

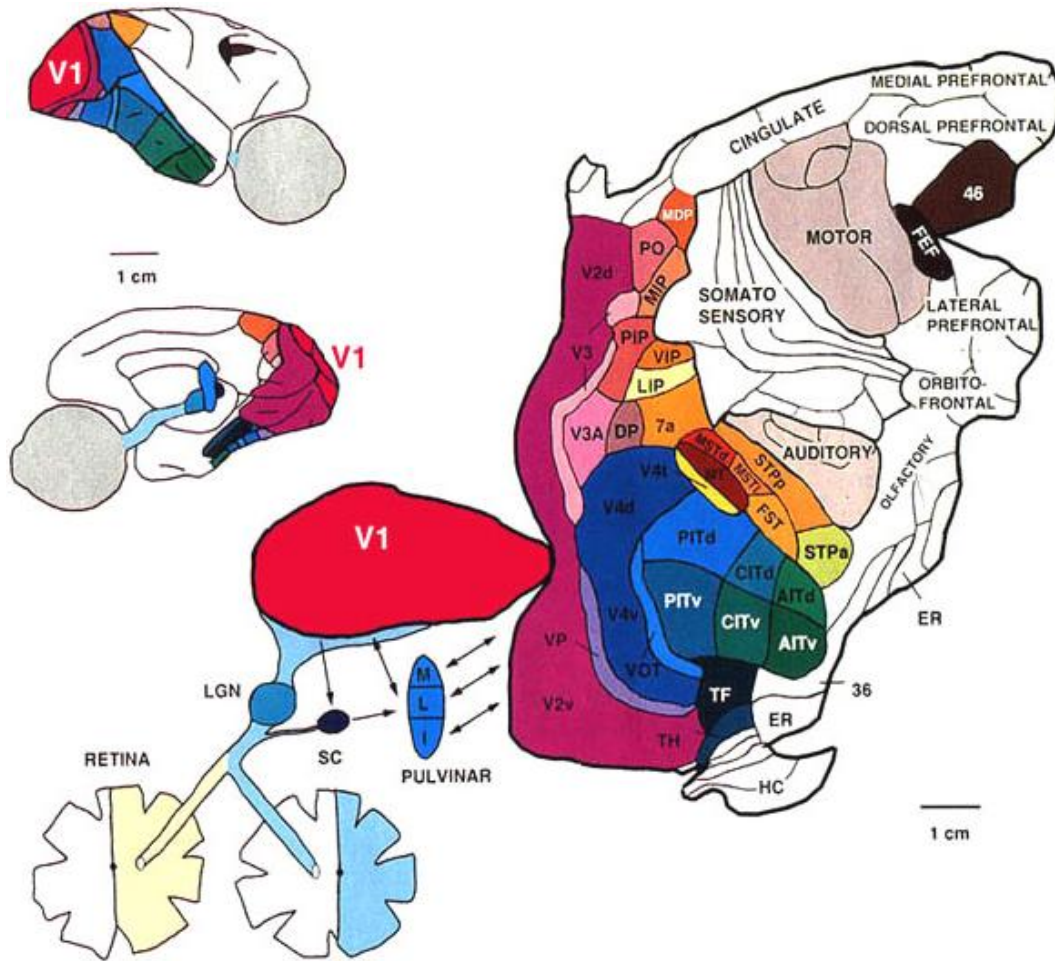
Modeling Extrastriate Areas

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Higher areas



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

Macaque visual areas (Van Essen et al. 1992)

What/Where streams

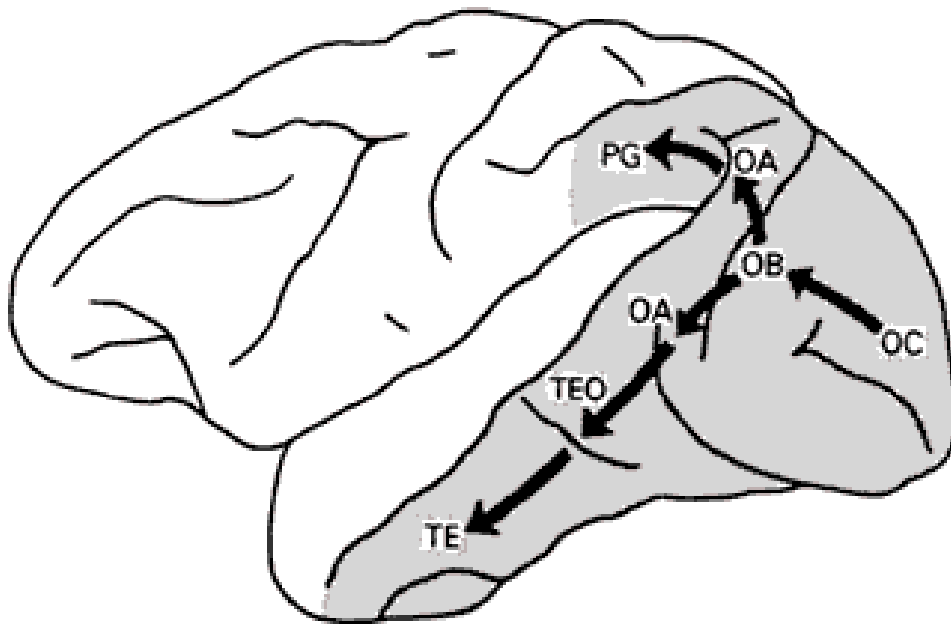
Typical division:

Ventral stream:

“What” pathway
from V1 to temporal
cortex (IT)

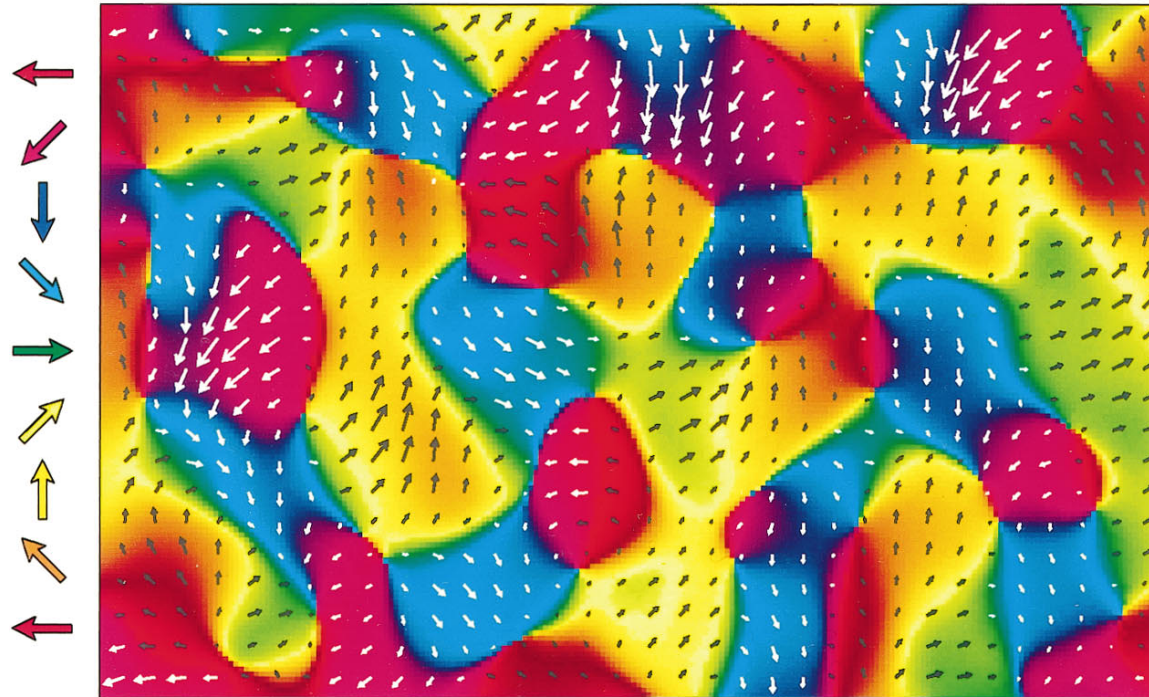
Dorsal stream:

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



(Ungerleider & Mishkin 1982)

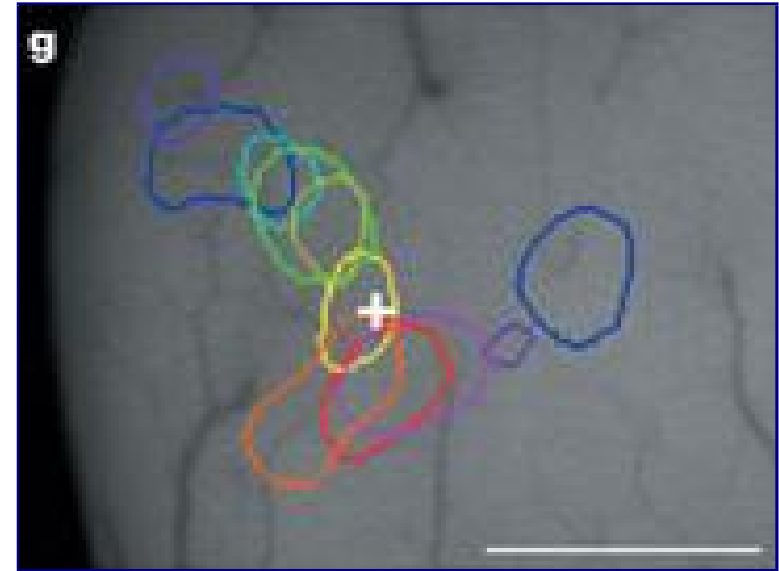
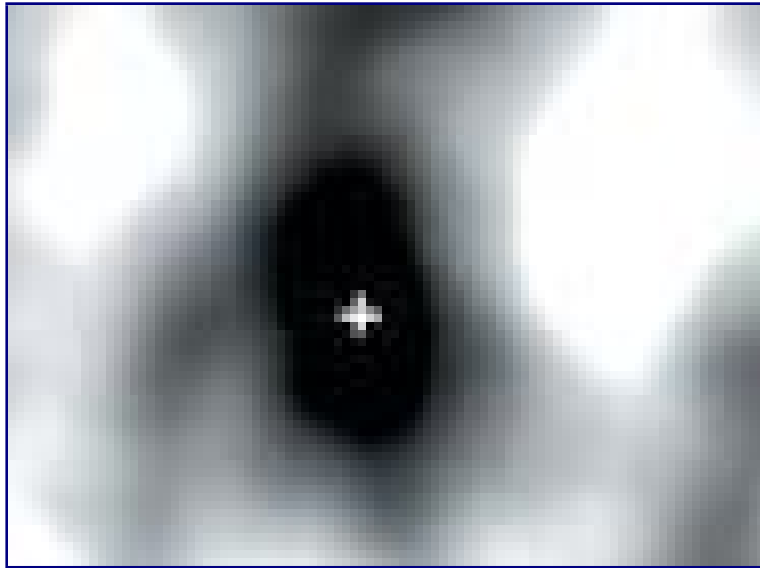
V2 OR/DR map



V2 cat direction map (Shmuel & Grinvald 1996)

- Except OD, maps found in V1 are usually also found in V2
- RFs are larger, maybe more complex (not really clear)
- Macaque V2 has complicated organization of thick/thin/pale stripes selective for color, luminance, etc.

V2 Color map



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

- 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

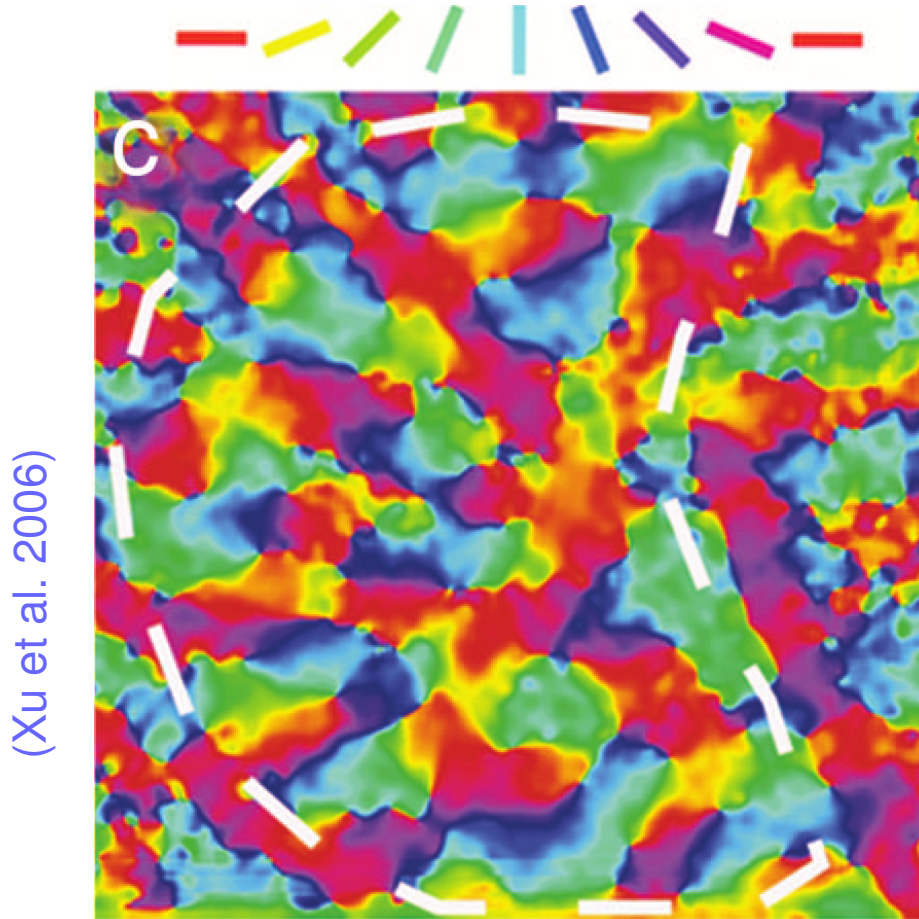
MT/V5

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

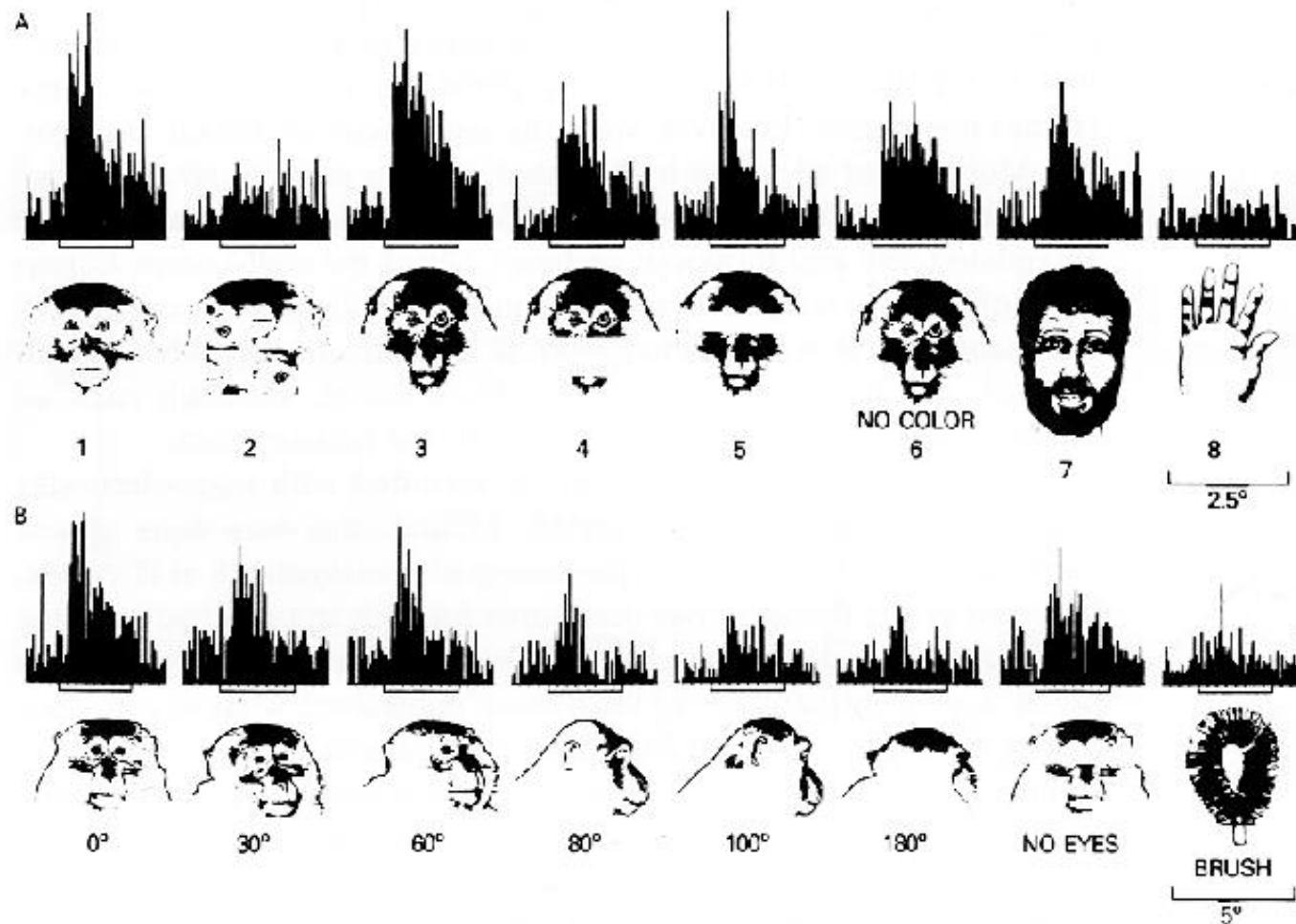
Involved in estimating
optic flow

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

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



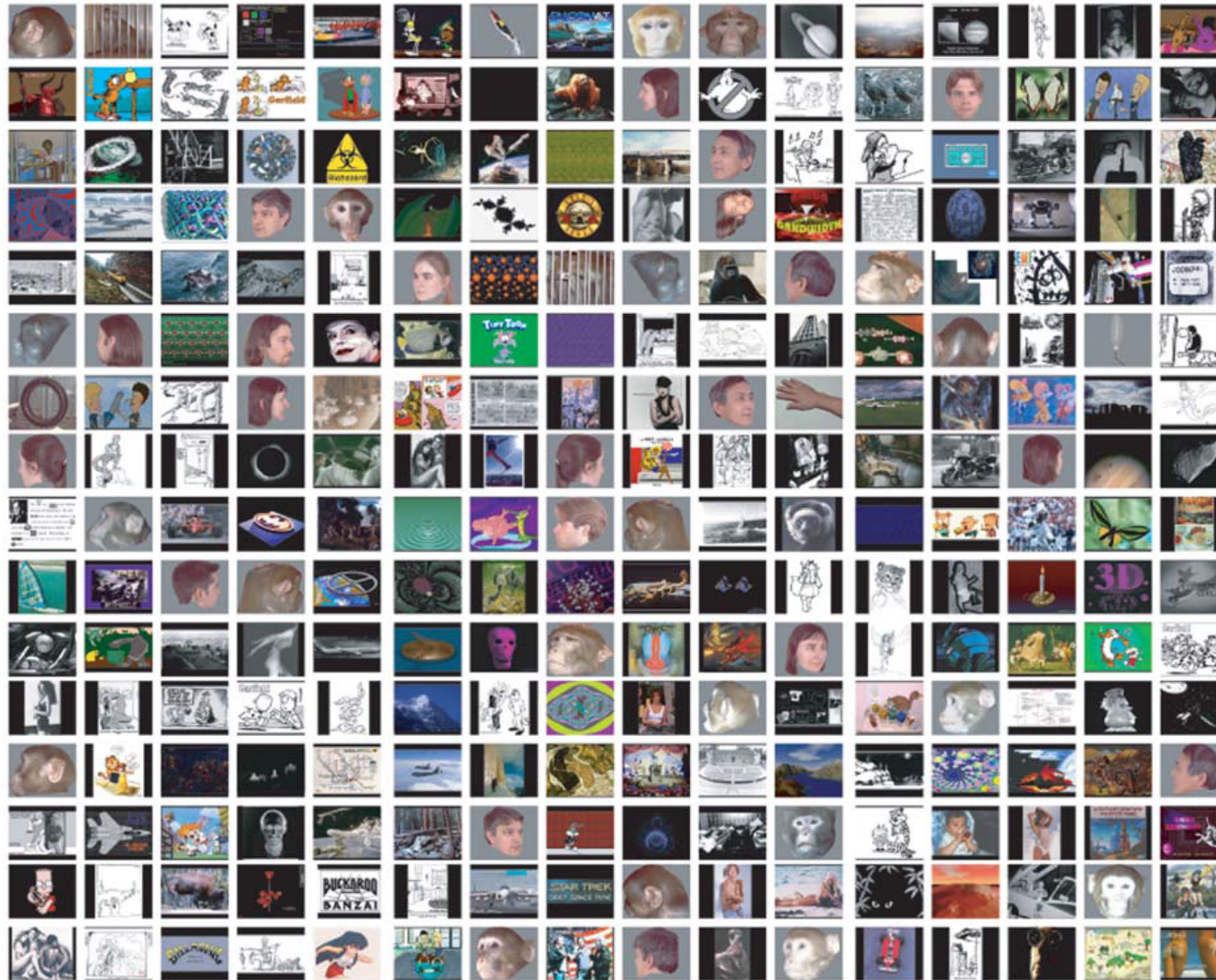
Object selectivity in IT



(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

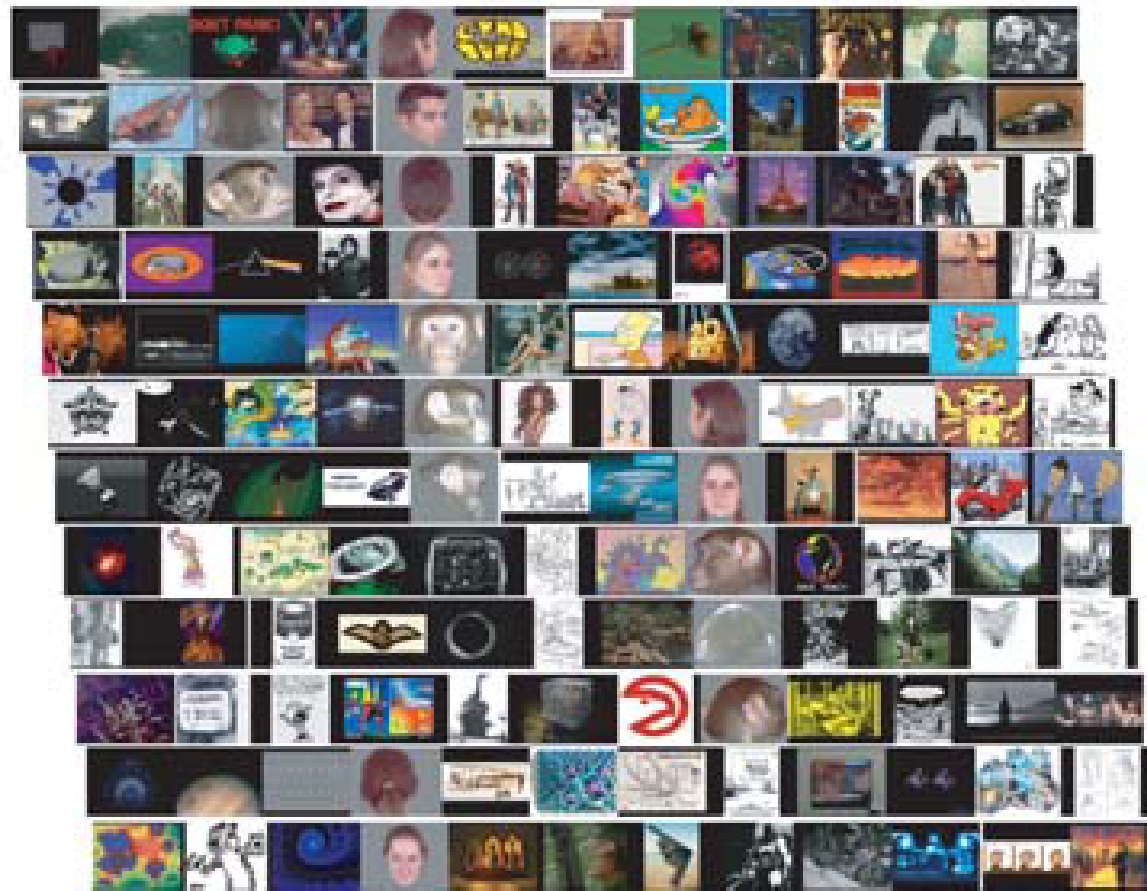
RSVP: Face-selective neurons



(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)

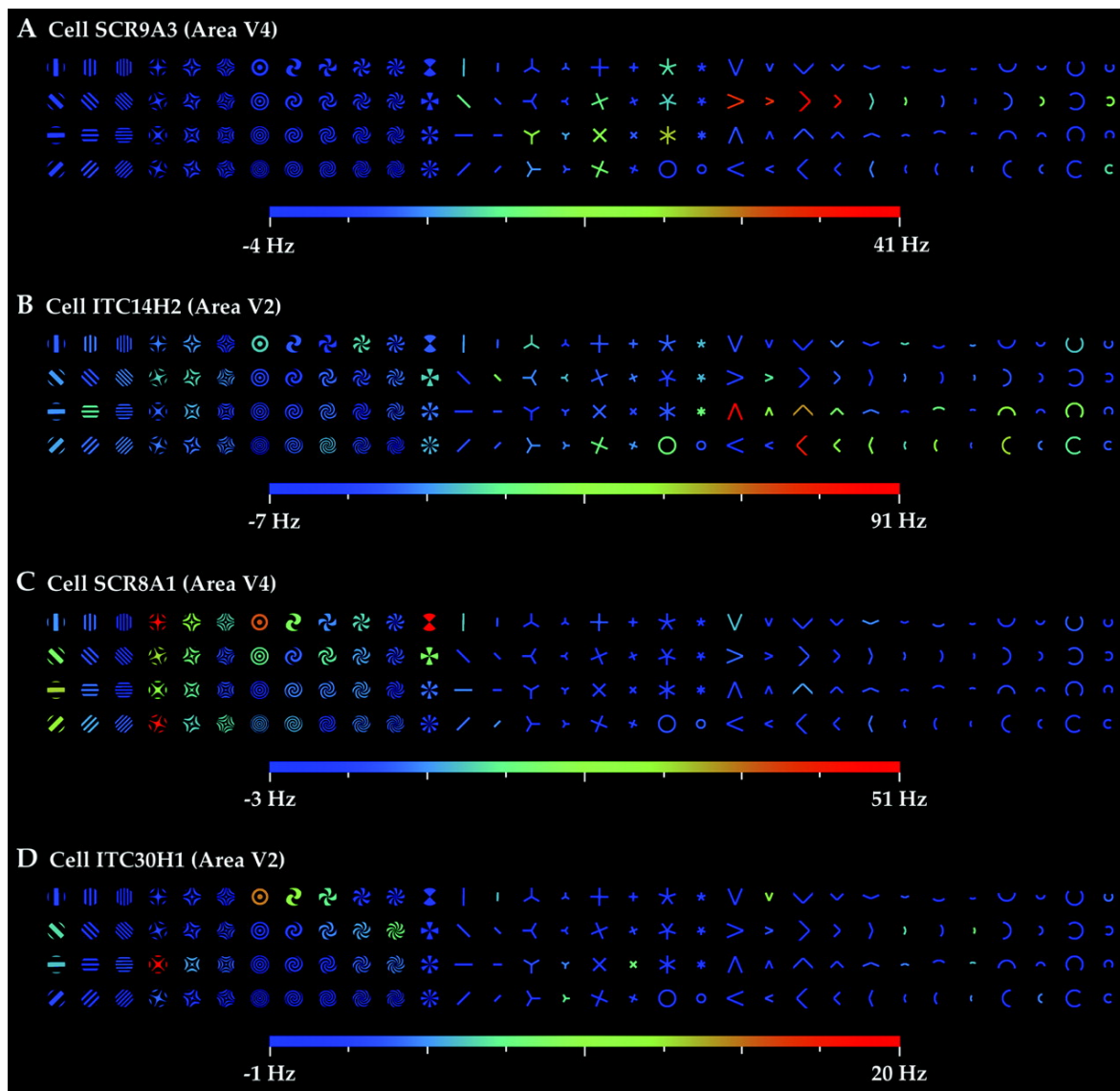
RSVP: Non-face-selective neurons



(Földiák et al. 2004)

- Other neurons don't make much sense at all
- See also Naselaris et al. (2009); mapping based on semantic category for tagged images

Parametric testing

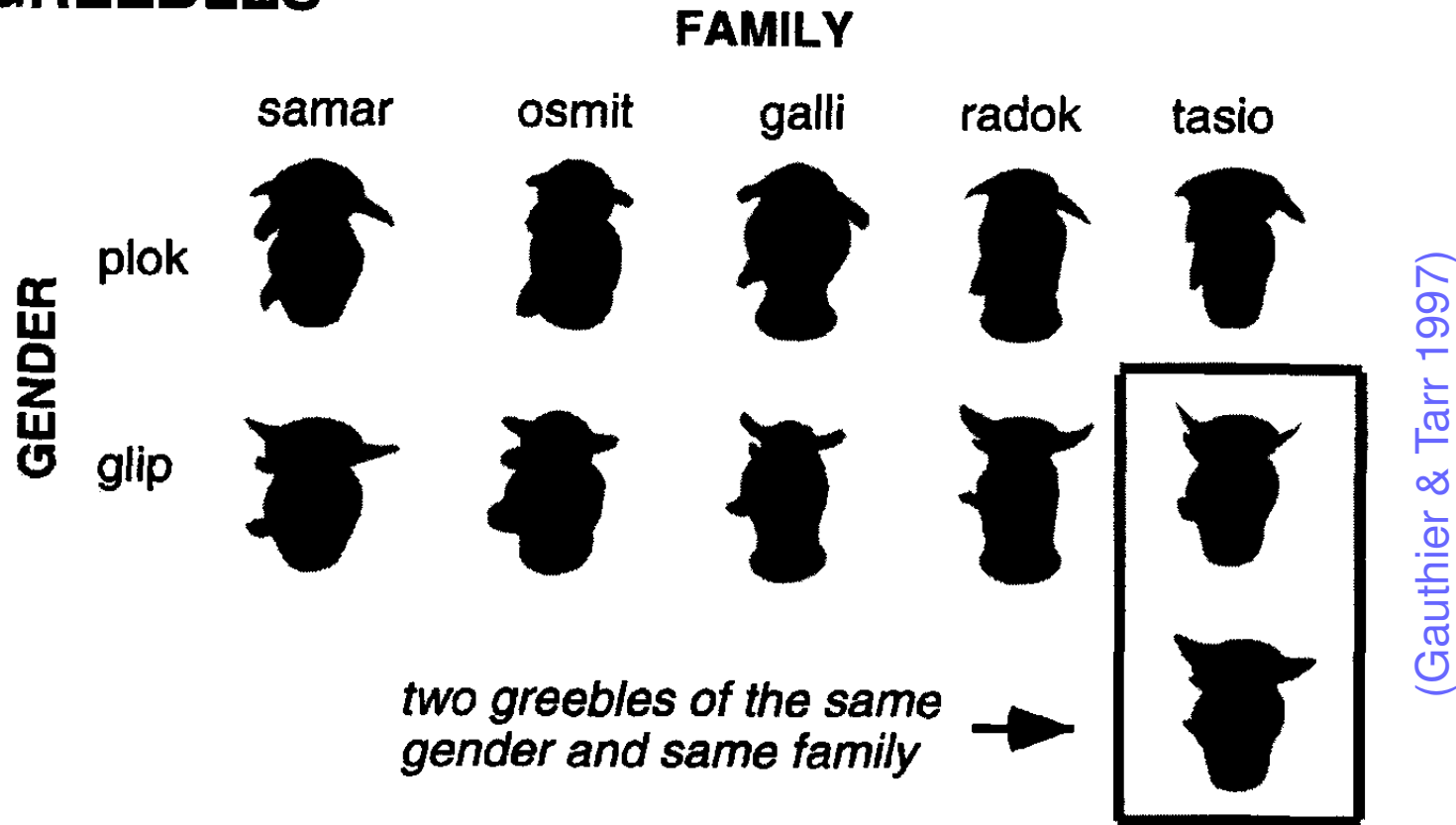


Difficult to see
differences in
kind in
responses to
geometric
stimuli across
the hierarchy

Macaque; (Hegd  & Van Essen 2007)

Form expertise

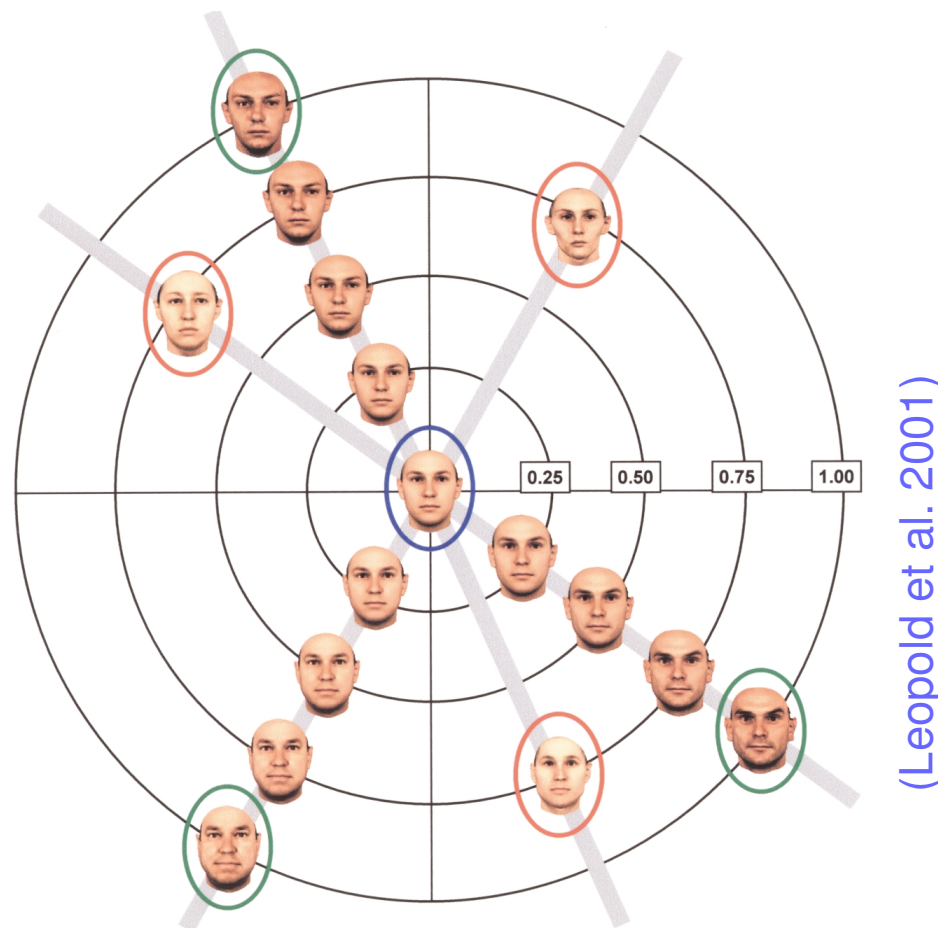
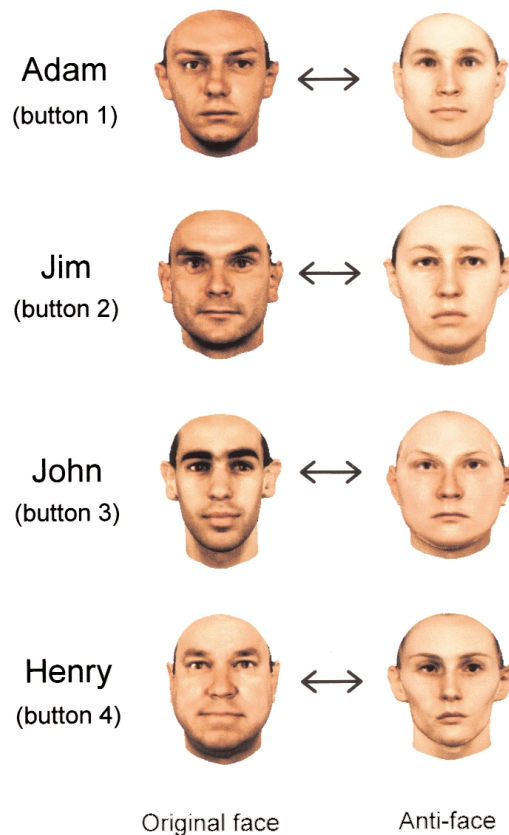
GREEBLES



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

Face aftereffects

"The usual suspects"



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.

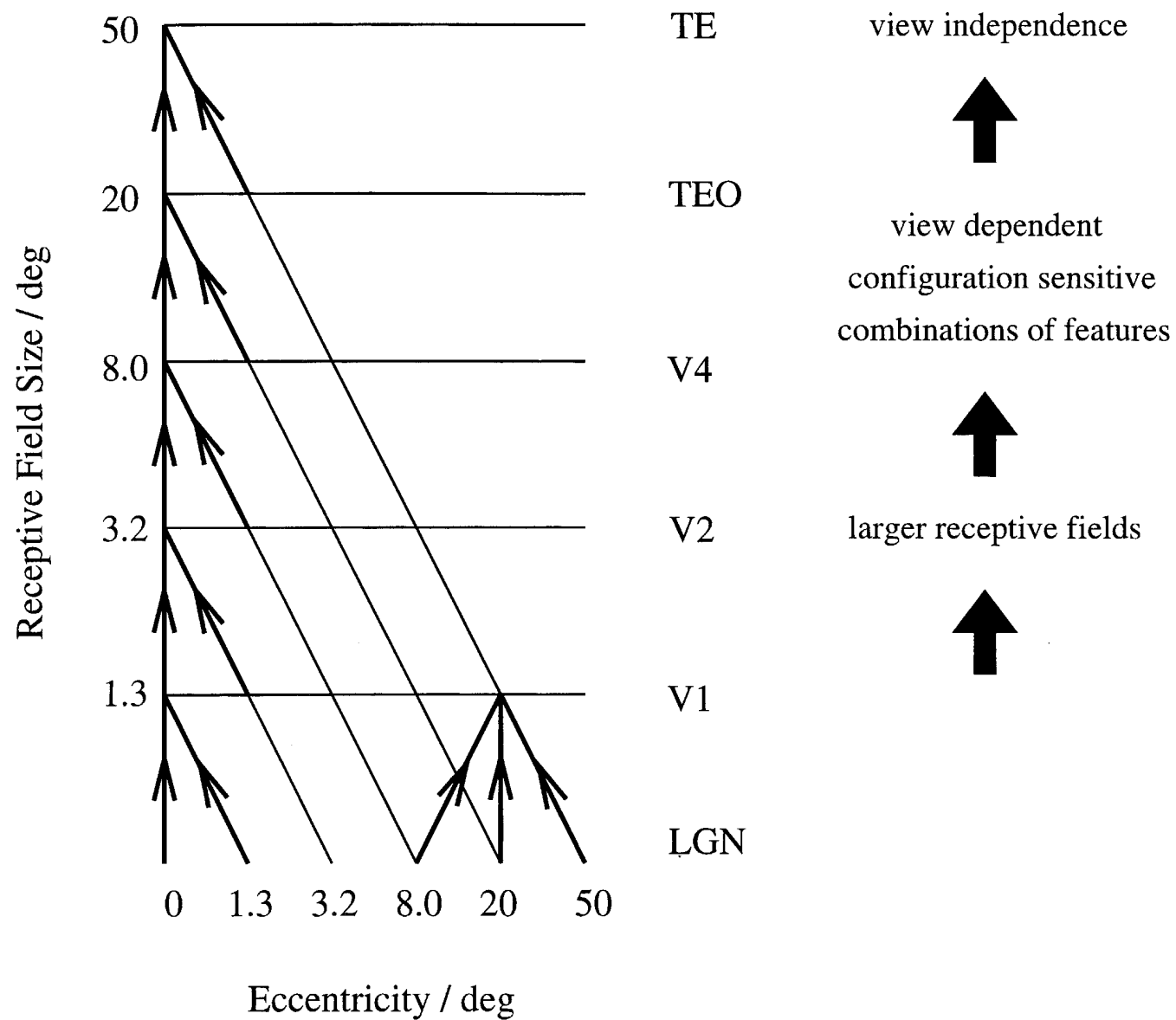
Similar to complex cells, but higher-order. E.g. can respond to face regardless of its location and across a wide range of sizes and viewpoints.

Why is invariance hard?



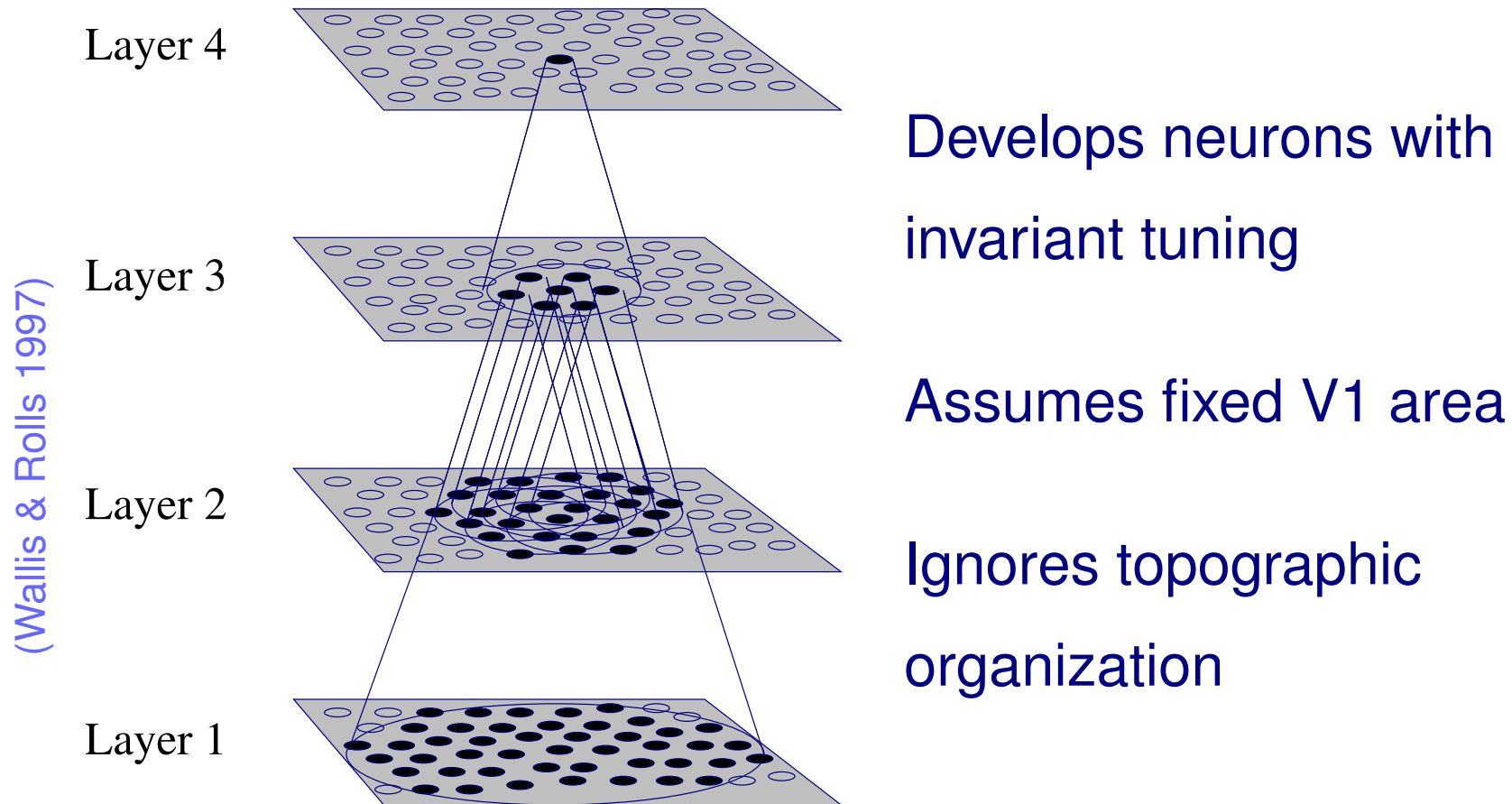
Simple template-based models won't provide much invariance, but could build out of many such cells.

RF sizes



(Rolls 1992)

VisNet



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^τ :

$$\Delta w_j = \alpha y^\tau x_j^\tau \quad (1)$$

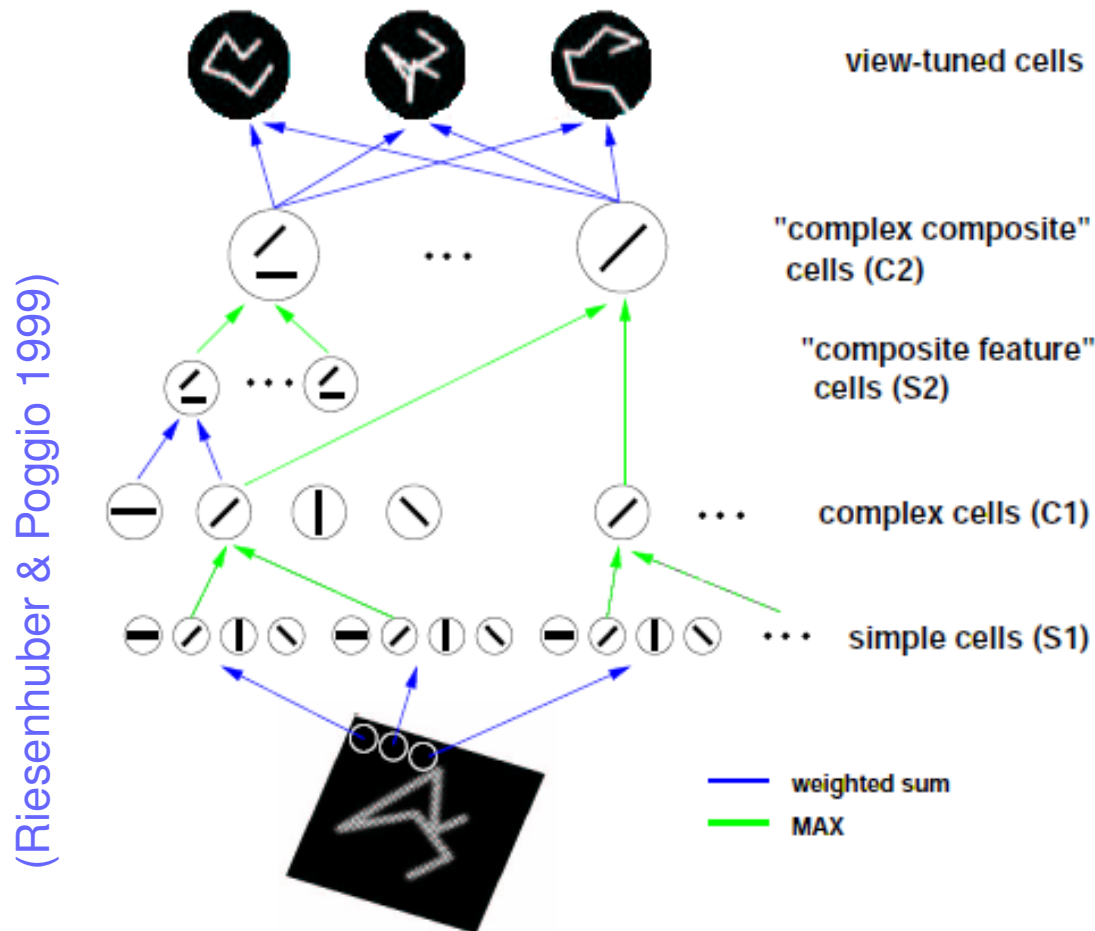
but modified to use recent history (“trace”) of activity:

$$\Delta w_j = \alpha \bar{y}^\tau x_j^\tau \quad (2)$$

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

General technique for invariant responses?

HMAX



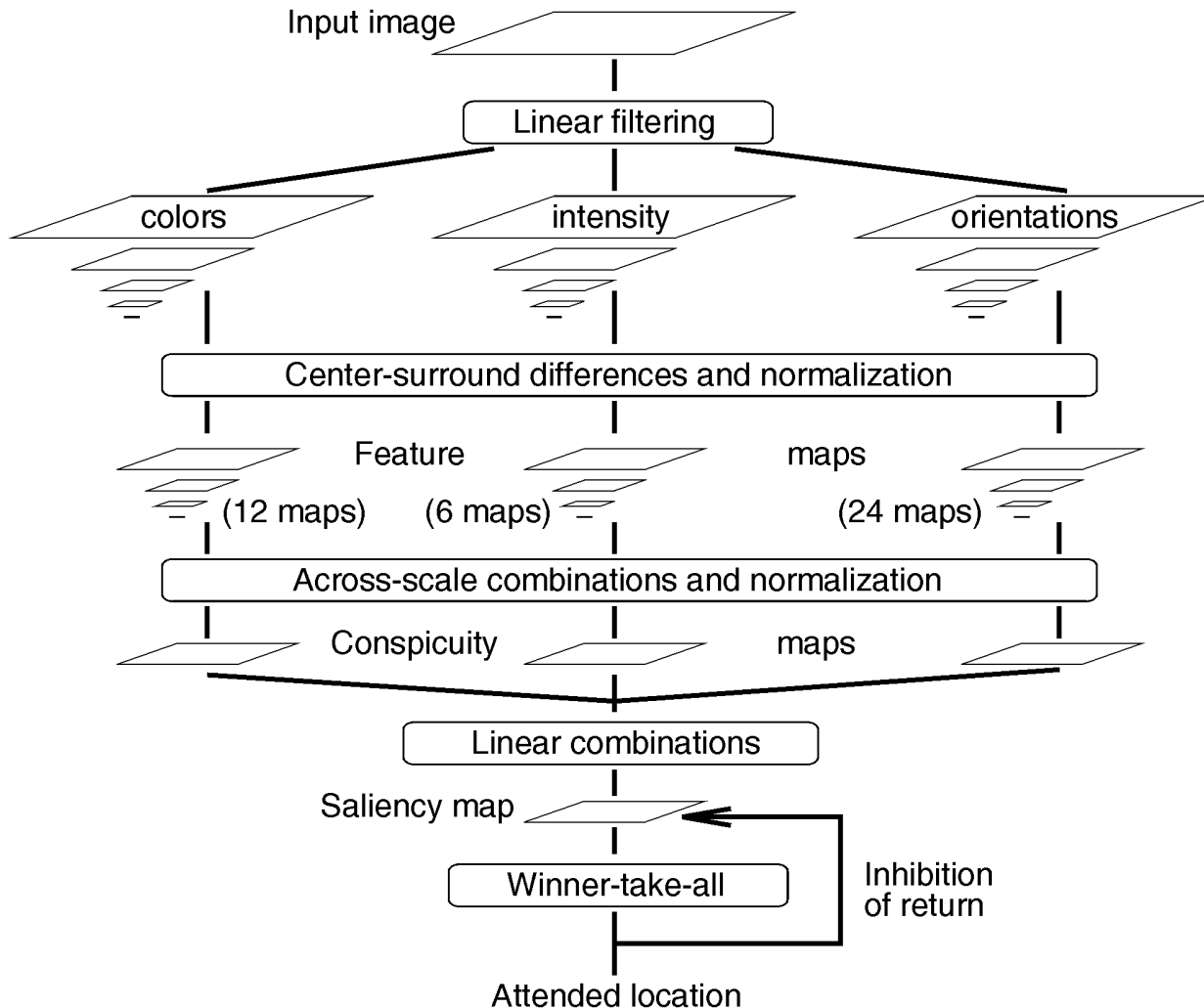
Top level (only) learns
view, position, size
invariant recognition

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)

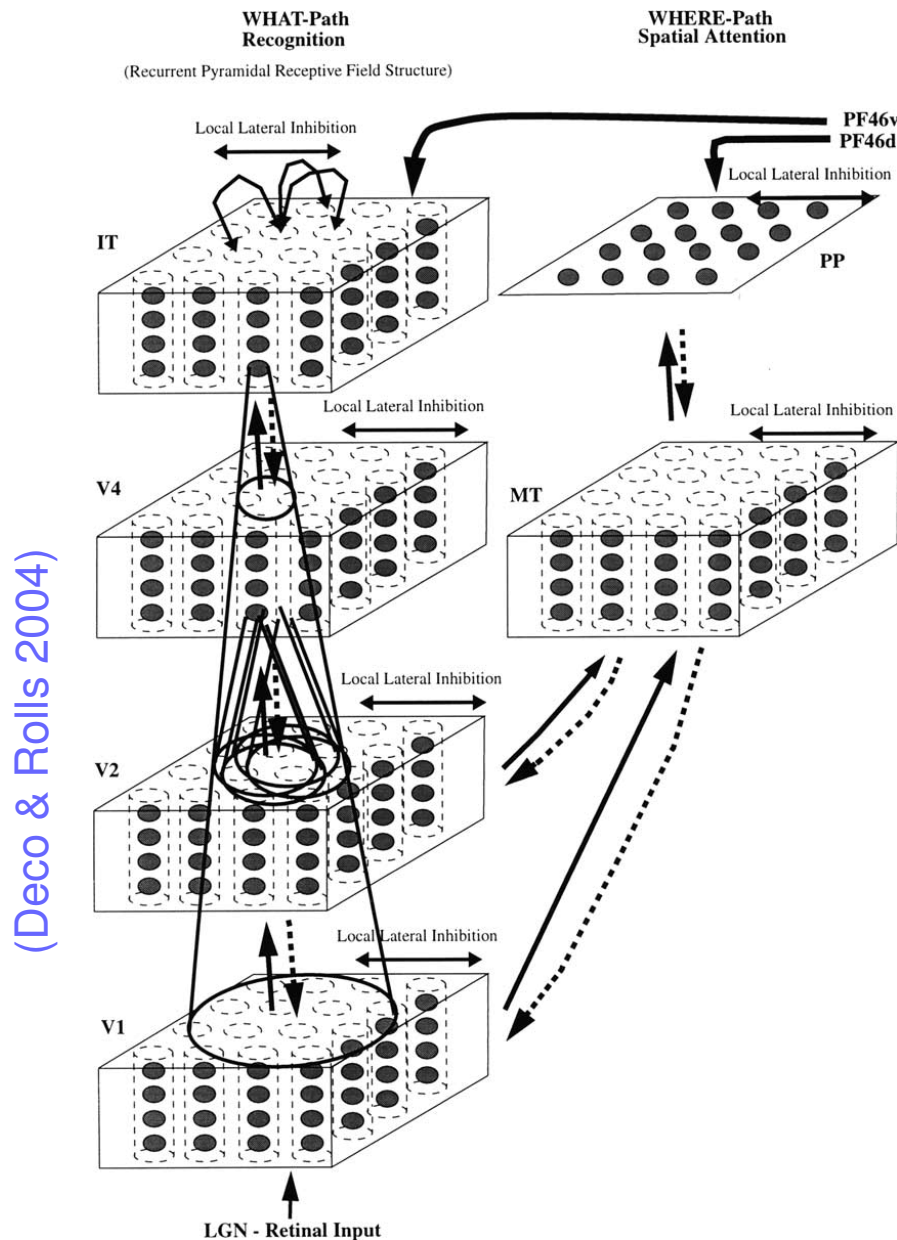
Attention model:
most salient
feature attended

Various feature
maps pooled at
different scales

Single winner:
attended location

Inhibition of return:
enables scanning

Other attention models

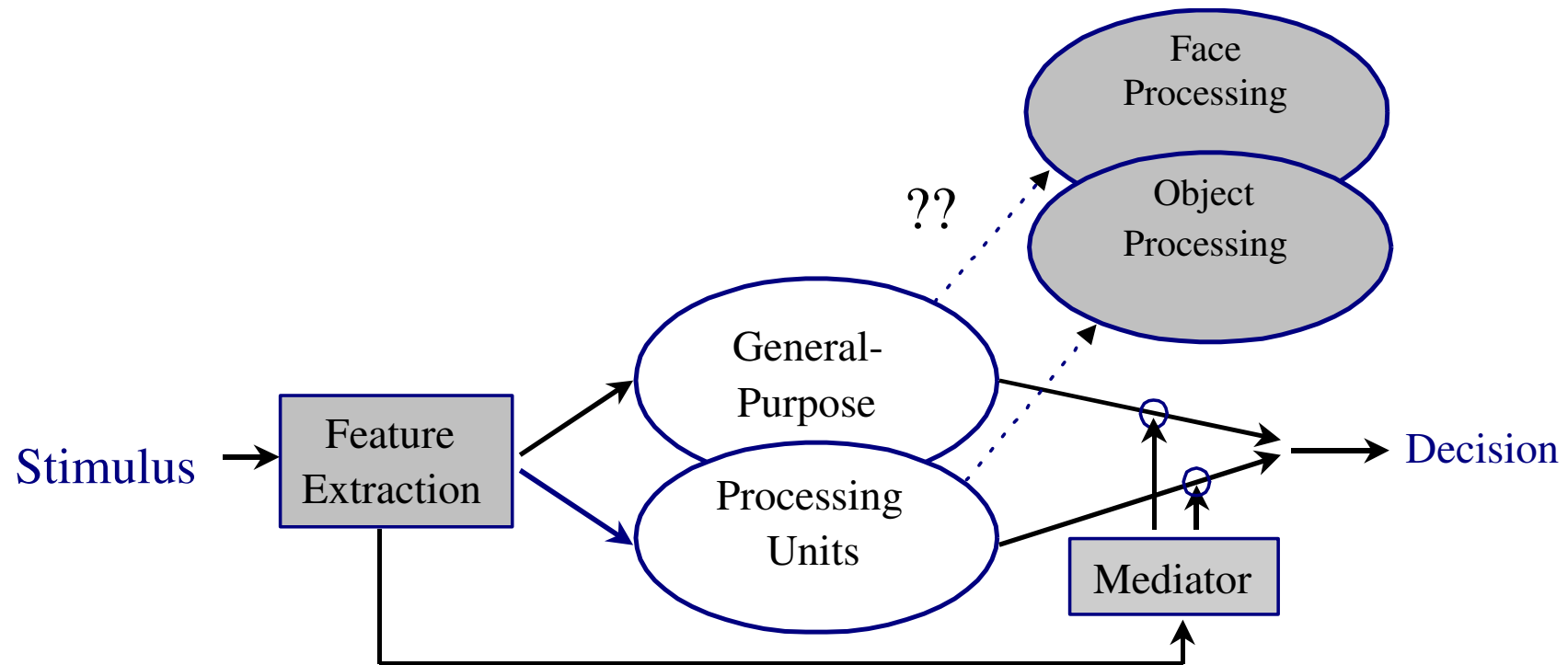


There are a number of other models of behavior like attention, most quite complex

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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