Extrastriate Visual Areas

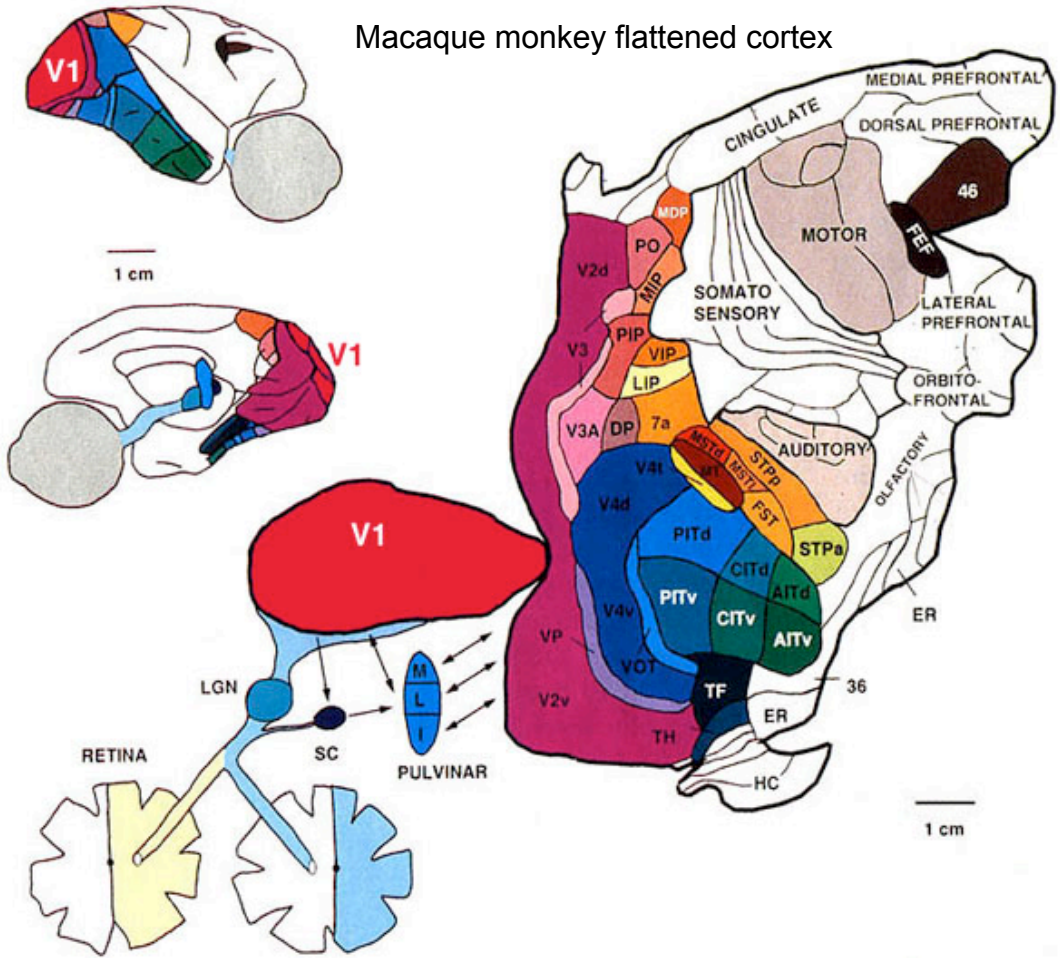
February 27, 2003

A. Roe

How many extrastriate areas are there?

LOTS!!!

Why?

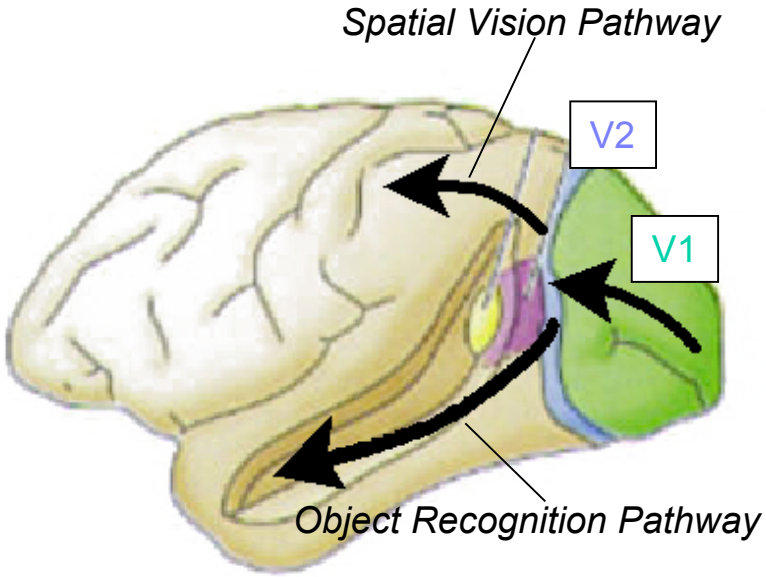


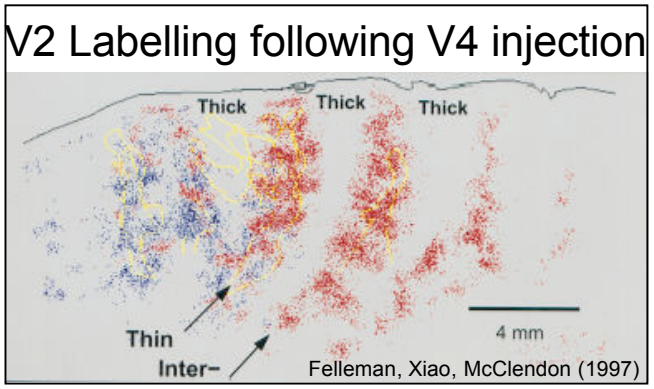
How do we know this?

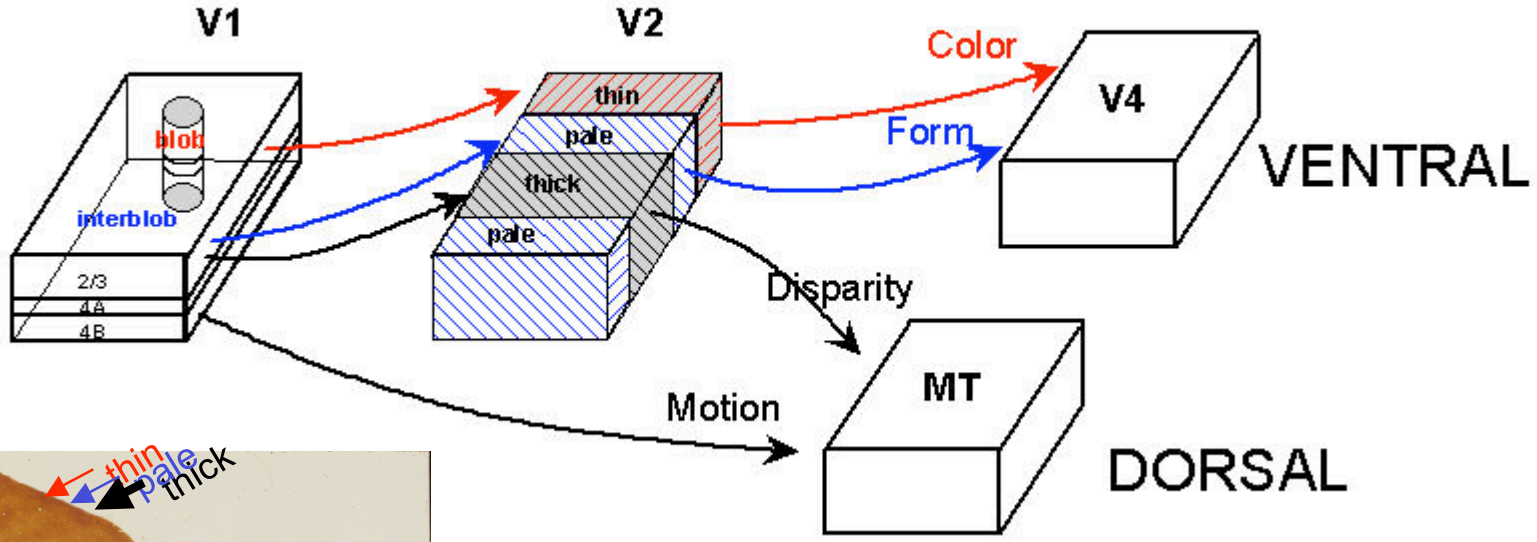
Topography
Functional properties
Connections
Cytoarchitecture

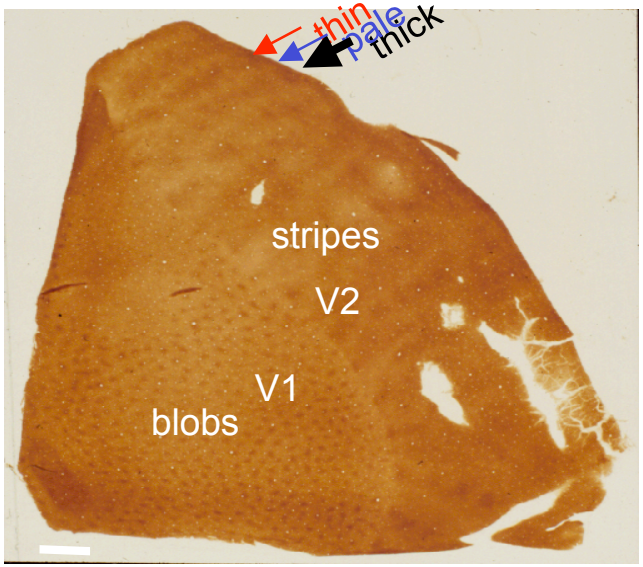
V2

Fedex of the Brain
Packaging and Distribution Center

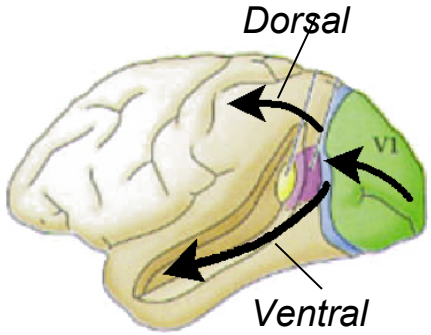




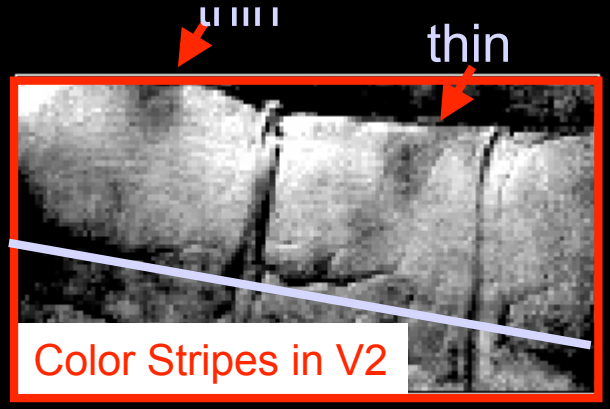


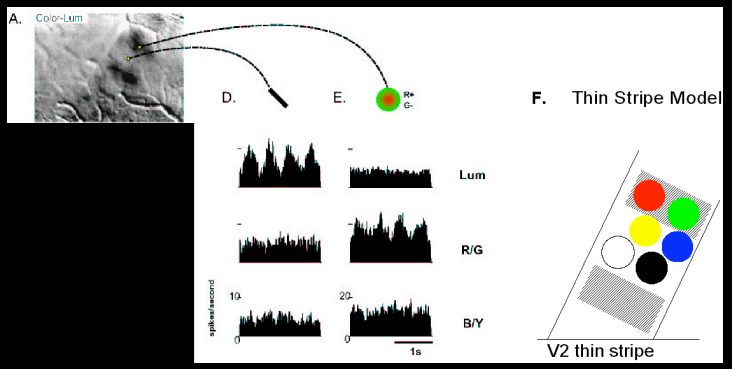


Thin: Color/Brightness
Pale: Form
Thick: Depth



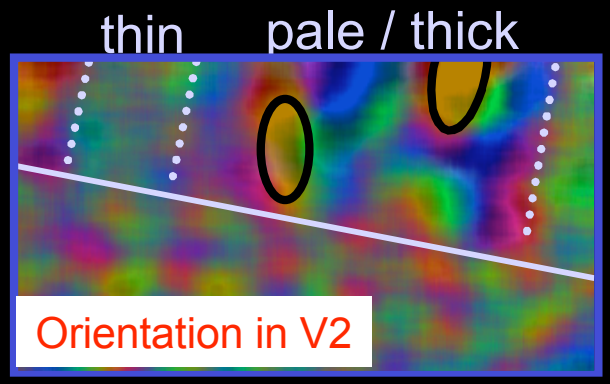
V2 kicks it up a notch!

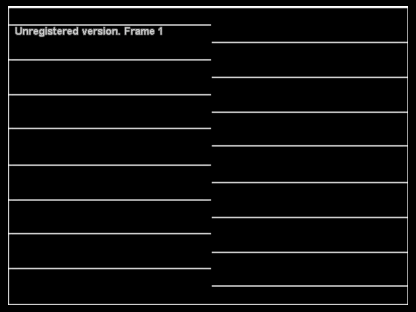


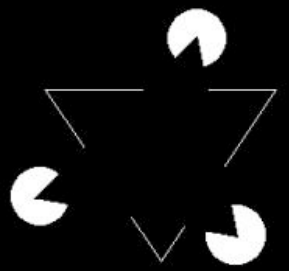


Hues and Brightness

Ts'o, Roe, Gilbert
Xiao, Felleman

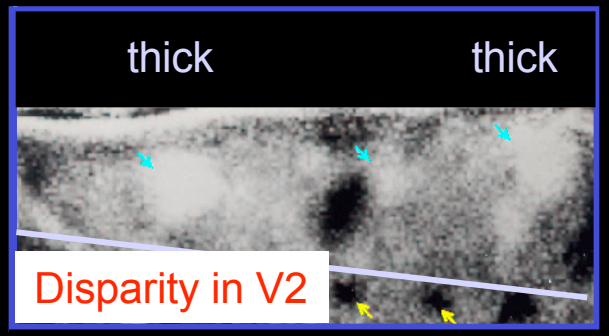


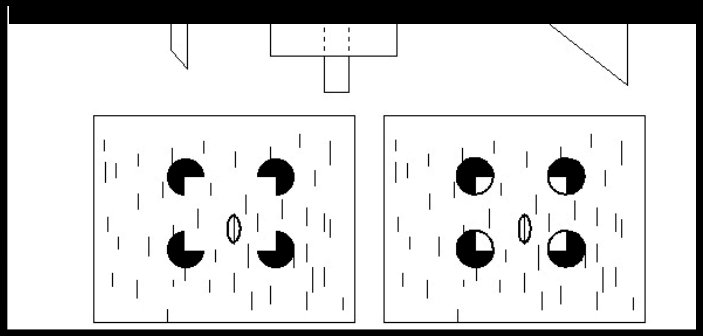




Higher Order Contours

Peterhans, von der Heydt
Ramsden, Hung, Roe





Relative Disparity

Cummings, Parker
Ts'o, Roe, Gilbert
Baker, Gilbert

SUMMARY OF V2 FUNCTIONS

1. Distribution to Ventral and Dorsal Pathways

2. Higher order transformations

   Form: Perceptual contours

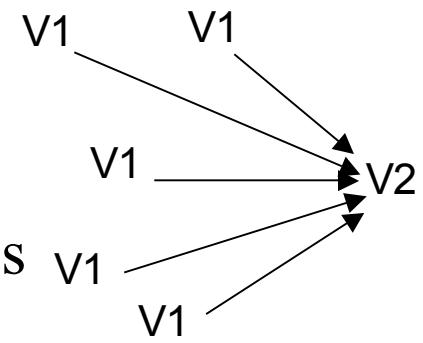
   (vs contrast contours)

   Surface Features: Hues, Brightness

   (vs RG, BY)

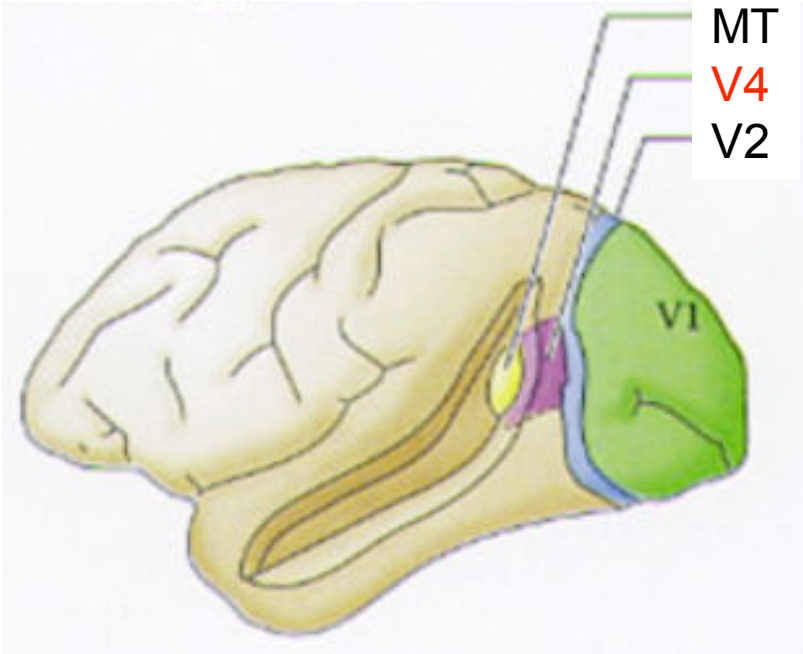
   Disparity: Disparity Capture, Relative Disparity

   (vs Absolute Disparity)



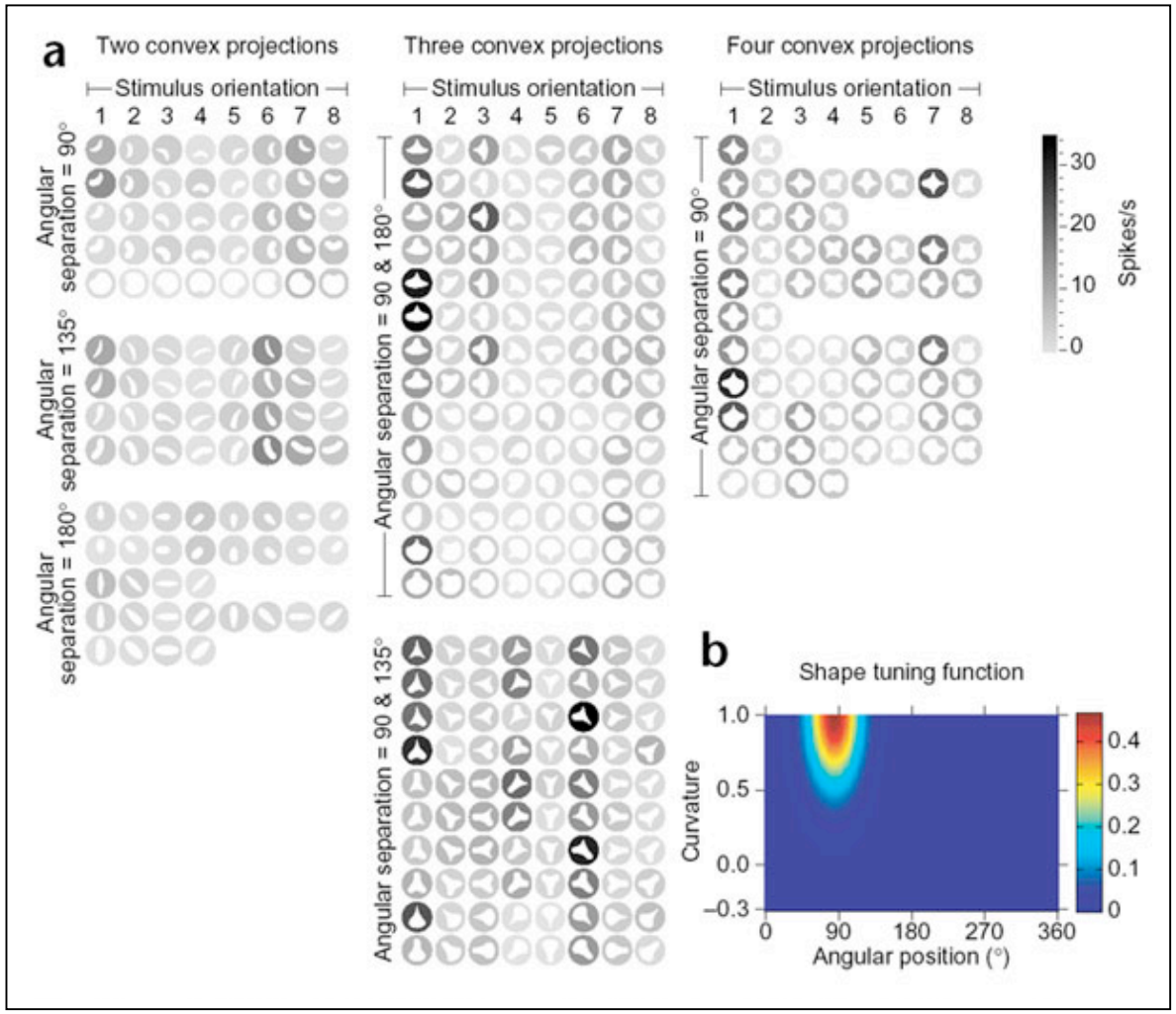
V4

Shape and Surface
Attention

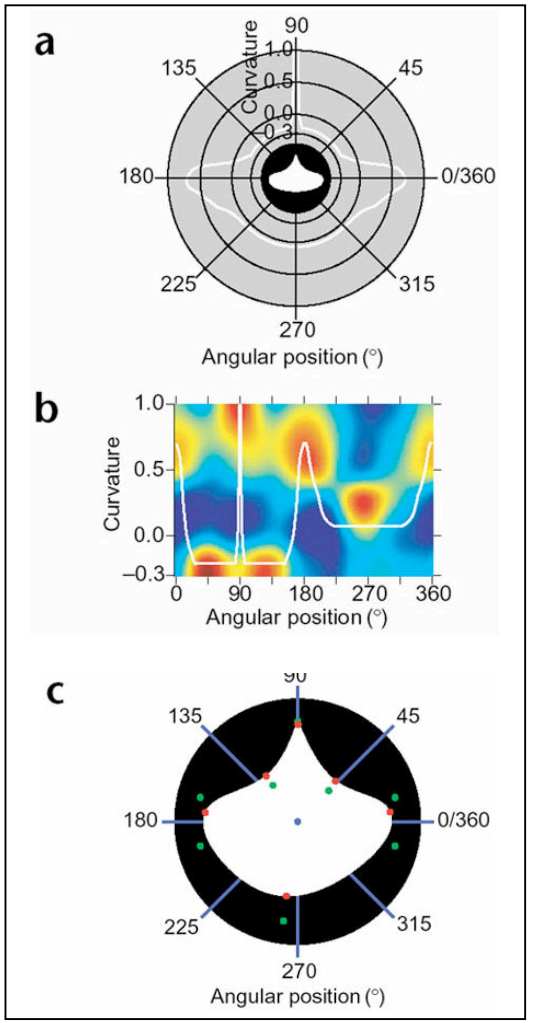


V4: Curvature and Shape

One Cell



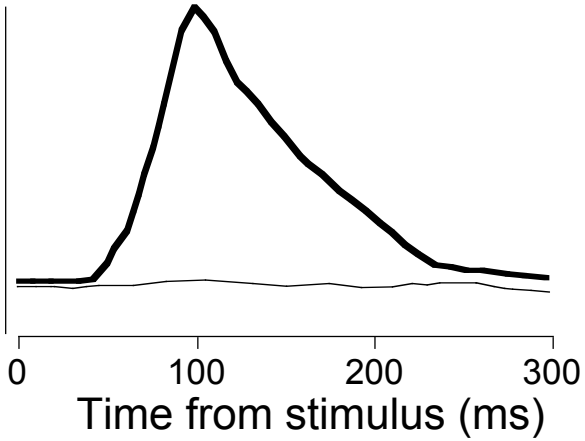
Population

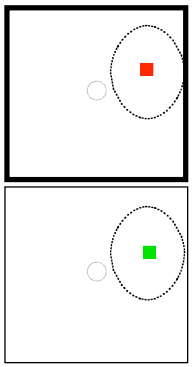


Pasupathy, Connor (2002) Nat Neurosci

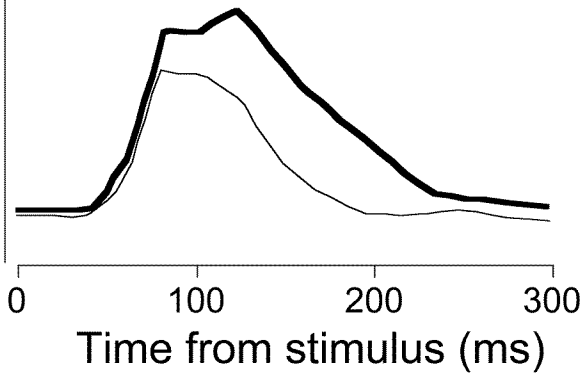
V4: Competing for your attention

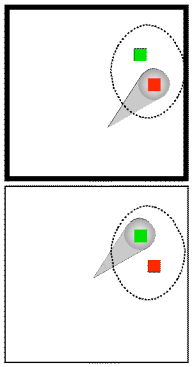
Color selective response





Modulation of response due to allocation of attention





Biased Competition Model of Attention

Chelazzi, Miller, Duncan, Desimone (2001) Cereb Cortex

SUMMARY OF V4 FUNCTIONS

Shape Perception

Curvature? Orientation? Size?

Surface Feature Perception

Color? Shading? Figure/ground?

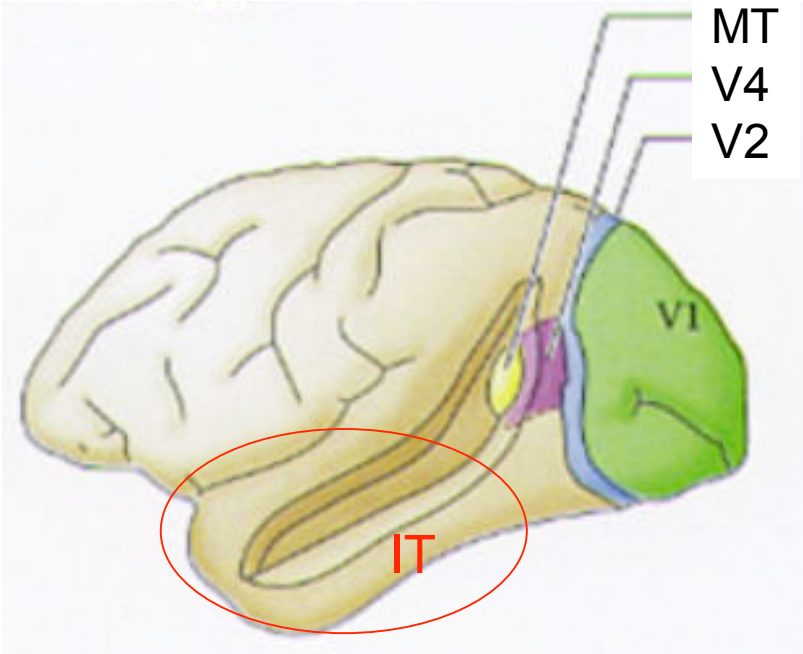
Attentional Effects

Increases neuronal response

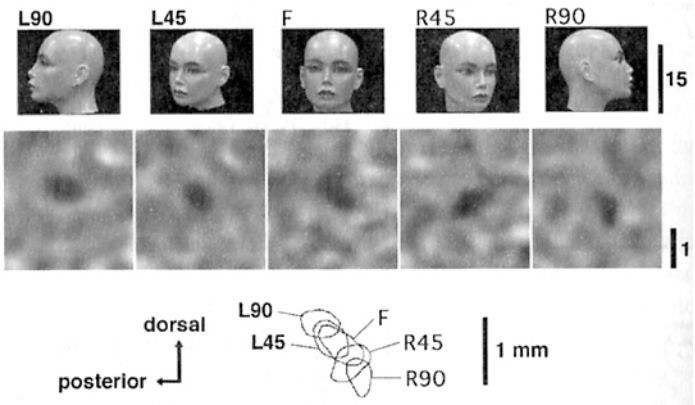
IT

(Inferotemporal Cortex)

Object Recognition

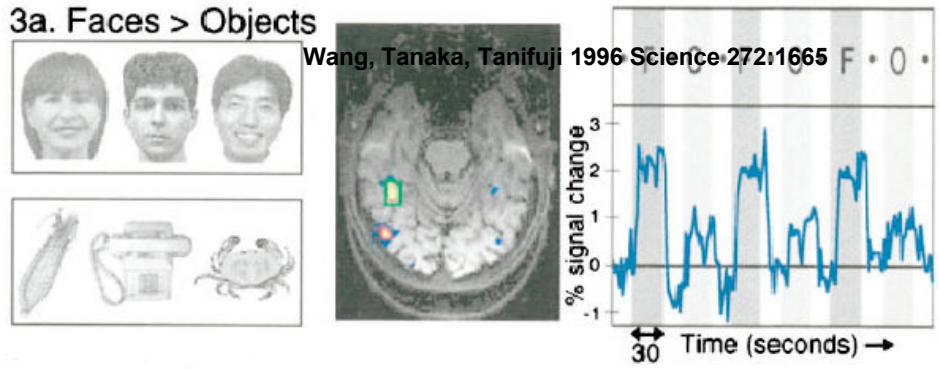


Monkey Inferotemporal Cortex: Object columns? Objects with Similar features map together



Wang, Tanaka, Tanifuji (1996) Science

The Fusiform Face Area: A Module in Human Extrastriate Cortex Specialized for Face Perception



Kanwisher, McDermott, Chun (1997) J. Neurosci

SUMMARY OF IT FUNCTIONS

Columnar organization of objects with similar features

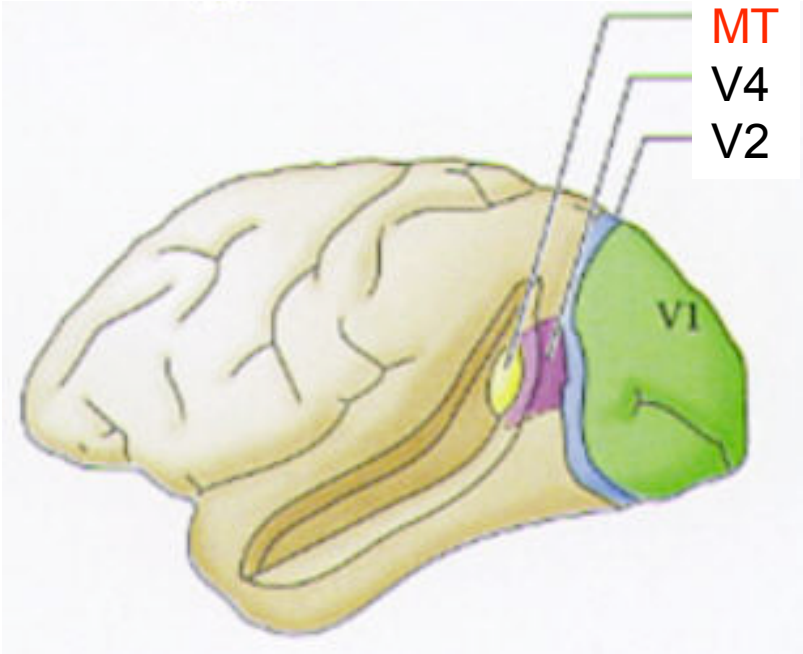
Object Columns?

Object Areas? Face Area?

3D surface shape?

MT/MST

Motion
(where it is, where it is going)



MT

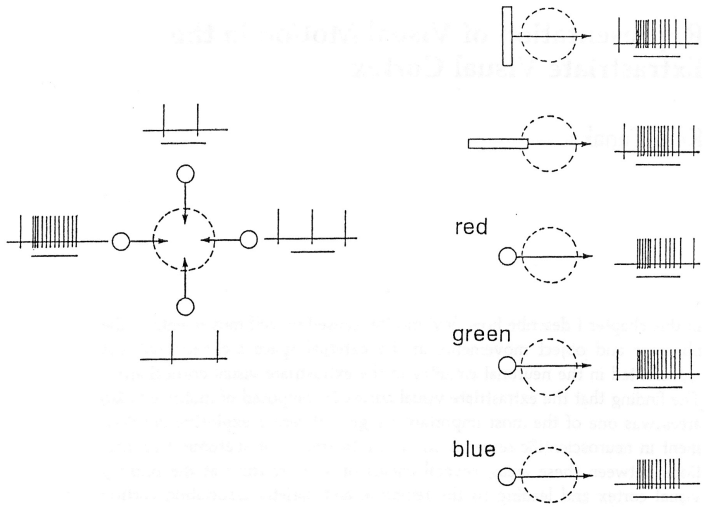


Figure 10.1 Responses of a typical MT cell. They are selective for the direction of motion but not the orientation of the slit or the color of the stimulus.

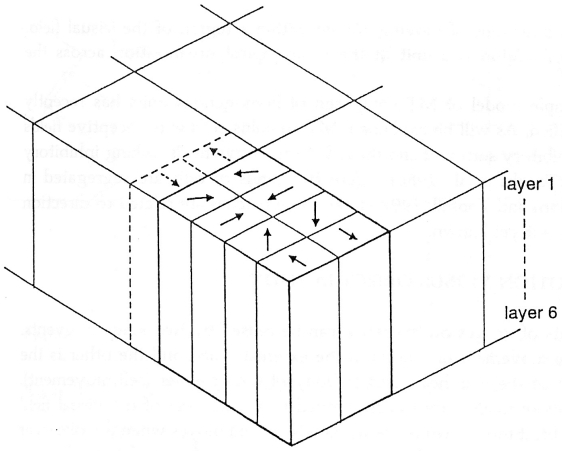
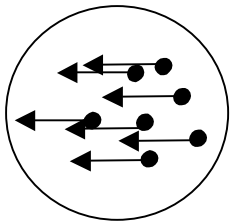
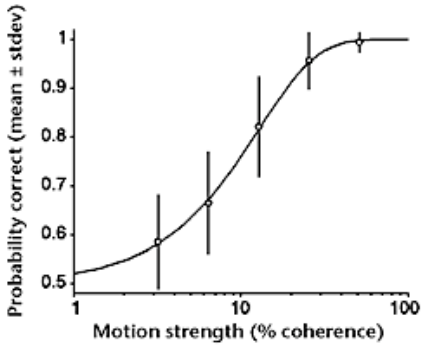


Figure 10.2 Columnar organization of MT.

The probability of a correct choice increases with the fraction of dots moving in the same direction.





MST

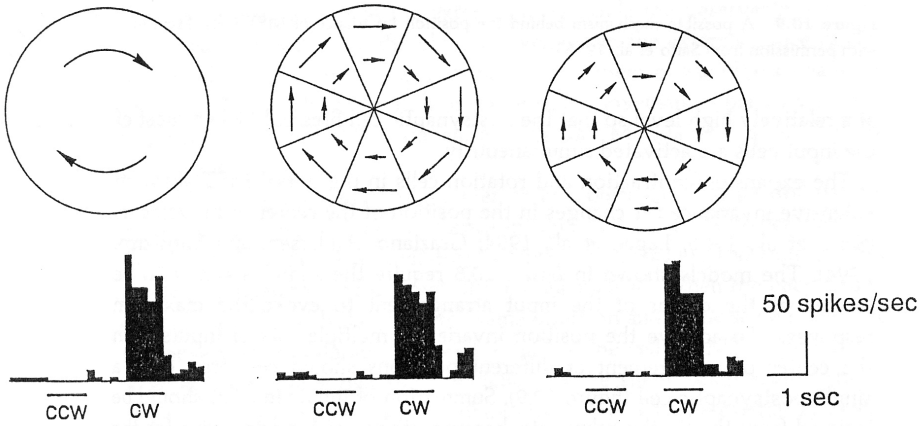
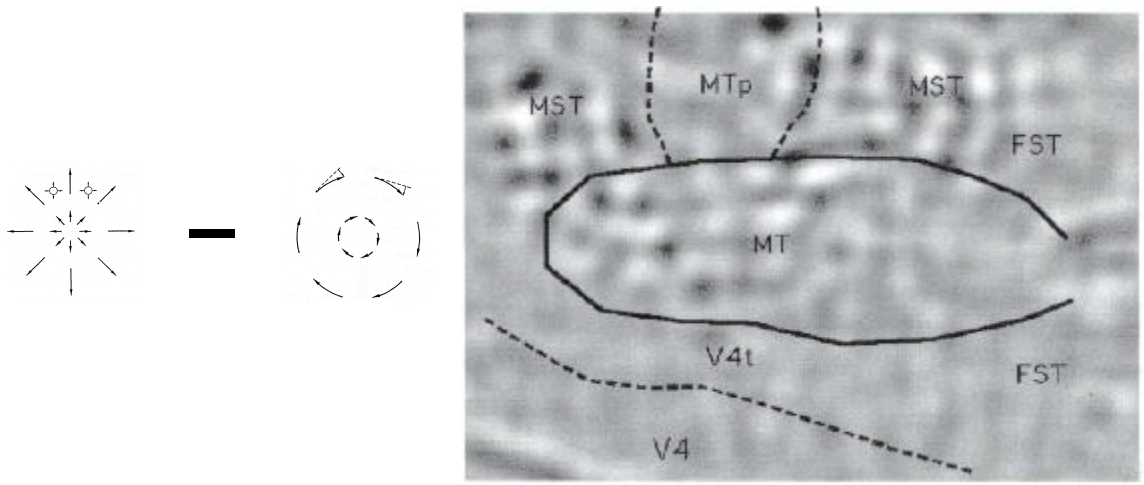


Figure 10.7 Responses of a rotation cell to the real rotation of a dot pattern (left), and a combination of straight movements of dots in eight directions with (middle) and without (right) a speed gradient. (Reprinted with permission from Tanaka, Fukuda, and Saito, 1989.)



Geesaman, Born, Anderson, Tootell (1997) Cerebral Cortex

SUMMARY OF MT/MST FUNCTIONS

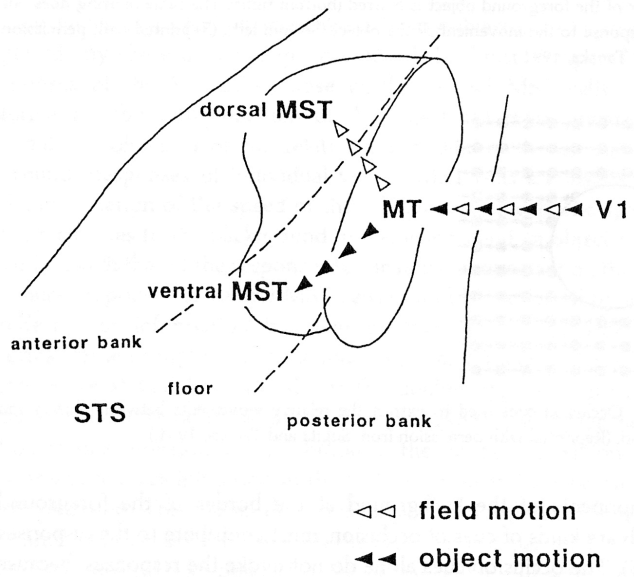
MT: Motion

MST: Flow field, Self-motion?

Functional Organization:

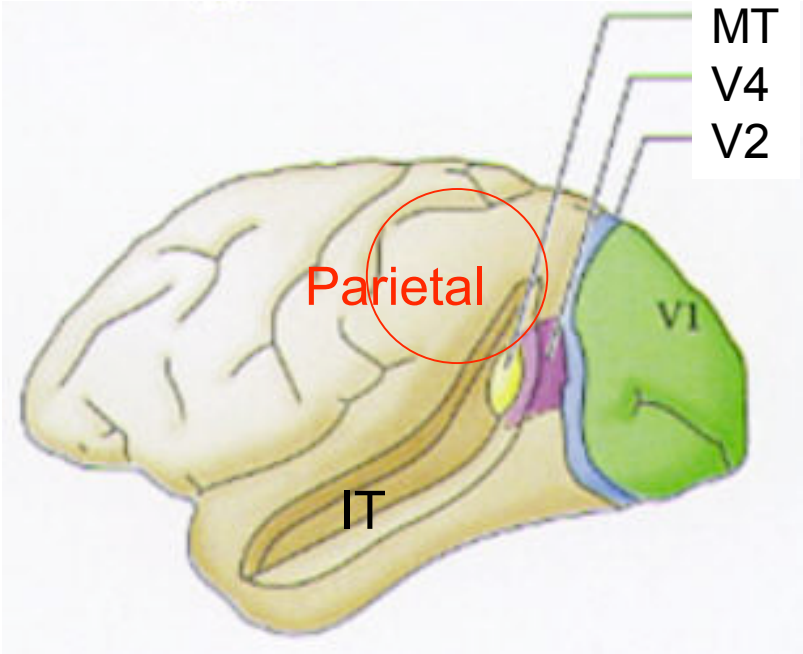
Local vs Global motion

Radial vs Concentric

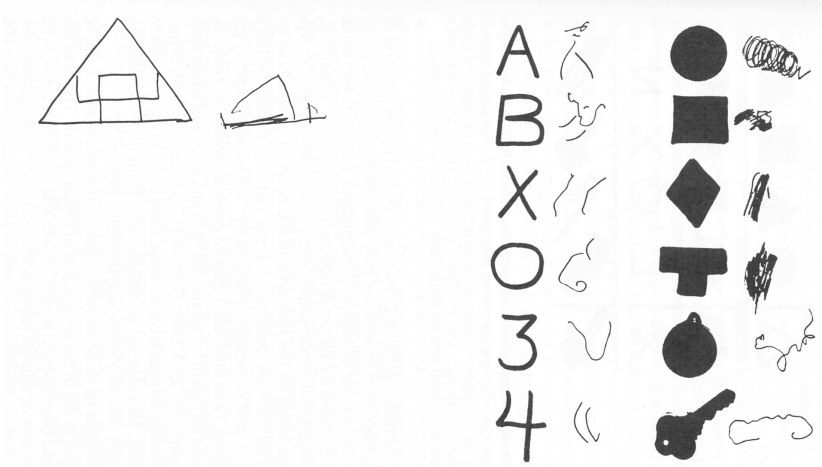


Parietal

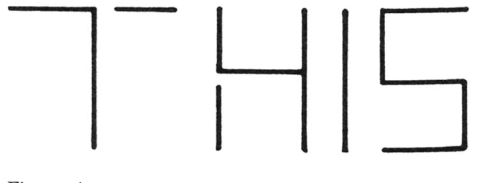
Spatial Cognition and Attention
(where it is and spatial movement)



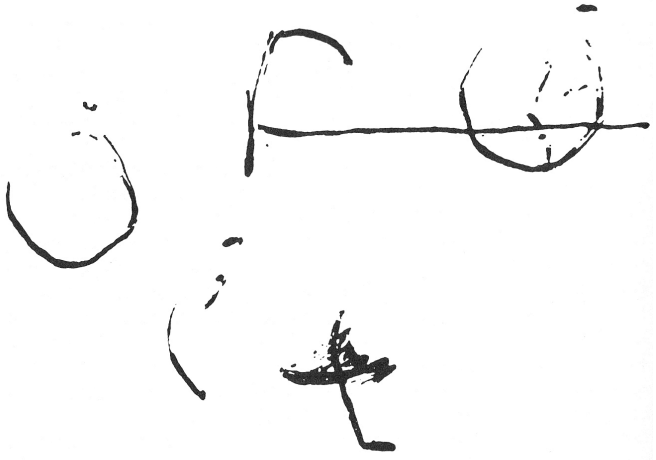
Perceptual Agnosias



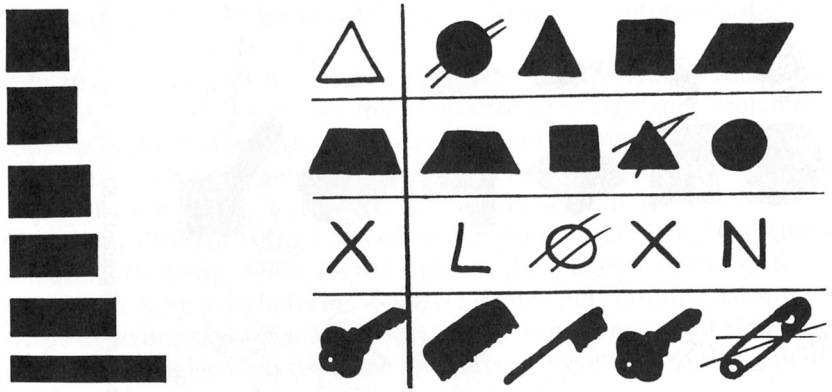
Copying ability of apperceptive agnosics



Consistently read by Patient X as 7415



Copy of a bicycle by dorsal simultanagnosic
Who was able to recognize objects and drawings



Shape-matching ability of apperceptive agnosic

Farah (1990) Visual Agnosia

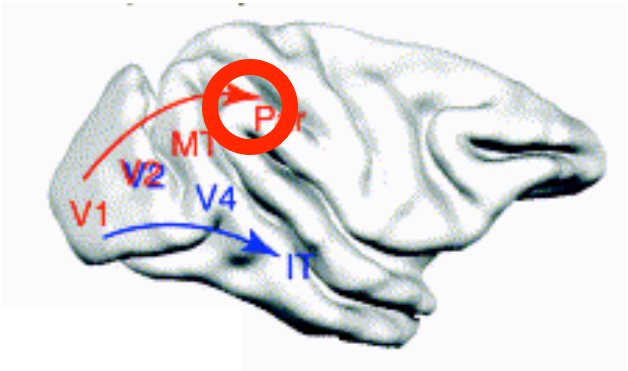
The Binding Problem

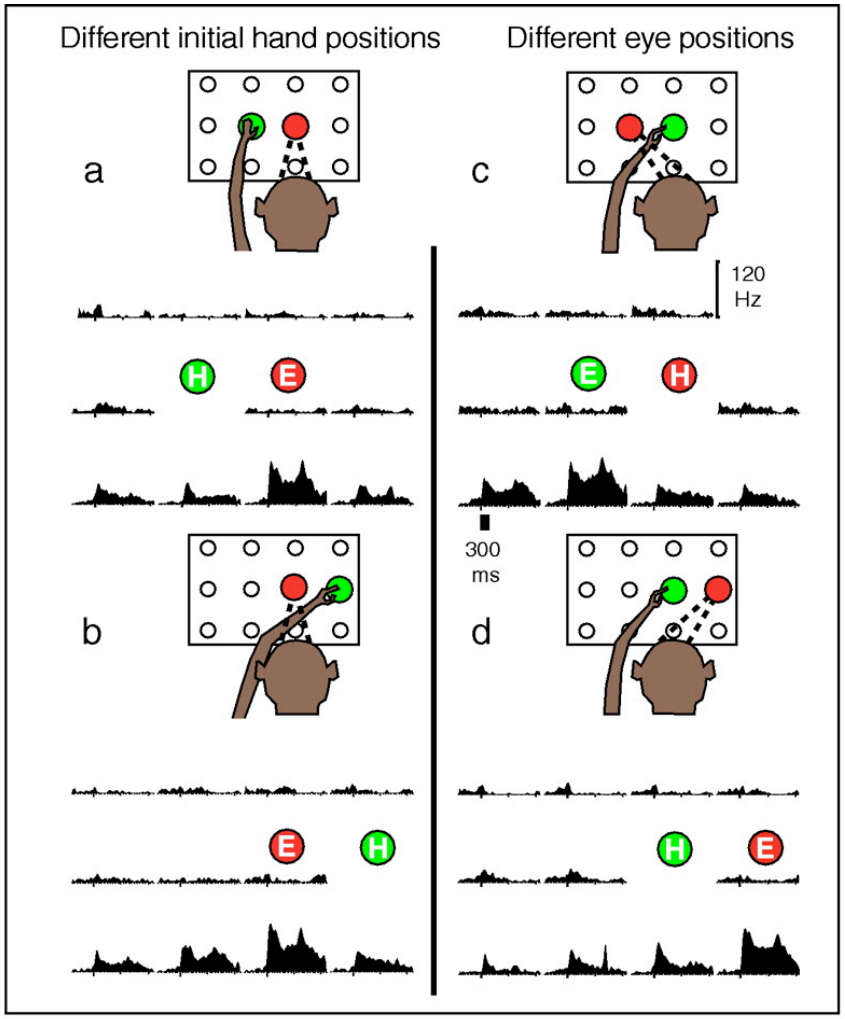
(featural relationships in space)

"Subject R.M. is a 59 year old patient with symmetrical bilateral parieto-occipital lesions. When presented with displays containing two colored letters, he could not report the name and color of the first letter he saw... When presented with an X and an O, he could not report whether the X was to the left or the right of the O, or above or below the O…Although RM can recognize letters and shapes, he has great difficulty in correctly binding the colors and sizes of two or more shapes. Our data suggest that the explicit spatial information associated with the dorsal pathway is also necessary to correctly bind features."

Friedman-Hill, Robertson, Treisman (1995) Science 269:853

Posterior parietal cortex: Space and action





How do you coordinate what you see and how you move your hands or your eyes? Neurons in PP cortex are active before visually guided movements of the eyes and limbs. The magnitude of activity varies with the coordinate relation of the eyes and limbs. For example, the activation of this neuron before movements of the arm varies with the angle of gaze.

Cohen, Anderson (1999) Neuron

SUMMARY OF PARIETAL FUNCTIONS

Spatial Perception, Spatial Coherence, Spatial Relationships

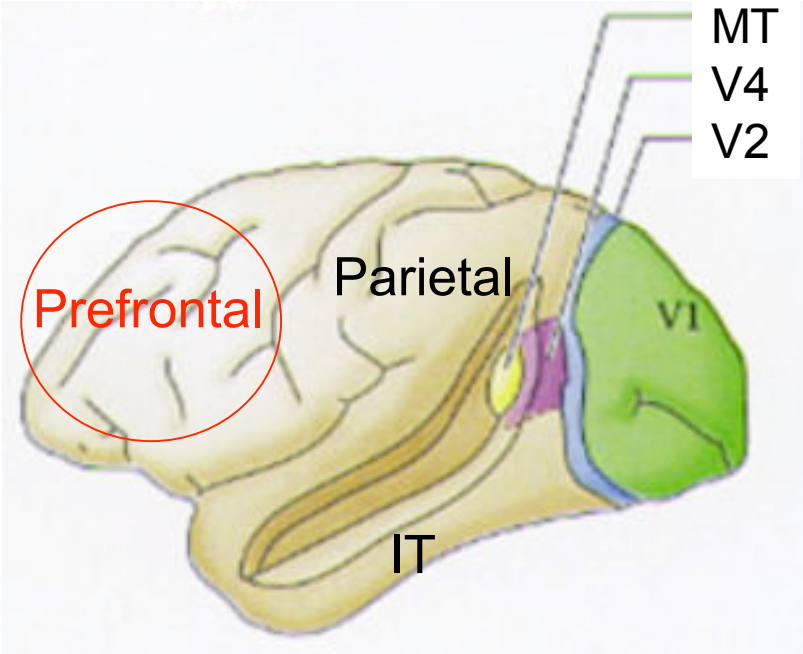
Eye-Centered Movement Coordinate System

- LIP (eye movements)
- PPR (posterior parietal reach area)

Feature Binding?

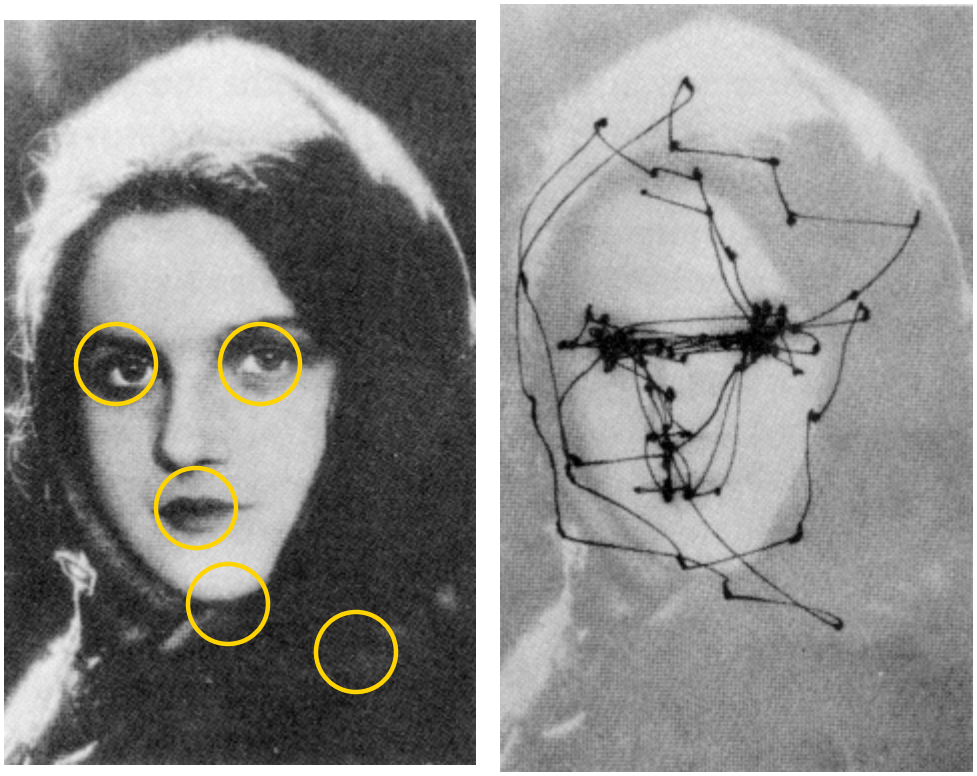
Prefrontal

Memory/Planning/Commands/Context



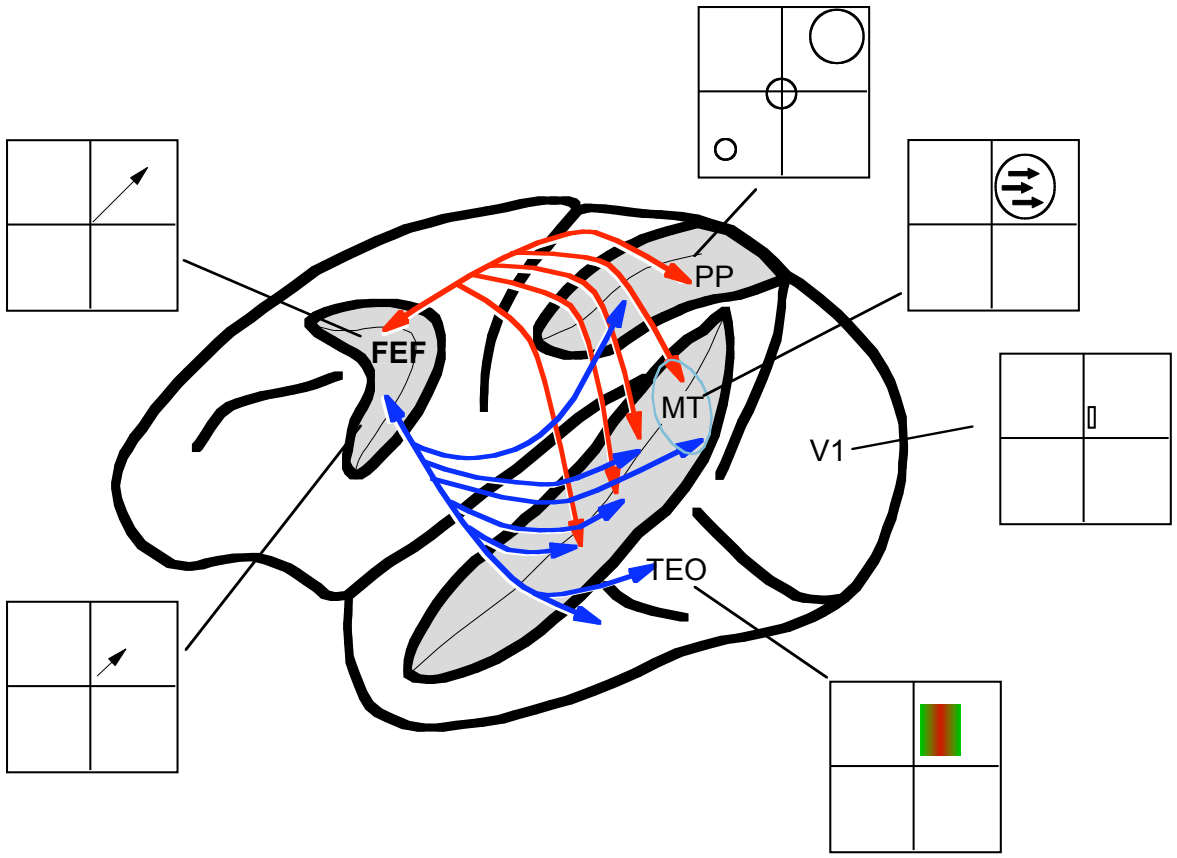
Prefrontal cortex: Planning and memory

Vision is an active, exploratory process. Movements of the eyes are necessary for sight.



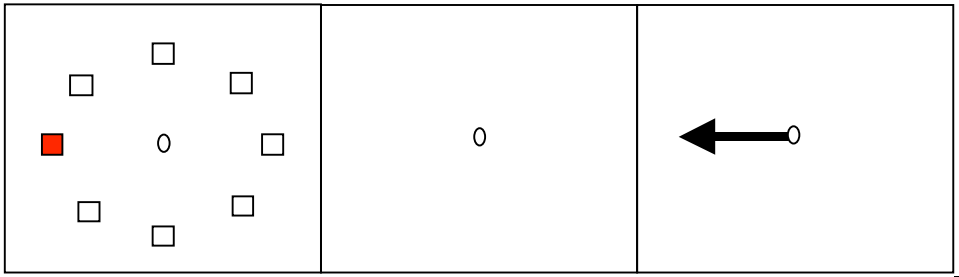
Prefrontal cortex

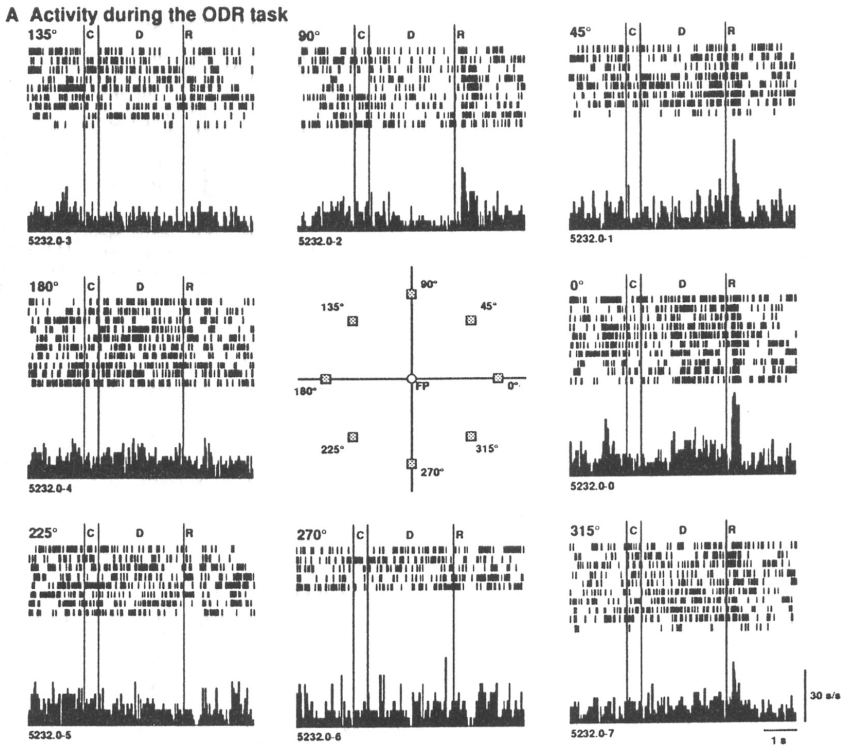
Areas in the frontal lobe such as the frontal eye field are heavily and reciprocally connected with numerous extrastriate visual areas. The frontal eye field converts the outcome of visual processing into a command to shift gaze.



Schall, Morel, King, Bullier (1995) J Neurosci

Prefrontal cortex: Short-term working memory





Cell in Area 46

Funihashi, Bruce, Goldman-Rakic (1991) J Neurophys

SUMMARY OF PREFRONTAL FUNCTIONS

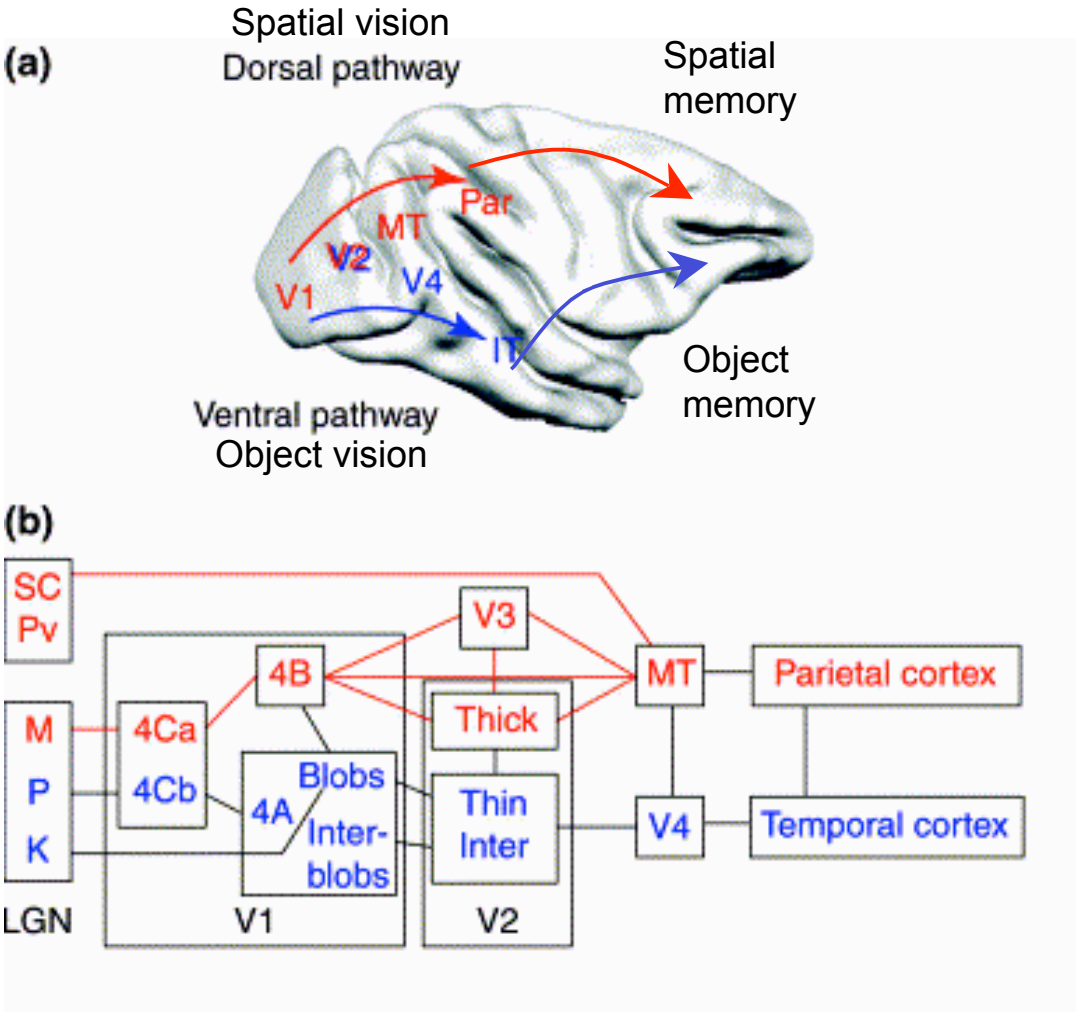
Eye movement commands (FEF)

Target Selection, Visual Search

Short-term working memory (Area 46)

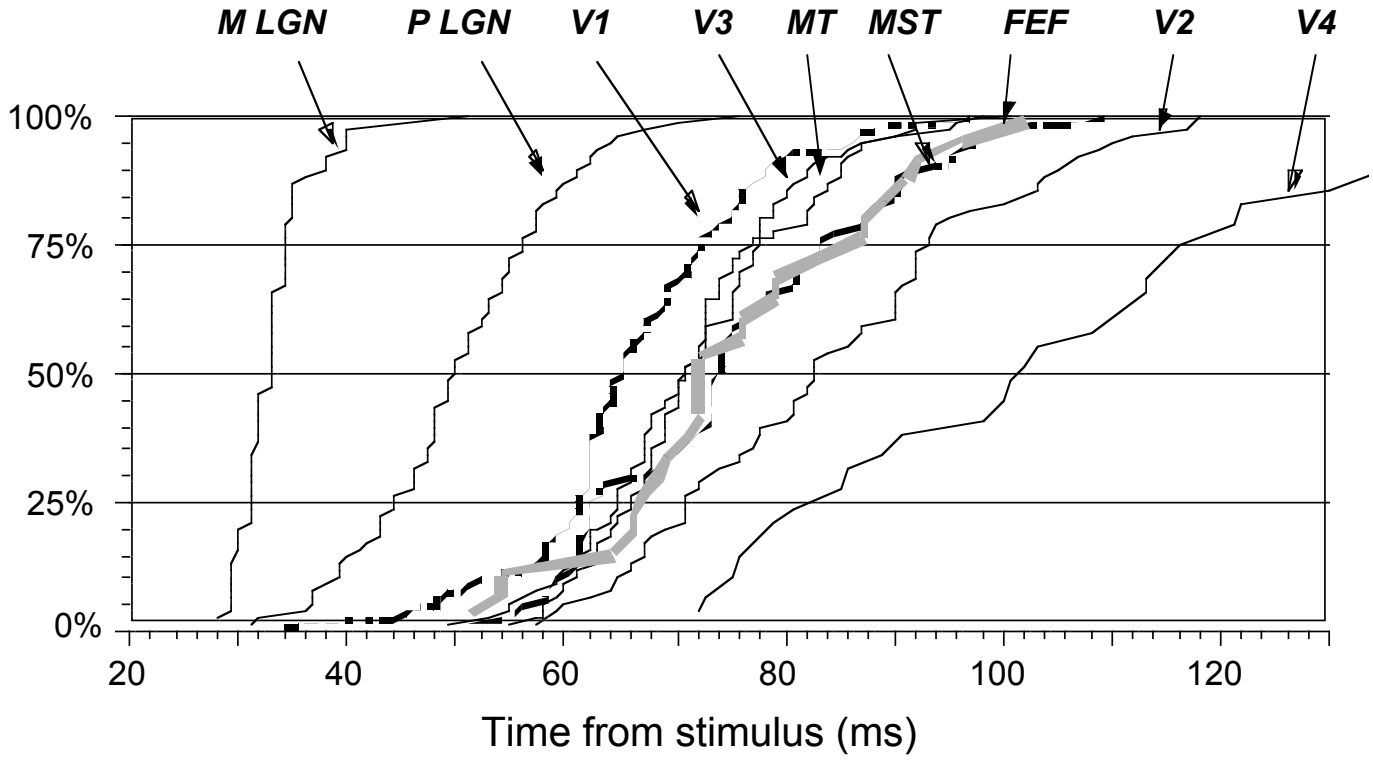
Efforts to define the organization of the connections between and properties of the many areas also led to formulation of concept of parallel pathways.

This view was attractive because it seemed to be motivated by the differences in retinal ganglion cell properties and accommodated findings from brain damaged patients.

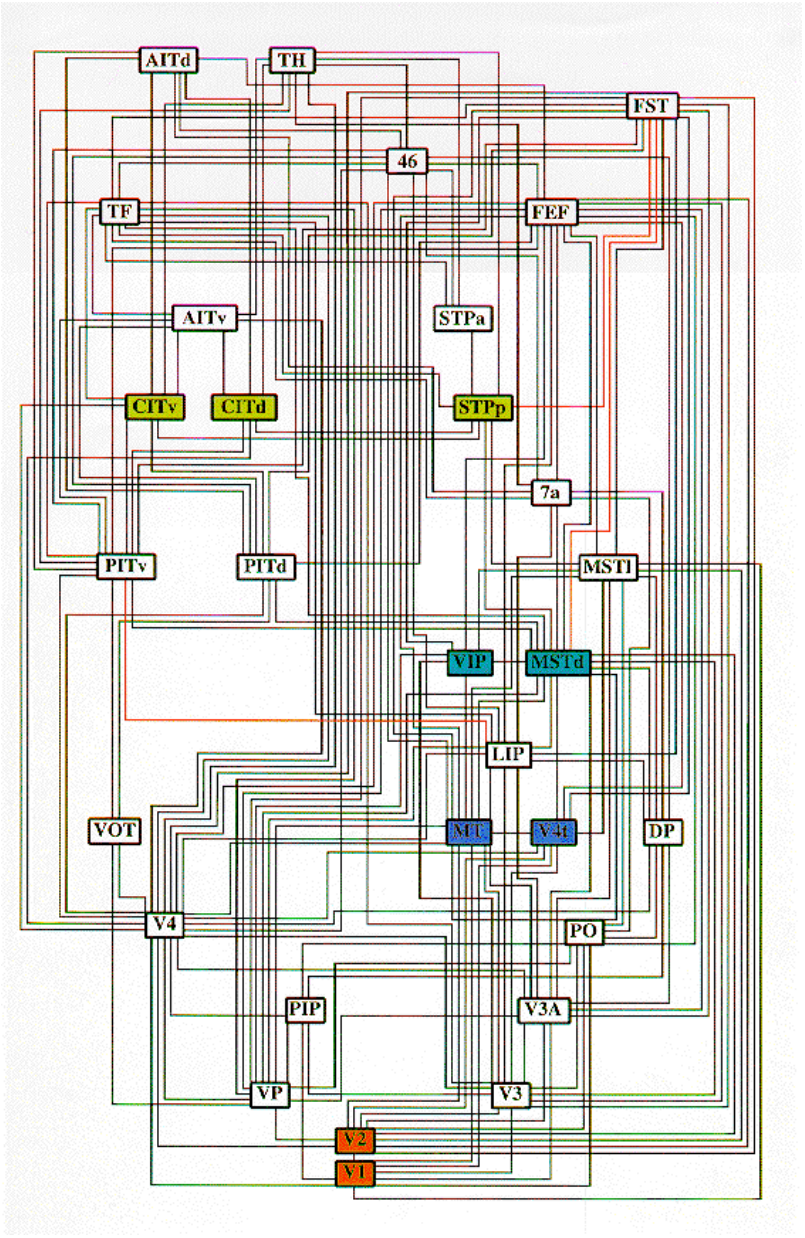


However, several lines of evidence demonstrate more mixture and integration across areas than can be accommodated by this hypothesis of strict segregation.

Is it HIERARCHICAL? **S**equential processing entails sequential activation. Measurements of visual response latency discovered some sequential activation but more than expected simultaneity among certain areas at different levels of the hierarchy.



Schmolesky MT, Wang Y, Hanes DP, Thompson KG, Leutgeb S, Schall JD, Leventhal AG. Signal timing across the macaque visual system. J Neurophysiol. 1998 Jun;79(6):3272-8.



The $1,000,000 Question:
Serial, Parallel, Distributed?