

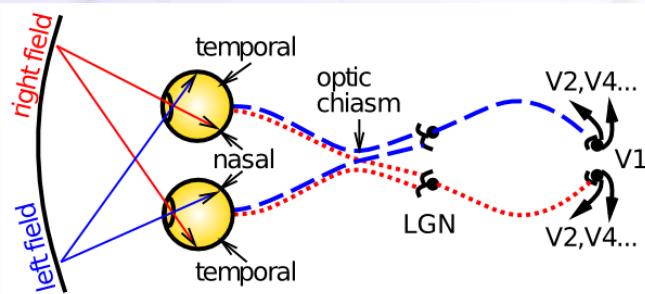
Perception & Attention

Computational Cognitive Neuroscience
Randall O'Reilly

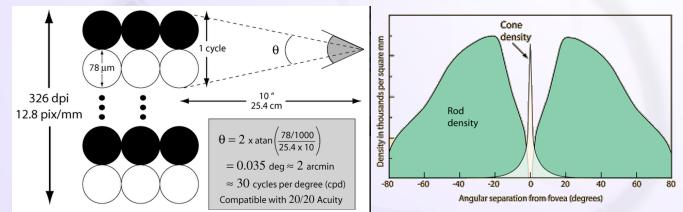
Perception Overview



Optic Pathway

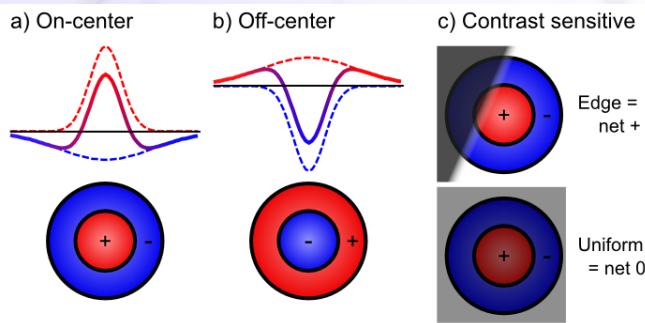


How Many Megapixels??

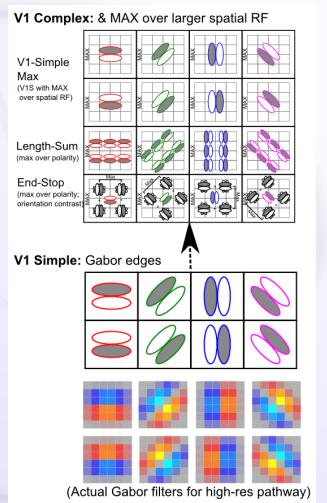
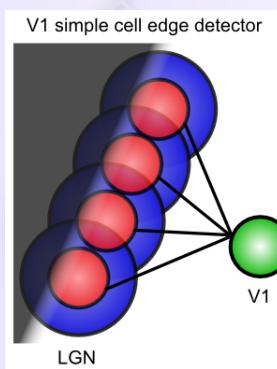


- Retina has ~100 mega-rods, only ~5-7 mega-cones
- Fovea can resolve about 30 cycles-per-degree (requires cone spacing of ~.3 arcmin) = ~300 dpi at 10° (close!)
- Focal length of human eye is ~22mm, max ISO about 800

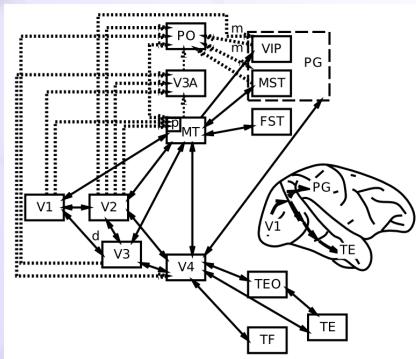
Retinal Contrast Filtering



V1

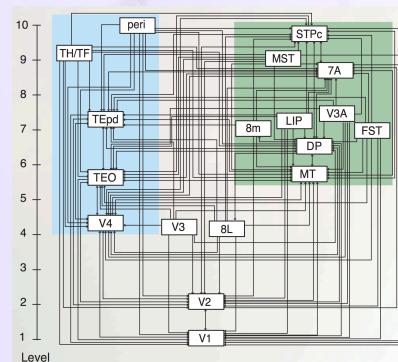


Visual Hierarchy: What vs Where



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“Van Essen” Hierarchy

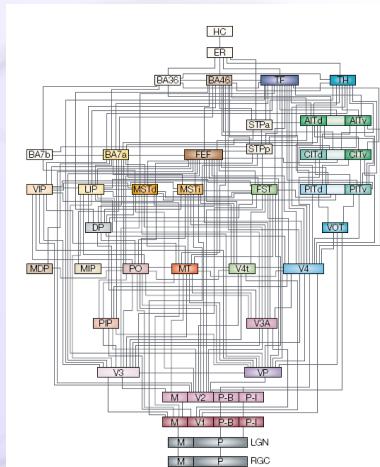


Markov et al., 2014

TE.. = Temporal
LIP, DP.. = Parietal
8L = Frontal Eye Field

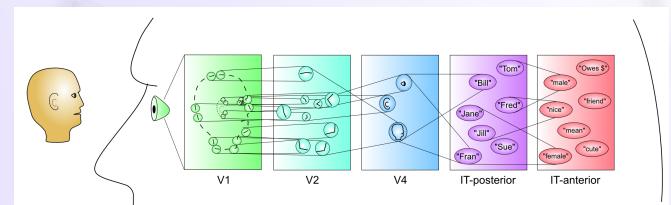
To hippocampus:
TH/F = Parahippo
peri = Perirhinal

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Hierarchy of Detectors..



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Self-Organization of V1 Orientation Selective Neurons

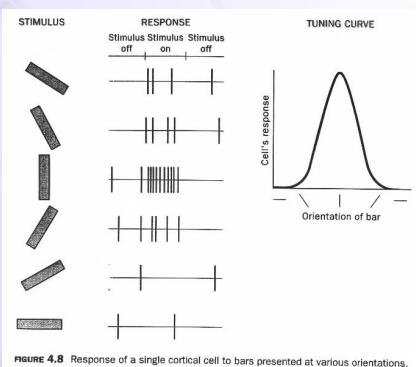


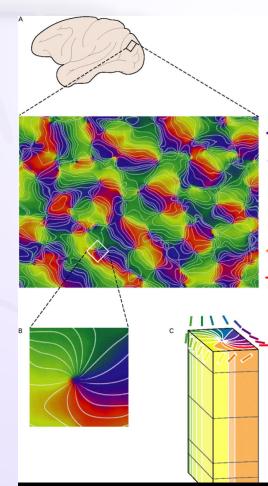
FIGURE 4.8 Response of a single cortical cell to bars presented at various orientations.

Topography!

Map of orientations

“Pinwheel” singularities

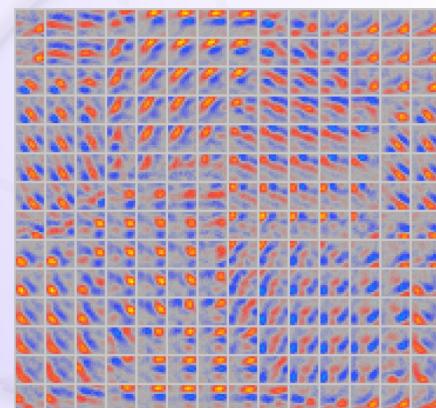
Hypercolumn organization



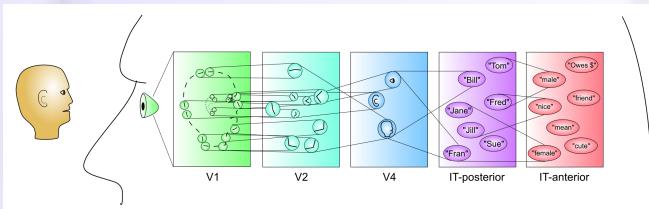
What is Common?



Self-Organized Topography

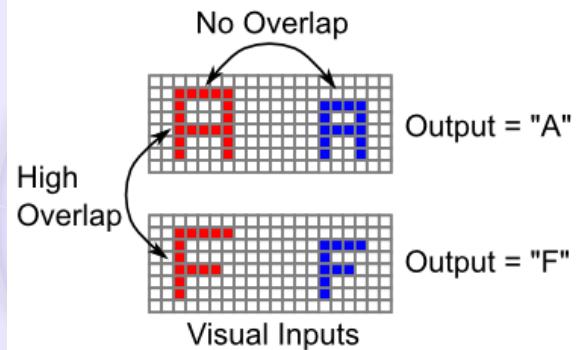


Invariant Object Recognition

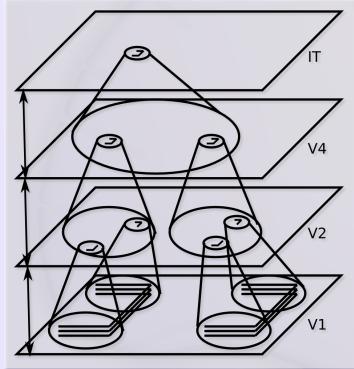


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It's Hard



Invariant Object Recognition

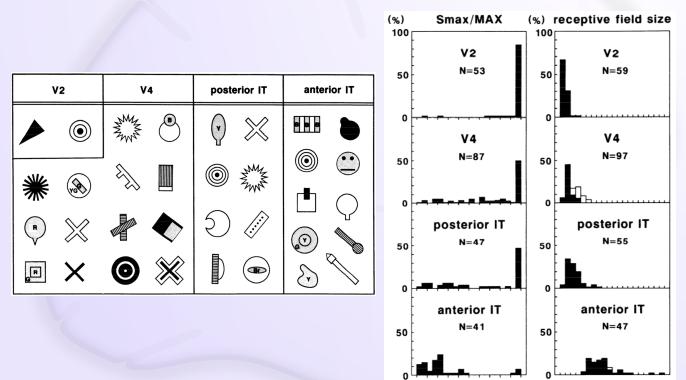


- Hierarchy of increasing:
 - Feature complexity
 - Spatial invariance
- Strong match to RF's in corresponding brain areas

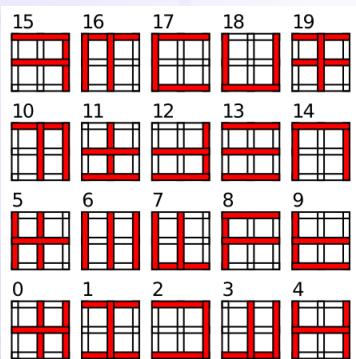
(Neocognitron, HMAX, SLF, Pinto/DiCarlo, etc.)

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Biological Data



Simple Textbook Test



3D Object Recognition Test

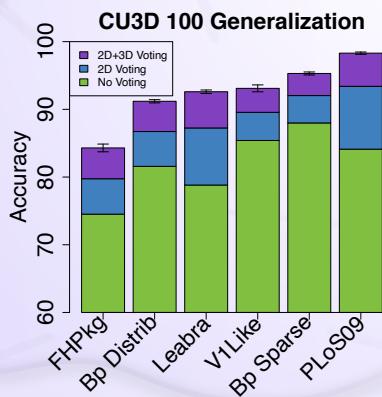


- 3D models from Google SketchUp
- 100 categories
- 9-10 objects per category
- 2 objects left out for testing
- +/- 20° horiz depth rotation + 180° flip
- 0-30° vertical depth rotation
- 14° 2D planar rotations
- 25% scaling
- 30% planar translations

<http://grey.colorado.edu/CompCogNeuro/index.php/CU3D>

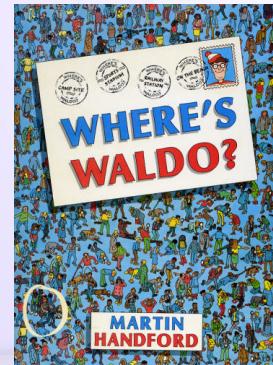
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Generalization to Novel Category Exemplars – Better than 90%

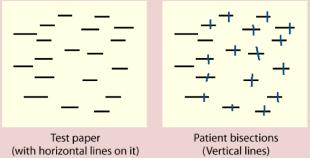
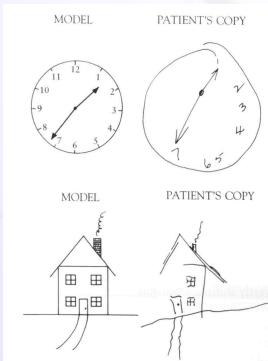


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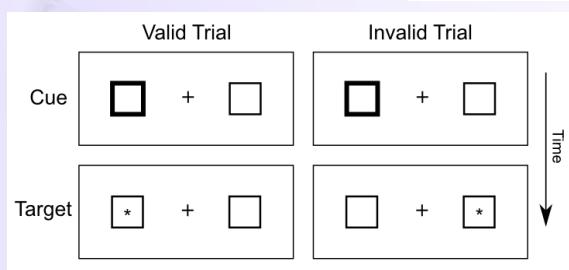
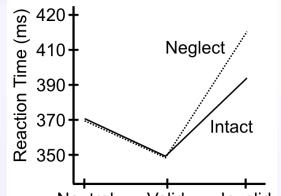
Spatial Attention and Neglect



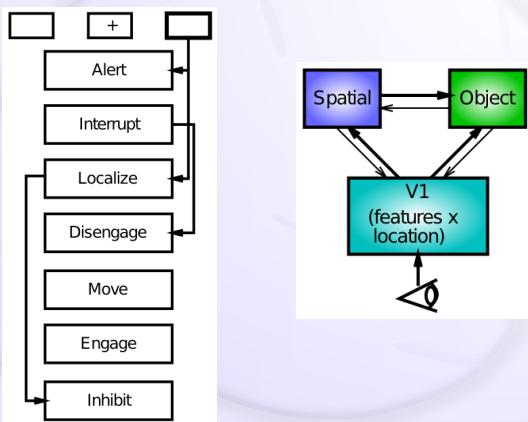
Hemispatial Neglect



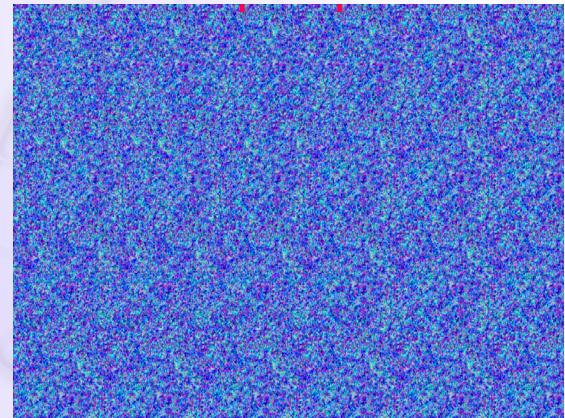
Posner Task



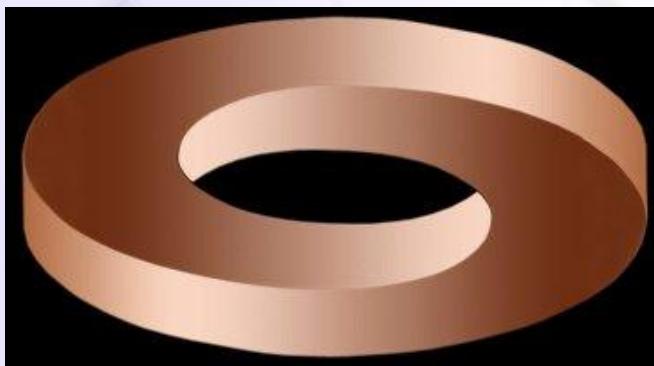
Boxology vs. Biology



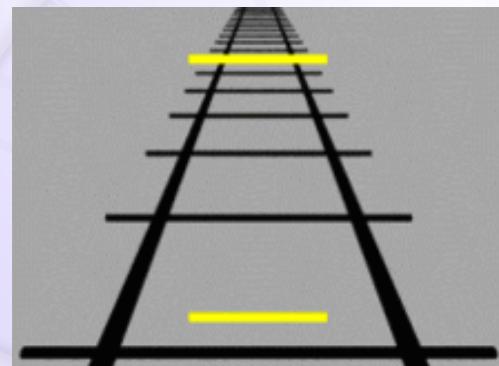
What's Missing? Lacking Depth..



Shape from Shading



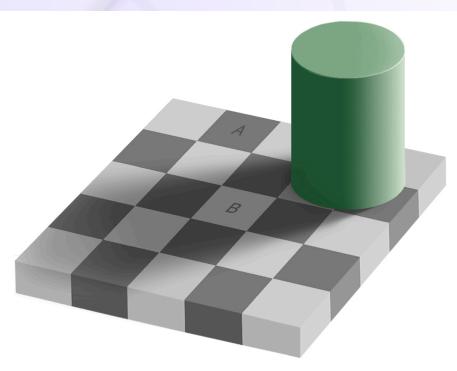
Depth Cues



Depth Cues



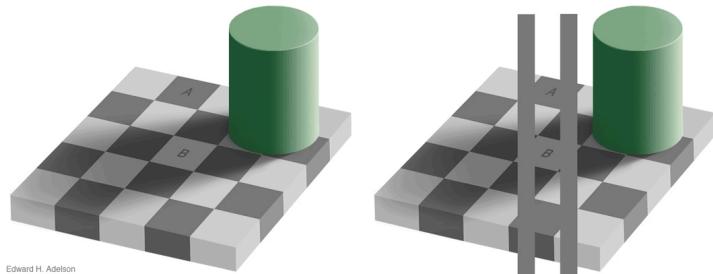
Contrast Illusions



A = B??

No Way!

Contrast Illusions



Edward H. Adelson

Way!