Modeling Extrastriate Areas

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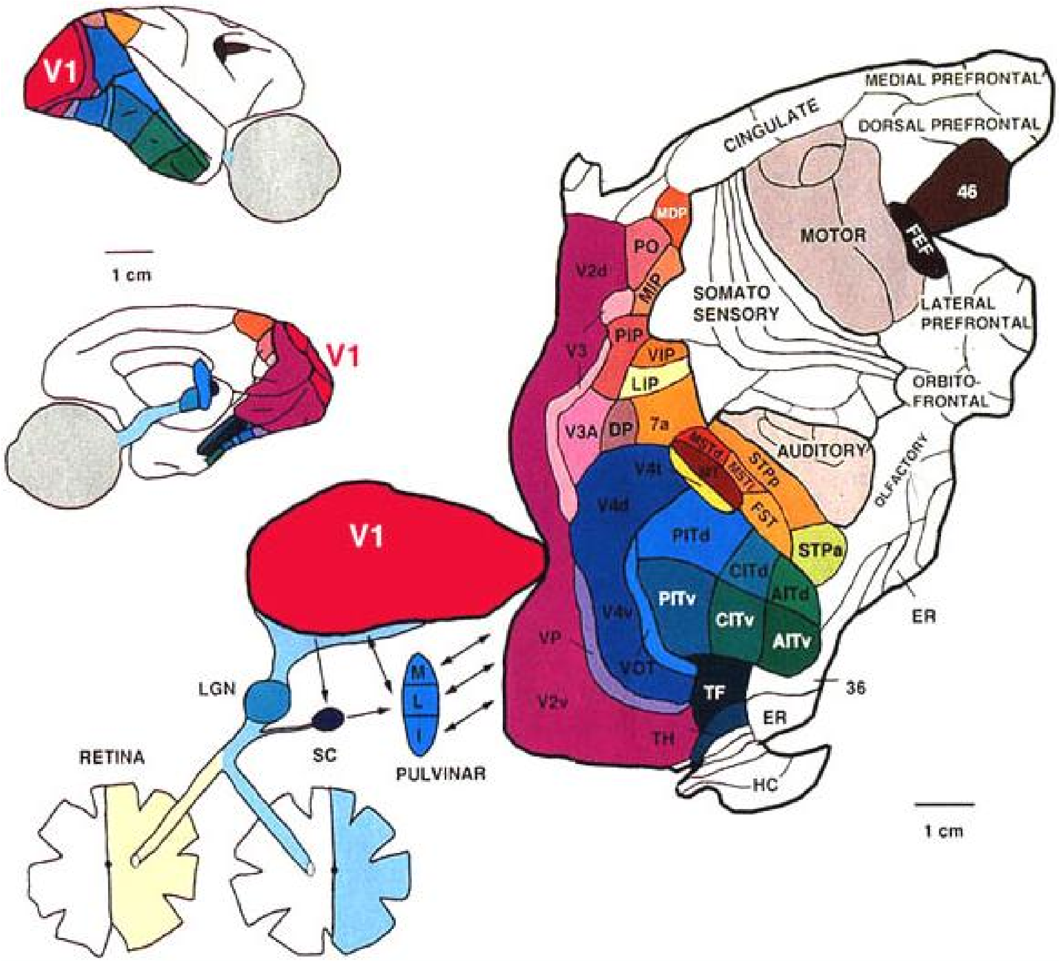
Higher areas



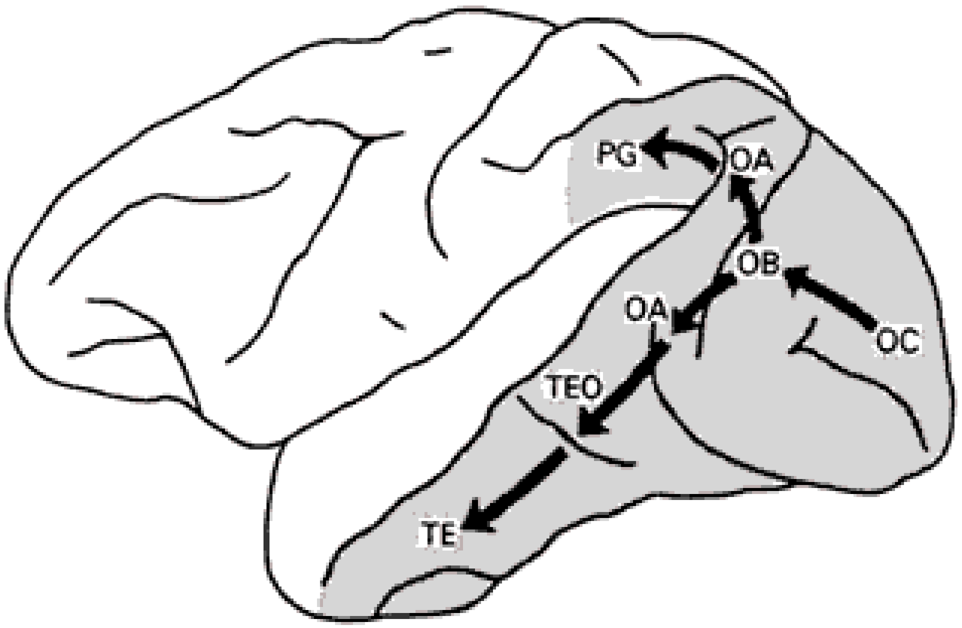
Macaque visual areas

(Van Essen et al. 1992)

- Many higher areas beyond V1
- Selective for faces, self-motion, etc.
- Not as well understood

What/Where streams

(Ungerleider & Mishkin 1982)



Typical division:

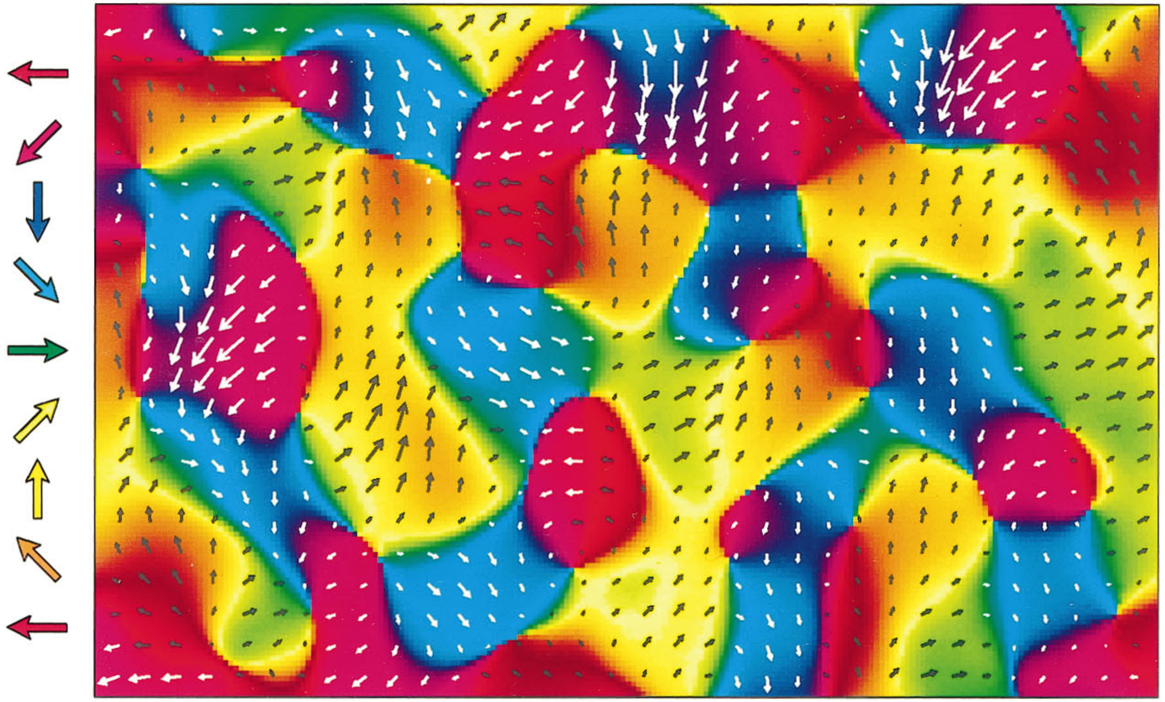
Ventral stream:

"What" pathway
from V1 to temporal
cortex (IT)

Dorsal stream:

"Where" pathway
from V1 to parietal
cortex (e.g. MT)

V2 OR/DR map

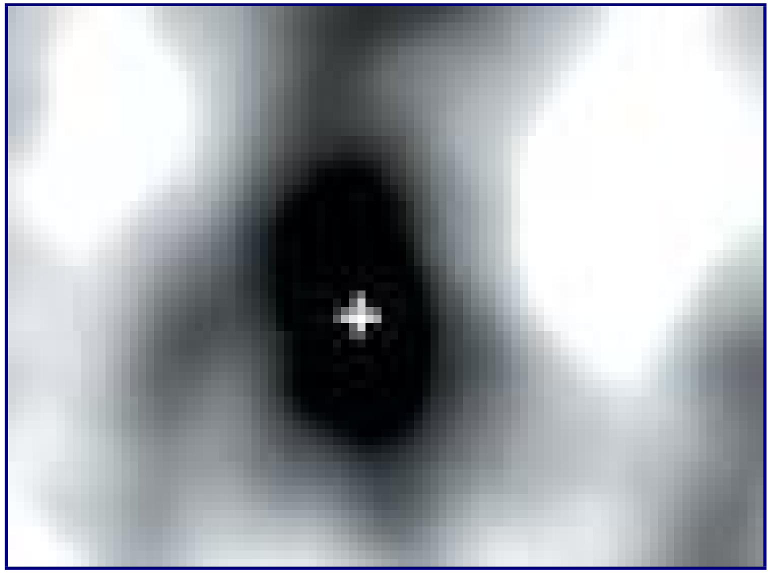


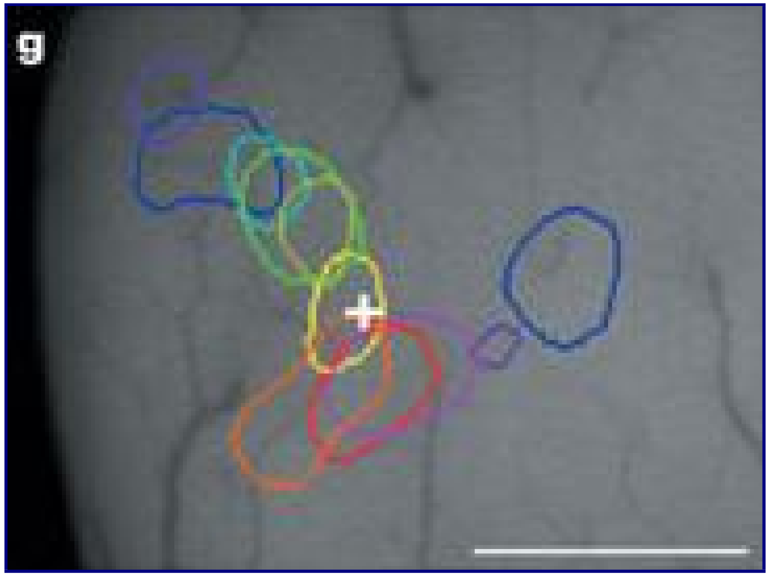
V2 cat direction map (Shmuel & Grinvald 1996)

Maps found in V1 are usually also found in V2 (except OD)

RFs are larger, probably more complex (not really clear)

V2 Color map

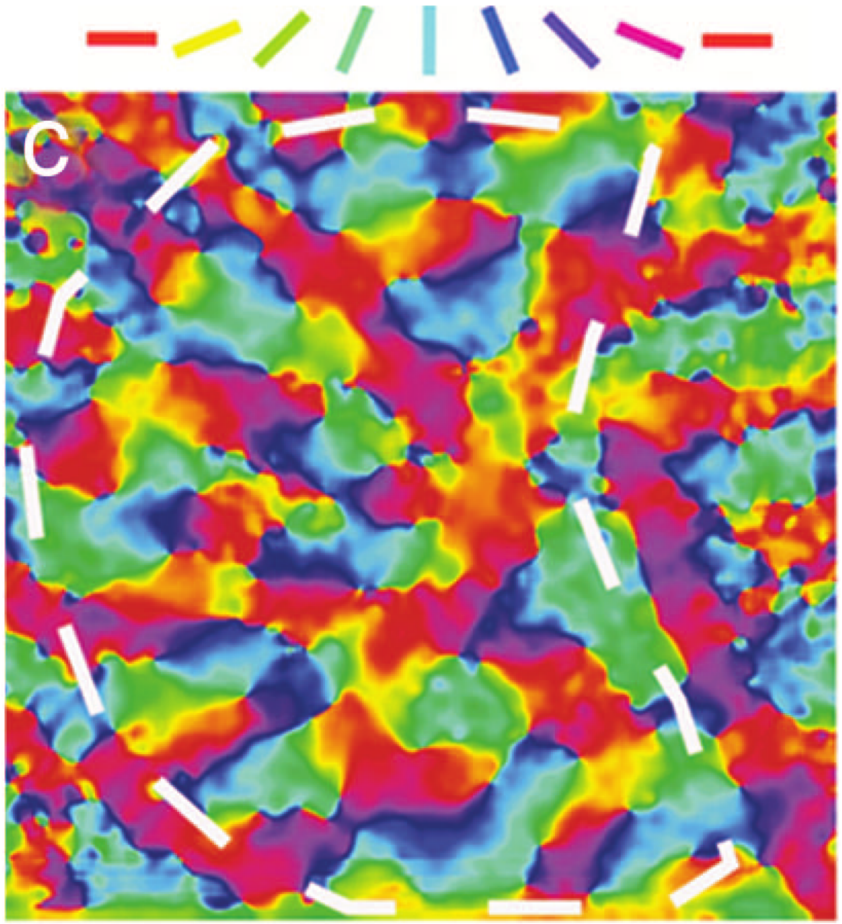




Xiao et al. 2003 – Macaque; 1.4 × 1.0mm

- Like V1, color preferences organized into blobs
- Rainbow of colors per blob (Xiao et al. 2007: in V1 too?))
- Arranged in order of human perceptual color charts (CIE/DIN)
- Feeds to V4, which is also color selective

MT/V5



(Xu et al. 2006)

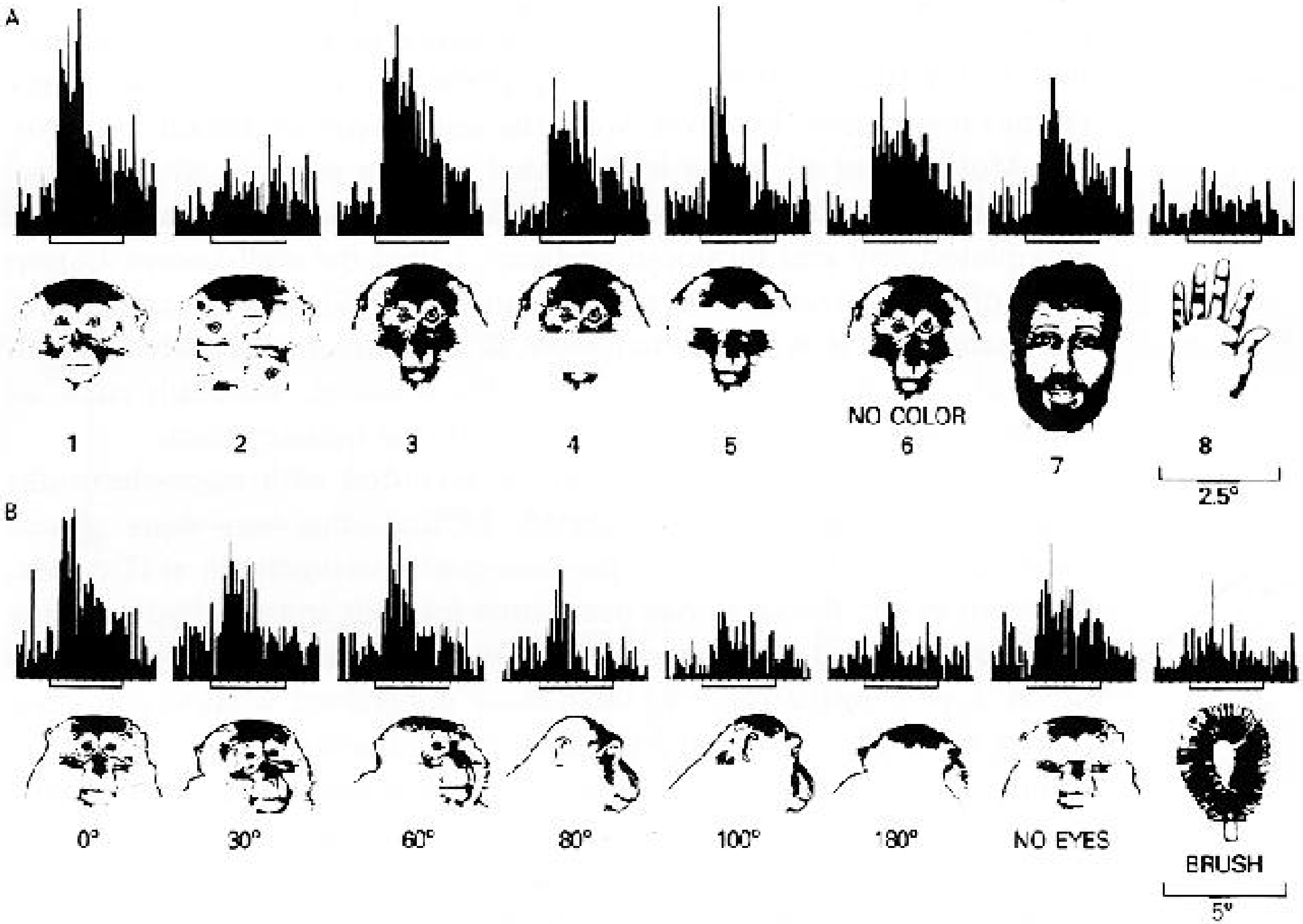
MT has orientation maps, but the neurons are more motion and direction selective

Involved in estimating optic flow

Neural responses in MT have been shown to directly reflect and determine perception of motion direction

(Britten et al. 1992; Salzman et al. 1990)

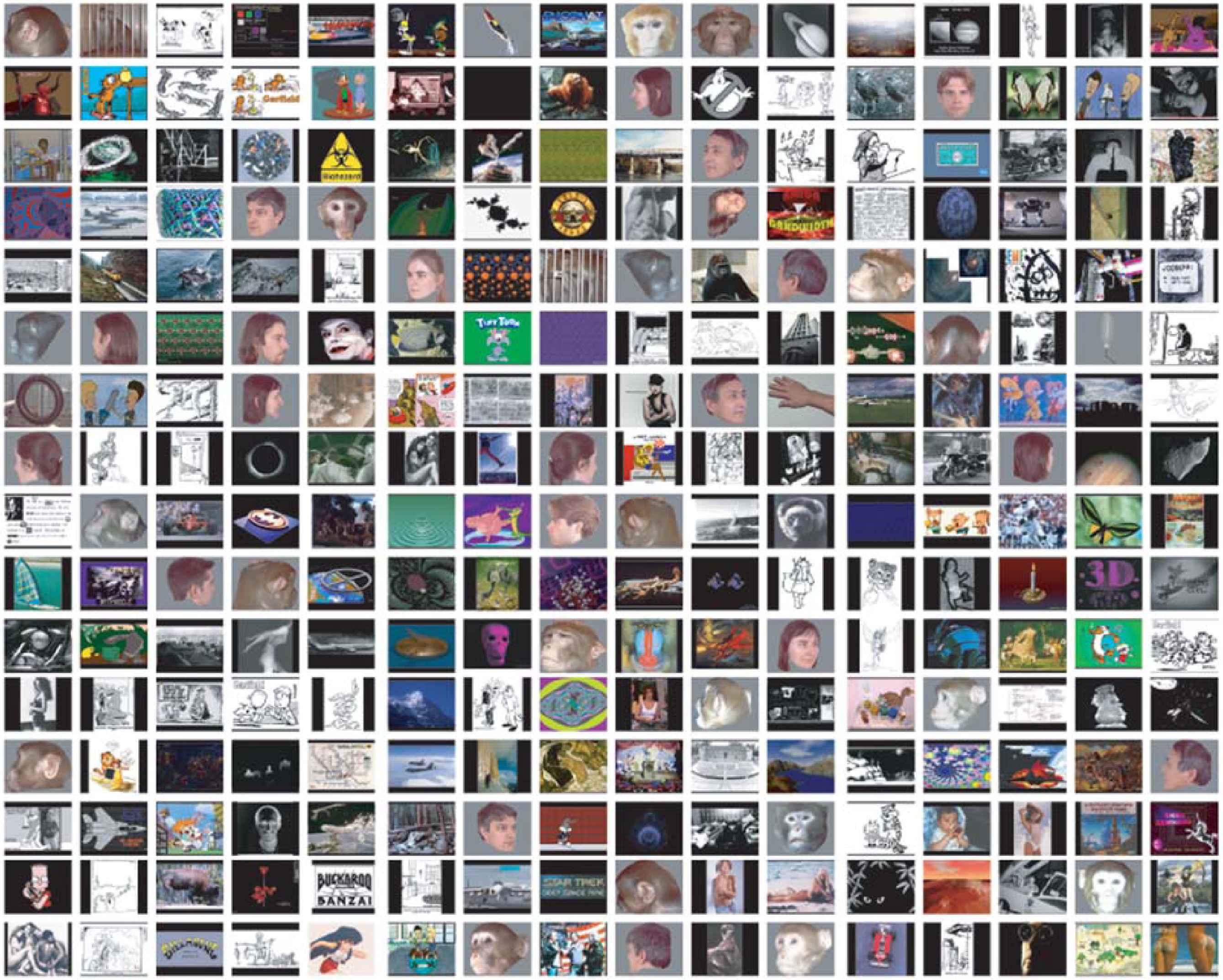
Object selectivity in IT



(Bruce et al. 1981)

Some cells show greater responses to faces than to other classes; others to hands, buildings, etc. Hard to interpret, though.

Rapid Serial Visual Presentation



(Földiák et al. 2004)

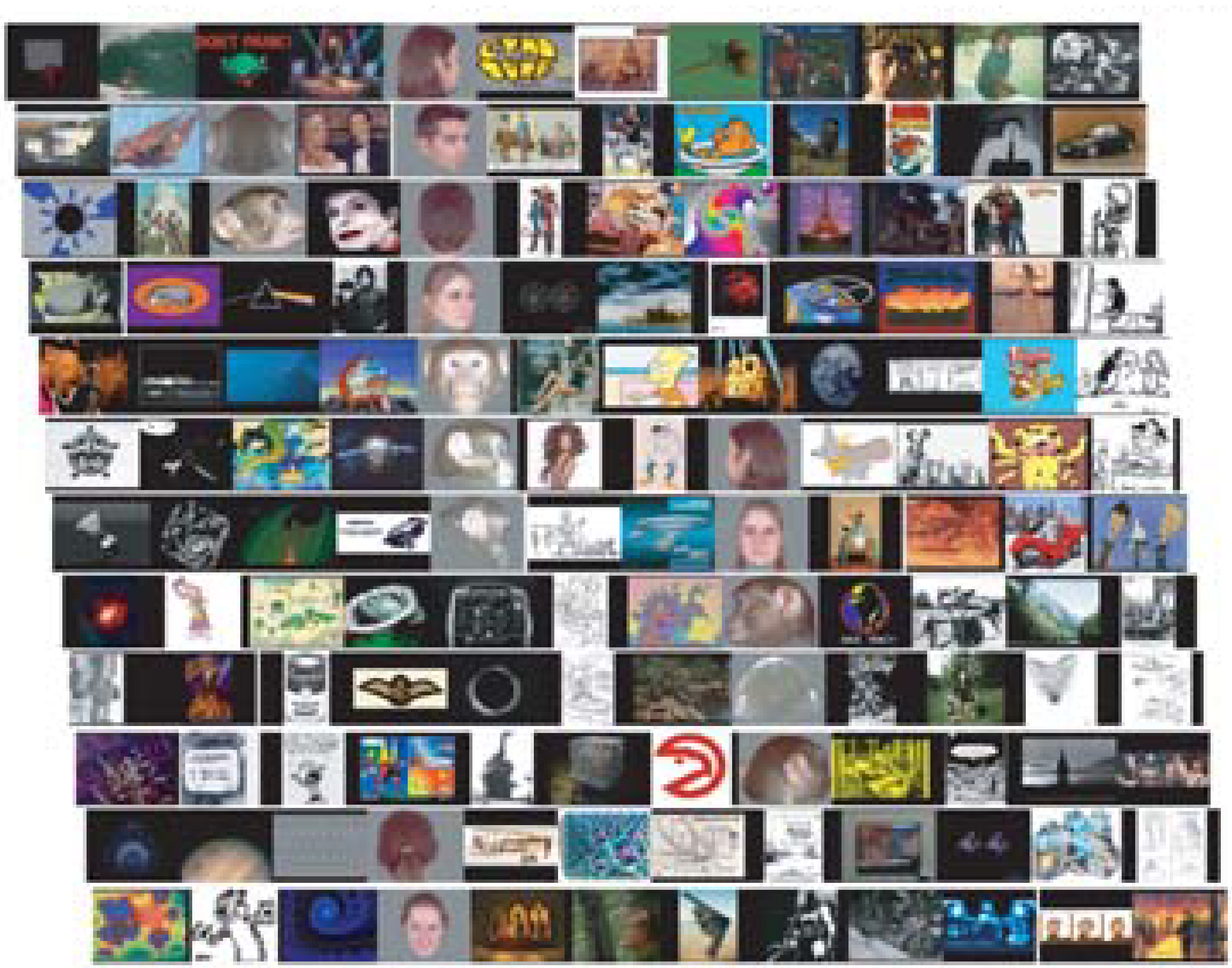
1000s of images ($> 15\%$ faces) presented to neuron for 55 or 110ms

RSVP: Face-selective neurons

(Földiák et al. 2004)

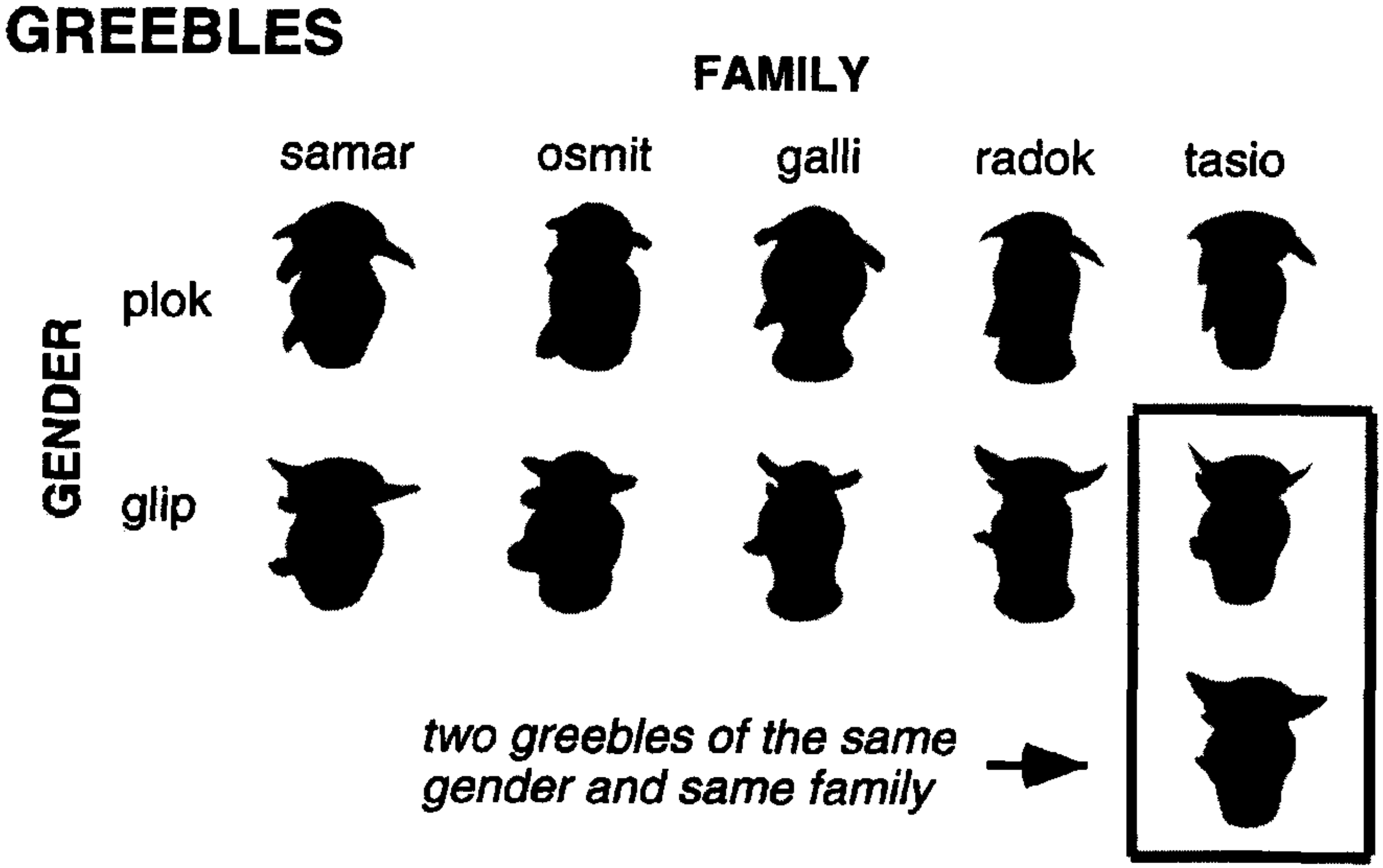
- Some monkey STSa neurons show clear preferences – top 50 faces are images
- Response low to remaining patterns
- Concern: faces are the only special category (overrepresented, aligned, blank background)

RSVP: Non-face-selective neurons



Other neurons don’t make much sense at all

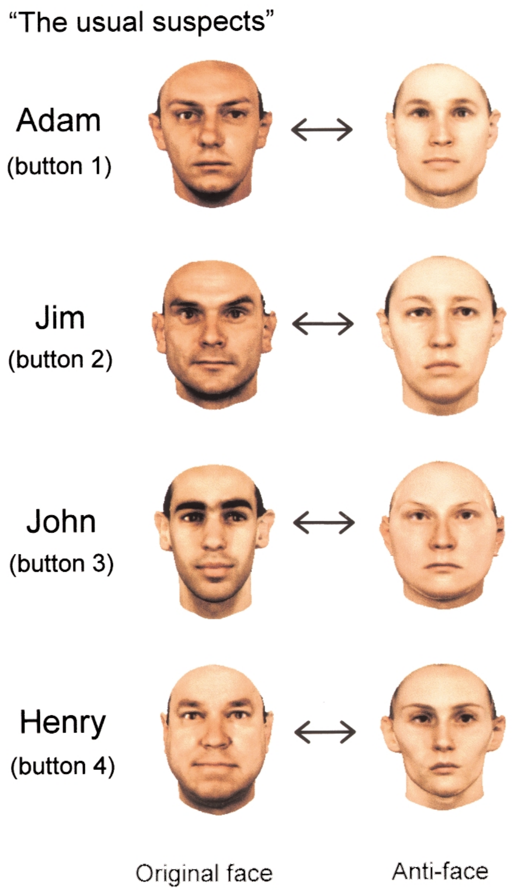
Form expertise

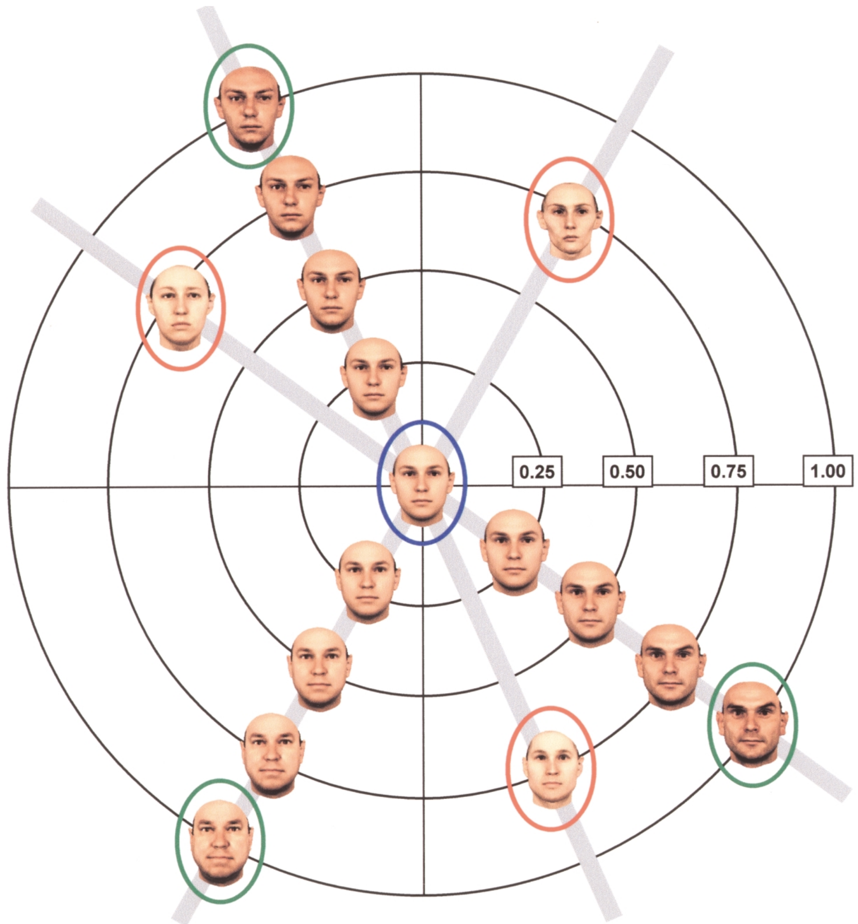


(Gauthier & Tarr 1997)

Most of the “specialness” of faces appears to be shared by other object categories requiring configural distinctions between similar examples.

Face aftereffects





(Leopold et al. 2001)

Aftereffects are seemingly universal. E.g.

face aftereffects: changes in identity judgments;

blur/sharpness aftereffects, contrast aftereffects. . .

Invariant tuning

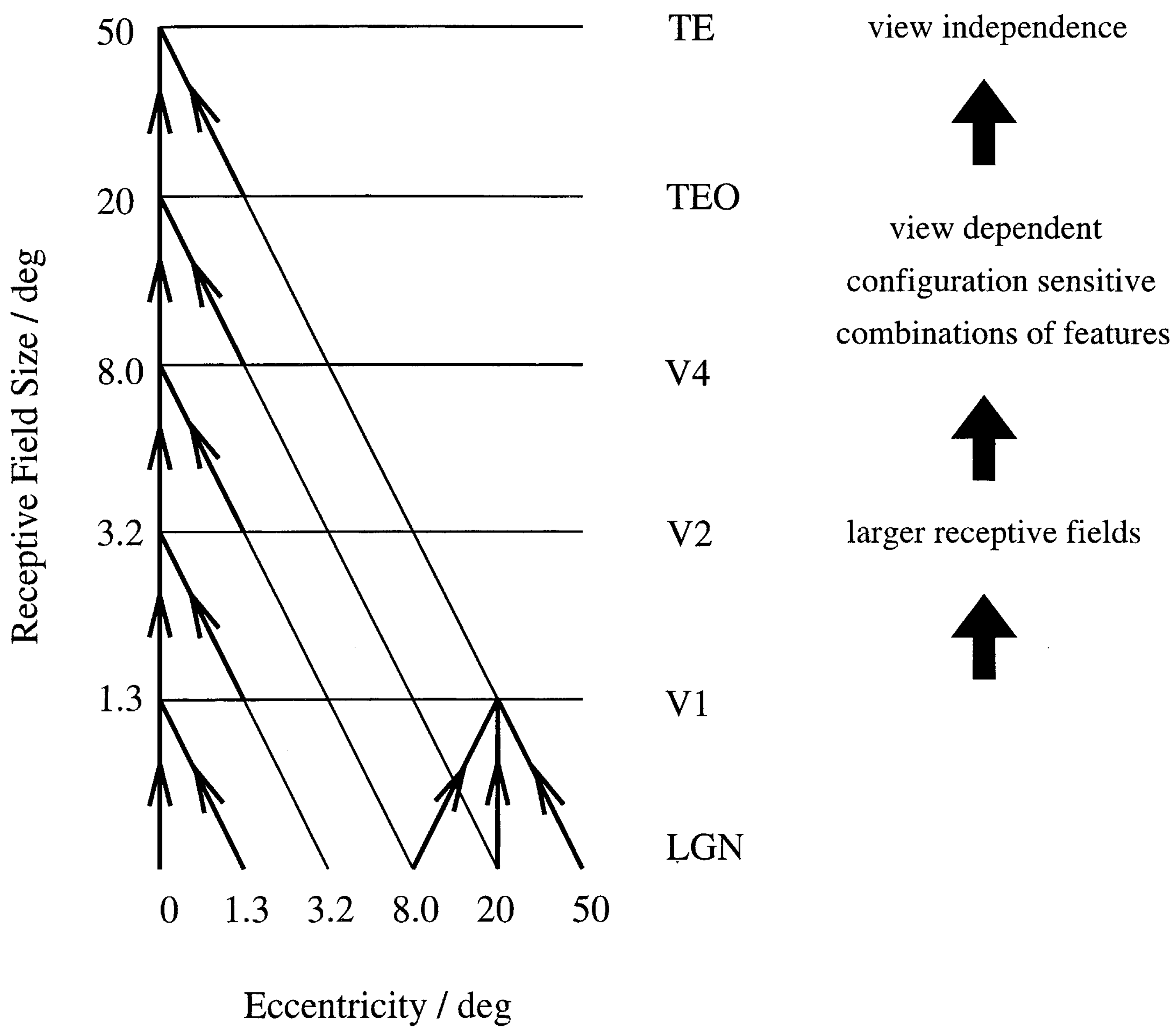
Higher level ventral stream cells have response properties invariant to size, viewpoint, orientation, etc.

Similar to complex cells, but higher-order. E.g. can respond to face regardless of its location and across a wide range of sizes and viewpoints.

Why is invariance hard?

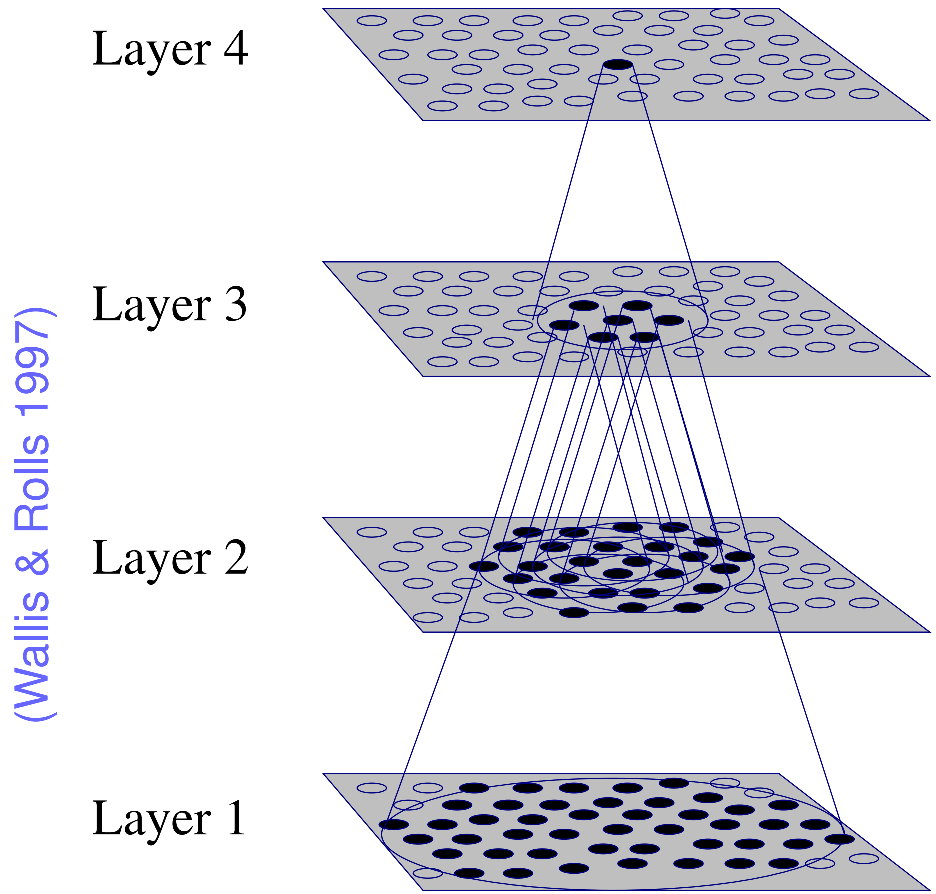
Simple template-based models won't provide much invariance, but could build out of many such cells.

RF sizes



(Rolls 1992)

VisNet



Develops neurons with invariant tuning

Assumes fixed V1 area

Ignores topographic organization

Trace learning rule

VisNet uses the trace learning rule proposed by Földiák (1991). Based on Hebbian rule for activity y^τ and input ${x_j}^\tau$:

$$\Delta w_j = \alpha y^\tau {x_j}^\tau \tag{1}$$

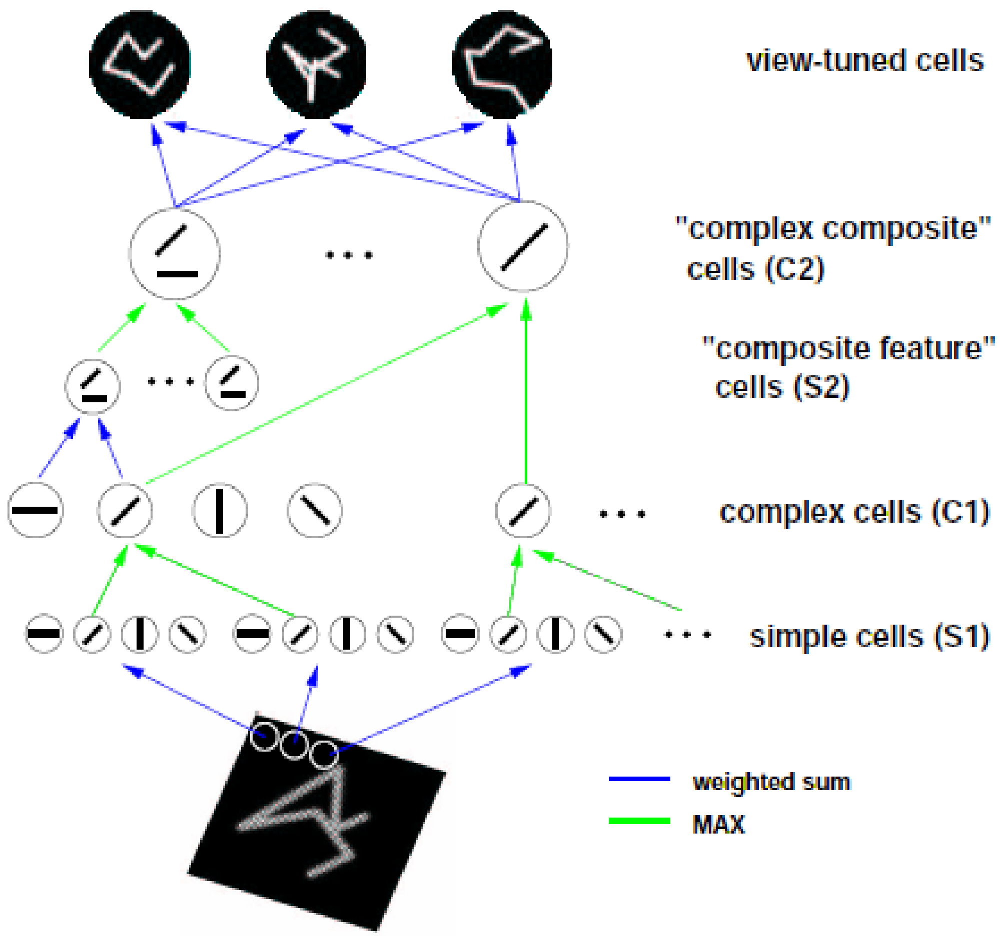
but modified to use recent history (“trace”) of activity:

$$\Delta w_j = \alpha \bar{y}^\tau {x_j}^\tau \tag{2}$$

$$\bar{y} = (1-\eta) y^\tau + \eta \bar{y}^{\tau-1} \tag{3}$$

General technique for invariant responses?

HMAX



(Riesenhuber & Poggio 1999)

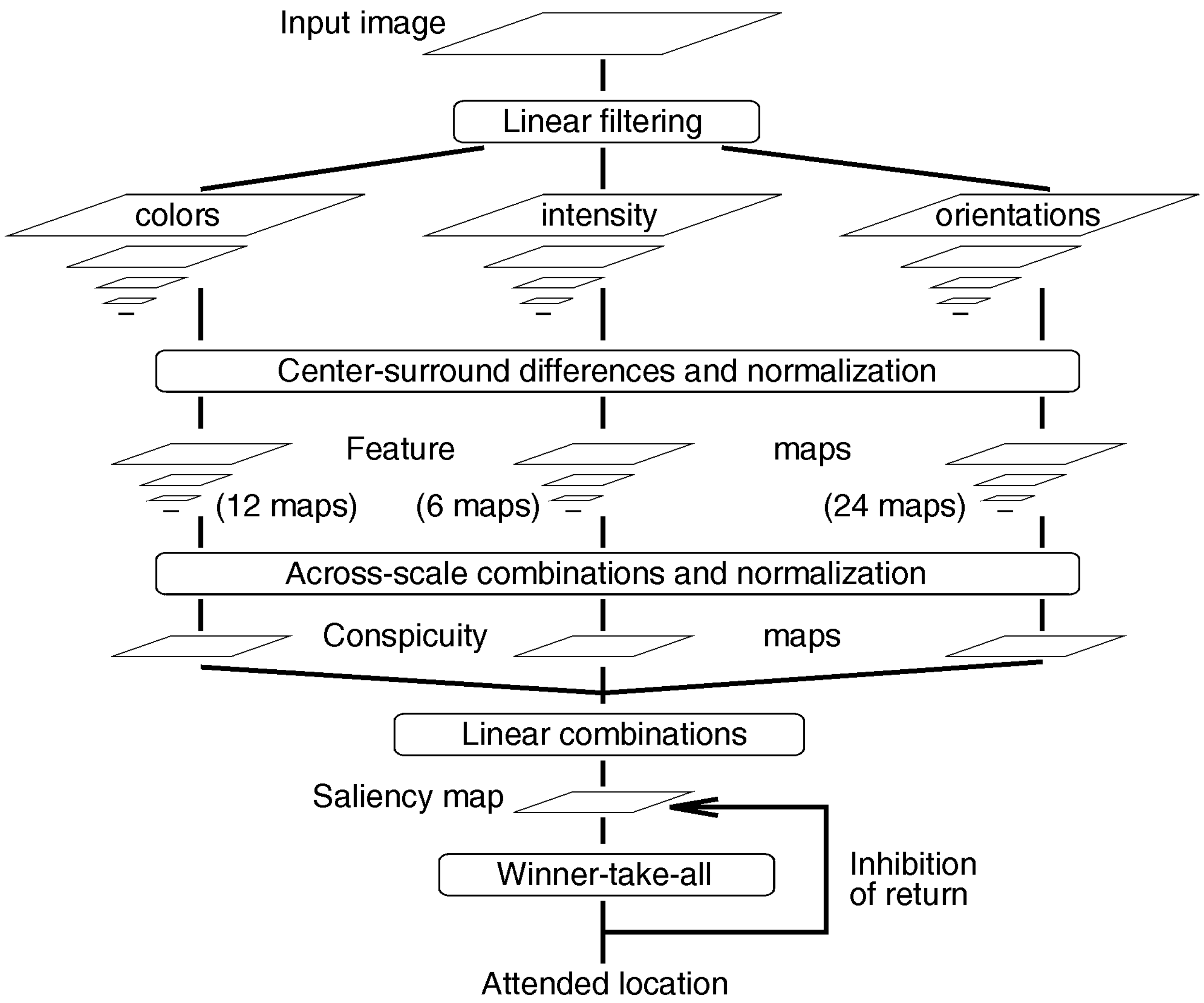
Top level (only) learns view, position, size invariant recognition

Max (C) units: nonlinear pooling, like complex cells

Linear (S) units: feature templates, like simple cells

No clear topography

Koch and Itti saliency maps



(Itti, Koch, & Niebur 1998)

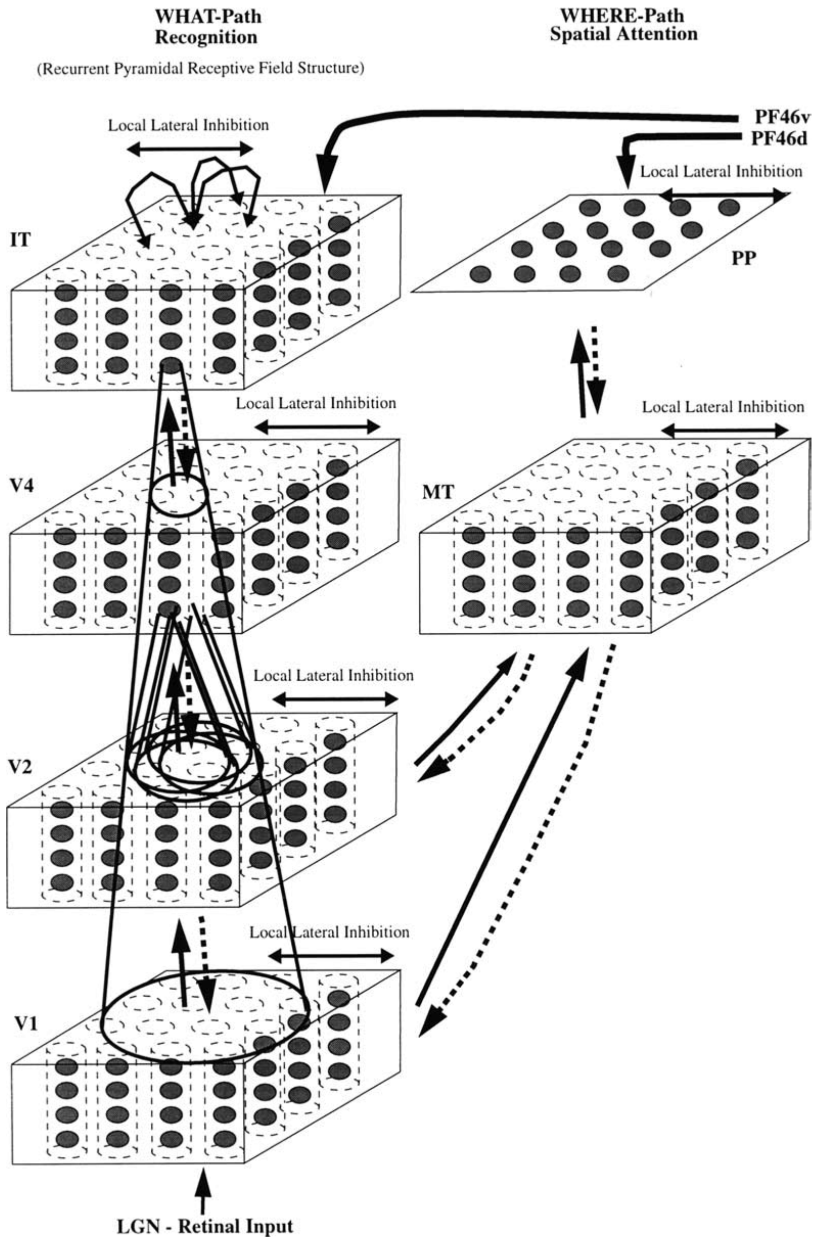
Attention model: most salient feature attended

Various feature maps pooled at different scales

Single winner: attended location

Inhibition of return: enables scanning

Other attention models



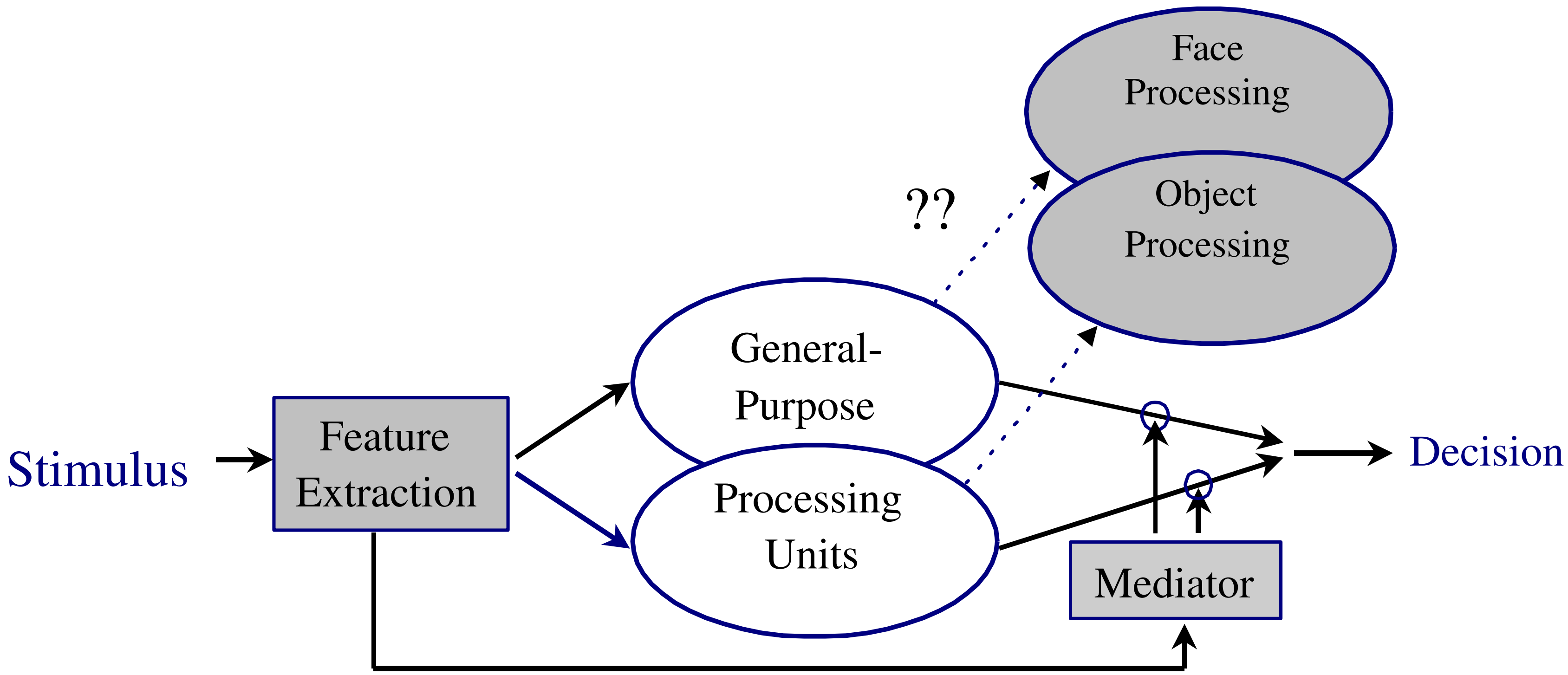
(Deco & Rolls 2004)

There are a number of other models of behavior like attention, most quite complex

Hard to tie individual model areas to specific experimental results from those areas

Also need to include superior colliculus

Modeling separate streams



(Dailey & Cottrell 1999)

Slight biases are sufficient to make one stream end up selective for faces, the other for objects

More complexities

Need to include eye movements, fovea/periphery.

At higher levels, neurons become multisensory.

Eventually, realistic models will need to include auditory areas, touch areas, etc.

Feedback from motor areas is also more important at higher levels.

Training data for such models will likely be harder to make than building a robot – will need embodied models.

Summary

- Need to include many areas besides V1
- Complexity and lack of data are serious problems
- Eventually: situated, embodied models
- May be useful to focus on species with just V1 or a few areas before trying to tackle whole visual hierarchy
- Lots of work to do

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