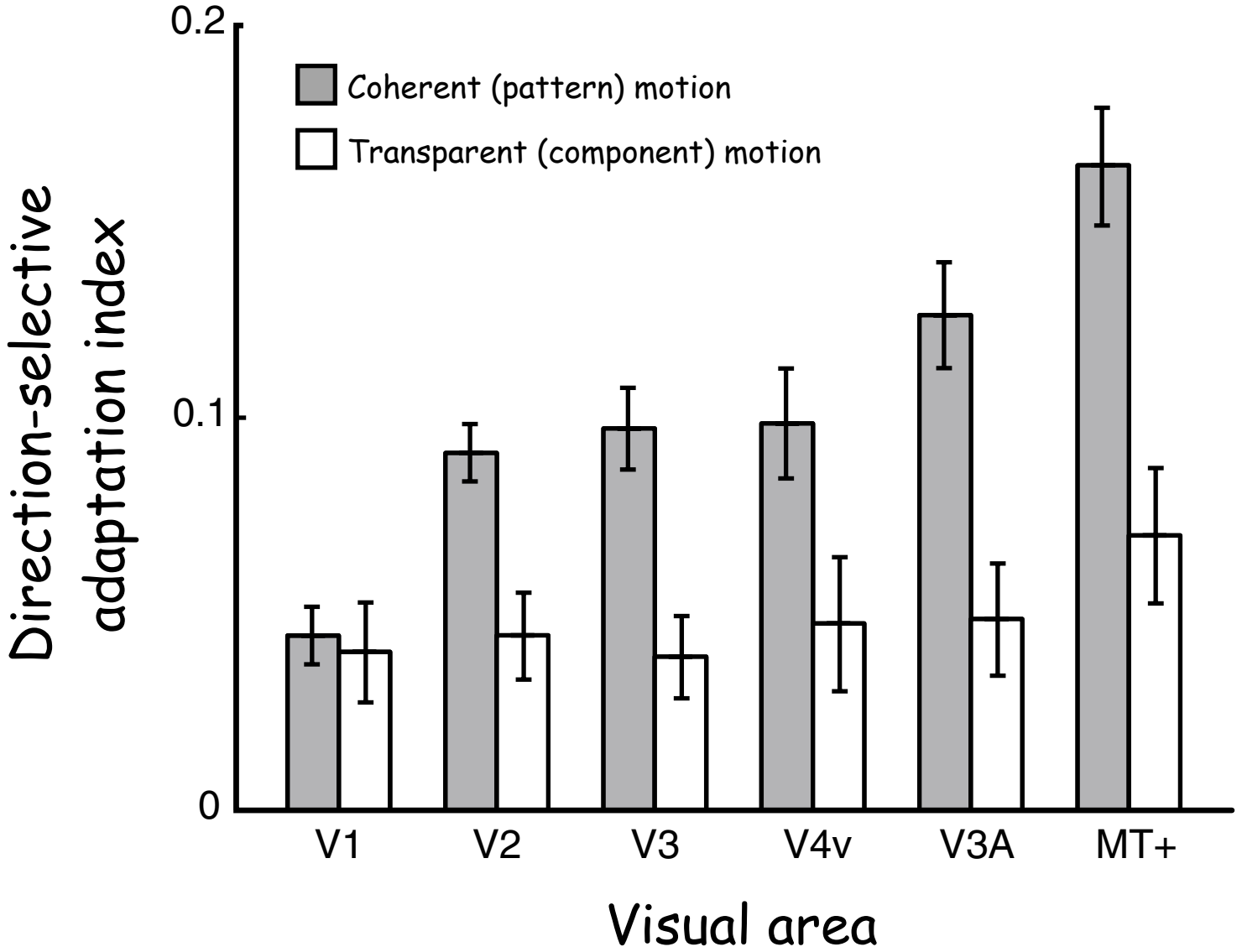


Pattern motion adaptation protocol



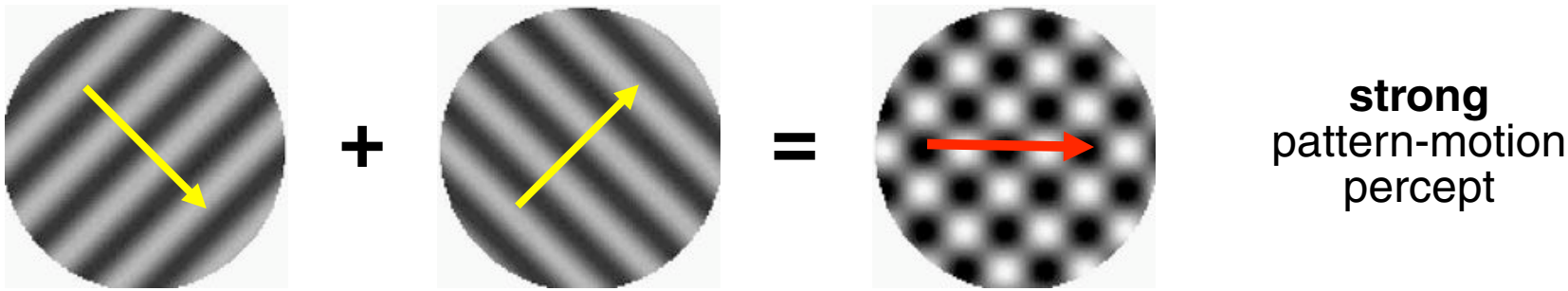
Huk & Heeger, Nature Neurosci, 5:72-75, 2002

Pattern motion adaptation

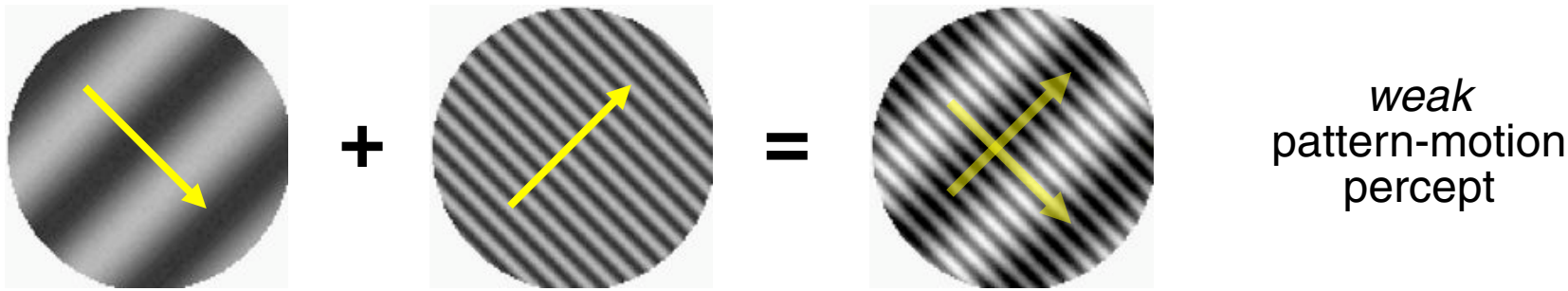


Huk & Heeger, Nature Neurosci, 5:72-75, 2002

Coherent vs. transparent percepts



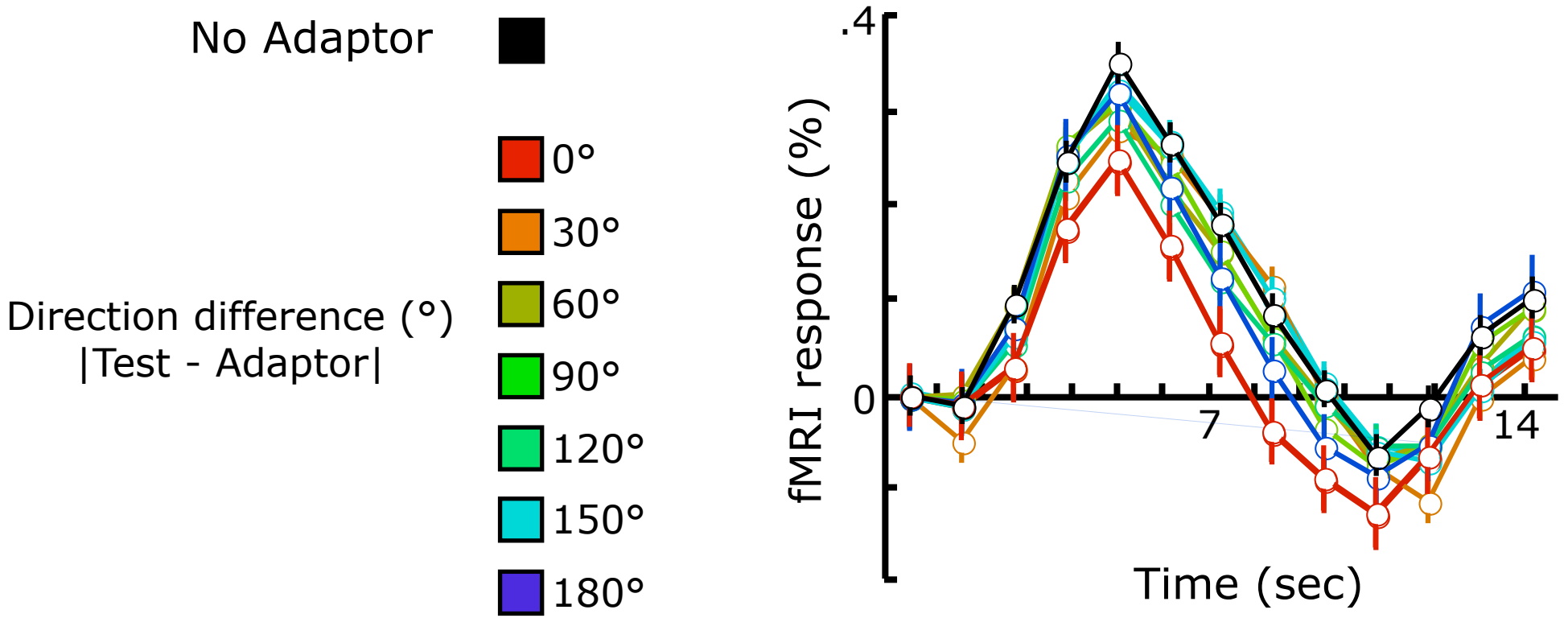
strong
pattern-motion
percept



weak
pattern-motion
percept

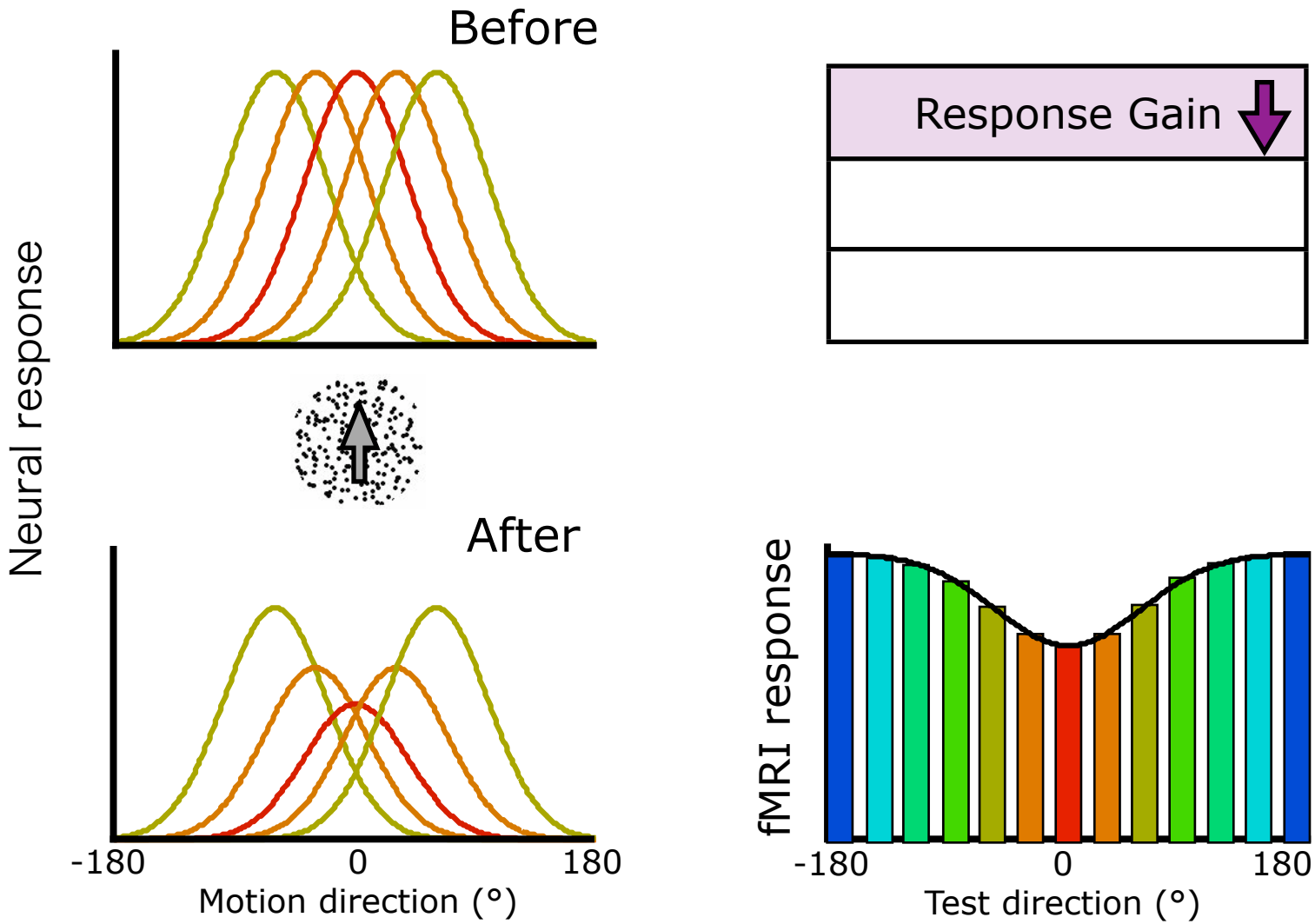
Huk & Heeger, Nature Neurosci, 5:72-75, 2002

Adaptation vs motion direction



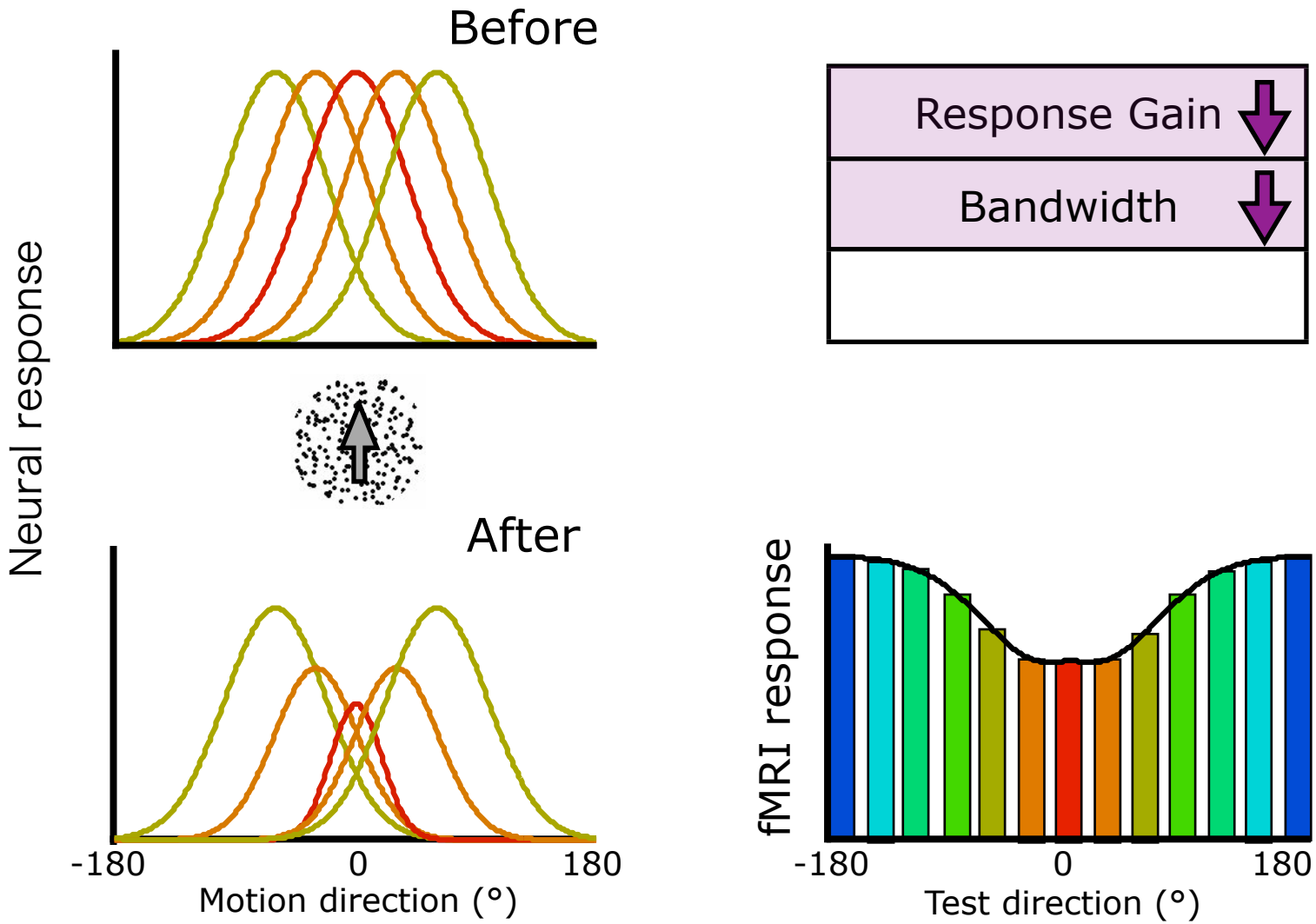
Lee, Lee, & Lee, SFN, 2005

Response gain reduction



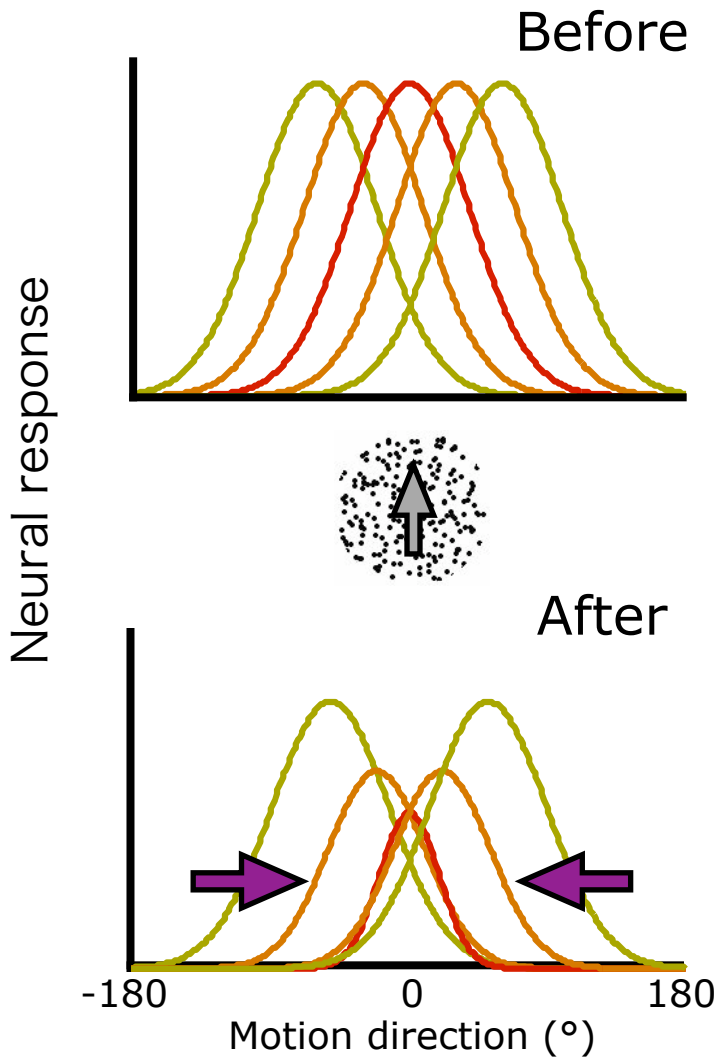
Lee, Lee, & Lee, SFN, 2005

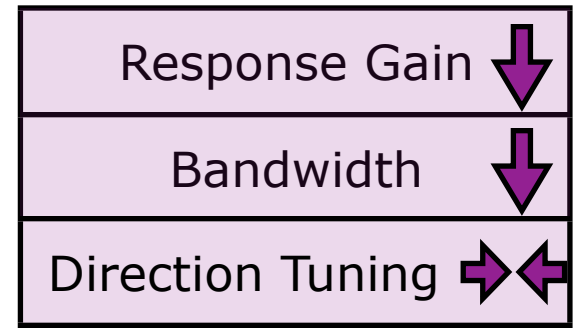
Bandwidth reduction



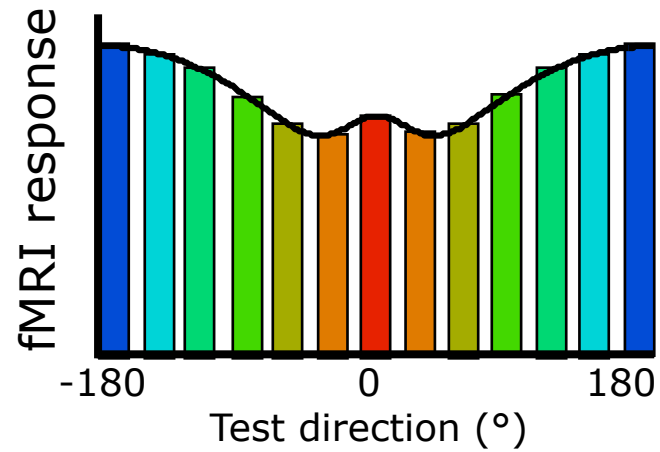
Lee, Lee, & Lee, SFN, 2005

Attractive shift



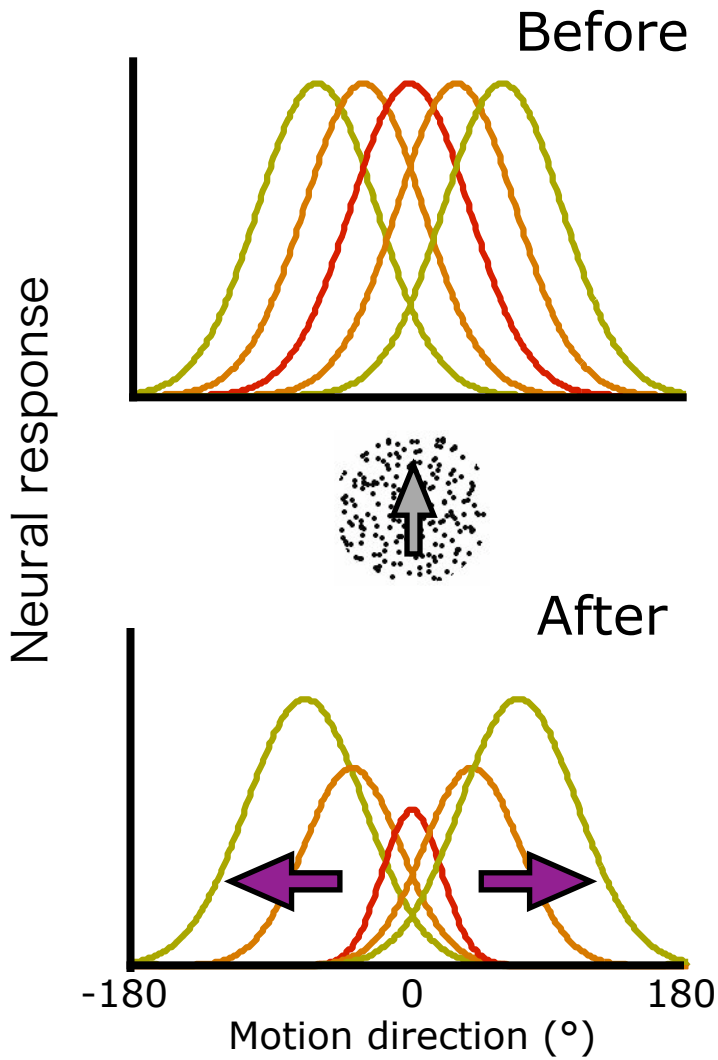


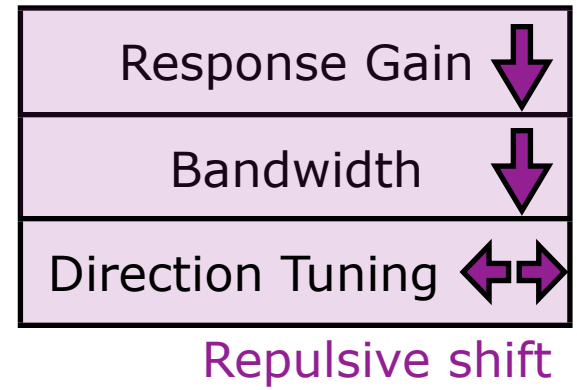
Attractive shift

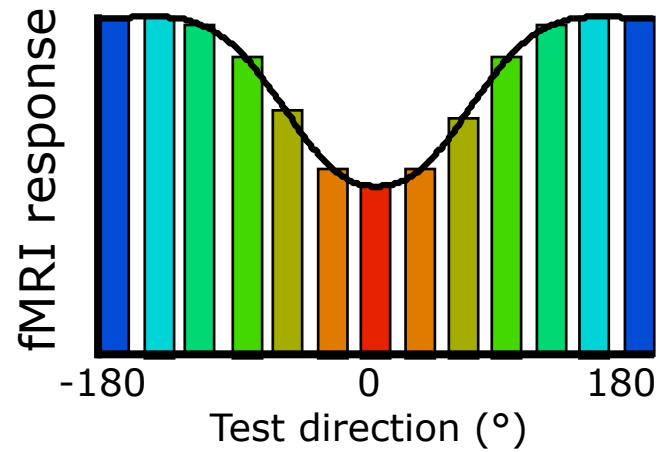


Lee, Lee, & Lee, SFN, 2005

Repulsive shift



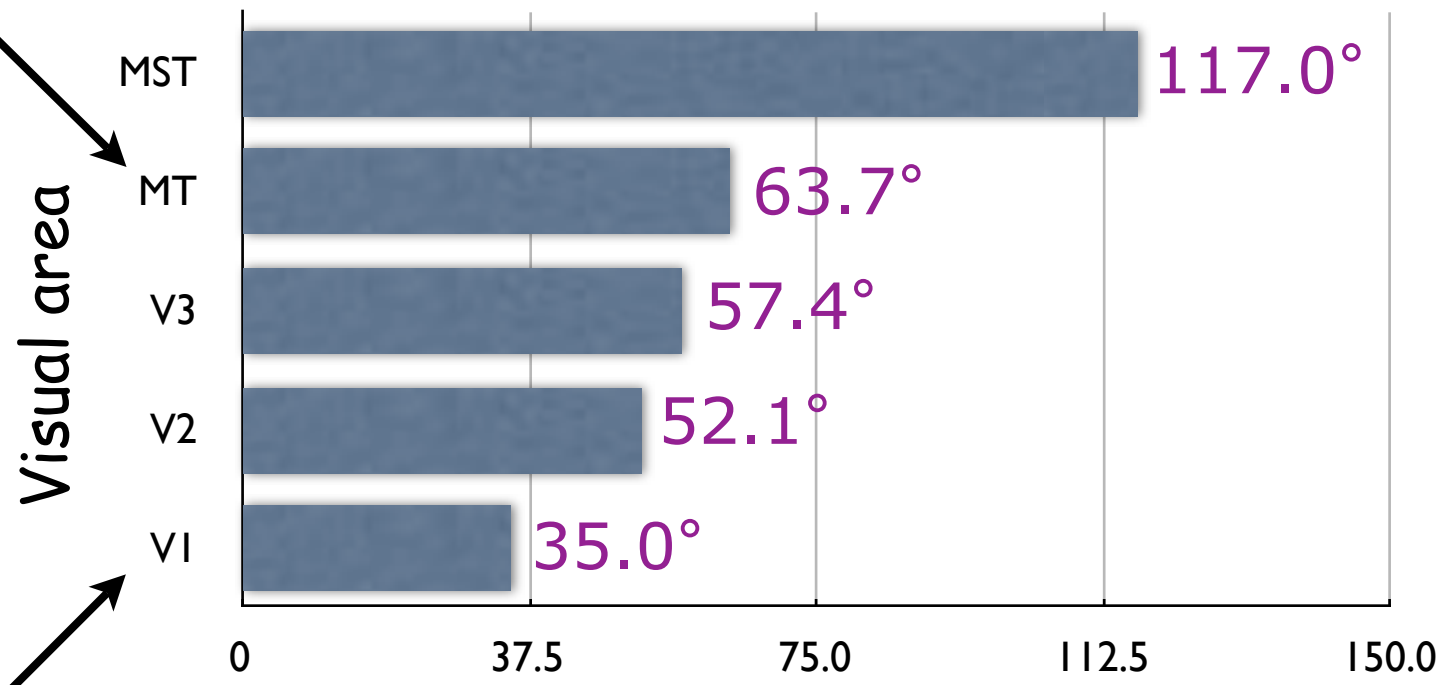




Lee, Lee, & Lee, SFN, 2005

Estimated tuning bandwidth

Response gain reduction and attractive shift

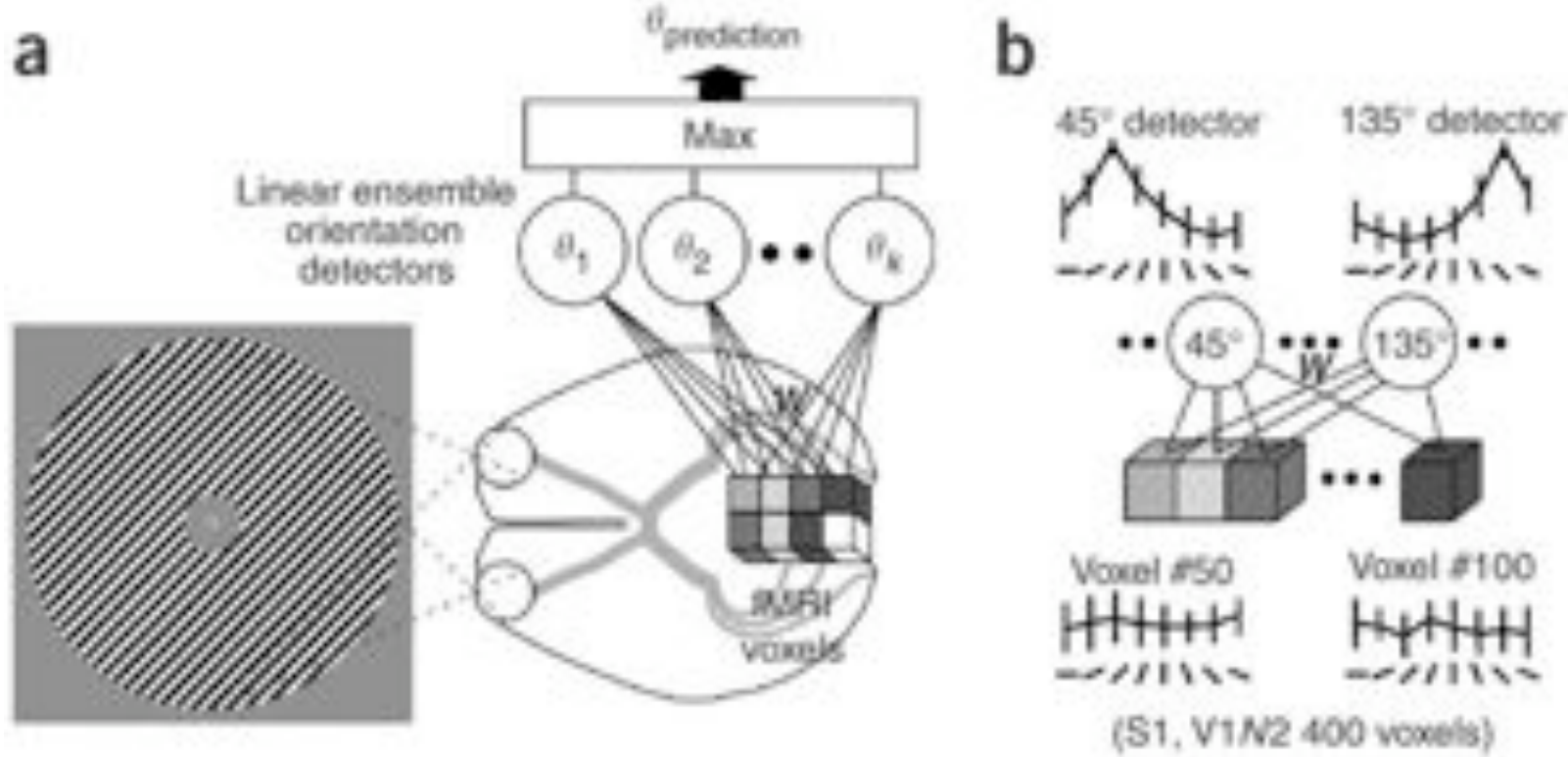


Response gain reduction

Lee, Lee, & Lee, SFN, 2005

Classification

Classifying stimulus orientation with conventional resolution fMRI

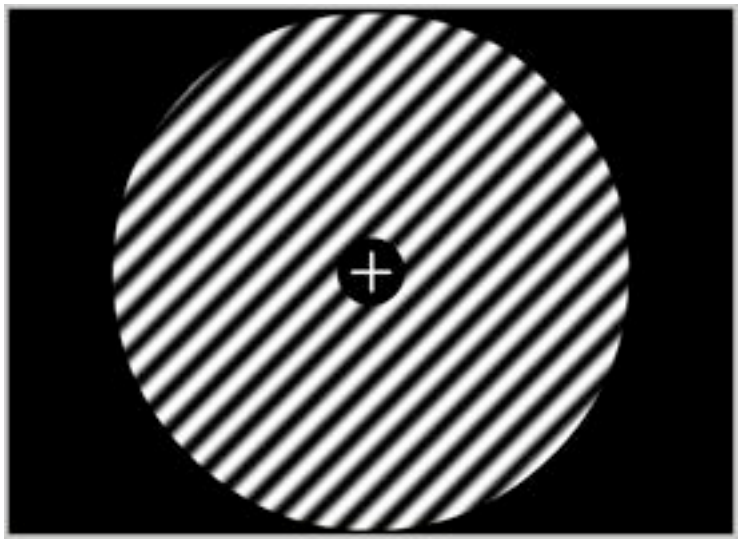


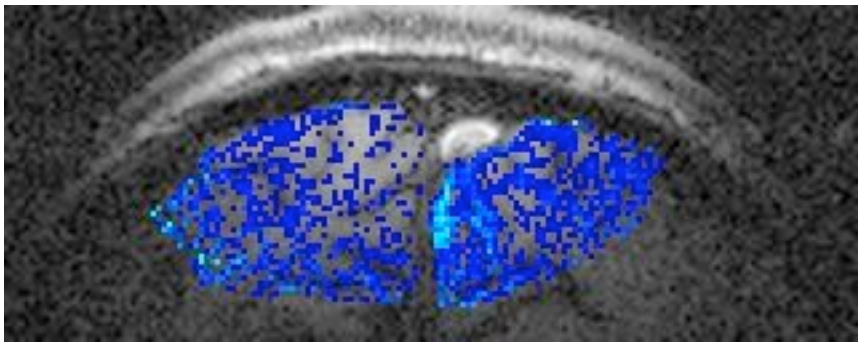
Kamitani & Tong, Nat Neurosci (2005)

Classifying orientation

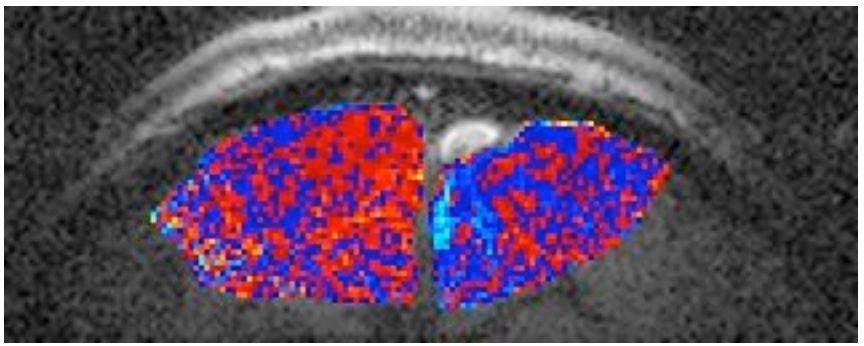
Classifier weights

Stimulus

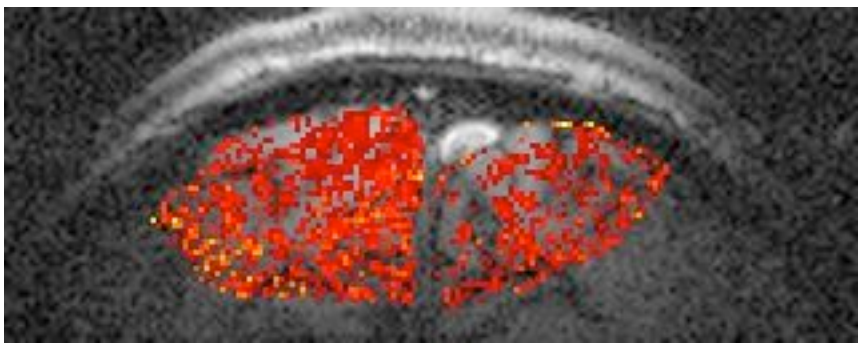




Clockwise tilt



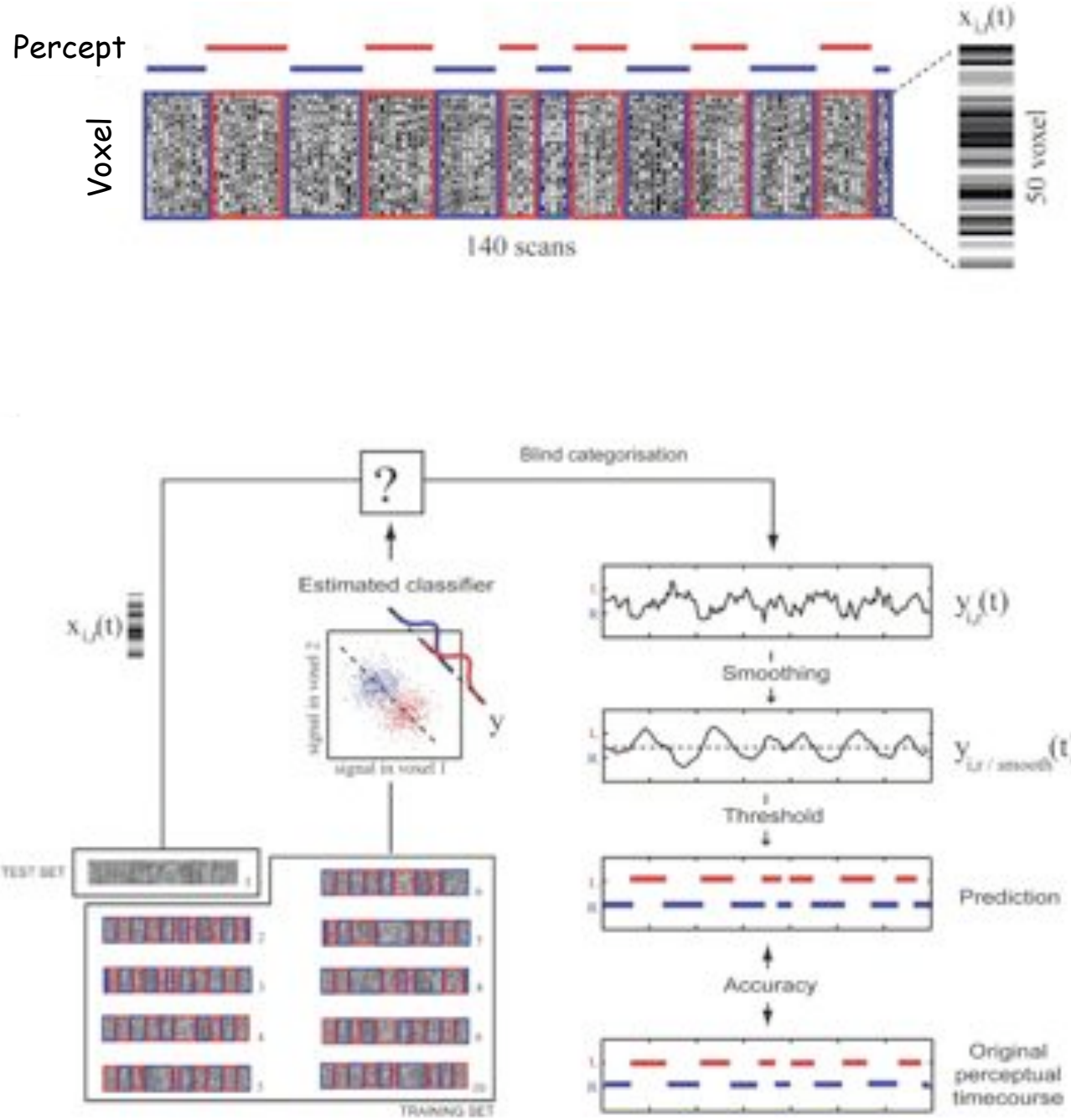
Both



Counter-clockwise tilt

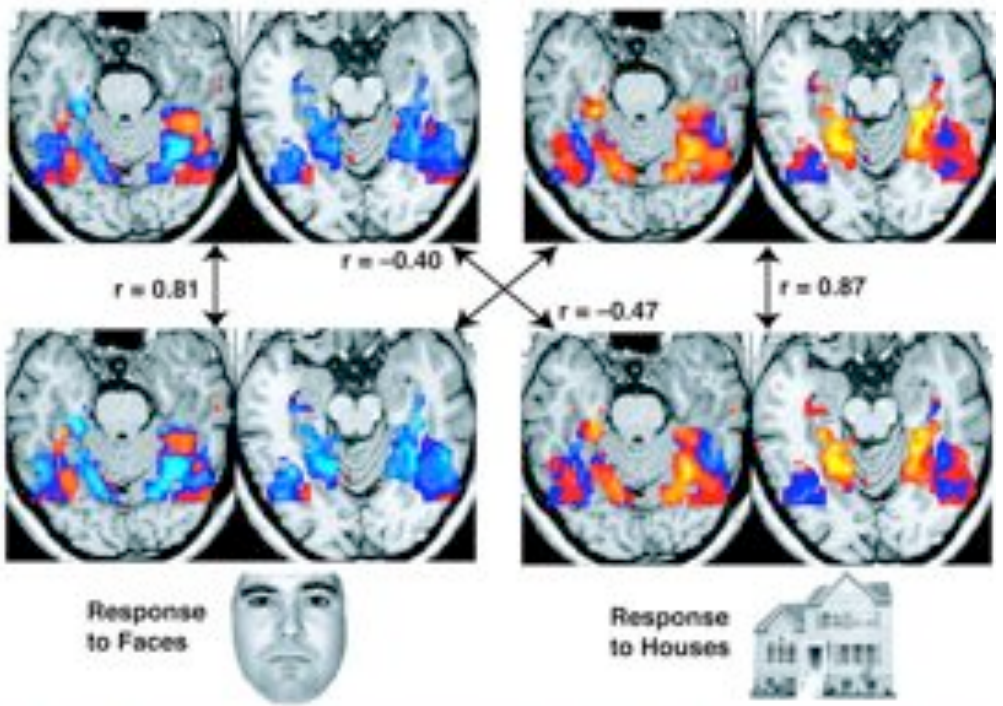
Justin Gardner

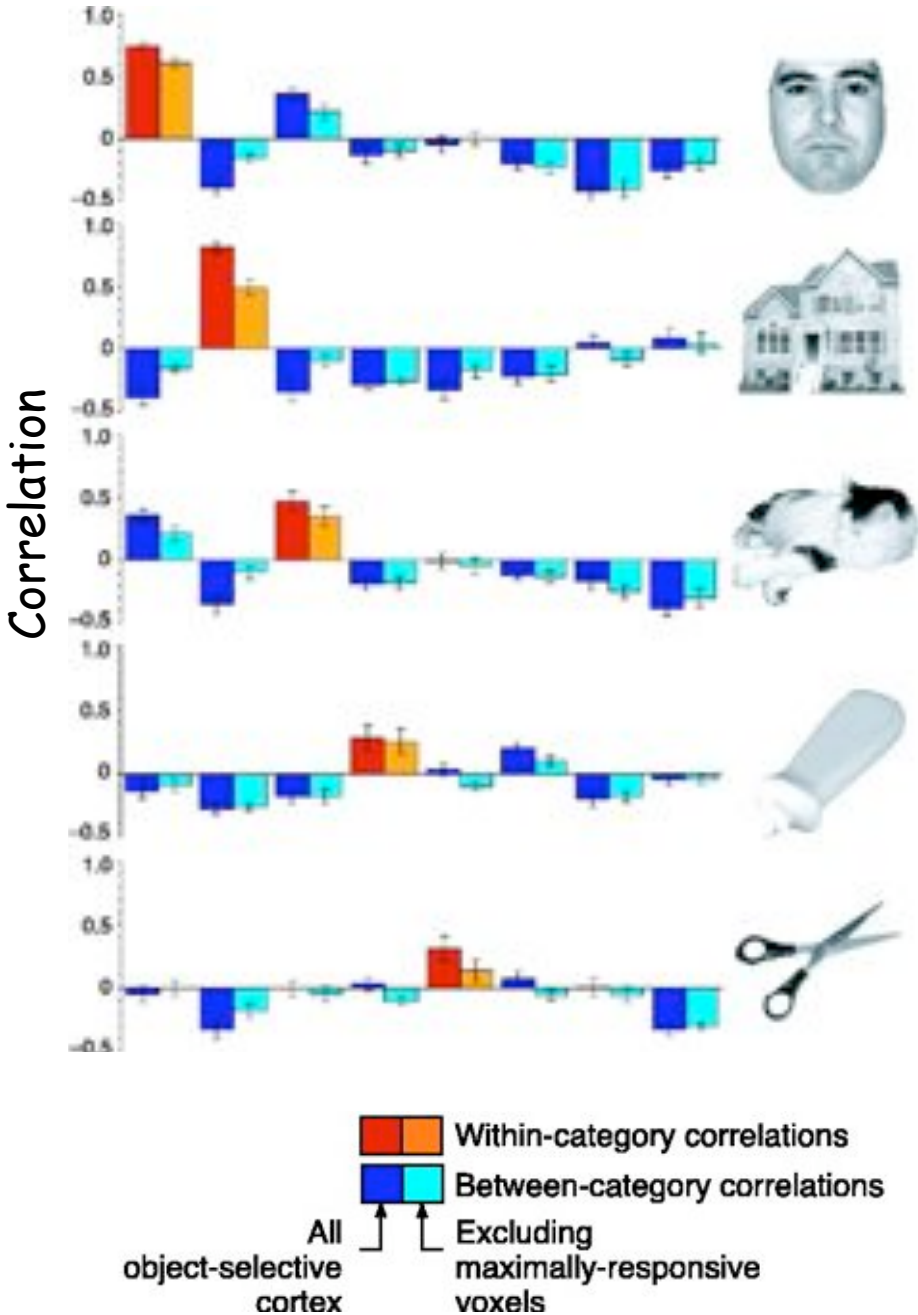
Classifying percepts during binocular rivalry



Haynes & Rees, Curr Biol (2005)

Object-category classification

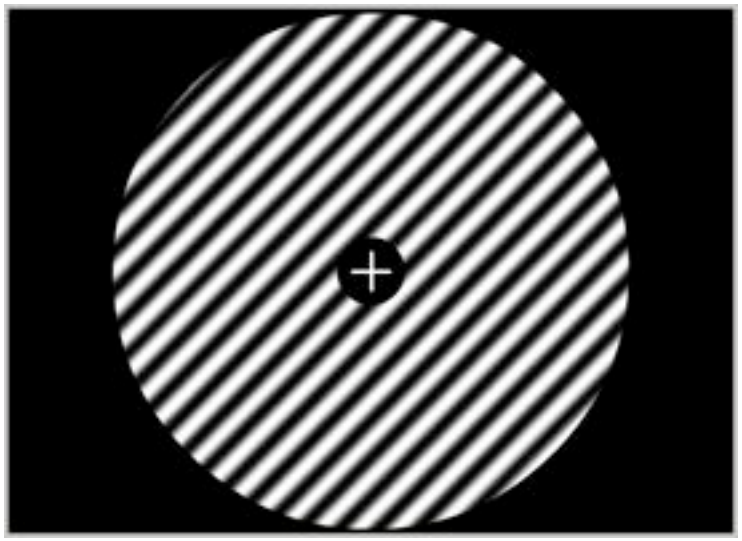




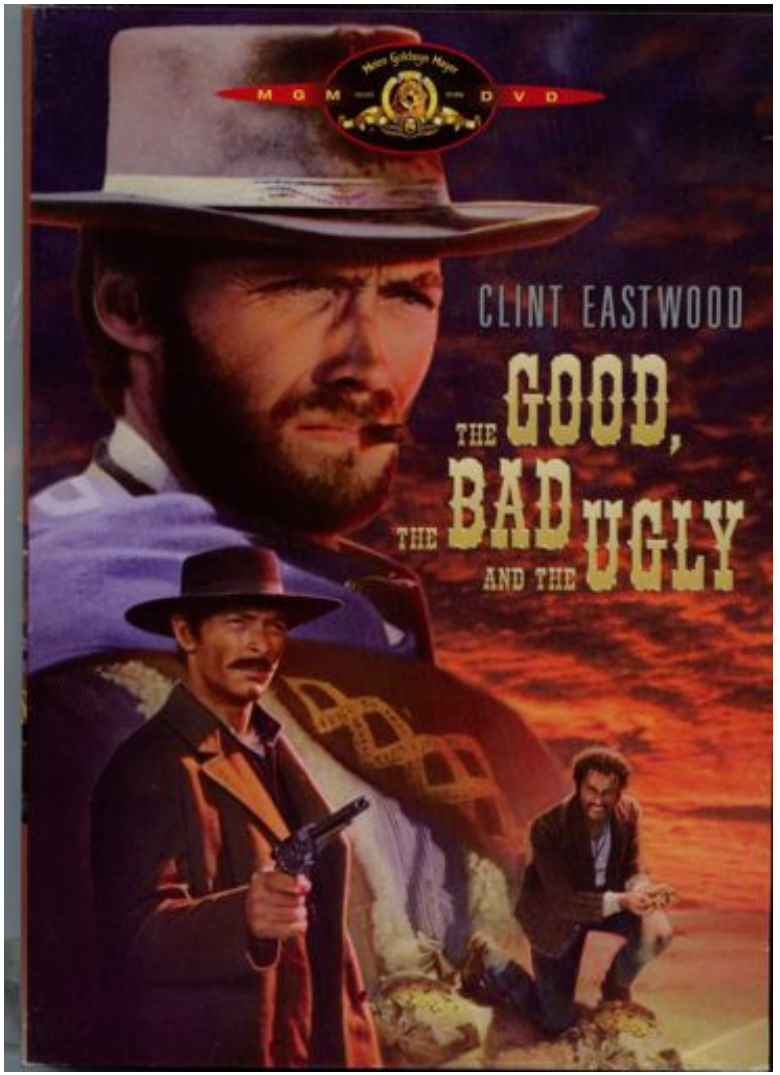
Haxby et al, Science (2001)

How the human brain interacts with the world in real life

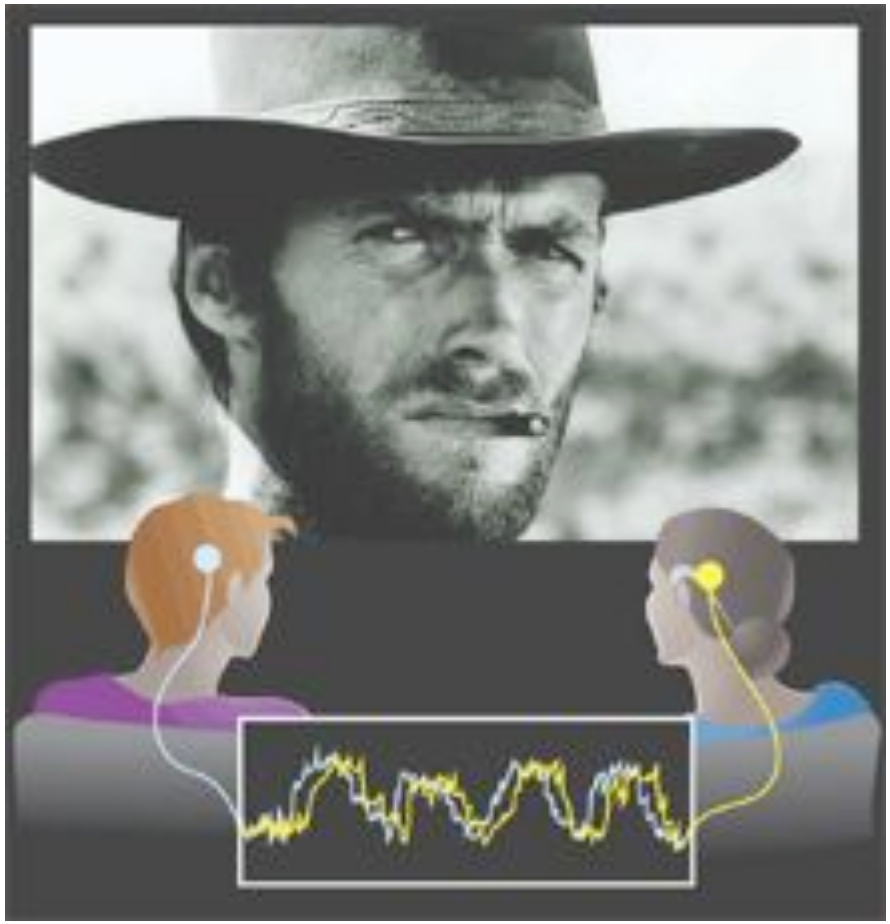
Simple sensory stimuli:

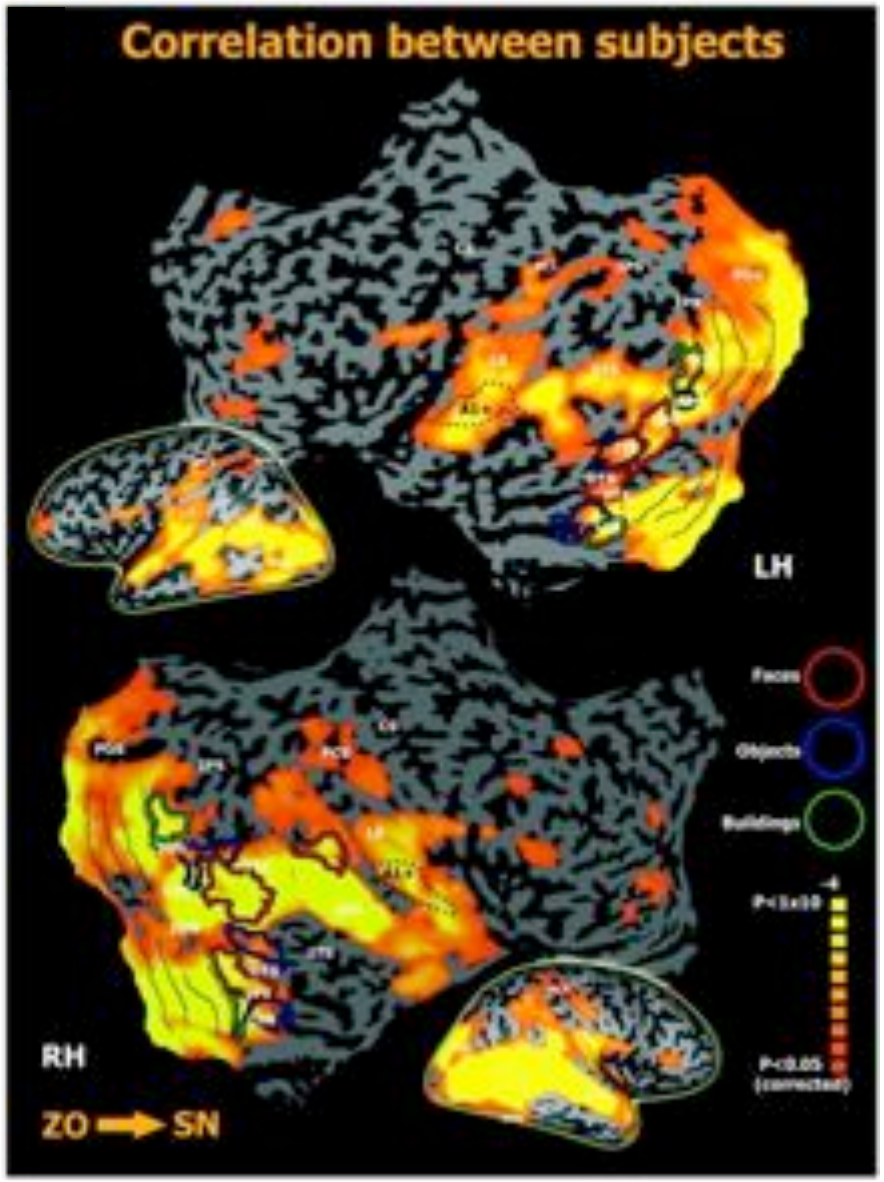


The full complexity of real life:



Do we share the same conscious experience from the same sensory stimulus?





Hasson et al., Science (2004)

Brain activity interpretation competition

"Mind reading" competition at Human Brain Mapping 2006 (http://www.ebc.pitt.edu/competition.html)

fMRI responses to video from 3 segments of the Home Improvement TV series, rated for a variety of features (e.g., faces, emotions).

Utilize data from segments 1 and 2 to train classifier, then generate predicted behavior ratings for segment 3.

Neuroscience-based lie detector

ELSEVIER

NeuroImage

www.elsevier.com/locate/ynimg
NeuroImage 28 (2005) 663 – 668

Classifying spatial patterns of brain activity with machine learning methods: Application to lie detection

C. Davatzikos,[a,*] K. Ruparel,[b] Y. Fan,[a] D.G. Shen,[a] M. Acharyya,[a] J.W. Loughead,[b] R.C. Gur,[b] and D.D. Langleben[b,c]

- Claim 88% accuracy
- Technology underlying commercial venture (http://www.noliemri.com/)