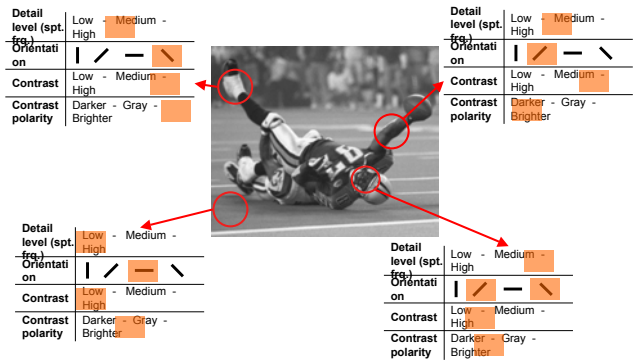
Announcements

Exam will be returned on Tues

Seeing objects and faces

- Parallel visual pathways
- How parallel is parallel?
  - evidence from lesion studies
- Object perception
- Face perception

Local spatial analysis

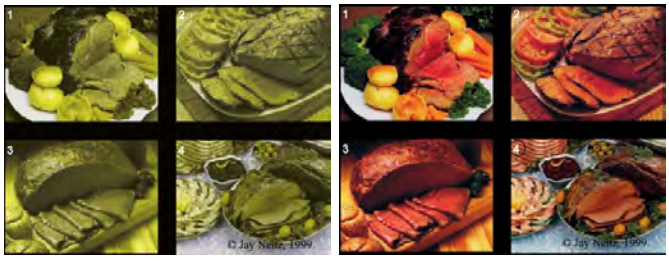


Perceptual Grouping

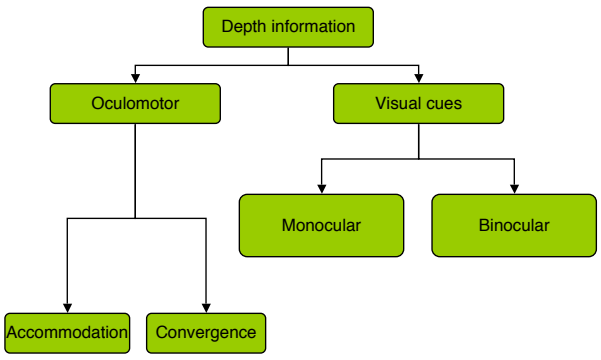
Gestalt principles of grouping:

- Similarity
- Proximity
- Common region
- Element connection
- Good continuation
- Symmetry
- Closure
- Simplicity
- Common fate/temporal structure

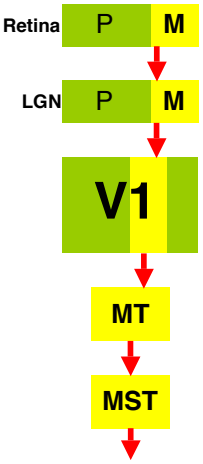
Color perception



Depth perception



Motion perception



M cells respond strongly to rapid changes in intensity, ideal for conveying motion info to the brain.

V1 : Local motion detection by directionally selective (DS) cells (~15%)

MT : "The motion area." Computation of object motion (~90% DS)

MST: Complex motion processing. Optic flow.

Levels of perception

Low level perception (simple visual sensations)
- Line orientation
- Spatial location
- Contrast & Spatial frequency
- Simple color (r-g, b-y)
- Motion detection

V1 (striate cortex)

Mid-level perception (basic visual properties)
- Motion interpretation
- Depth perception
- Color perception
- Basic perceptual grouping

Extrastriate visual areas

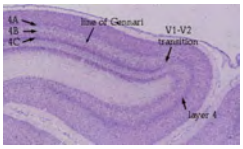
High-level perception (complete visual perception and recognition)
- Shape & 3D shape
- Object recognition & categorization
- Space perception
- Attention & Visual Search
- Interaction with Memory & Experience
- Action planning

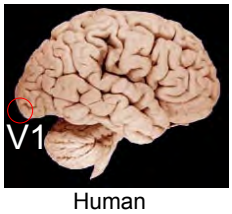
Extrastriate visual areas

(cortical visual areas other than V1)

V1 = striate cortex

Extra - outside, except, beyond
Stria - a stripe or line





Human

Rhesus Monkey

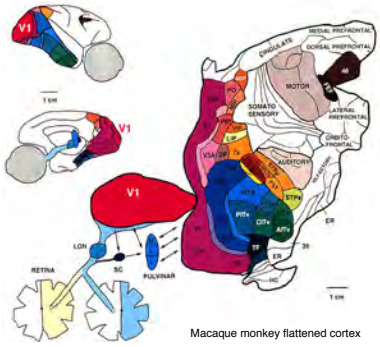
Squirrel Monkey

Different Visual Areas

How many extrastriate areas are there?

LOTS!!!

How do we know this?
- Topography
- Functional properties
- Connections
- Cytoarchitecture

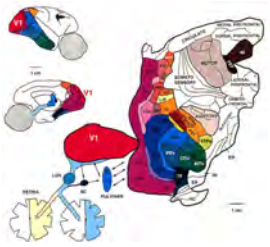


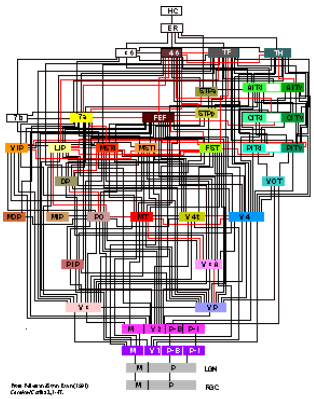
Macaque monkey flattened cortex

Different Visual Areas

Note: V5 = MT

Different Visual Areas





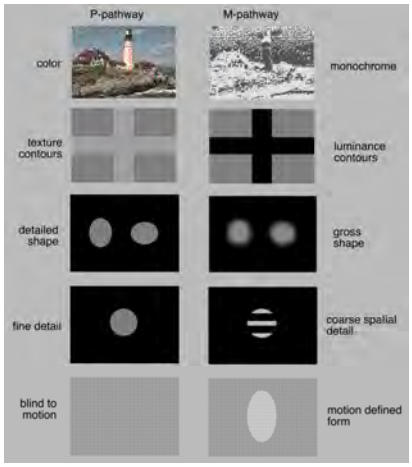
Parallel Visual Pathways

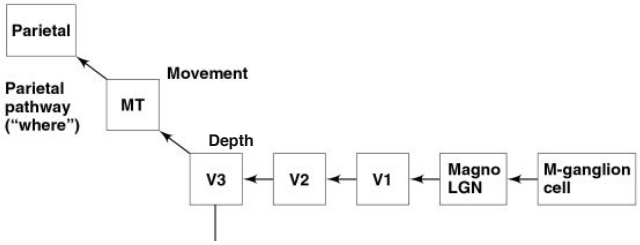
"Any large computation should be split up and implemented as a collection of small sub-parts that are as nearly independent of one another as the overall task allows.

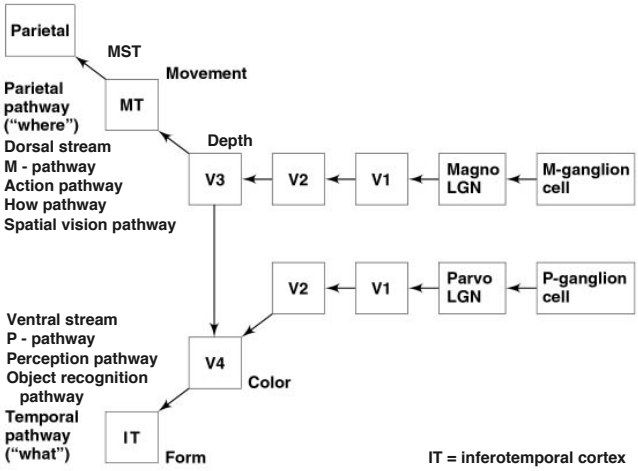
If a process is not designed in this way, a small change in one place will have consequences in many other places.

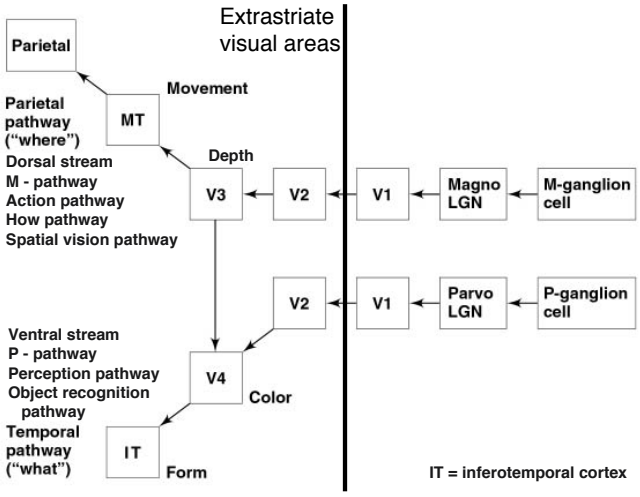
This means that the process as a whole becomes extremely difficult to debug or to improve, whether by a human designer or in the course of natural evolution, because a small change to improve one part has to be accompanied by many simultaneous compensating changes elsewhere."

(Marr, 1976, p. 485)

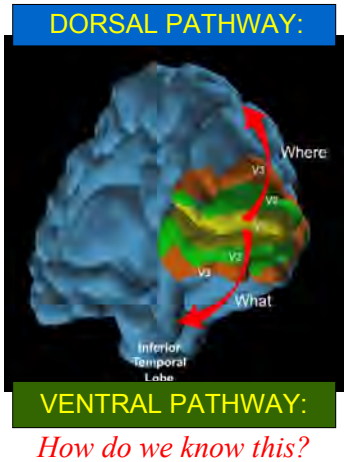








(Think: dorsal fin, back)



How do we know this?

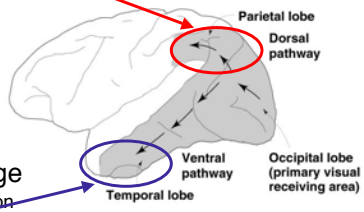
Seeing objects and faces

- **Parallel visual pathways**
- **How parallel is parallel?**
  - **evidence from lesion studies**
- **Object perception**
- **Face perception**

Dorsal vs Ventral Pathways

- Milner & Goodale (1995)
  - ***Ventral***: object **perception** and recognition
  - ***Dorsal***: locations, directions, inter**action** with objects
- Evidence comes from studies and patients that dissociate action and perception

- Parietal lobe damage
- Normal object perception
- Impaired "time/space" perception



- Temporal lobe damage
- Normal "time/space" perception
- Impaired object perception

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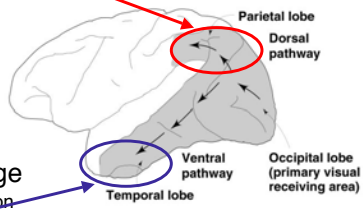

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Parietal lobe damage

Visual Neglect

Decreased awareness within parts of the visual field, typically contralateral to the side of the brain (parietal lobe) that is damaged.

Patients with this condition are not blind but, instead, simply ignore objects in a given part of the visual field when other, distracting objects are present within the normal visual field; **neglect is a problem in attending/orienting**

Parietal lobe damage
(dorsal/m pathway)

Parietal lobe damage

Visual Neglect

Parietal lobe damage
(dorsal/m pathway)

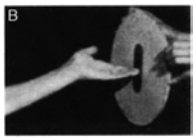
Optic Ataxia — Parietal lobe damage

Deficit in reaching under visual guidance that cannot be explained by motor, somatosensory, visual field deficits or acuity deficits.

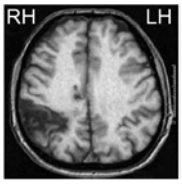
A KEY symptom of the Balint's Syndrome:

- Visual perceptual abilities intact, can describe object features accurately
- No problems with motor movement per se, can move limbs normally
- Able to move their eyes but cannot fixate on specific visual stimuli
- Field of attention which is limited to one object at a time (**simultanagnosia**)
- Activities like reading difficult because each letter is perceived separately
- Severe deficits in reaching under visual guidance **(optic ataxia).**

Unable to Orient Hand



Extrastriate Dorsal Stream lesions (parietal lobe)



How can these patients recognize objects but not be able to act on them accurately?

Akinetopsia — Parietal lobe damage

Akinetopsia description:

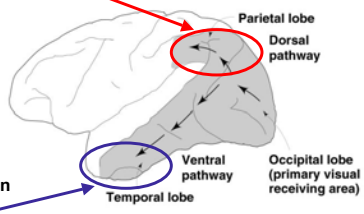
http://www.hhmi.org/senses/b210.html

Agnosias: Failures of Object Recognition

Agnosia = "non-knowledge"

implies damage to a higher stage of visual processing where representations are more abstract and selective

- Parietal lobe damage
- Normal object perception
- Impaired "time/space" perception

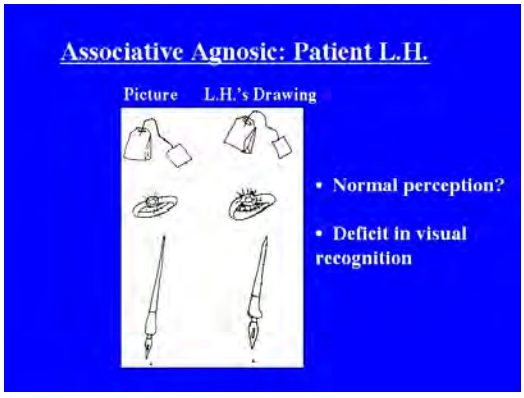


- **Temporal lobe damage**
- **Normal "time/space" perception**
- **Impaired object perception**

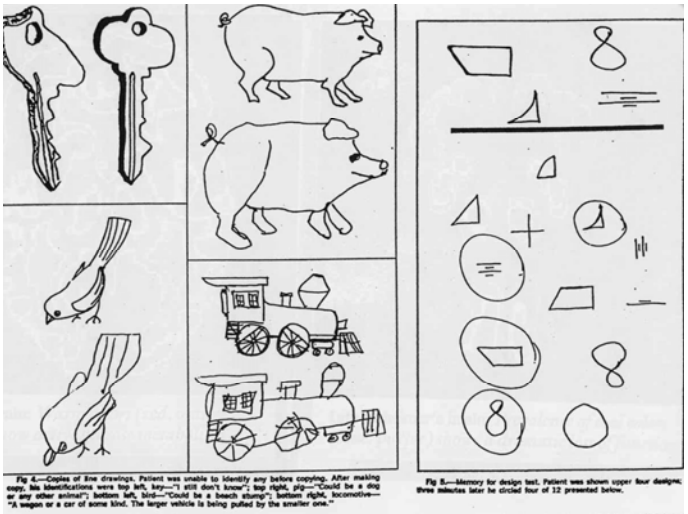
- Subtypes of agnosia
  - **Apperceptive agnosia**: deficit in perceptual processing
  - **Associative agnosia**: "normal" perceptual processing, but deficit in linking percept to name

Temporal lobe damage (ventral pathway)

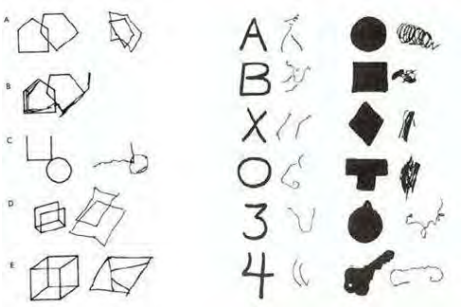
Associative Agnosia — Temporal lobe damage



Patient can describe visual scenes and objects but still fails to recognize them. Patient is able to reproduce an image through copying.



Apperceptive Agnosia — Temporal lobe damage



Other elementary visual functions such as acuity, color vision, and brightness discrimination are still intact.

Inability to distinguish visual shapes, thus, has trouble recognizing, copying, or discriminating between different visual stimuli.

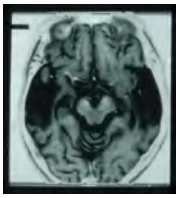
Patients are only able to identify objects based on inferences using color, size, texture and/or reflective cues to piece it together.

Apperceptive Agnosia — Temporal lobe damage

A profound impairment in shape perception (what an object is) coupled with intact visuomotor functions (how to act on an object), demonstrating a dissociation between visual perception and action.

Patient DF (Milner et al 1991):
- Intact visual acuity & point localization, color perception
- Cannot identify common objects, copying impoverished
- Cannot recognize single letters, no face recognition even of familiar people
- Cannot report orientation of lines, can see colors of spots but cannot identify shape defined by those spots
- Able to correctly identify direction of motion but not shape of moving object
- Cannot see biological motion
- Cannot distinguish squares from rectangles, no Gestalt grouping ability

Extrastriate Ventral Stream lesions



How can these patients act on objects that they cannot perceive?

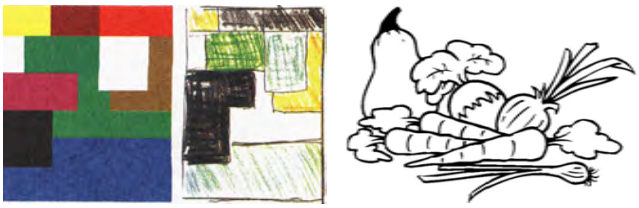
Prosopagnosia — Temporal lobe damage

- Patient can't consciously recognize familiar faces, sometimes even including their own.
- Faces might make no sense (jumble of features), or a patient sees "a face" but can't associate it with anybody
- Can still show emotional responses to faces
- Can use other cues, like voice or gait, to recognize people
- Can extend to others classes of objects with which a person has a lot of experience

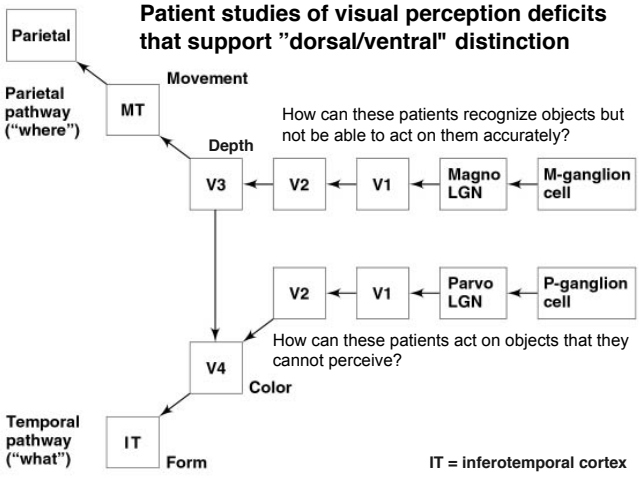
http://news.bbc.co.uk/2/hi/health/860188.stm

Color agnosia (Central achromatopsia)

Good color vision (can tell if two objects differ in color).
Inability recognize colors
Inability to assign colors to objects



Temporal lobe damage



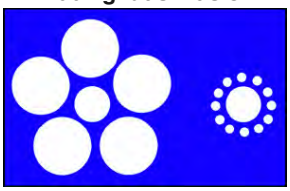
Patient studies of visual perception deficits that support "dorsal/ventral" distinction

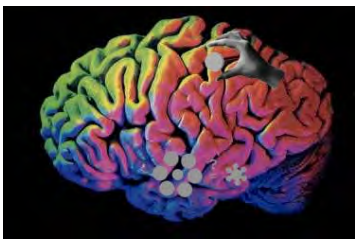
How can these patients recognize objects but not be able to act on them accurately?

How can these patients act on objects that they cannot perceive?

IT = inferotemporal cortex

Ebbinghaus Illusion





Affects perception, but not reaching

Seeing objects and faces

- Parallel visual pathways
- How parallel is parallel?
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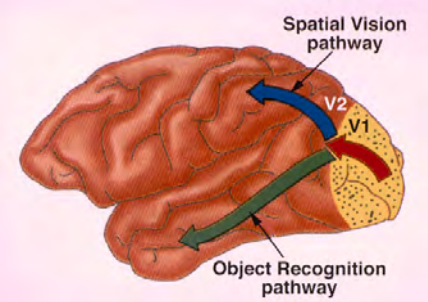
Normal Object Perception



The Challenge of Object Perception

- Objects look different from different viewpoints
  - Viewpoint invariance: the ability to recognize an object regardless of the viewpoint

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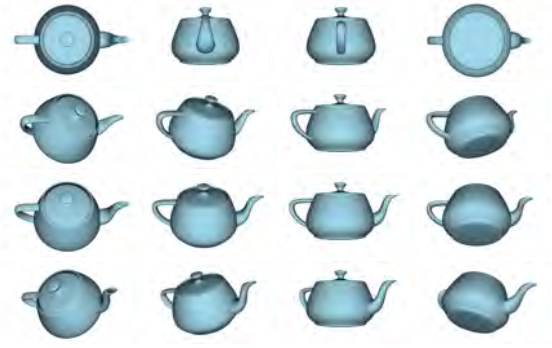
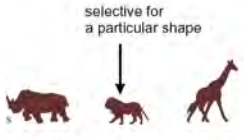
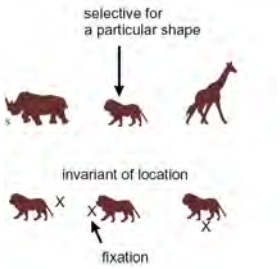




The Challenges of Object Perception

Object Perception is characterized by a range other invariances



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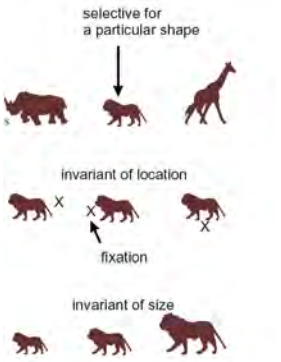

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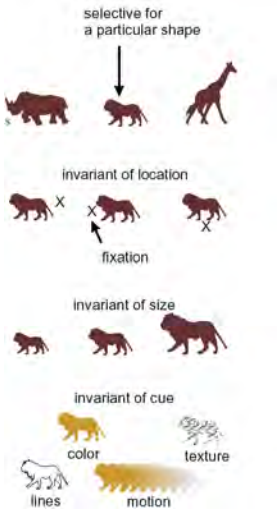

The Challenges of Object Perception

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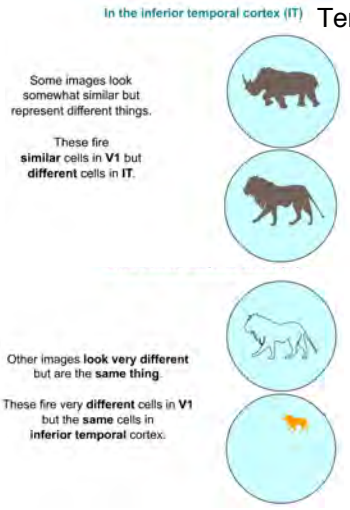
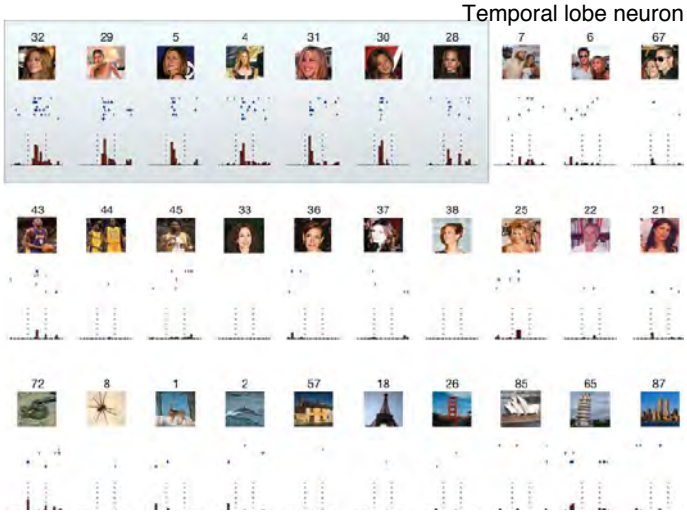
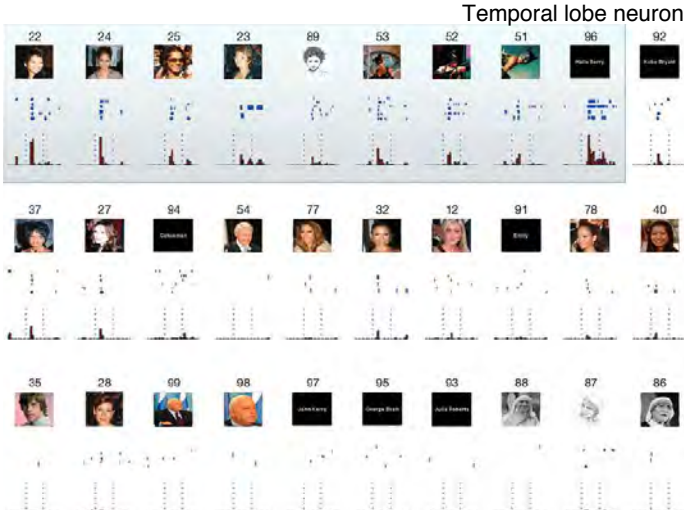
Temporal lobe



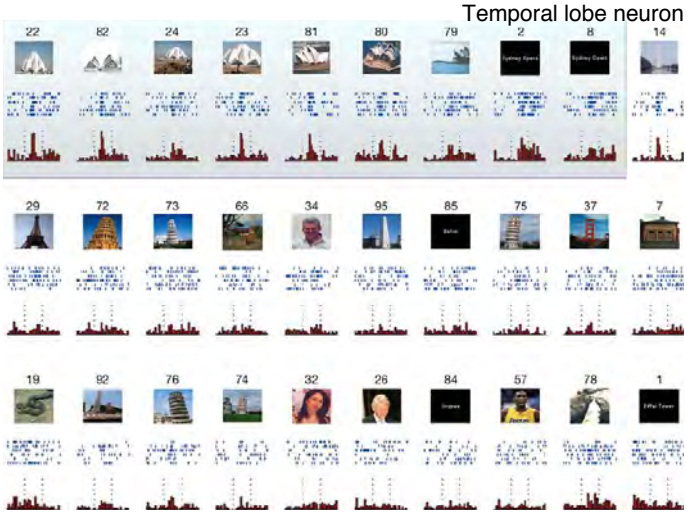
Temporal lobe neuron



Temporal lobe neuron



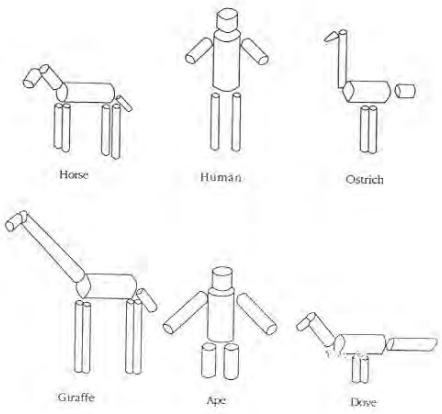
Temporal lobe neuron



Object perception

- **Structural Description Models** : Small set of primitives can specify large set of objects (**Recognition by components)**
- **View Based Models**: Maintain a memory of many different views for each object we need to recognize.

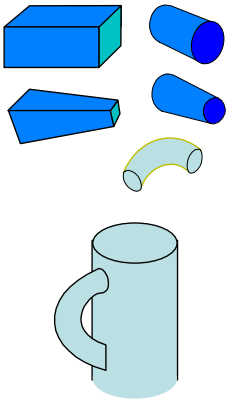
Structural Description Models



Structural Description Models

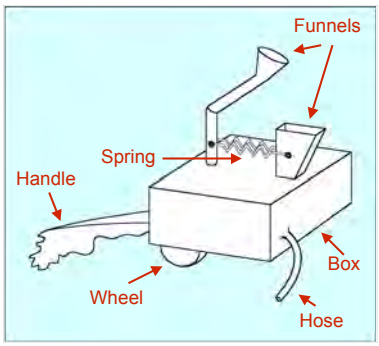
Small set of primitives can specify large set of objects

- Specify features and their relations
  - Decompose object into simple volumetric parts
  - Describe the parts and their inter-relations
    - pipe-side
    - cylinder-middle



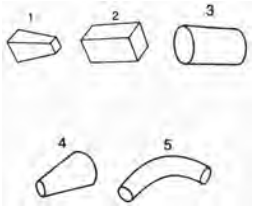
Describe this object

When asked to describe a novel object, observers typically do so by identifying different parts.



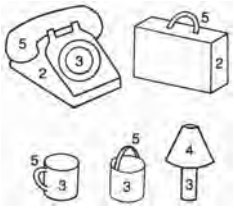
Structural Description Models
RECOGNITION BY COMPENENT THEORY

Geons



Each type of geon is defined by a particular configuration of non-accidental properties.

Objects



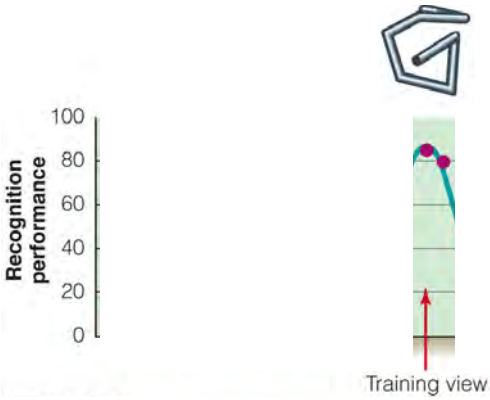
Each type of object is defined by a particular configuration of geons.

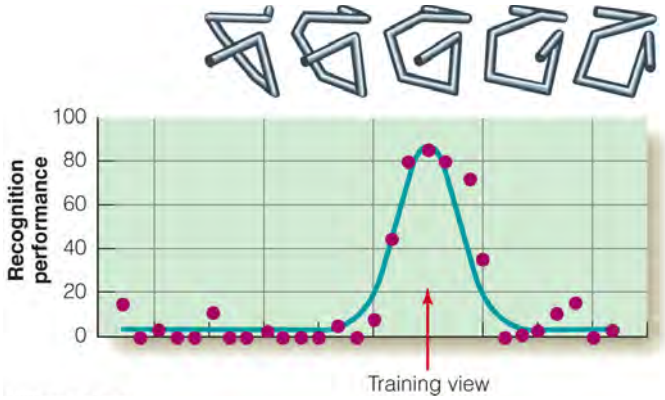
Structural Description Models
RECOGNITION BY COMPENENT THEORY

But,…
can all objects be recognized based on “geon decompositions”

View Based Models

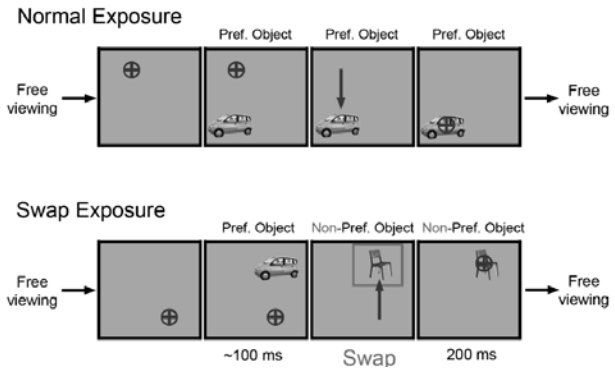
- Ability to identify 3-D objects comes from stored 2-D viewpoints from different perspectives
  - For a familiar object, view invariance occurs
  - For a novel object, view invariance does not occur
    - This shows that an observer needs to have the different viewpoints encoded before recognition can occur from all viewpoints





A result showing that a monkey is better at identifying the view of the object that was presented during training (arrow).
The drop-off in performance for other viewpoints is an example of a lack of view invariance.

View Based Models
Position invariance



Object perception

- **Structural Description Models** : Exploit those properties that can distinguish most objects from one another, yet remain relatively stable over changes in view (**Recognition by components)**
- **View Based Models**: Maintain a memory of many different views for each object we need to recognize.

Seeing objects and faces

- Parallel visual pathways
- How parallel is parallel?
  - evidence from lesion studies
- Object perception
- Face perception

Face aftereffect experiment

Adapt

Test

Face aftereffect experiment

Adapt

Face aftereffect experiment

test

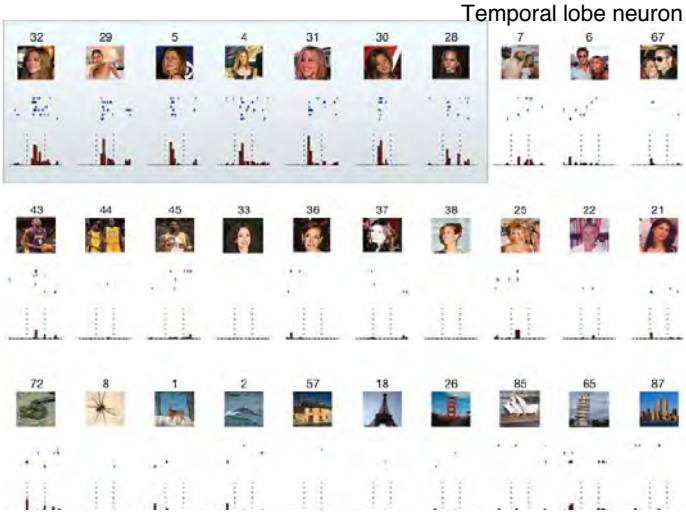
Face aftereffect experiment

Adapt

Face aftereffect experiment

Test

Temporal lobe neuron



Recognizing faces is one of the most difficult challenges to the visual system:

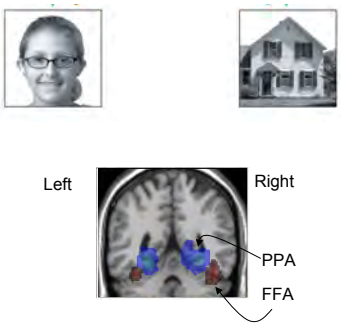
• Faces are highly similar in 3-D structure: only fine variations distinguish one from another.

• All of us have seen thousands of faces over our lifetime.

• Yet, we can still recognize many of these effortlessly, sometimes within a single glance, sometimes after years without contact.

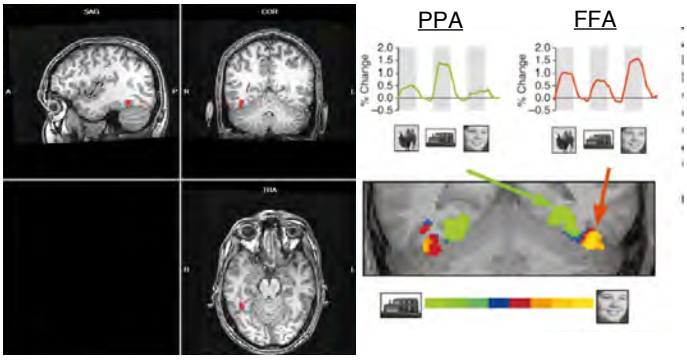
HOW?
WHAT HAPPENS WHEN IT GOES WRONG?

Fusiform face area (FFA)

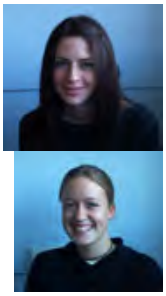


Parahippocampal place area (PPA)

Fusiform face area (FFA)



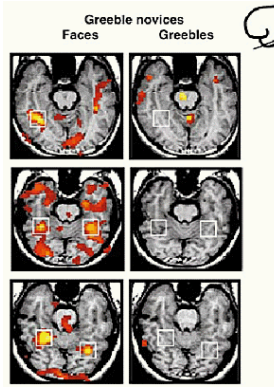
Are faces really that special?
Or are they special because of our level of <u>expertise</u>?



Activation of FFA increases with expertise
Gauthier et al., 1999

Greebles

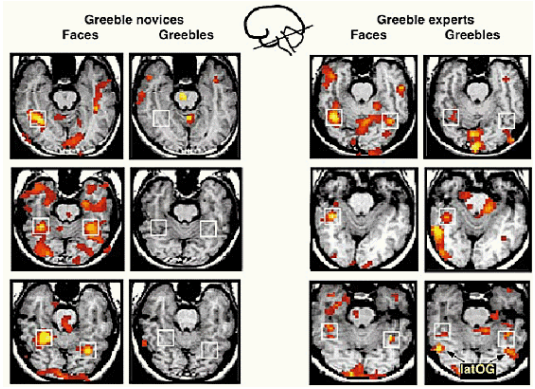
<u>Fusiform face area (FFA)</u>



Right Left

Gauthier et al., 1999

<u>Fusiform face area (FFA)</u>



Right Left

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HOW?
WHAT HAPPENS WHEN IT GOES WRONG?

<u>Prosopagnosia</u> Temporal lobe damage

• Patient can't consciously recognize familiar faces, sometimes even including their own.
• Faces might make no sense (jumble of features), or a patient sees "a face" but can't associate it with anybody
• Can still show emotional responses to faces
• Can use other cues, like voice or gait, to recognize people
• **Can extend to others classes of objects with which a person has a lot of experience**

How do you diagnose prosopagnosia ?

Evidence that they fail to recognize familiar faces as previously encountered.

Famous faces test
- Famous faces from different decades

Familiarity discrimination test
- famous and anonymous faces

Warrington face recognition test
- 50 faces shown, then again paired with a new one: which one did you see?
- short term familiarity

Relatives test
- faces of their own relatives from photos
- need to eradicate local cues (unique hair style)

How do you diagnose that it is ONLY prosopagnosia ?

- Test their vision - exclude blindness
- Test their memory - exclude amnesia
- Test their object recognition - exclude “object agnosia” at a category level - can they tell their wives from hats?

Specificity in prosopagnosia

- Faces differ only in subtle variations on a basic geometric arrangement.
- To differentiate one from another requires extensive training, with years of both (1) exposure AND (2) interest.
- While virtually all humans have expertise and interest in faces, this may not be true of many other objects.

HARVARD GAZETTE ARCHIVES

'Face-blindness' disorder may not be so rare

Little- known condition may affect up to 2 percent of the population

By Steve Bradt
FAS Communications

Researchers at Harvard University and University College London have developed diagnostic tests for prosopagnosia, a socially disabling inability to recognize or distinguish faces. They've already used the new test and a related Web site (http://www.faceblind.org) to identify hundreds of "face-blind" individuals, far more than scientists had identified previously.

Prosopagnosic individuals, having just seen various views of the face in the top row, have trouble picking out the same face lit differently in the bottom row. (Graphic courtesy of Ken Nakayama)

The researchers, led by Ken Nakayama and Richard Russell at Harvard and Bradley Duchaine at University College London, have found evidence that prosopagnosia, once thought to be exceedingly rare, may affect up to 2 percent of the population - suggesting that millions of people may be face-blind.

"Until a few years ago, only 100 cases of prosopagnosia had been documented worldwide, but it now appears the condition is much less rare than had previously been assumed," says Nakayama, the Edgar Pierce Professor of Psychology in Harvard's Faculty of Arts and Sciences. "Testing of 1,600 individuals found that 2 percent of the general public may have face-blindness and a German group has recently made a similar estimate. It's conceivable that millions of people may have symptoms consistent

www.faceblind.org/facetests