

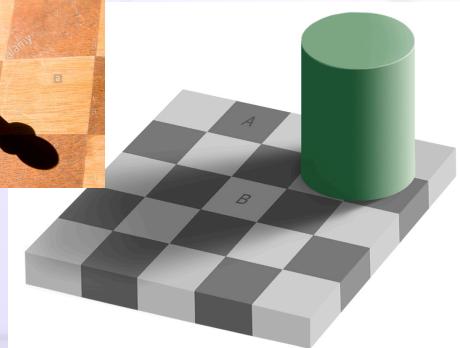
Sensation, Perception & Attention

Randall C. O'Reilly

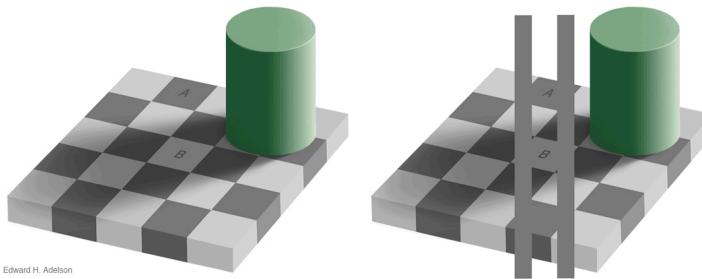
Perception = Compression



Nothing interesting
to see here – keep
moving on..

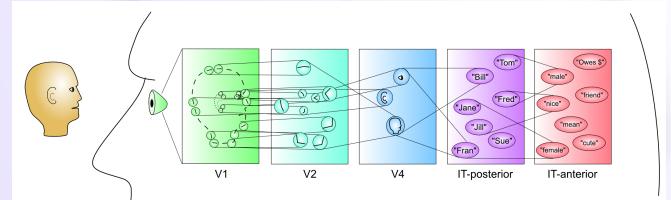


What!?



Way!

Awareness: Top of Compression



Perception = awareness of high levels of hierarchy of compression – just the simple, “sensible” story

We see the world, not our raw sensory input!

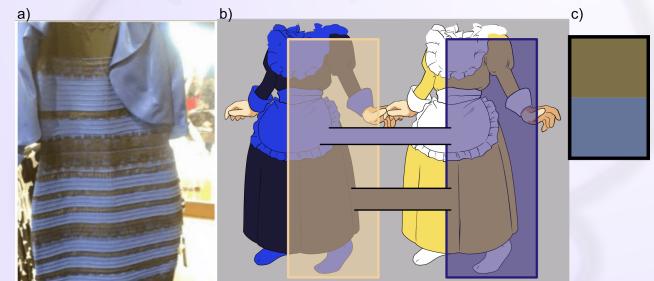
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“Constancy”



We see the world, not our raw sensory input: the world is constant despite differences in lighting, positions, etc

Viral (In)constancy



Perception: Open Them Doors!

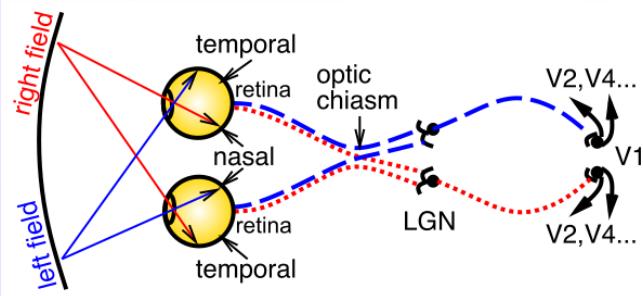


Perception opens the door to illusion, as well as truth, sadness, and other strange things..

5+2 senses

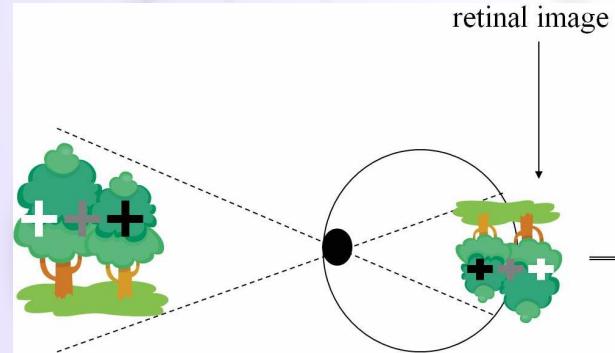
Modality	Stimulus	Receptors	Thal-> Cortex	Absolute threshold
Vision (sight)	Light (photons)	Rods & Cones in Retina	LGN -> V1	Candle flame from 30 miles (on clear night)
Audition (hearing)	Sound (variation in air pressure)	Hair cells in Cochlea	MGN -> A1	Tick of watch at 20 feet (in a quiet room)
Olfaction (smell)	Airborne molecules	Hair cells in Olfactory epithelium	(none) -> Olfactory cortex	1 drop of perfume diluted in air of 6 room house
Gustation (taste)	Food molecules	Taste Buds in Papillae	VPN -> Insula	1 teaspoon of sugar in 2 gallons of water (try it!)
Somesthesia (touch)	Touch, pressure, temperature, pain	Free nerve endings in Skin	PMN, VPN -> S1	Wing of a fly falling on cheek from 1cm
Proprioception (self movement)	Muscle stretch	Muscle Spindle fibers	VPS -> S1	
Vestibular (balance)	Head rotation, acceleration	Semicircular Canals & Otoliths	VPN -> S1	

The First Sense: Vision



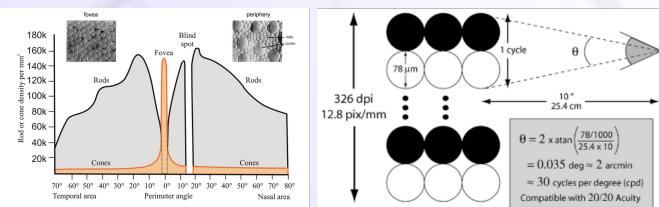
Light goes through **pupil**, size of which controlled by **iris**, **lens** focuses on **retina**, containing **rod** (fast, b/w) and **cone** (slow, color) **photoreceptors**. **LGN** = thalamus, **V1** = primary visual cortex.

More proof we don't see retina



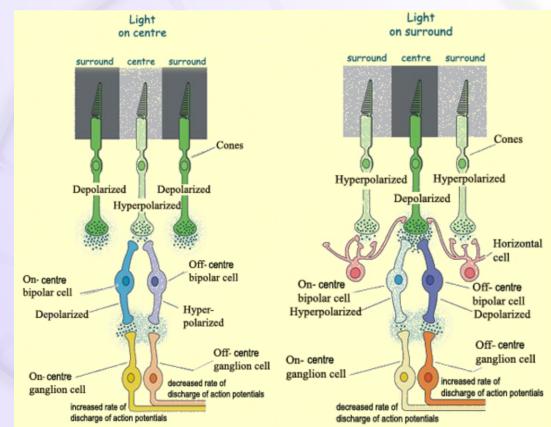
Why do mirrors flip horizontally, not vertically?
<https://www.youtube.com/watch?v=vBpxhFBIVLU> (Physics Girl)

How Many Megapixels??

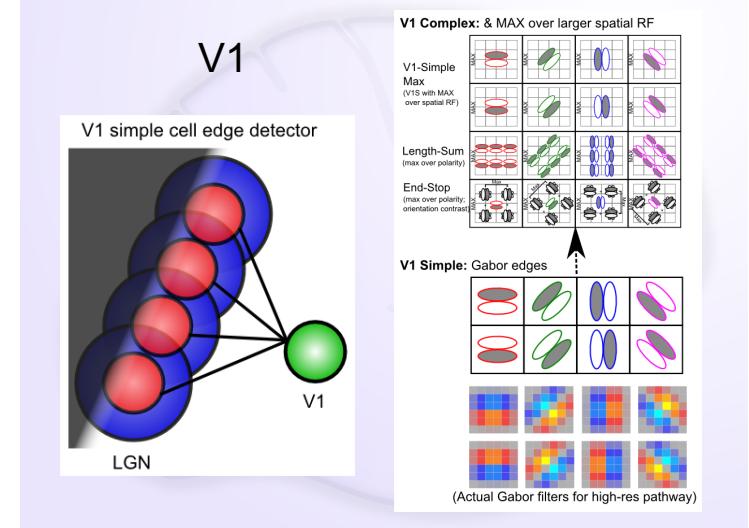
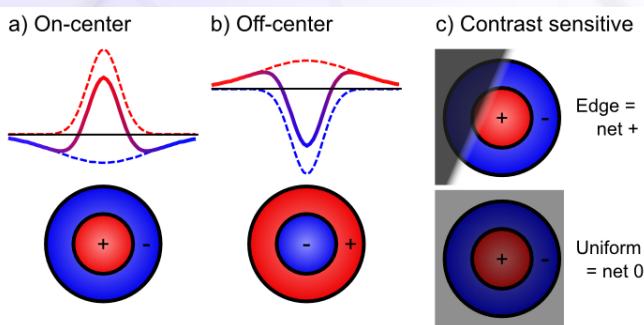


- Retina has ~100 mega-rods, only ~5-7 mega-cones
- Fovea can resolve about 30 cycles-per-degree (requires cone spacing of ~.3 arcmin) = ~300 dpi at 10° (close!)
- Focal length of human eye is ~22mm, max ISO about 800

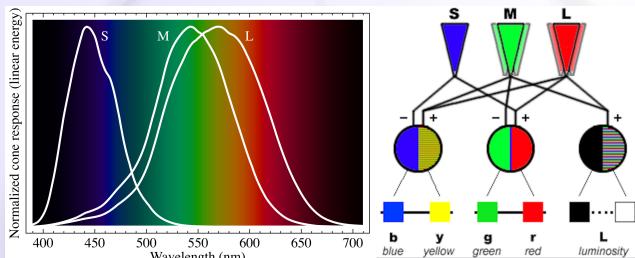
Compression Starts in Retina



Retinal Contrast Filtering



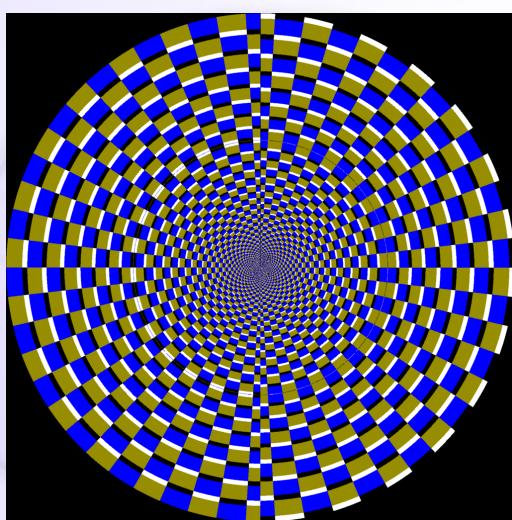
Trichromatic Color Vision



Color opponent process theory:
red vs. green,
blue vs. yellow
black vs. white (achromatic)

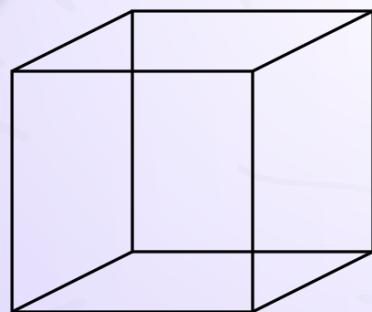
Color Contrast

<https://www.youtube.com/watch?v=gur- IGV7F8>



Time Contrast

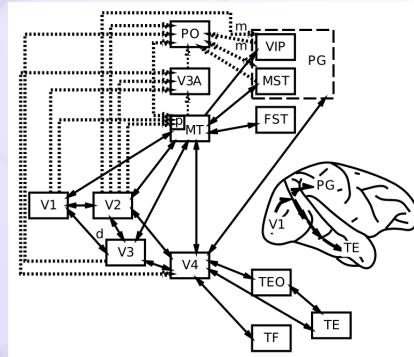
(we have a model of this)



Time Contrast

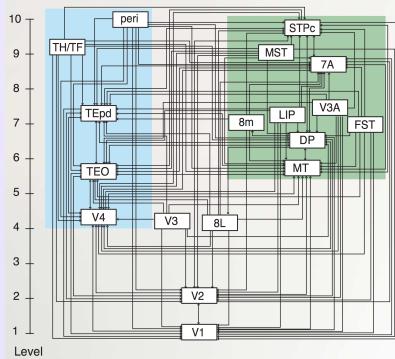


Visual Hierarchy: What vs Where



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"Van Essen" Hierarchy



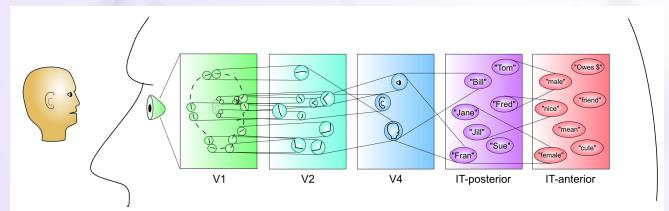
Markov et al., 2014

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

To hippocampus:
TH/F = Parahippo
peri = Perirhinal

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Hierarchy of Detectors (CCC = Compression: abstract, simplify)



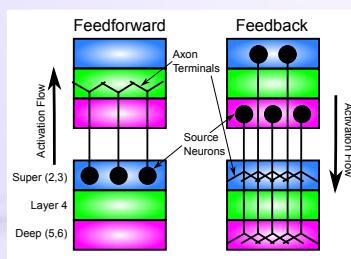
Inferior Temporal (IT) cortex has high-level abstractions that are *relevant* to your life!

It takes a village of neurons to build up these abstractions.

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Top-down Effects (recurrent, bidirectional connections)

TAE CAT



We see objects, not dots..



(much easier than disconnected pixels..)

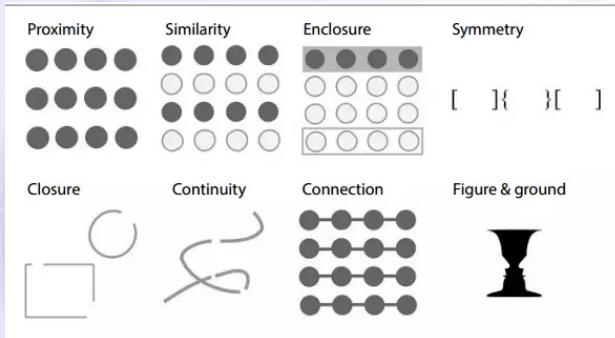
Sometimes, it goes *too far...*



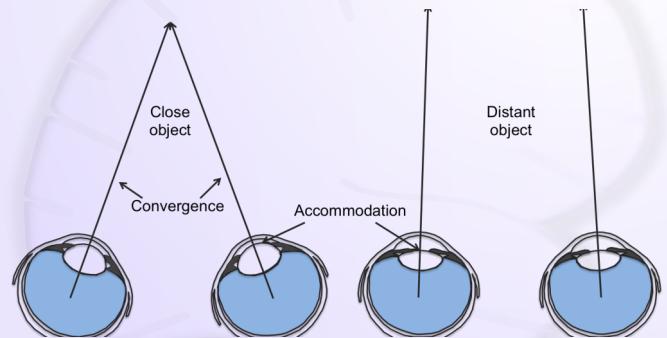
Dali!



Gestalt Principles



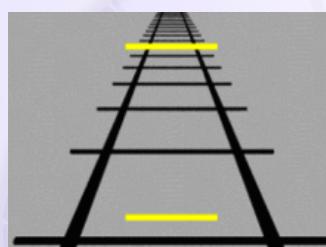
Binocular Disparity = 3D Depth



Binocular Disparity = 3D



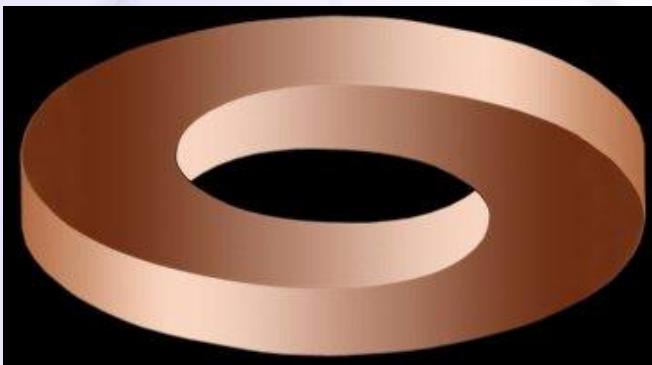
Monocular Depth Cues



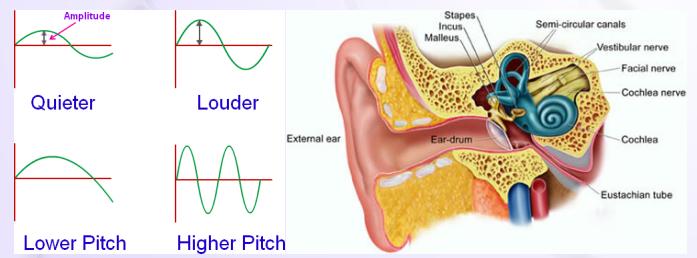
Linear Perspective, relative size, interposition (blocking), horizon position



Shape from Shading



Audition



Basilar membrane: retina of the ear, located in cochlea
hair cells transduce sound, *location along membrane = frequency* (place theory), except low-frequency = direct firing rate (frequency theory)

Interaural time / level differences = auditory localization

Olfaction, Taste, Touch

- Olfactory receptors detect chemicals, including pheromones; olfactory bulb -> piriform cortex
- Taste buds: sweet, salty, sour, bitter, umami?, fatty? -> insula cortex
- Tactition: "touch" – mechanoreceptors, Thermoception: heat – thermoreceptors, Nociception: pain – A-delta (first), C-fibers (second) -> somatosensory cortex

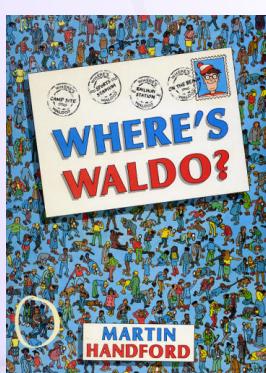
CU: Chris Lowry: warmth -> serotonin happy cells

Nonstop Illusions!

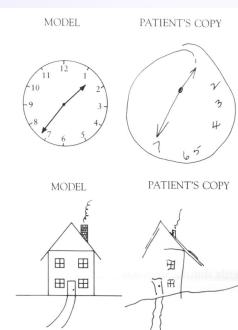
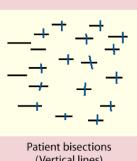
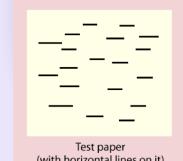
https://www.youtube.com/watch?v=m86ae_e_ptU

Illusions reveal assumptions brain makes to compress sensory inputs into simplest interpretation of scene.

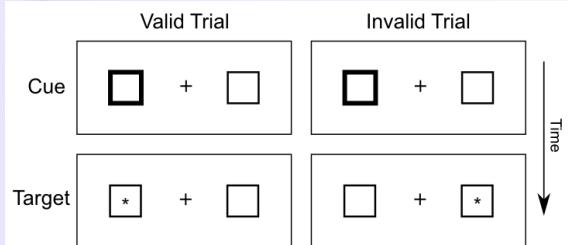
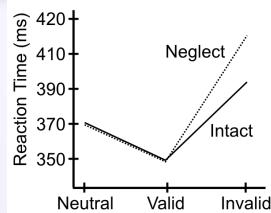
Spatial Attention and Neglect



Hemispatial Neglect



Posner Task



Psychophysics

- **Absolute threshold**
 - Lowest level of stimulus intensity for 50% response
 - "How low can you go?"
- **Just-noticeable difference (JND)**
 - Difference in stimulus intensity for 50% response
- **Weber's law: JND proportional to stimulus intensity**
 - Easier to tell small weight diff between two light objs, vs. two heavy
 - **Contrast effect:** relative to stimulus intensity, not an absolute difference!

Signal Detection Theory

		Signal	
		Present	Absent
Response	Yes	Hit	False Alarm
	No	Miss	Correct Rejection