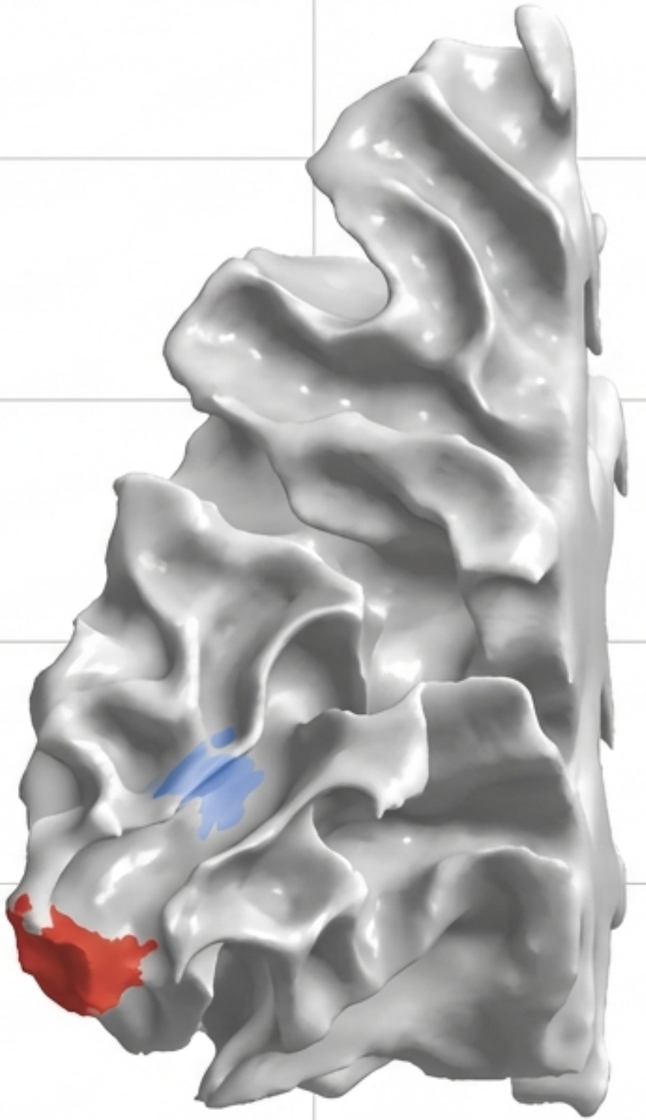
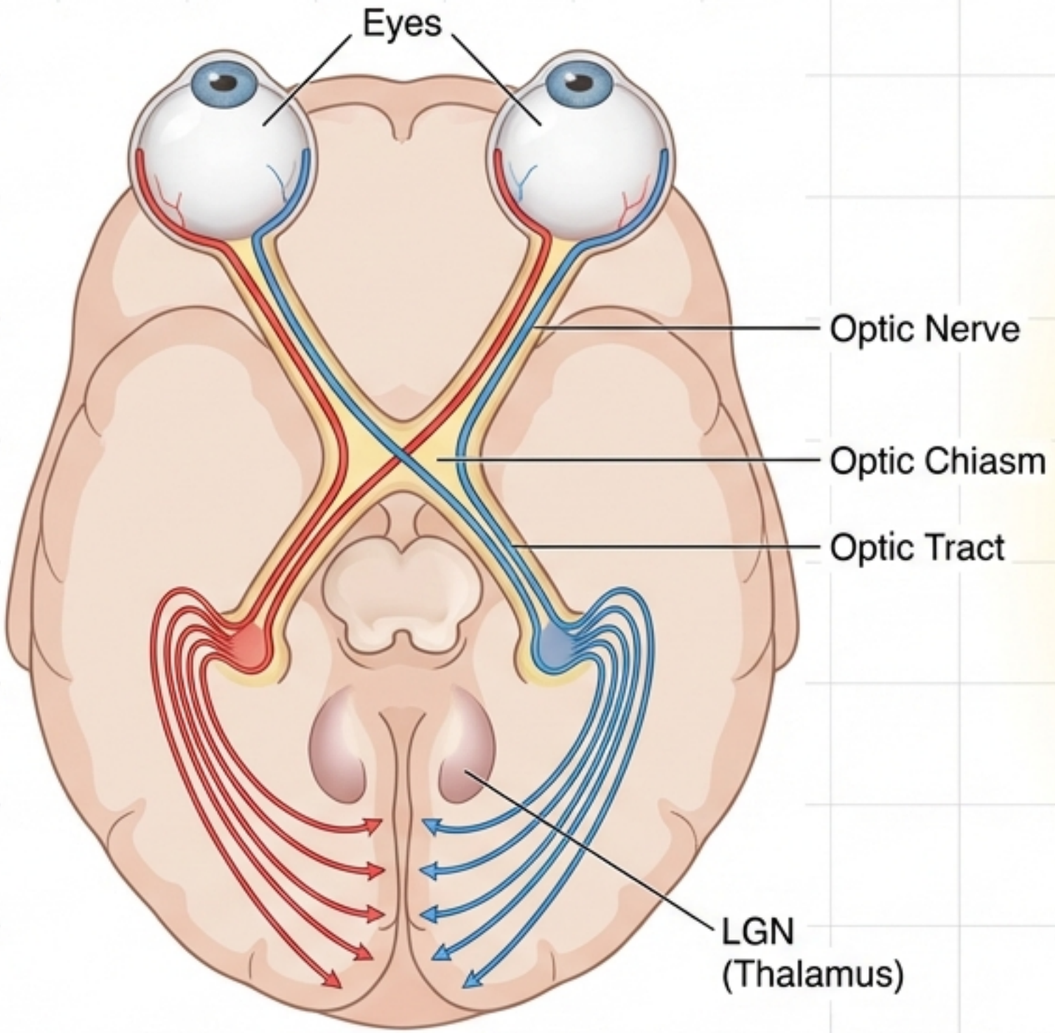
The Visual Cortex and Beyond

How the Brain Builds Reality



Vision is not a camera snapping a photo. It is a complex reconstruction of electrical signals. This presentation traces the signal's journey from the eye to the specialized areas of the cortex.

The Journey Begins: Optic Nerve to LGN



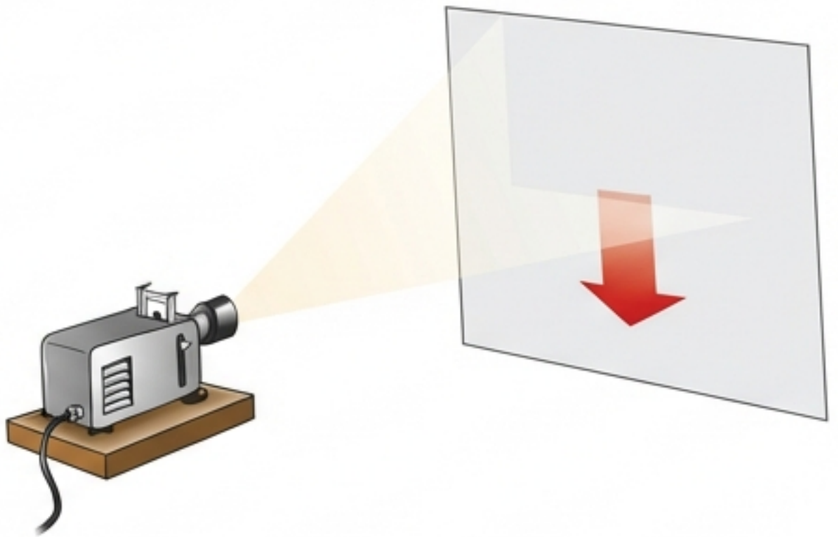
The Optic Chiasm: Signals leave the eye and meet at the X-shaped chiasm where fibers cross.

Contralateral Processing: The left hemisphere processes the right visual field, and vice versa.

The Thalamus Relay: 90% of signals travel to the Lateral Geniculate Nucleus (LGN).

Feedback Loop: The LGN receives more signal from the cortex than from the retina, suggesting a regulatory role.

Mapping the Invisible: The Hubel & Wiesel Experiments



The Method

In the 1960s, Hubel and Wiesel projected light onto a screen while recording from single neurons in the striate cortex (V1) of anesthetized cats.

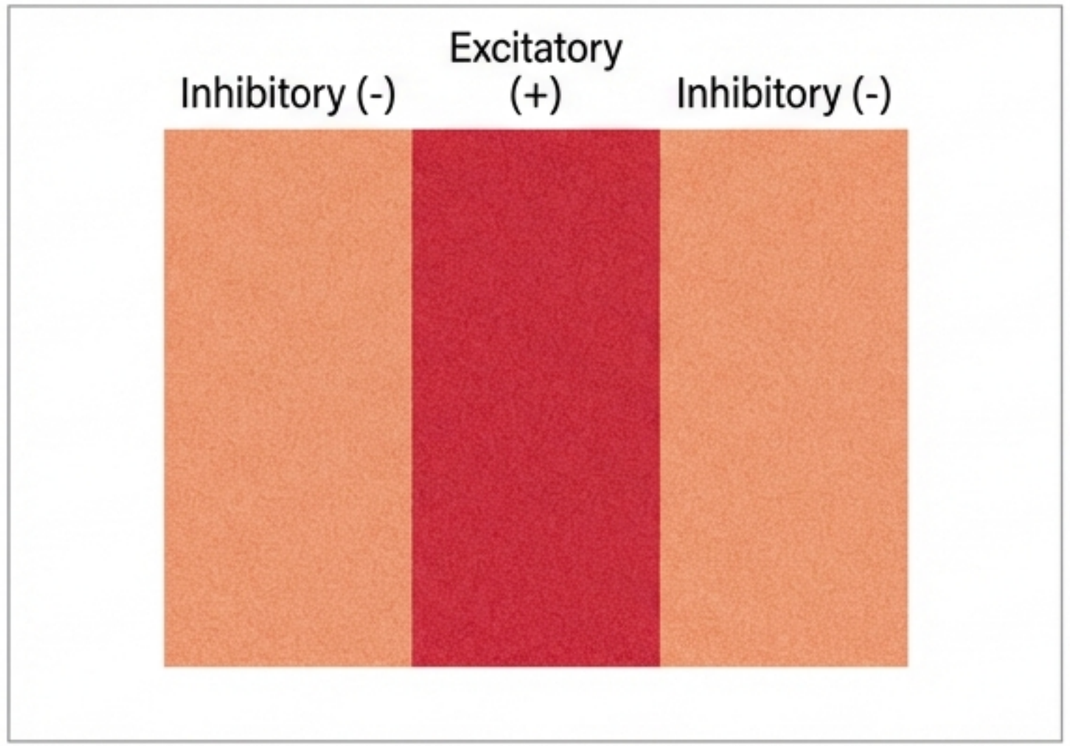
The Key Concept

A neuron's "receptive field" is the specific area on the retina that affects that neuron's firing.

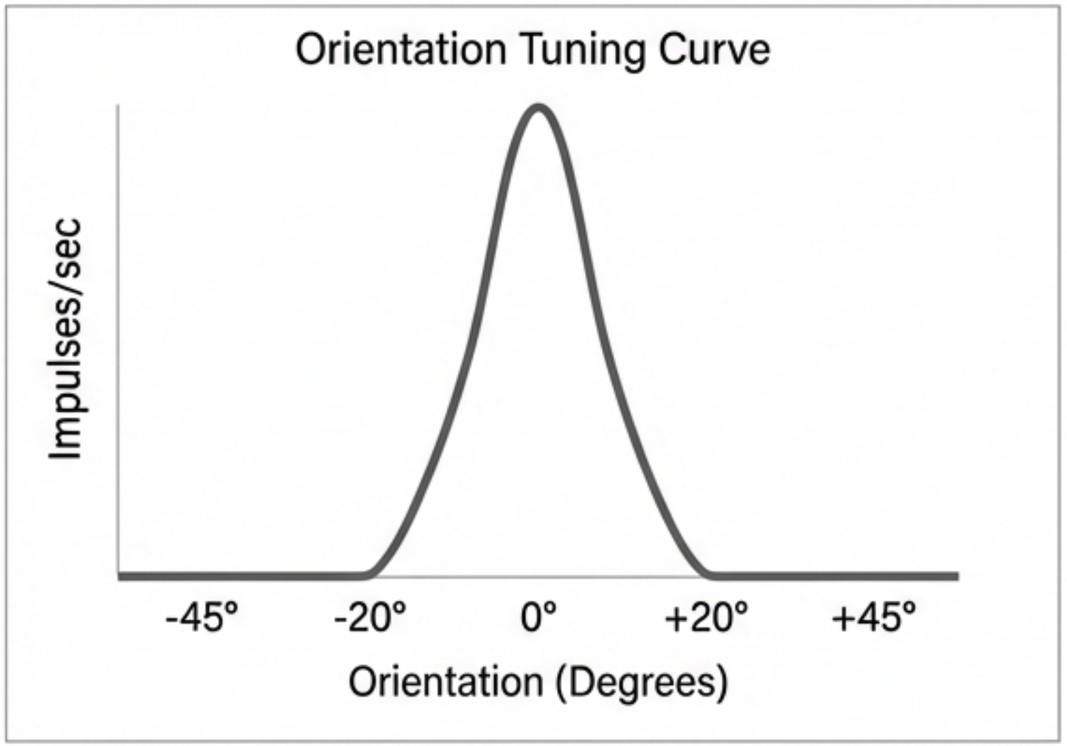
The Discovery

Unlike the retina (which likes spots of light), the cortex ignores spots and responds to features.

V1: The Deconstruction into Lines

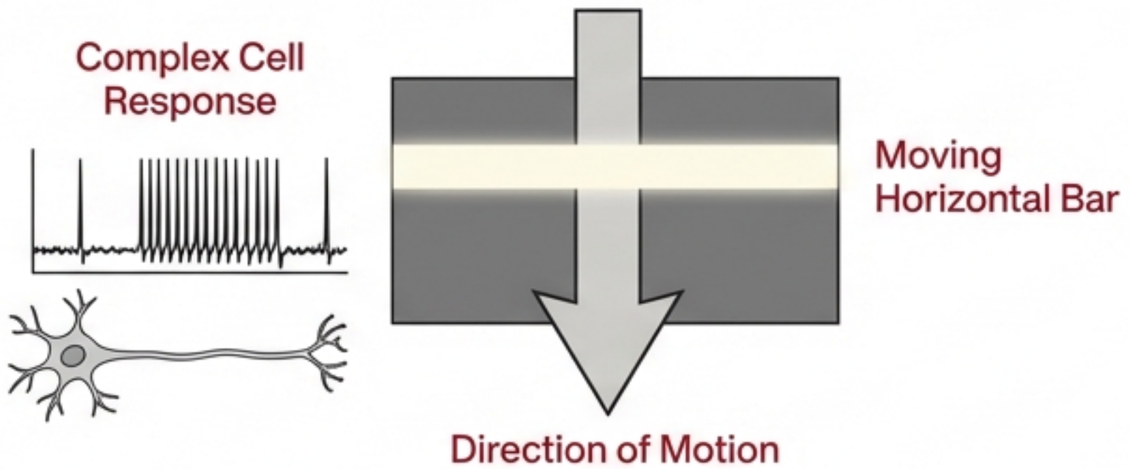


Simple Cortical Cells: Have side-by-side excitatory and inhibitory areas.



Orientation Tuning: Cells are picky. A specific cell fires rapidly to a vertical bar but stops if tilted.

Complex Cells and Motion Detection



End-Stopped Cells: The most specific V1 neurons. They respond to moving lines of a specific length or moving corners.

The Accidental Discovery: Hubel and Wiesel discovered motion sensitivity when a slide stuck in their projector—the moving edge caused the neuron to fire.

Complex Cells: Respond to oriented bars of light, specifically when they move across the receptive field.

Summary: V1 breaks the world down
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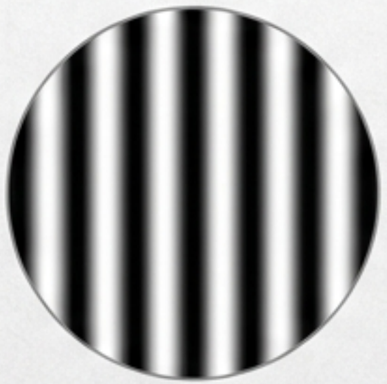
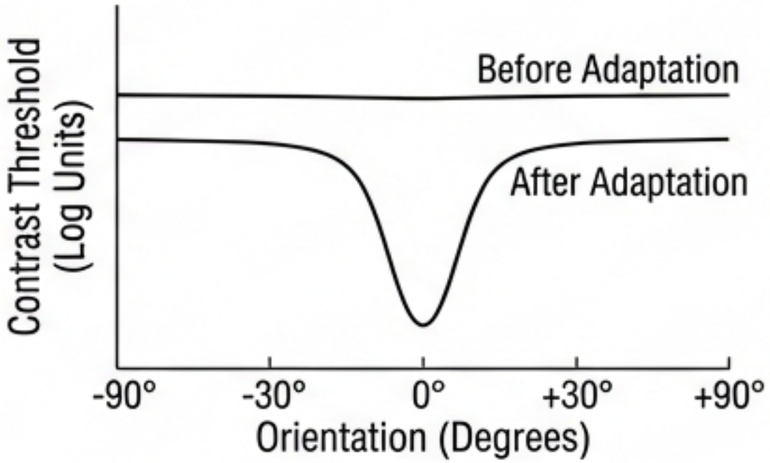
into edges, movements, and angles.

Linking Physiology to Perception: Selective Adaptation

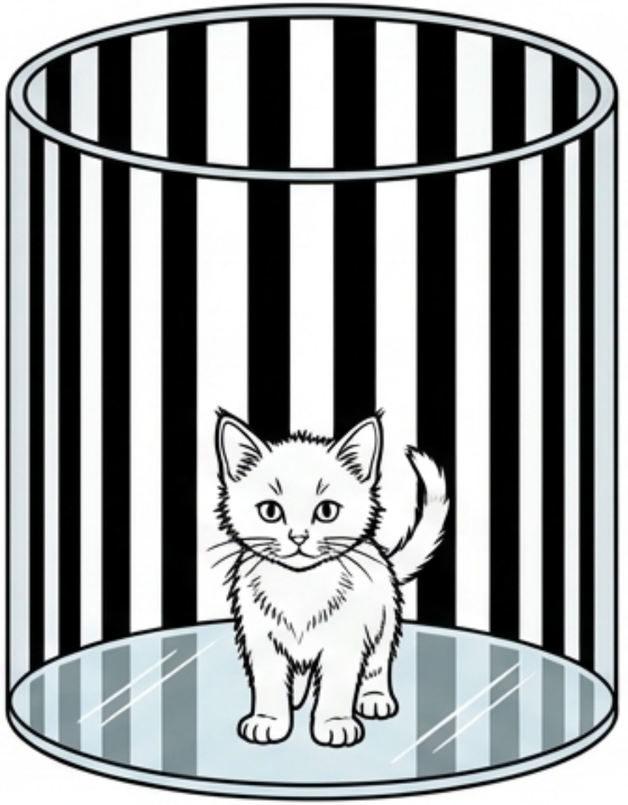


Measure contrast threshold (minimum intensity to see a grating). → Adapt subject to high-contrast vertical grating for 2 minutes. → Remeasure thresholds.



The Logic: If specific neurons detect specific orientations, tiring them out should temporarily blind us to those orientations. The subject becomes selectively less sensitive to verticals.

Selective Rearing: Use It or Lose It

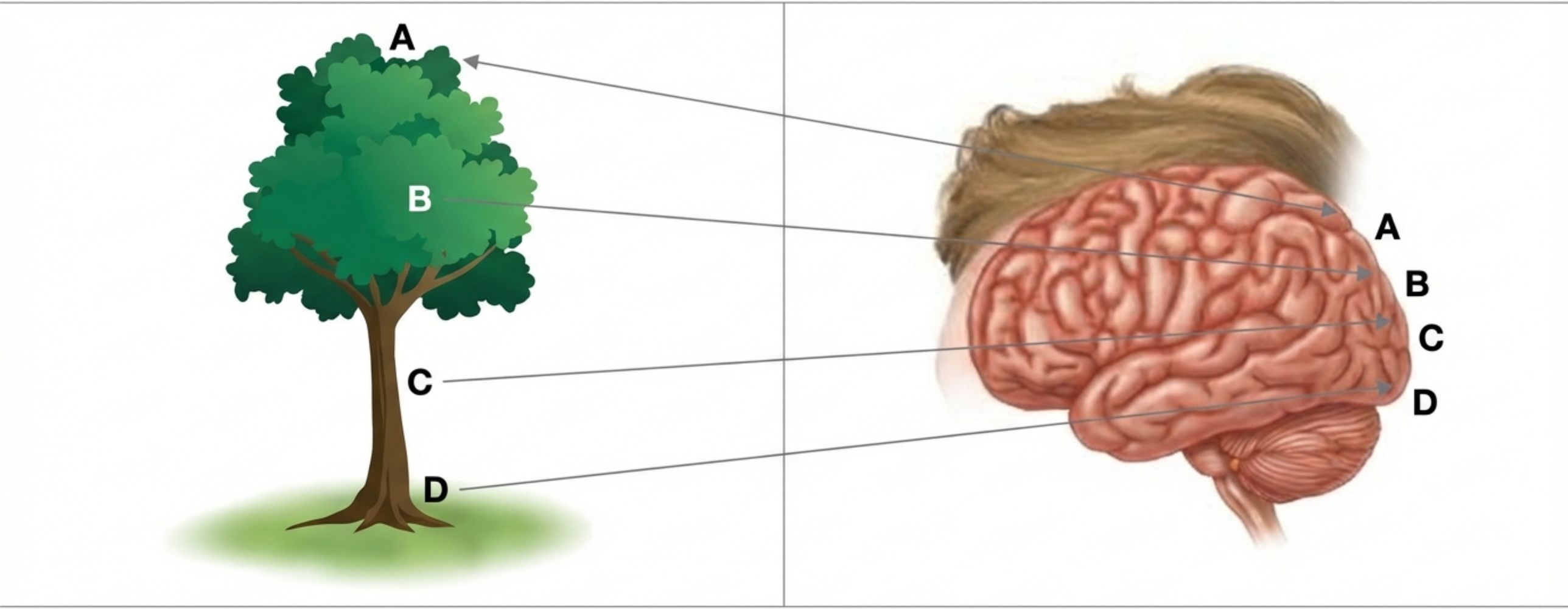


Neural Plasticity: Response properties are shaped by experience.

The Experiment: Blakemore & Cooper (1970) reared kittens in tubes containing only vertical stripes.

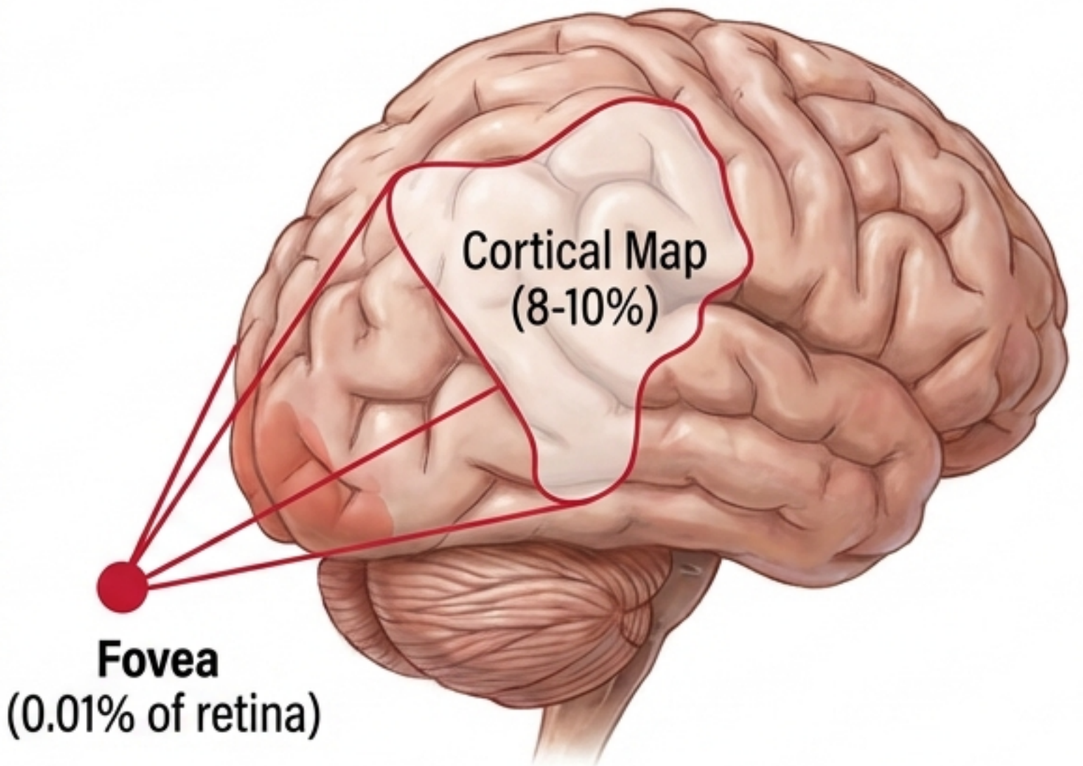
The Consequence: After 5 months, the cats were behaviorally blind to horizontal lines. Their brains lacked neurons capable of responding to horizontals.

Retinotopic Mapping: The Map in the Brain



Electronic Map: Stimulating a specific point on the retina activates a specific point on the striate cortex (V1). Two points close on the object are represented by neurons close together in the cortex.

Cortical Magnification: The Fovea's VIP Status

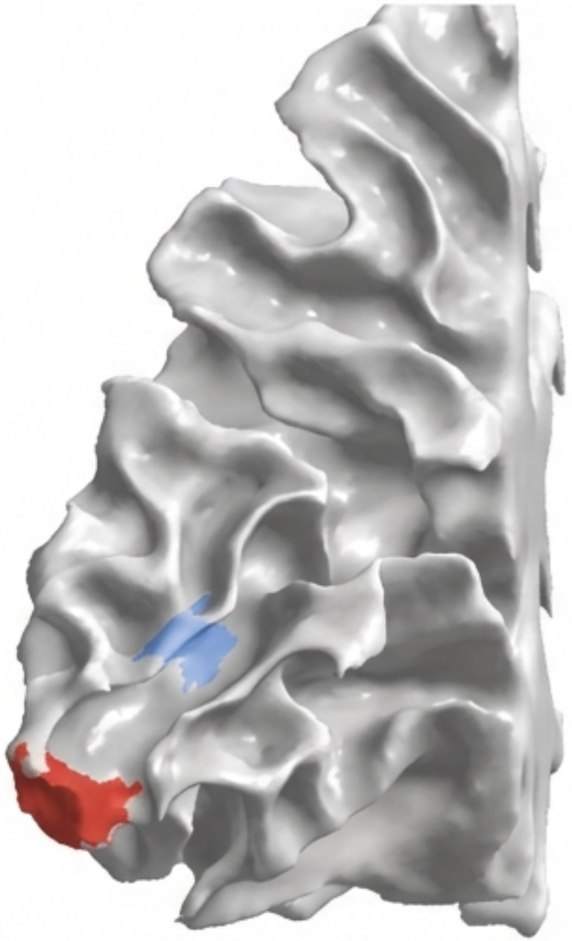


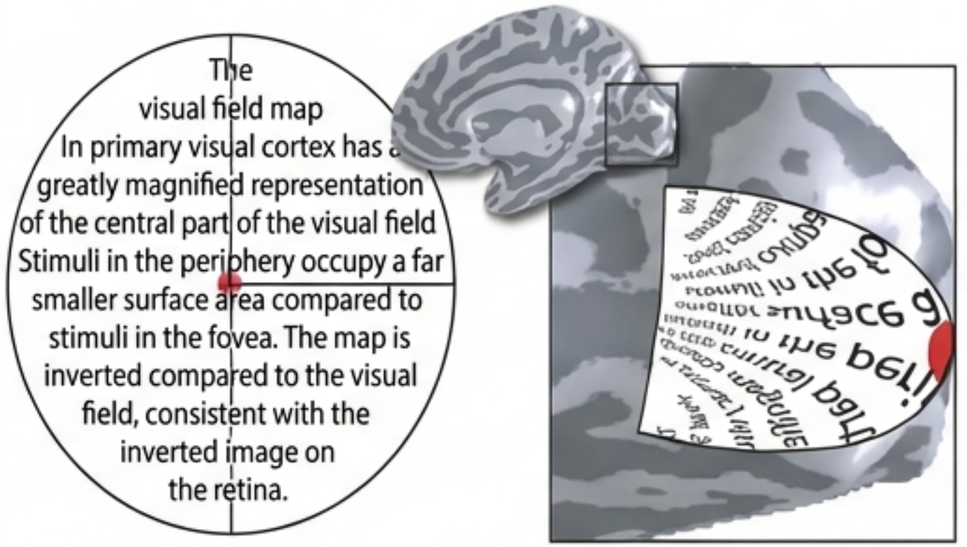
The Data: The fovea is 0.01% of the retina but occupies 8-10% of the cortical map.

Why? High visual acuity requires massive computing power.

Demonstration: Look at your finger at arm's length. The image of your finger utilizes as much brain power as your entire hand in the periphery.

Visualizing Magnification (fMRI Evidence)





Robert Dougherty's Study (2003): Used fMRI to map the human visual cortex.

Red Area: Stimulation near the fovea activates a large red area on the cortex.

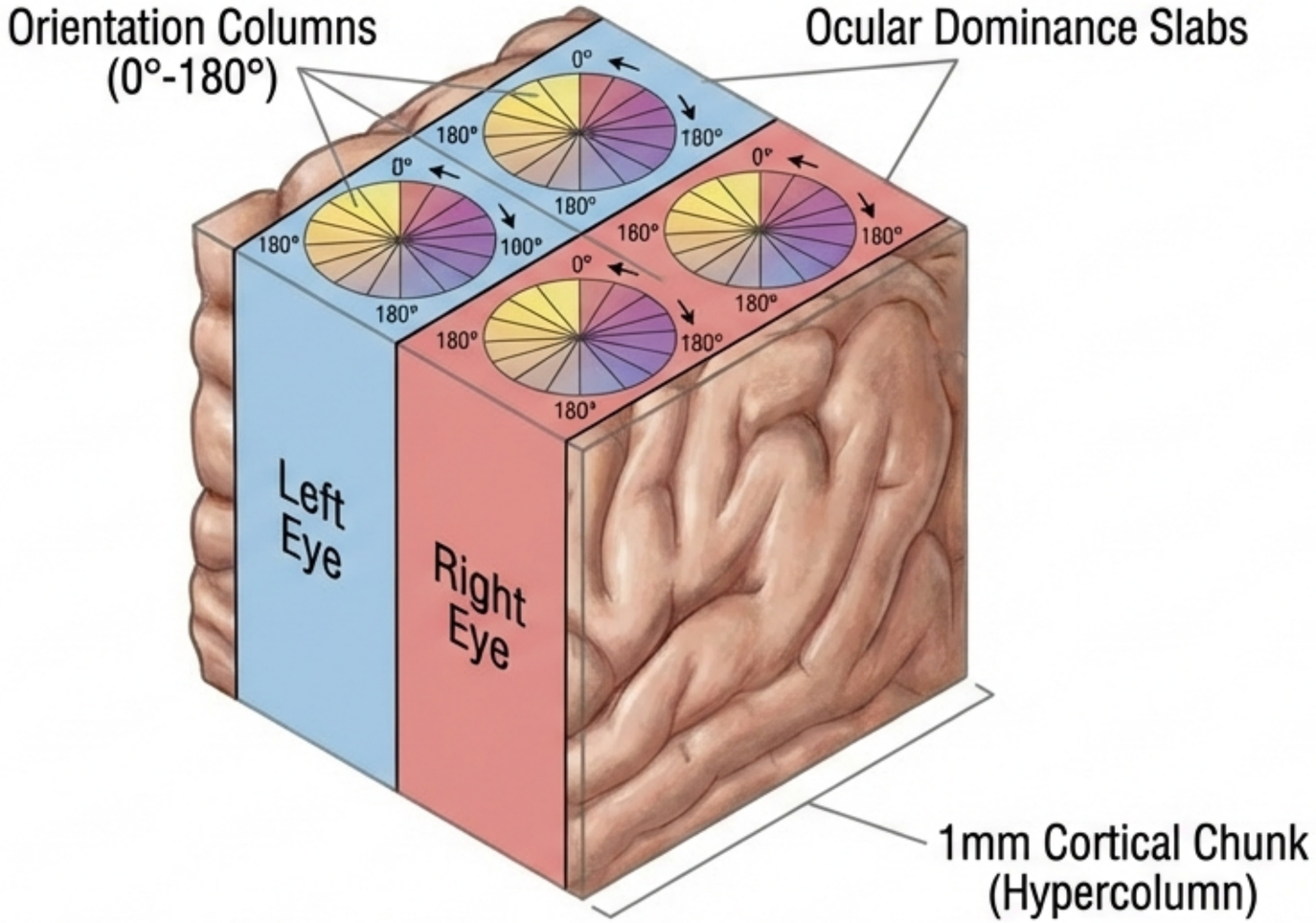
Blue Area: Stimulation of the periphery activates a much smaller blue area.

Conclusion: Confirms that massive cortical space is allotted to the center of vision.

The Architecture of V1: Location & Orientation Columns

The cortex is not a soup; it is a grid of specialized columns.

The Hypercolumn: The Brain's Processing Pixel

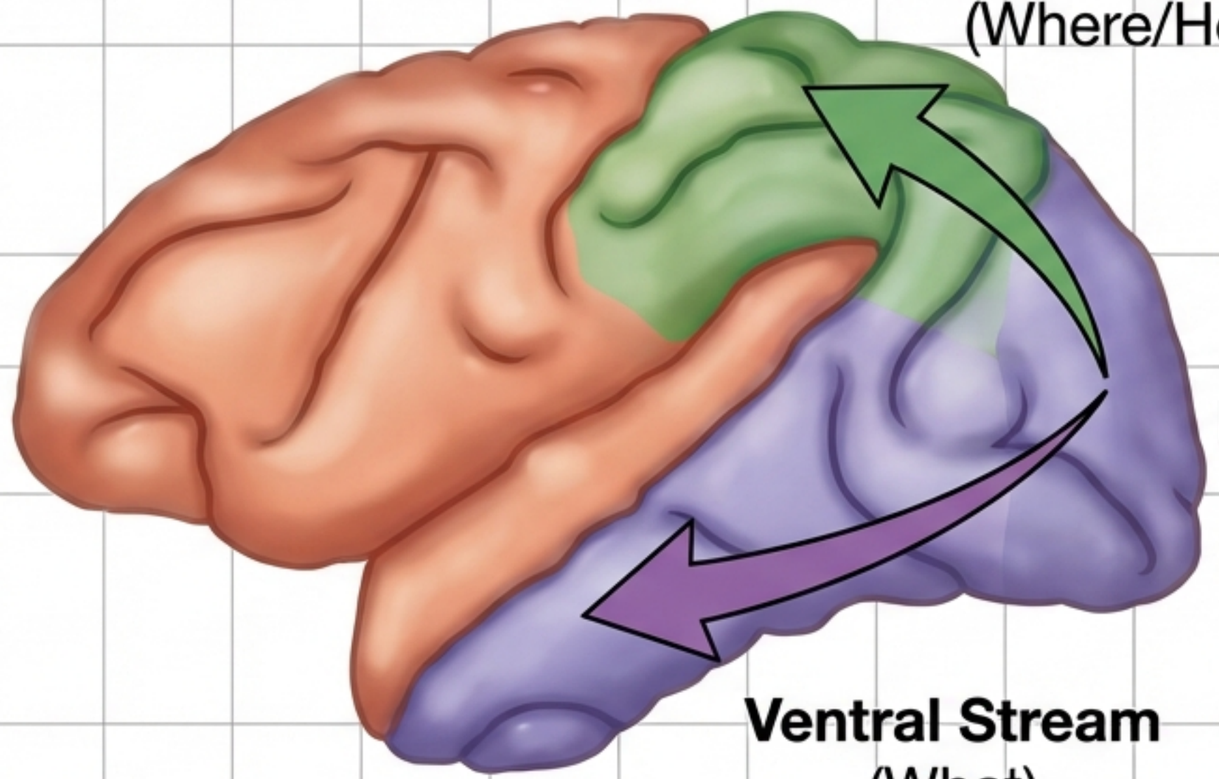


Definition: A Hypercolumn is a 1mm block of cortex containing all machinery needed to process one specific spot in space (Location + Orientation + Ocular Dominance).

Tiling the World: Reconstructing the Scene

The Tiling Concept: The visual field is covered by thousands of adjacent hypercolumns, like pixels on a screen. The brain combines these separate firing events into the continuous perception of a forest.

Beyond V1: The Two Streams

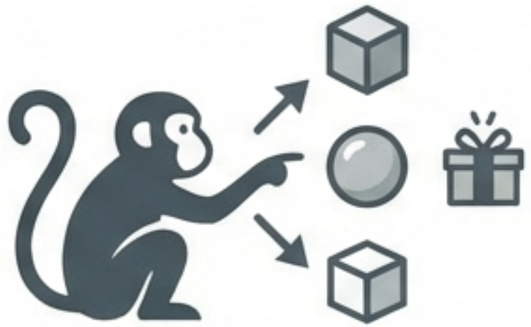
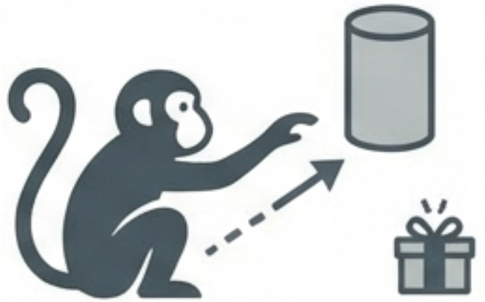


After V1, signals split. The Ventral stream identifies objects (What). The Dorsal stream locates objects and guides action (Where/How).

Ablation Studies: What vs. Where

Lesion Data

Ungerleider & Mishkin (1982)

Object Discrimination (What)	**Landmark Discrimination** (Where)
	
Failed when Temporal Lobe removed.	Failed when Parietal Lobe removed.

The ‘How’ Pathway: The Case of Patient D.F.

The Deficit (Perception):

D.F. could not visually match the orientation of a card to this slot.

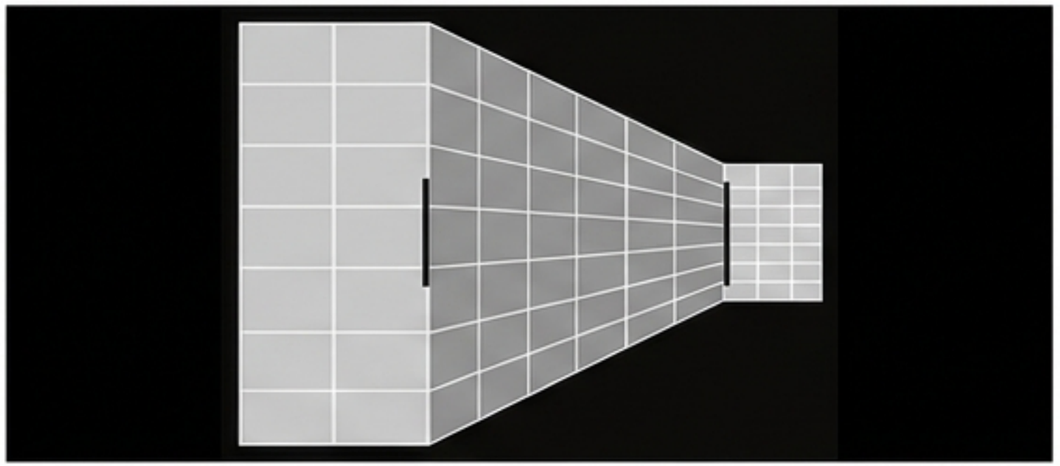
The Ability (Action):

However, she could physically “mail” the card through the slot perfectly.

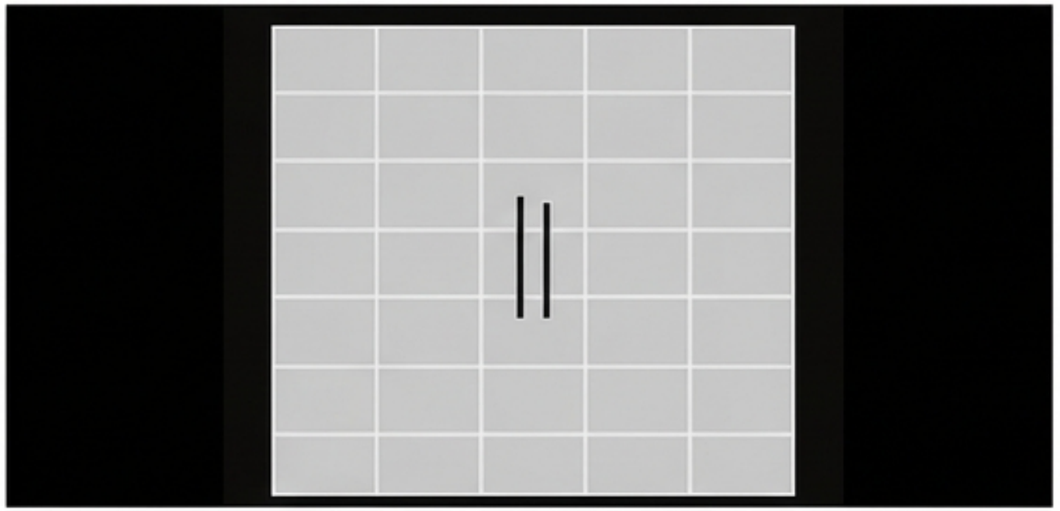
Conclusion:

The Dorsal stream is not just ‘Where’, it is ‘How’—an Action pathway.

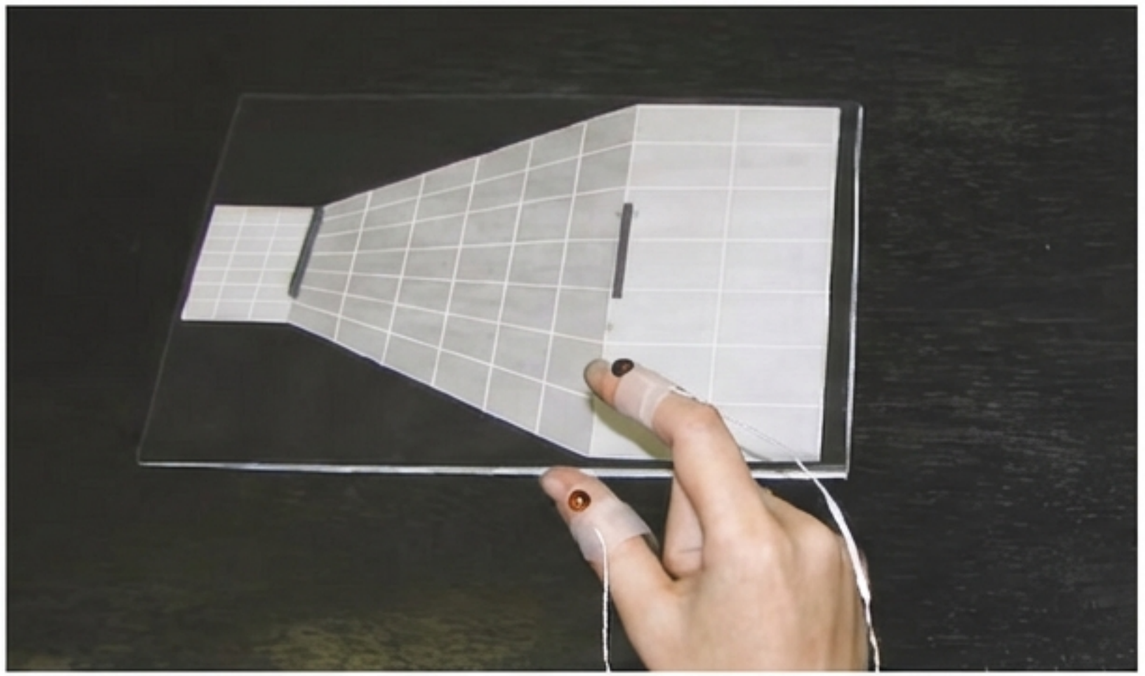
Perception vs. Action in Healthy Brains



Perception (The Illusion)



Reality (Physical Length)



Action (Grasping Aperture)

The Ganel Experiment: Perception was fooled by the illusion (estimating length), but Action was not (grasping aperture matched physical reality).
Your hand knows what your eyes don't.

The IT Cortex: From Lines to Shapes

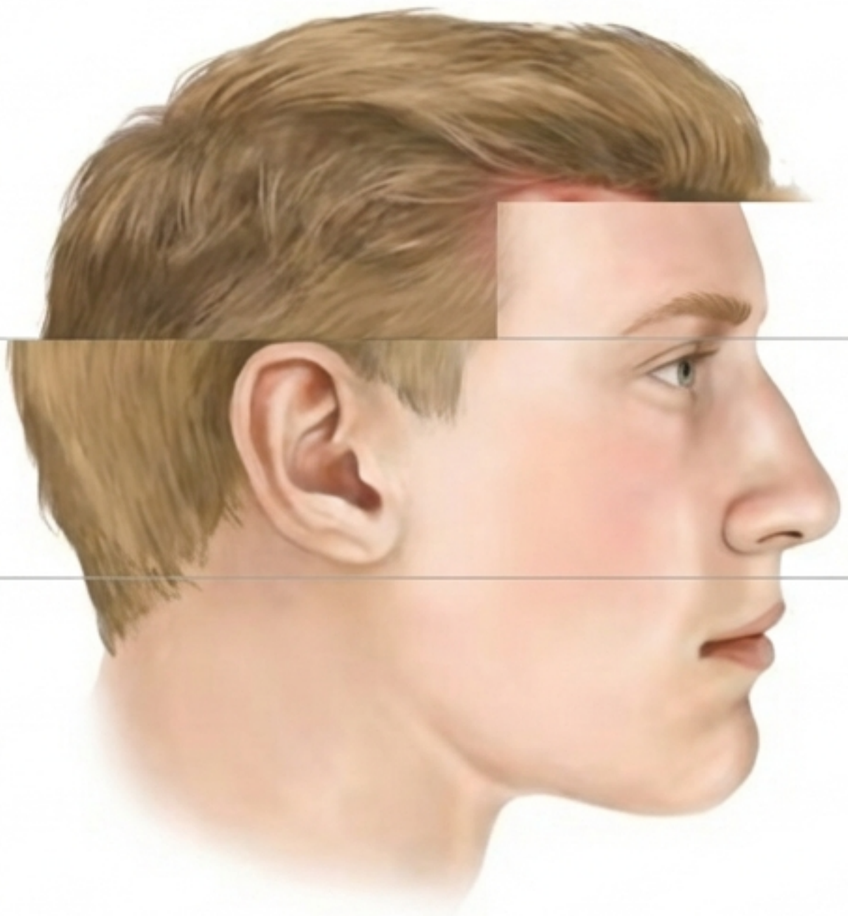
Charles Gross recorded from neurons in the Inferotemporal (IT) Cortex.

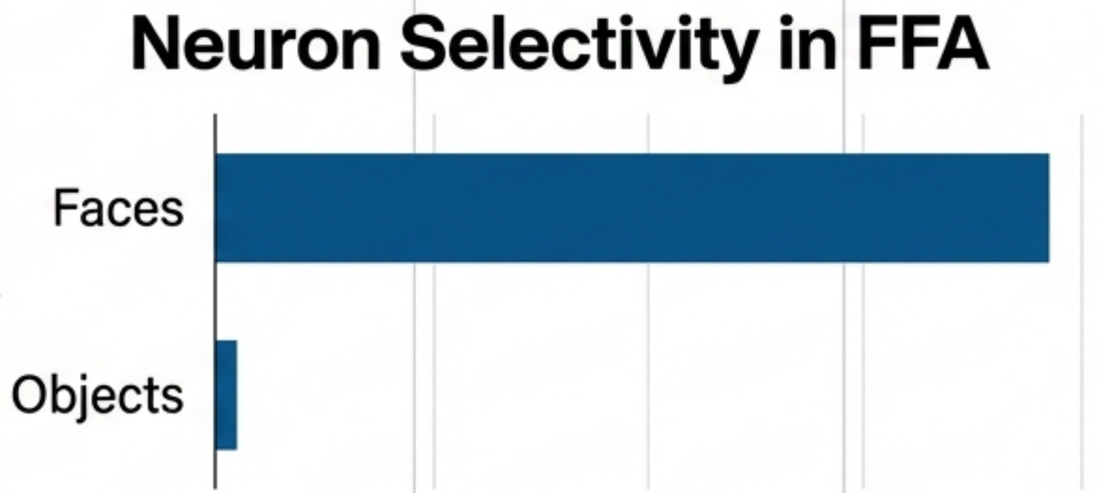
Standard lines and circles failed to trigger a response.

The Discovery:
A neuron fired vigorously to the shadow of a hand.

Specificity:
IT neurons ignore simple lines and respond to complex shapes like hands and faces.

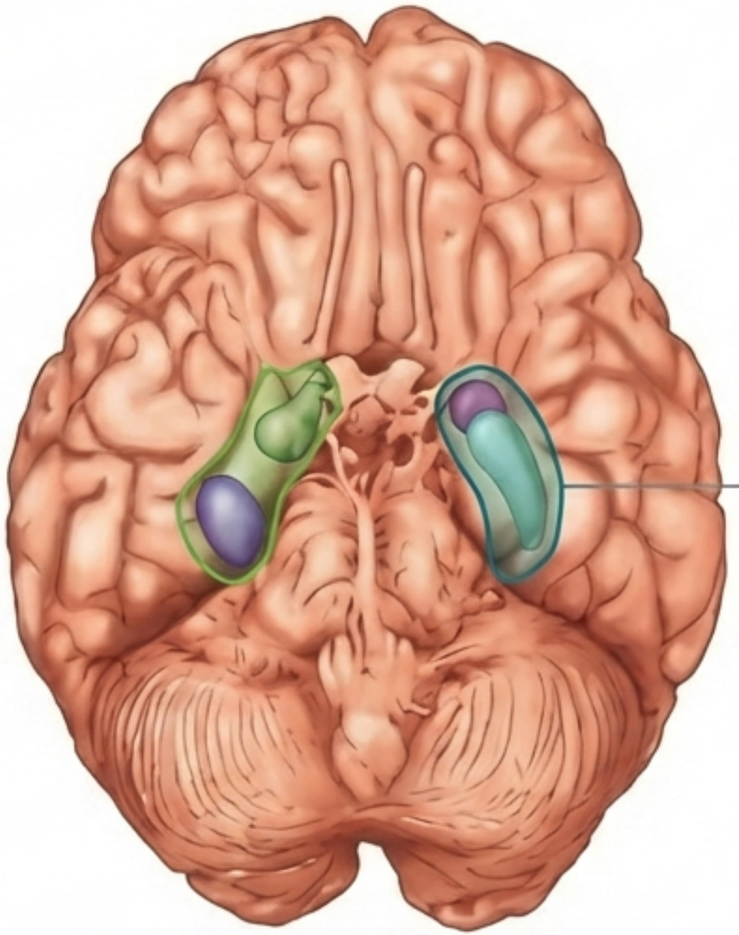
The Fusiform Face Area (FFA)





Tsao et al. (2006): 97% of neurons in this area are face-selective. Damage here causes Prosopagnosia (Face Blindness).

Where Perception Meets Memory



Hippocampus & MTL

Patient H.M.: Removal of the hippocampus eliminated the ability to form new long-term memories.

Concept Cells: Neurons here are abstract. A single cell might fire for “Jennifer Aniston”—whether seeing her face or reading her name.

The Parahippocampal Place Area

Just as we have a face area, we have the Parahippocampal Cortex. This area responds specifically to pictures of indoor and outdoor scenes, encoding spatial layout for navigation.

Summary: The Evolution of the Signal

Retina: Spots of light

↓

V1 Cortex: Oriented lines & edges

↓

Extrastriate: Corners, shapes, colors

↓

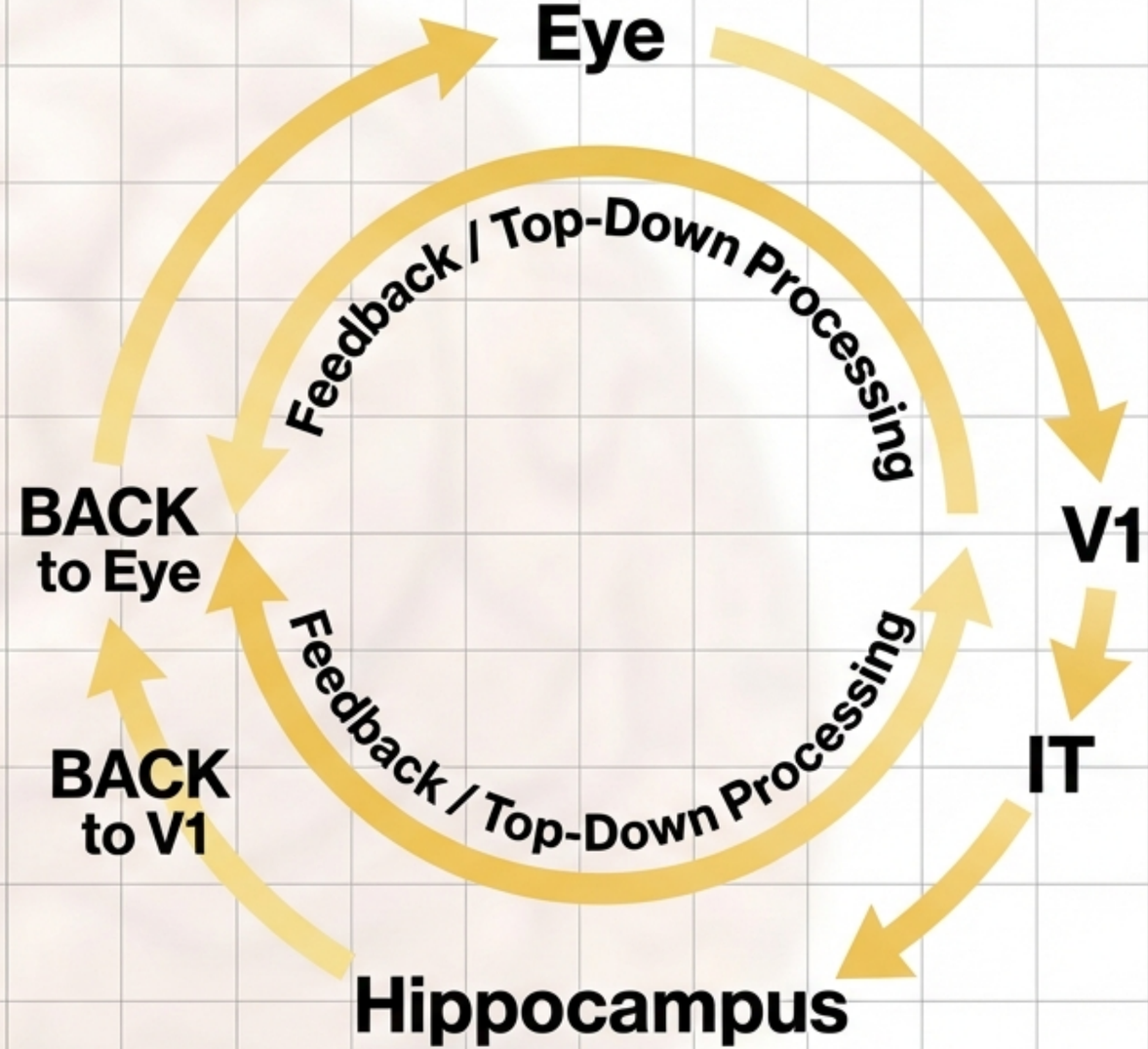
IT Cortex: Objects & Faces

↓

Hippocampus: Memory & Concept →

The Flexible Brain: Feedback Loops

Vision is not a one-way street. Signals flow backward from memory to the eyes. Your expectations help shape what you see before the signal is fully processed.



Reality is a Construction

The brain does not contain a picture of a tree. It contains a symphony of firing neurons that we experience as a tree.