# Perception

# Preliminaries

# Experiment ad!

## NEUROANTHROPOLOGY STUDY WITH FNIRS

*LOOKING FOR PARTICIPANTS*

Crafa's Lab will be performing a research project in Neuroanthropology with fNIRS technology at IMC.

This is a Bachelor's thesis project with multiple students involved so if you could volunteer and help us get data for our thesis that would be lovely! <3

We will study how we can use fNIRS technology as a method for research in anthropology, that is to say, neuroanthropology.

The experiment will take 1,5 h approx.

AARHUS UNIVERSITY

IMC
INTERACTING MINDS CENTRE

# NEUROANTHROPOLOGY

# STUDY WITH FNIRS

## *WHAT DO YOU HAVE TO DO?*

### *REQUIREMENTS*

-Right-handed
-18 years old or older
-Normal hearing
-Normal or correct vision (i.e., glasses/contact lenses)
-Not color-blind
-Danish (born and raised to Danish parents)
-Fluent in Danish

### *SIGN UP*

If you are interested in being part of groundbreaking research just send us an email to:

**crafalab.au@gmail.com**

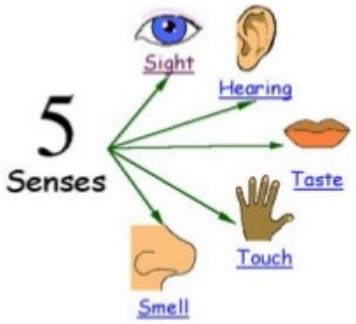
We will then give you a timeslot that fits your schedule to come to the lab.

# Perception

# Sensation vs Perception

## Sensation vs. Perception

**Sensation** –What comes into our body through our sensory organs




**Perception** –What our brain does with that information

# Context and Pattern Recognition

## BOTTOM-UP PROCESSING -

- Information from the physical stimulus is used to help recognize a stimulus.
  - Start with small bits of information and combine them to form your perception.

# Context and Pattern Recognition

## TOP-DOWN PROCESSING

- Information from the general context is used to help recognize a stimulus.
  - High-level general knowledge contributes to the interpretation of the low-level perceptual units.

# Vision: Inverse projection problem

The stimulus on the retina is ambiguous

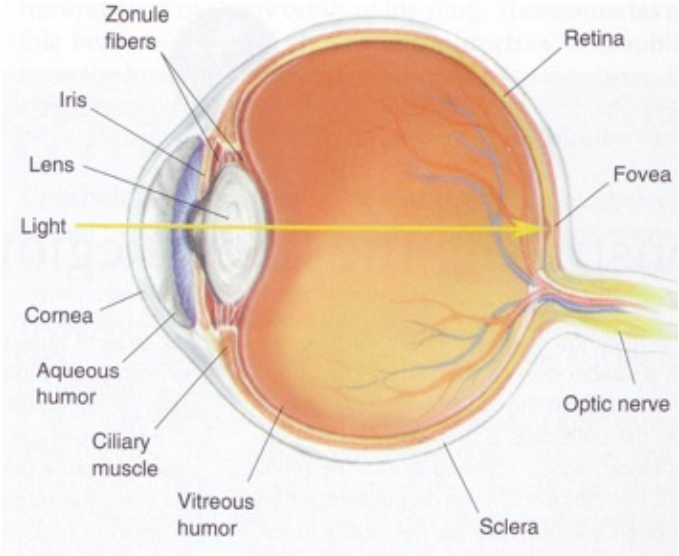
› We spend time collecting more information until we perceive the stimulus

Bottom-Up Processing

› Eye-to-brain

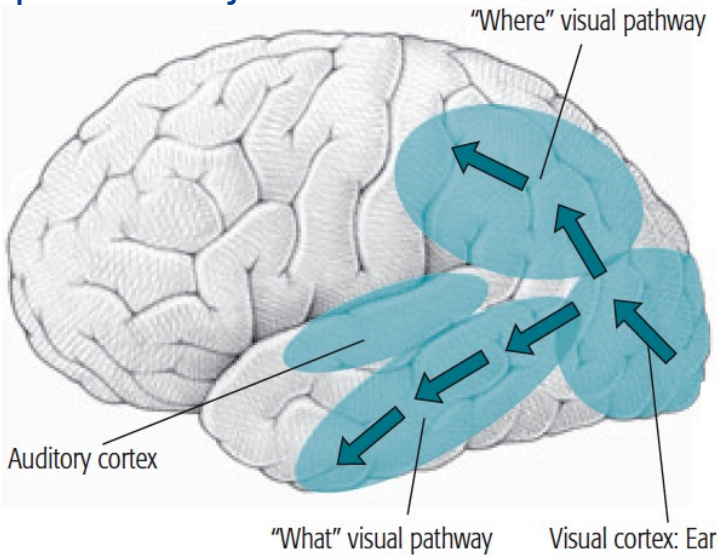
Top-Down Processing

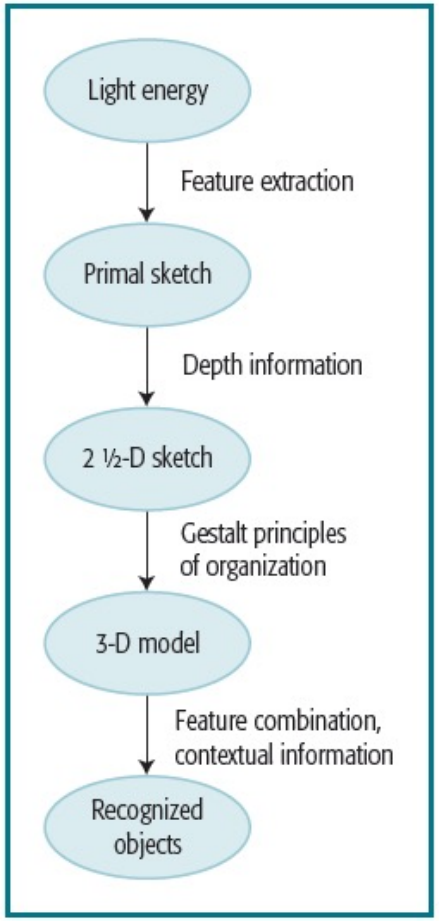
› Brain-to-perception



# Visual perception – in the brain

- Early phase – in which shapes and objects are extracted from the visual scene
  - e.g. features, position, orientation, movement, etc.
- Later phase – in which the shapes and objects are recognised
- Cortical structures:




The "bottom-up" direction

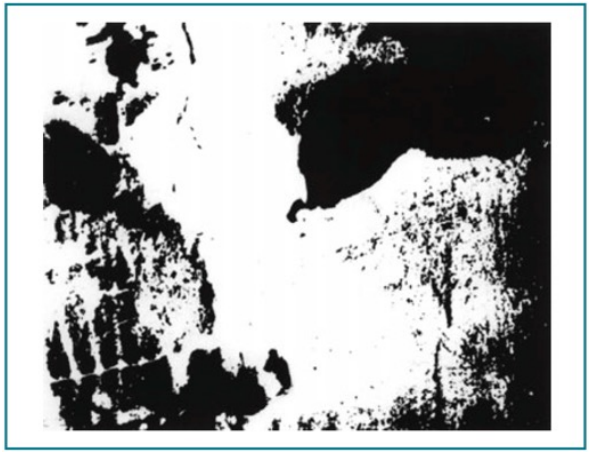
# Visual perception – in the brain

Illustrative example of phases: Visual Agnosia

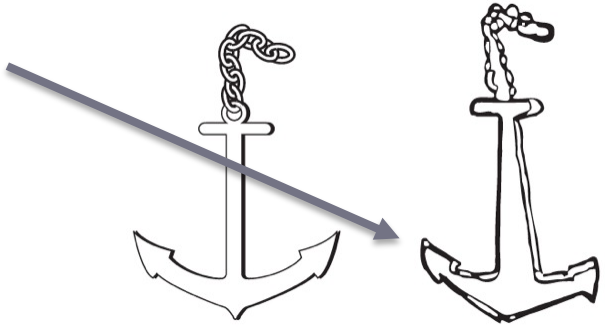
- The inability to recognize visual objects, which is neither a function of general intellectual loss nor a loss of basic sensory abilities

Two types:

- Apperceptive = cannot recognize shapes – deficit of early phase
- Associative = cannot recognize complex objects – deficit of late phase



A sense of the agnosia experience



Drawing by patient with associative agnosia

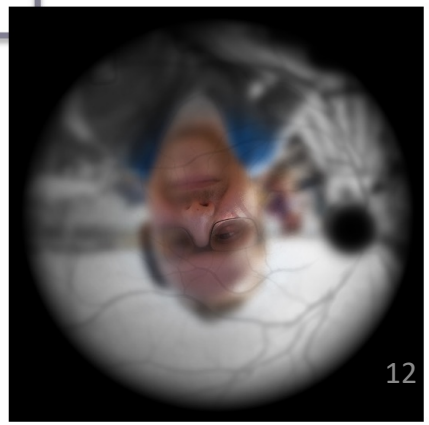
Early visual information processing begins in the eye.

Light passes through the lens and the vitreous humor and falls on the retina at the back of the eye.

The retina contains the photoreceptor cells, made up of light-sensitive molecules that undergo structural changes when exposed to light.

Light is scattered slightly when passing through the vitreous humor, so the image that falls on the back of the retina is not perfectly sharp.

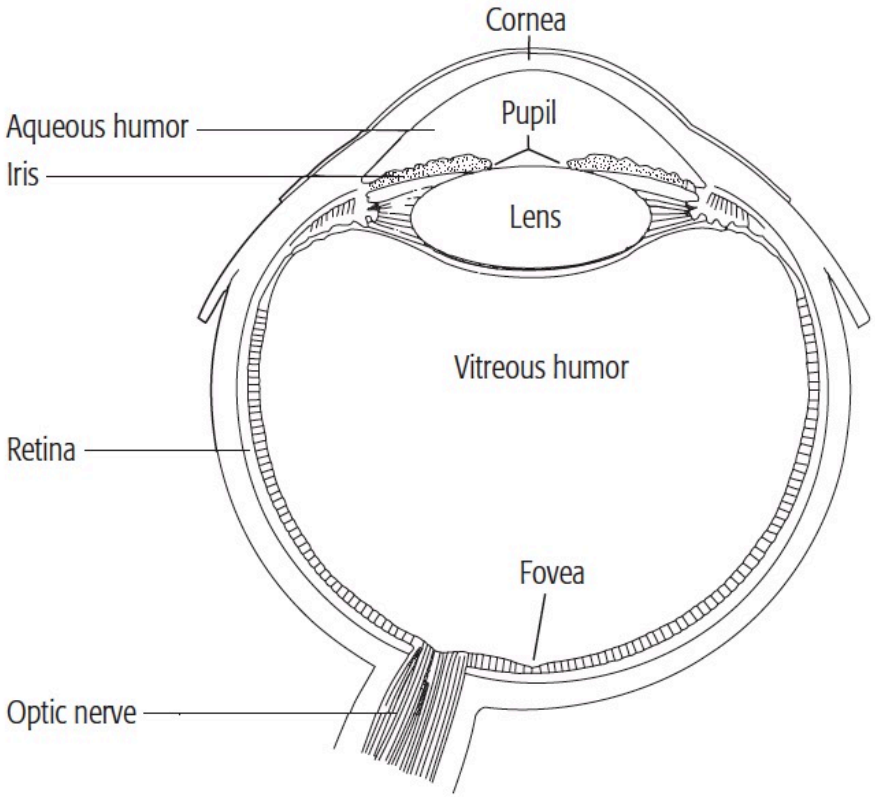
One of the functions of early visual processing is to sharpen that image.





# Visual perception: overview of eye

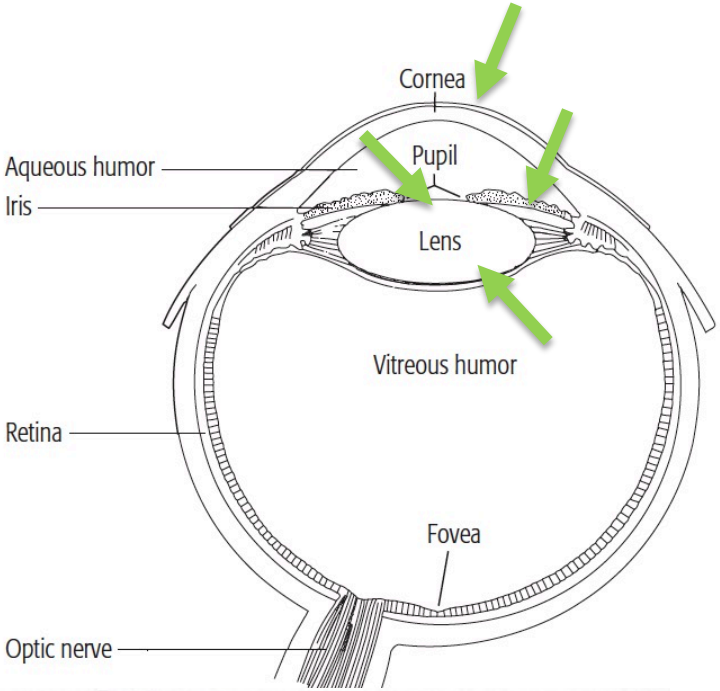
# Visual perception – the eye

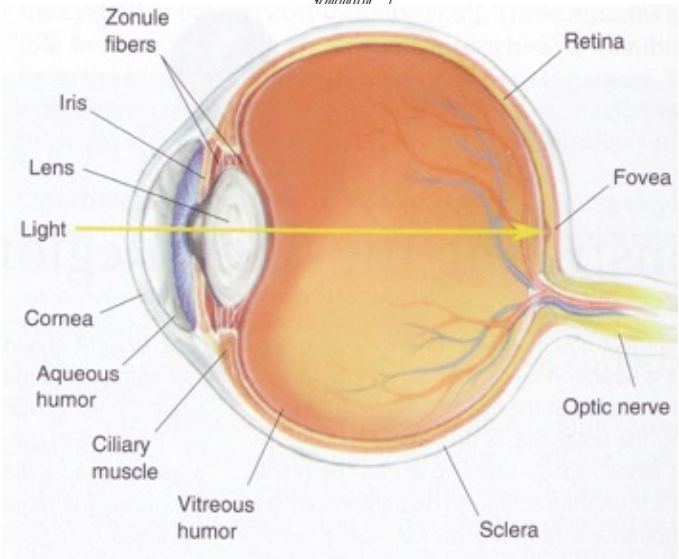



A schematic representation of the eye. Light enters through the cornea; passes through the aqueous humor, pupil, lens, and vitreous humor; then strikes and stimulates the retina.

# Visual perception – the eye

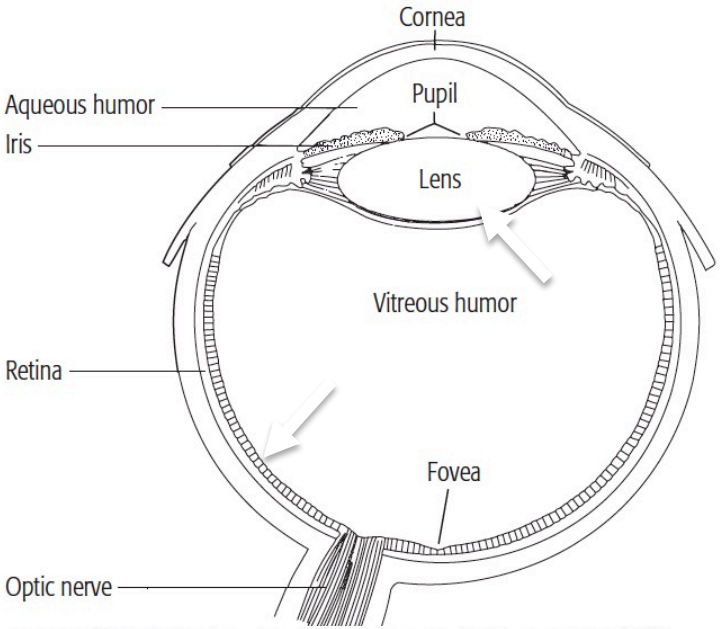
- Cornea - the clear membrane covering the visible part of the eye
  - helps gather and direct incoming light
- Iris - colored part of the eye
  - The muscle that controls the size of the pupil
- Pupil - opening in the middle of the iris
  - Changes size to allow different amounts of light to enter the eye
- Lens - transparent structure located behind the pupil
  - Actively focuses, or bends, light as it enters the eye

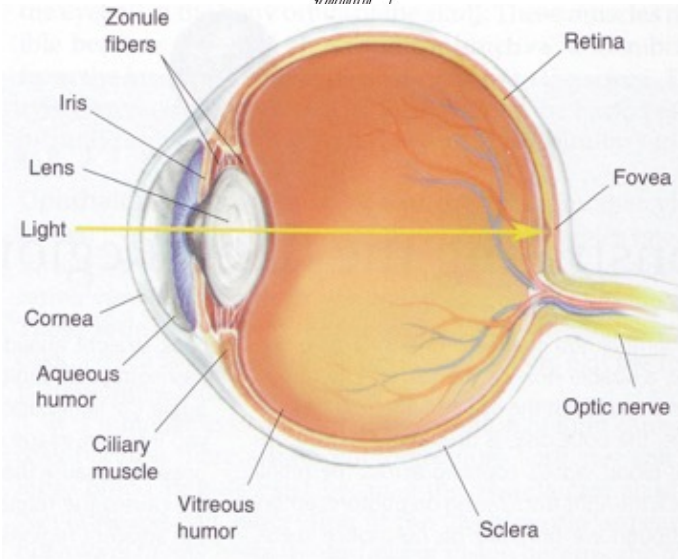


# Visual perception – the eye

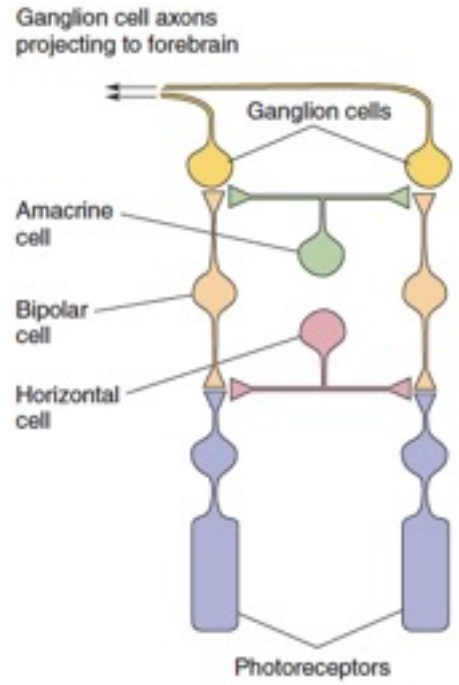
- Accommodation - a process by which the lens changes shape to focus incoming light so that it falls on the retina
- Retina - thin, light-sensitive membrane located at the back of the eye
  - Contains sensory receptors for vision:
- Rods - Long, thin, blunt receptors, highly sensitive to light, but not to color
  - Primarily for peripheral and night vision
- Cones - Short, thick, pointed sensory receptors of the eye that detect color
  - Primarily for color vision and acuity

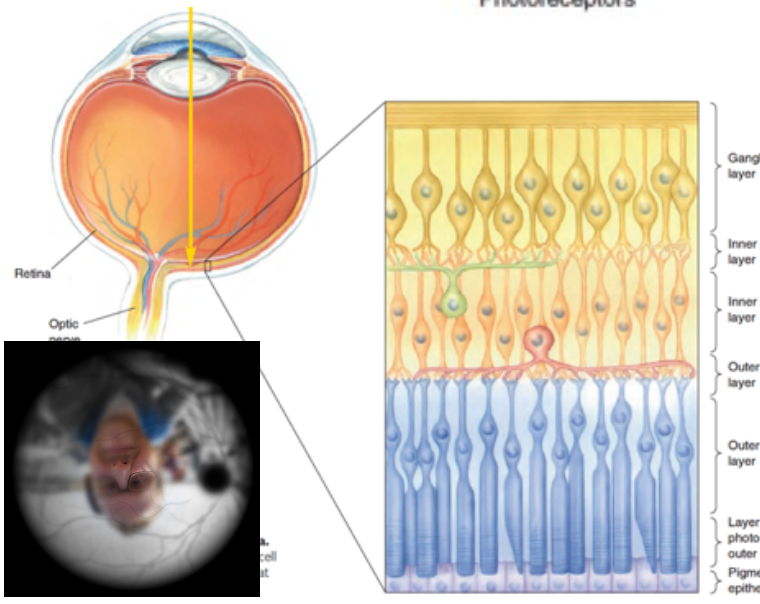


# Visual perception – optics

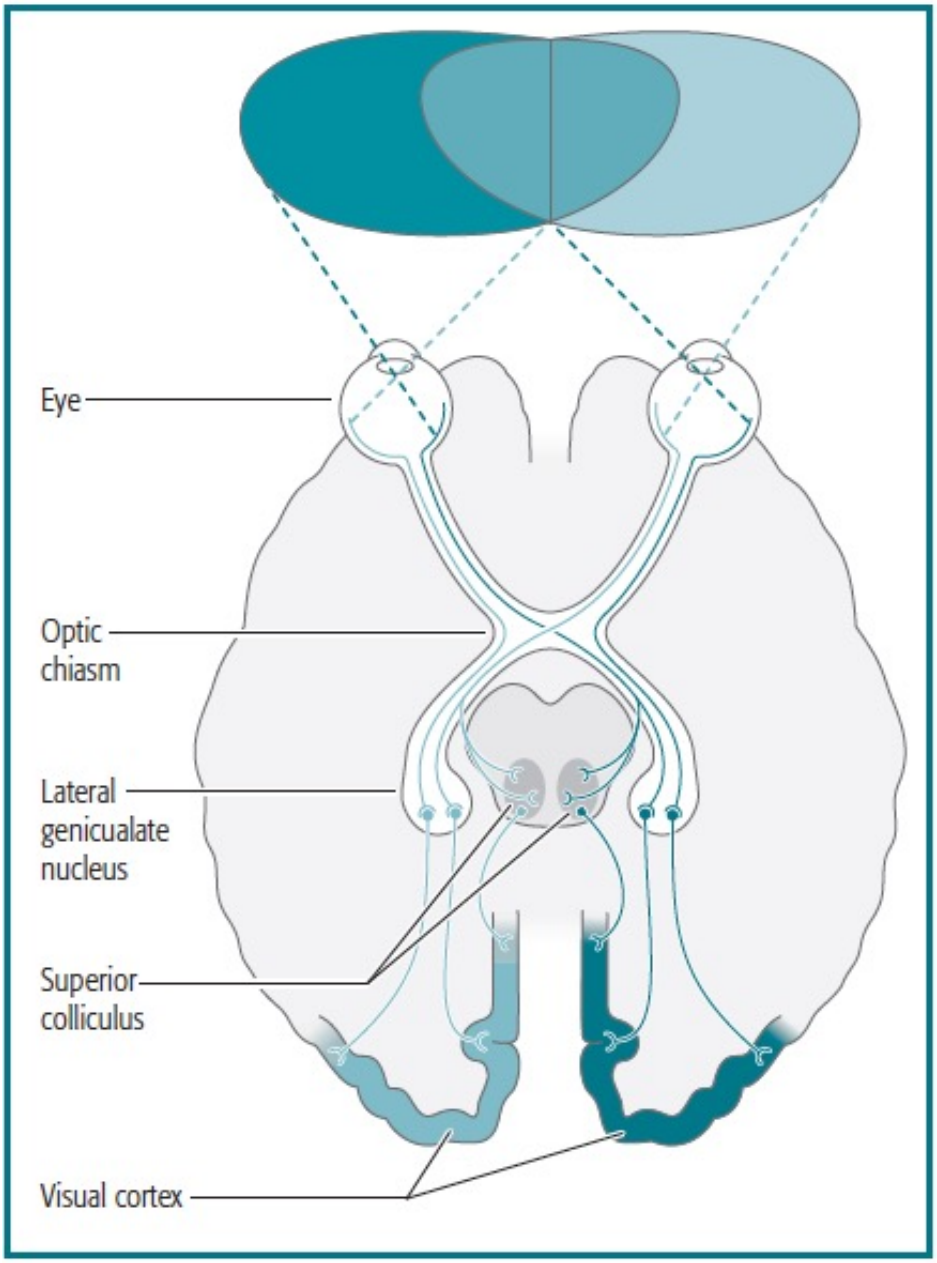
- From photoreceptors to optic nerve - Light striking the retina is converted into neural energy by a photochemical process
- Information from the rods and cones is collected by the bipolar cells, which transmit the information to the ganglion cells
- The ganglion cell axons are bundled together to form the optic nerve, which transmits the information to the brain



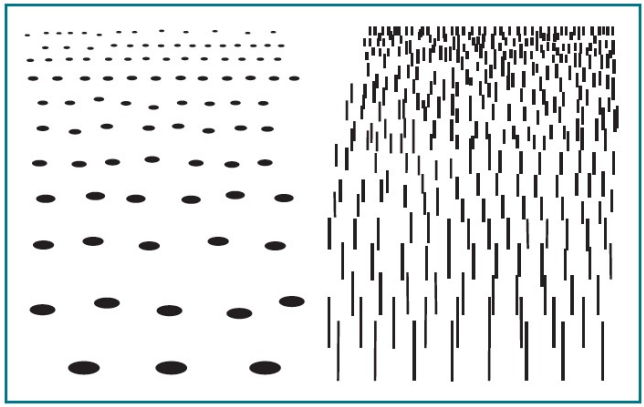



# Visual projections

- The optic nerves from the left and right eyes meet at the optic chiasm, then partly cross over
- Left/right visual hemifield (*not left/right eye*) vs hemisphere



# Perceiving depth and surfaces

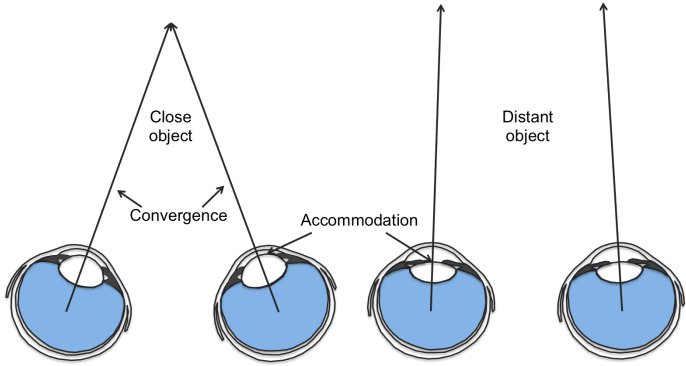


Texture gradient

- Elements tend to appear more closely packed together as the distance from the view increases

Stereopsis

- The ability to perceive 3D because two eyes receive slightly different view of the world




Motion parallax

- Provides 3D information when an object is in motion
- As more distant points move they will move more slowly across the retina than closer points.

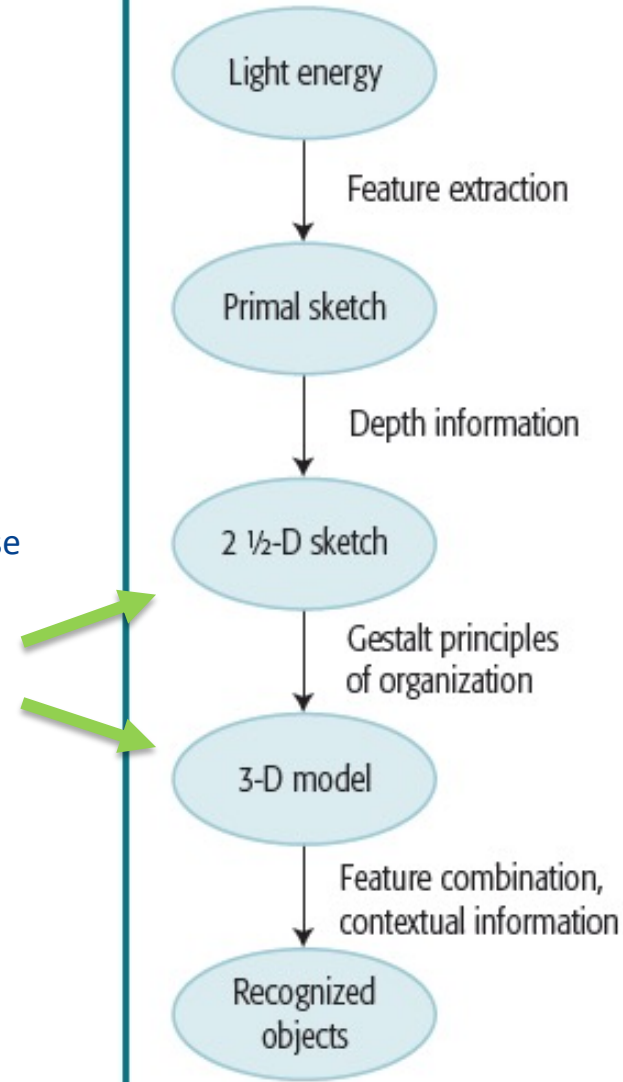
# Object perception

## 2 ½ D SKETCH

- Identifies where various visual features are located relative to the viewer
- Represents only parts of surfaces and does not yet identify *how* these parts go together to form images of objects in the environment

## 3D MODEL

- The representation of objects in a visual scene
- How are features and segments combined to form 3D objects?

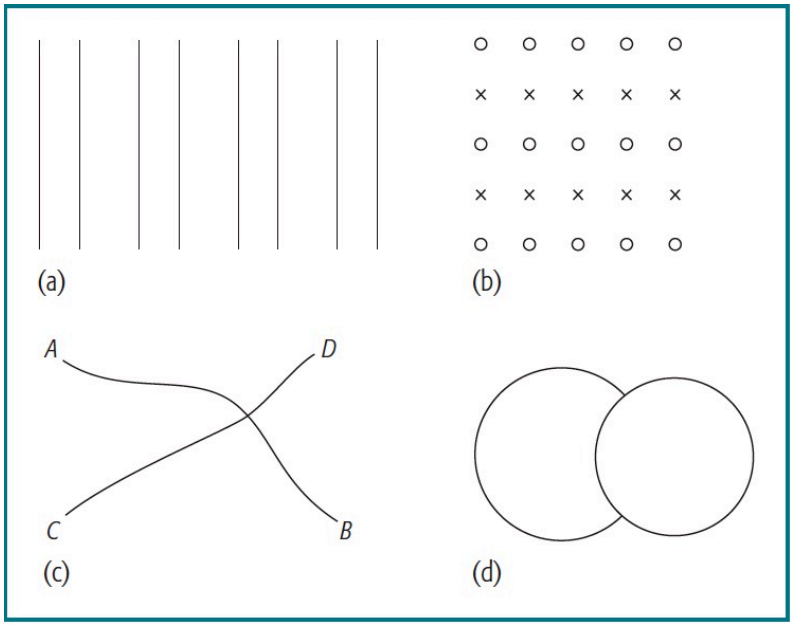


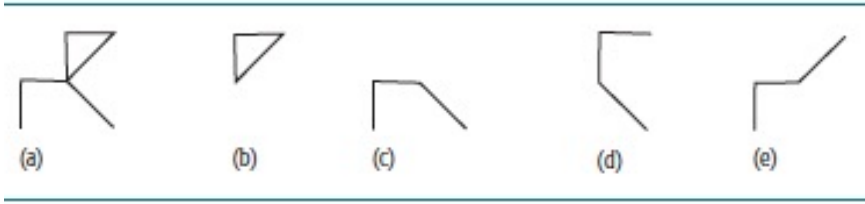
# Gestalt principles of organisation

*Explain how the brain segments visual scenes into objects*

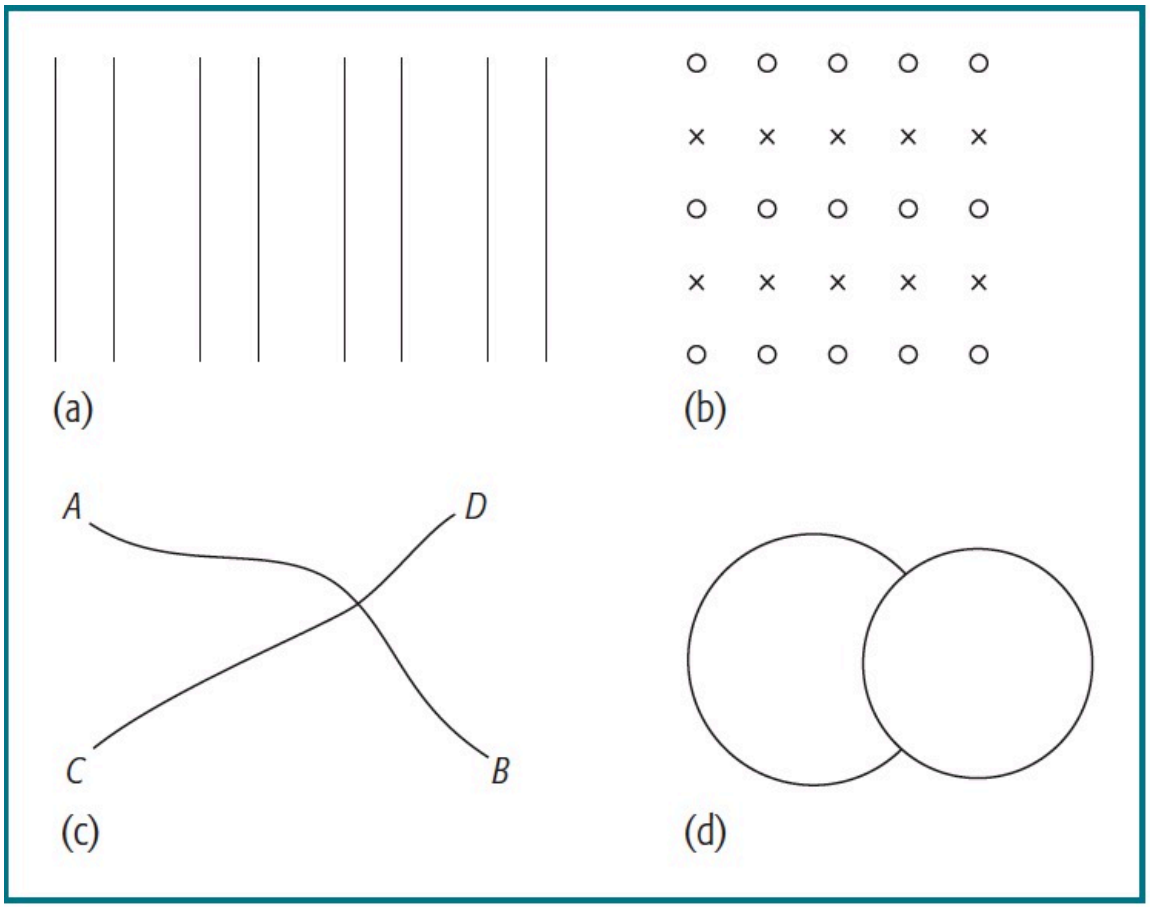
PRINCIPLES

- Principle of proximity
- Principle of similarity
- Principle of good continuation
- Principle of closure



# Illustrations of the Gestalt Principles of Organization




(a) Principle of proximity

(b) Principle of similarity

(c) Principle of good continuation

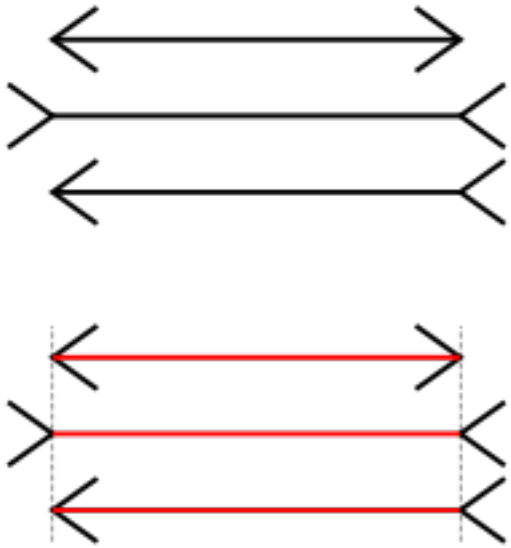
(d) Principle of closure

# Helmholtz's theory

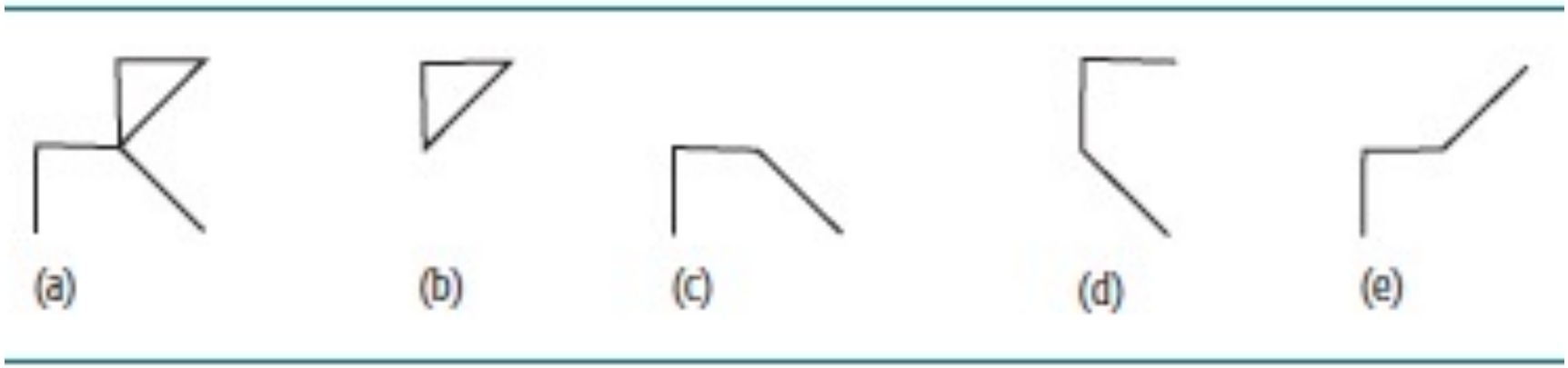
How does the perceptual system perceive patterns?

› Likelihood principle = we infer what is most likely

› Unconscious Inference = the process of inference is unconscious



# Organizing novel stimuli into units



# Why is this hard to read?

FoRiNsTaNcEtHiSsEnTeNcEiShArDtOrEaD

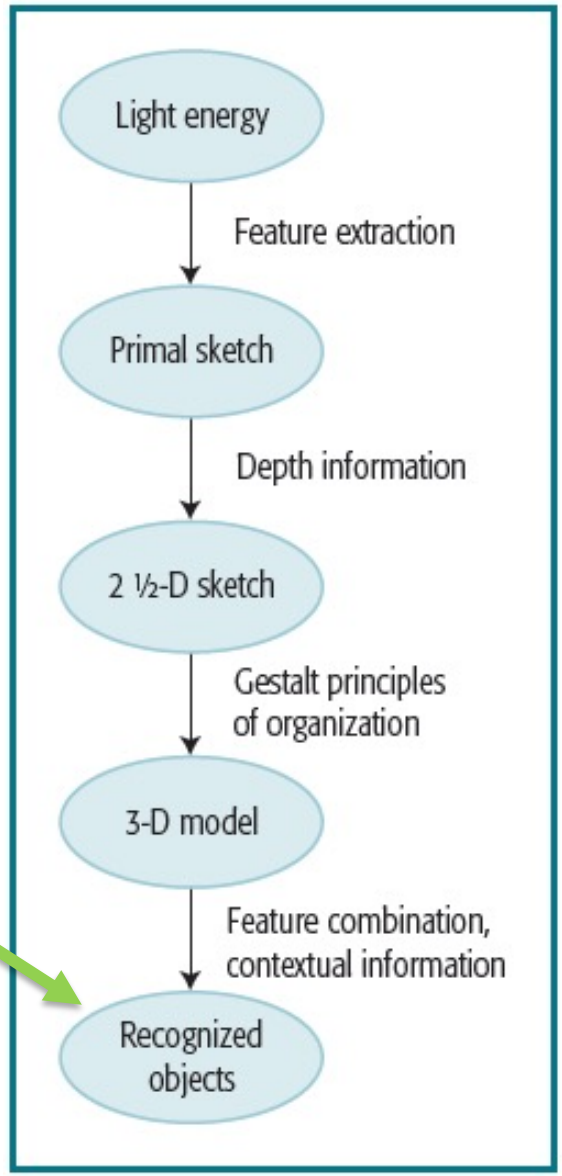
Gestalt principle of similarity is violated, so hard to perceive adjacent letters when they're in different cases

Removing spaces between words also eliminates proximity cues

# Object recognition

The visual world is *organized into patterns that underlie different objects*

› We must also identify what those objects are and what categories they originate from



# Visual pattern recognition: from identifying to recognizing

## Feature analysis = detecting features and their combinations

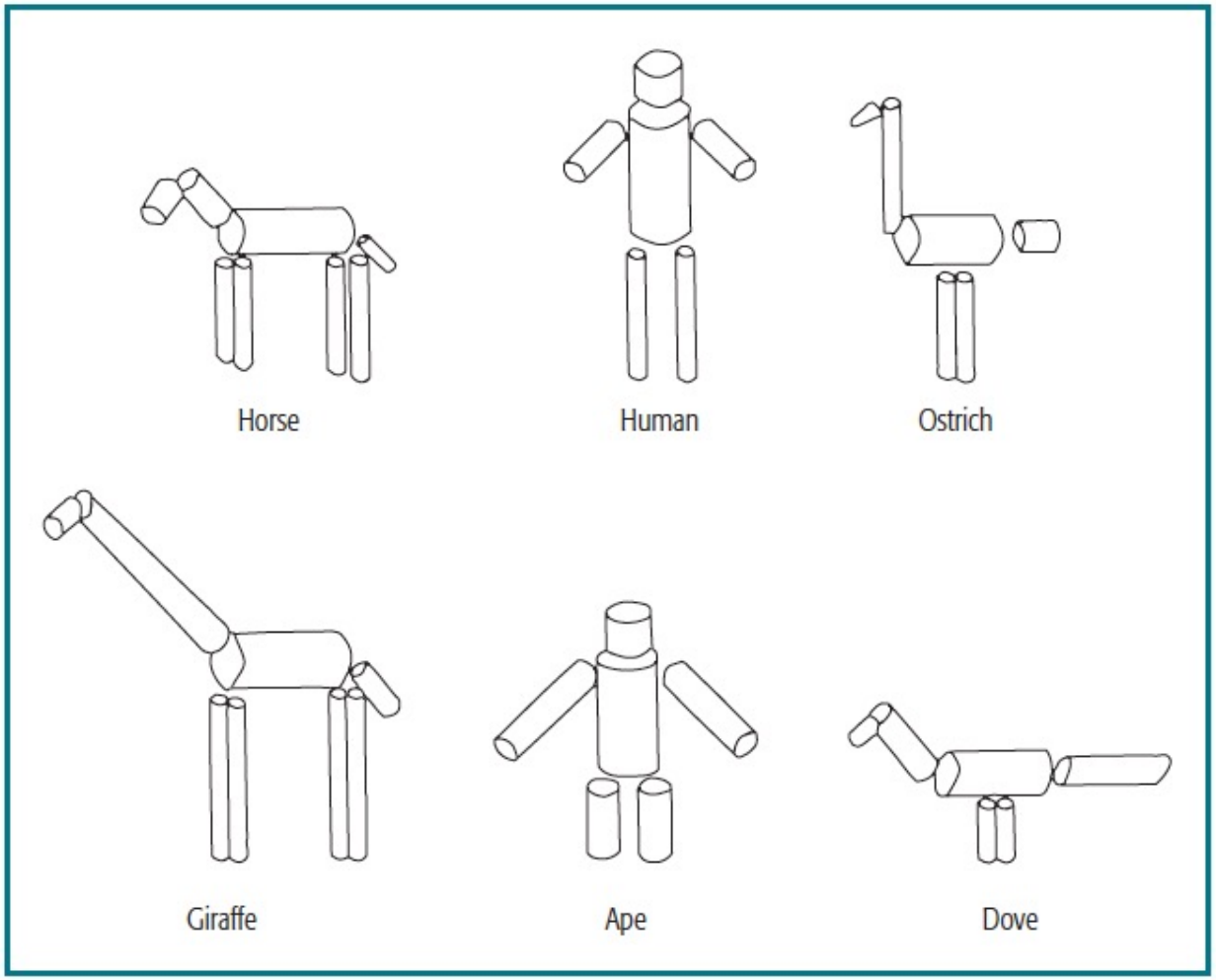
- Stimuli are thought of as combinations of elemental features
- We can perceive an object because what we store in our long-term memory are its parts/features
- We compare retinal image and see what object in long-term memory has the most features that match the object.

## Template model = comparing image to past experiences

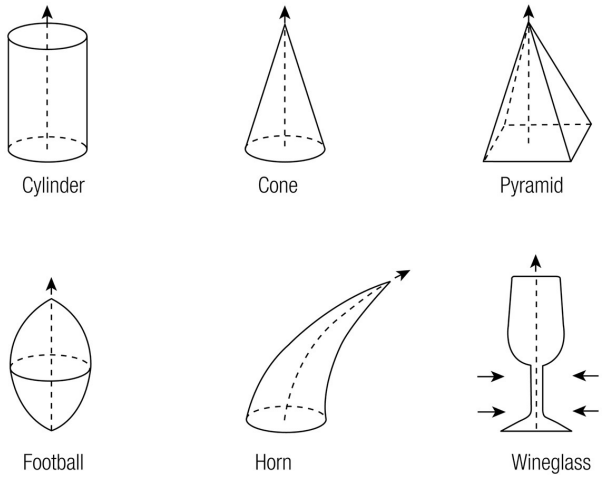
- Features are simpler
- Computationally less intensive
- Flexible in terms of real variation

# Segmentation of Some Familiar Objects into Basic Cylindrical Shapes

Recognition by components theory



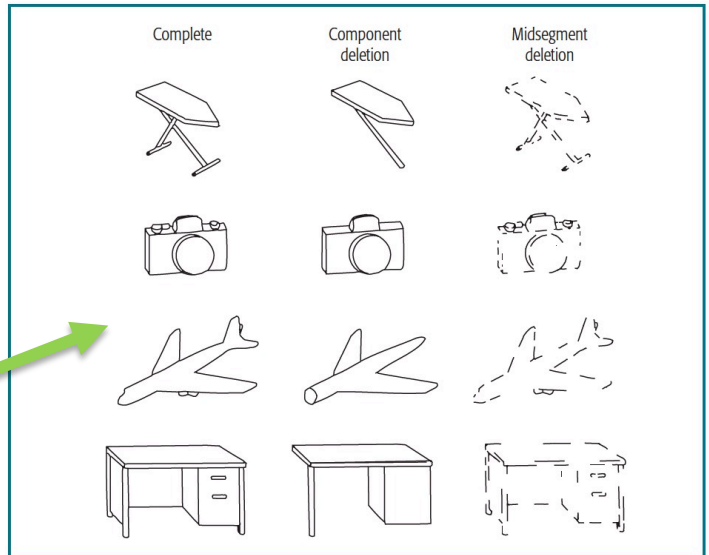
# Object recognition (from patterns)



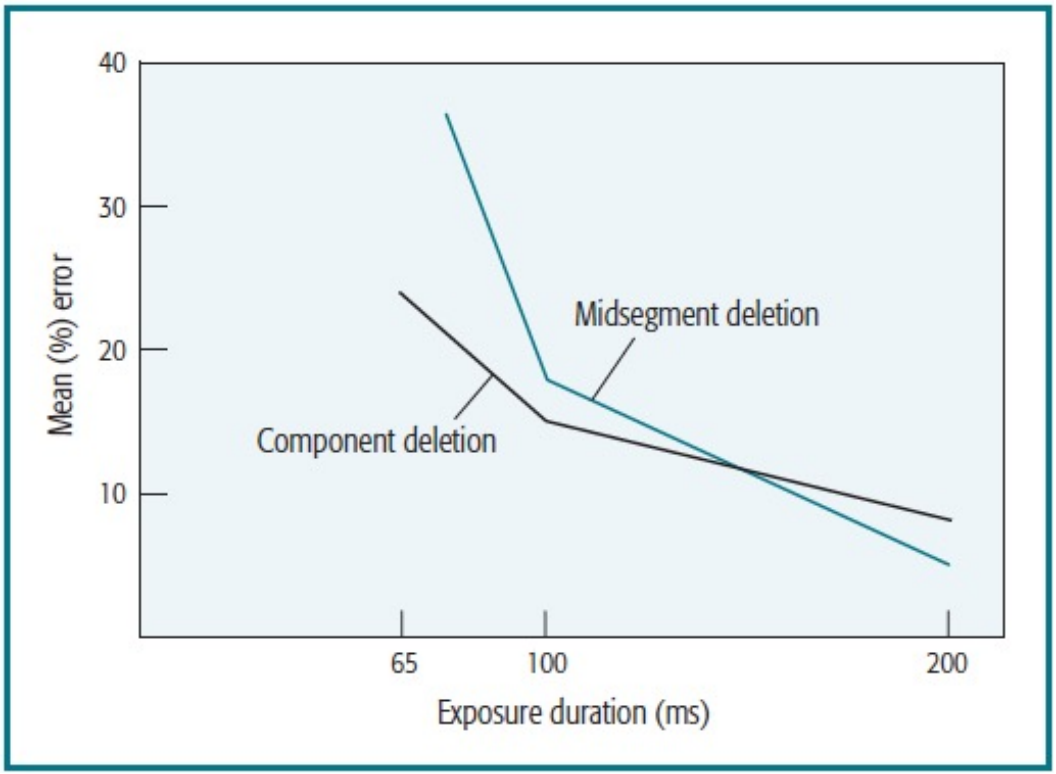

Recognition-by-components theory (Biederman)

- Classical approach, consisting of 3 stages:
  - The object is segmented into a set of basic subobjects
  - Then, the category of each subobject is classified
    - 36 basic categories of subobjects, called *geons*
  - Having identified the pieces out of which the object is composed and their configuration, one recognizes the object as the pattern composed from these pieces

Test stimuli: Equivalent proportions either of **whole components** or of **contours at midsegments** were removed



# Biederman: Are Components Recognized?




Results from the test conducted by Biederman, Beiring, Ju, and Blickle (1985) to determine whether object recognition is mediated by recognition of components of the object.

# Environment and regularities

## Characteristics in the environment that occur frequently

- Physical regularities
  - Oblique effect = horizontals and verticals occur more often, so oblique angles are harder to perceive
  - Light-from-above assumption

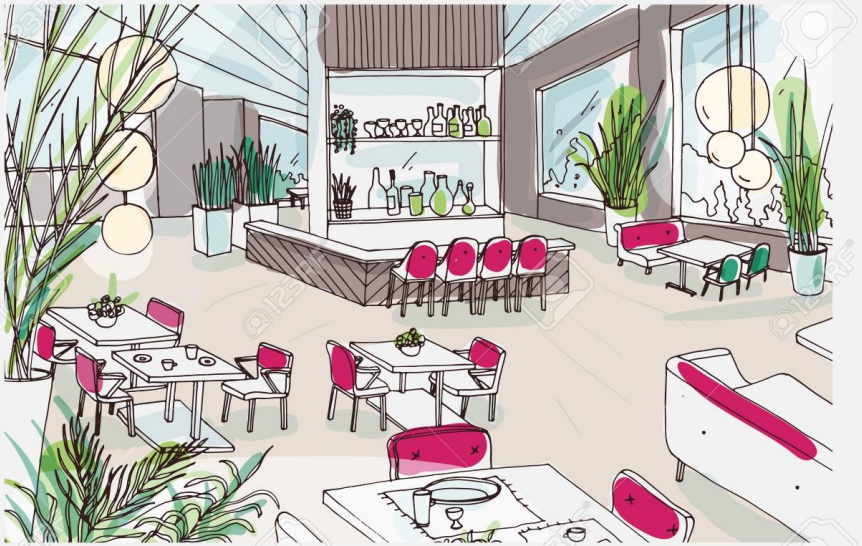
# Semantic regularities

## Beyond physical regularities

- Semantics = meaning
- Semantic regularities = functions common to a scene
  - What does it mean to go to a restaurant? The function of a restaurant is to provide food
- Scene schema = Knowledge of what a scene typically contains
  - A restaurant will have tables and a kitchen

# Bayesian Inference

- Prior probability = “the prior” = our beliefs about the probability of an outcome
  - Based on likelihood



# Experience-Dependent Plasticity

# Experience-dependent plasticity

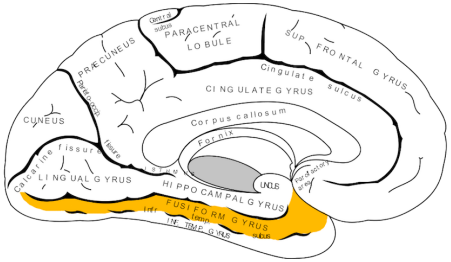
- Our experiences shape our brains
  - FFA, PPA, EBA
- Specialized neurons
  - Respond selectively to horizontals and verticals
  - Kittens – raised in only horizontal or vertical environments changed number of neurons
- Role of culture in perception
  - Culture = social environment
  - Humans are social animals
  - If our environment shapes our brains, then probably the social environment does too

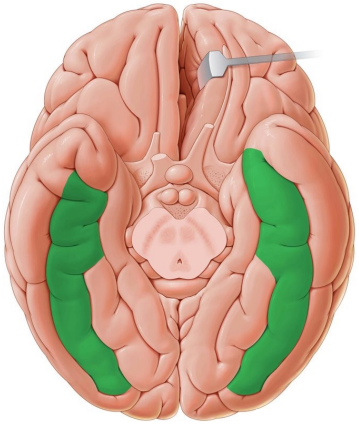
# Kittens in constrained environments

## Blakemore and Cooper (1970)

- The visual system of kittens changed depending on the environments that they were raised in
- Measured by number of neurons that respond to vertical or horizontal lines

# Face recognition



## Prosopagnosia

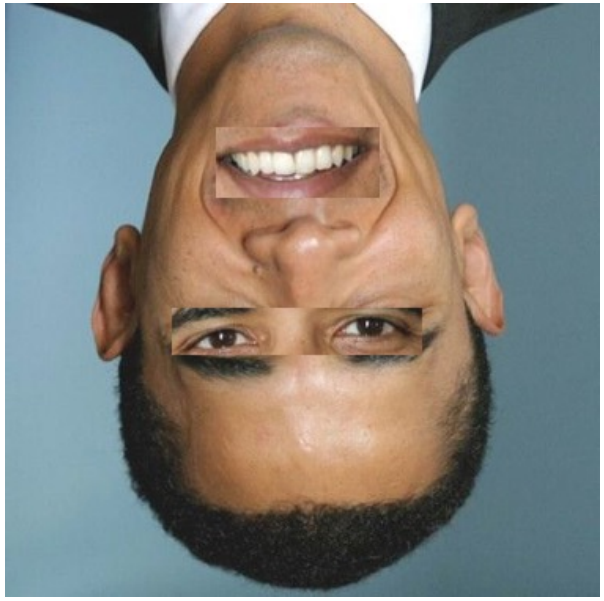
› Selective difficulties in recognizing faces due to damage to the temporal lobe

## Fusiform gyrus

› The region of the temporal lobe that responds when faces are present in the visual field

Many psychologists believe that humans are specifically predisposed to identify whole faces.

# Can you recognize this face?



# Evidence of experience-dependent plasticity

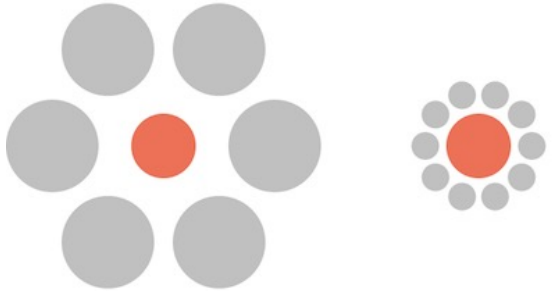
# Greebles

## Gauthier et al. (1999)

"Greeble experts" use the face area when recognizing these objects

› Also, bird and car experts

# Culture and Perception



## Ebbinghaus illusion

- Processing styles
  - Field-dependence = context-dependence = holistic processing style
  - Field-independence = context-independence = analytical processing style

- Many studies show that some South East Asian cultures are more context-dependent than some American/European cultures
  - Being context-in/dependent may relate to social environment
  - Individualism vs Collectivism

- Caveat: Best to avoid East vs West thinking
  - Is the “West” really the whole western part of the globe? Is the “East” really the whole eastern part? No.
  - Himba live in North Nambia and share context-dependence

# Someone asked

- Why is the Ebbinghaus Illusion controversial?
  - Answer: Culture influences results (explained on previous slide)

# Illusion of Certainty

# Certainty

› What is the illusion of certainty and why must scientists be careful?

Journal of Evaluation in Clinical Practice
International Journal of Public Health Policy and Health Services Research

**Journal of Evaluation in Clinical Practice ISSN 1365-2753**

Forum on Systems and Complexity in Medicine and Healthcare

## The illusion of certainty – a deluded perception?

Joachim P. Sturmberg MBBS DORACOG MFM PhD FRACGP

A/Prof of General Practice, Monash University, Melbourne, Australia and A/Prof of General Practice, Newcastle University, Newcastle, Australia

**Keywords**
certainty, perception, complex adaptive systems, nonlinear dynamics

**Correspondence**
A/Prof Joachim Sturmberg
PO Box 3010
Wamberal, NSW 2260
Australia
E-mail: jp.sturmberg@gmail.com

**Abstract**

**Background** Certainty is seen as the 'Holy Grail' of science, despite the fact that all science is based in doubt, and that good scientists always leave a door open for an alternative explanation of their findings. Certainty also is a human desire providing comfort and surety. How can these two notions coexist?

**Results** The way we perceive is the way we see and understand. Perception, however, is not objective; the way we 'know' what the sensory input we receive means arises from matching it against stored images of prior experiences, or put differently, the way we perceive the world depends on successfully predicting our own sensory status. Only large

# Certainty

Certainty = firm conviction that something is true

- A good scientist always asks
  - Is this evidence-based?
  - Are there alternative explanations?

Perceptual errors
Illusions = misinterpretations of true sensations that our brain makes during perception

Predictive coding = the brain exploits prediction and anticipation to make sense of signals, which in turn guide perception, thought and action

Confirmation bias = favoring results that support predictions or readily 'overlooking' or discarding more complex or refuting evidence

# Certainty

Certainty = firm conviction that something is true

- A good scientist always asks
  - Is this evidence-based?
  - Are there alternative explanations?

Perceptual errors
Illusions = misinterpretations of true sensations that our brain makes during perception

Predictive coding = the brain exploits prediction and anticipation to make sense of signals, which in turn guide perception, thought and action

Confirmation bias = favoring results that support predictions or readily 'overlooking' or discarding more complex or refuting evidence

# Certainty

Sources of scientific certainty:

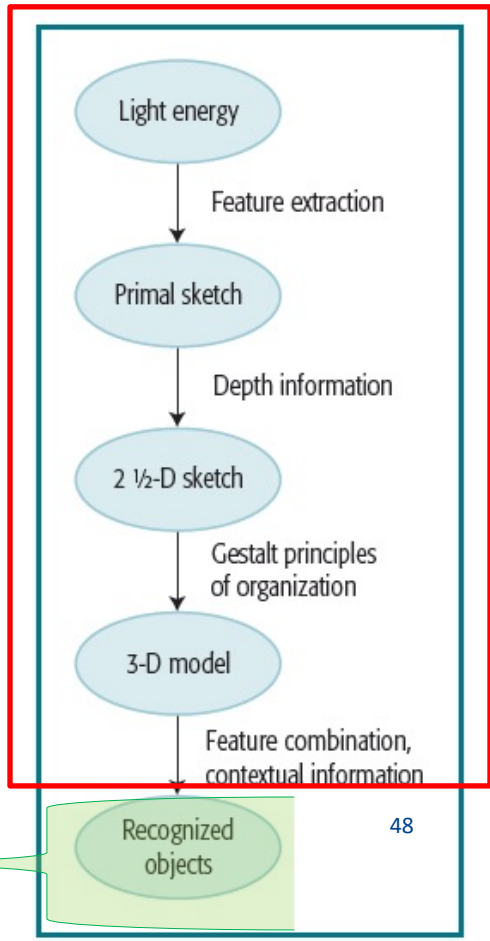
- Statistical certainty = trust your results over your beliefs
- Symptom-driven certainty = see the whole picture instead of just its parts
- Action-driven certainty = test your observations by implementing actions (e.g., experiments or treatments)
- Direction-driven certainty = if something isn't working as expected, try to figure out what

# Your Questions

- What is the difference between early and late visual processing?

- ANSWER: Early processing is when you process the raw sensory information (bottom up). Late processing is when you become aware of relevant information and integrate higher-level information, like meaning and context (top down).

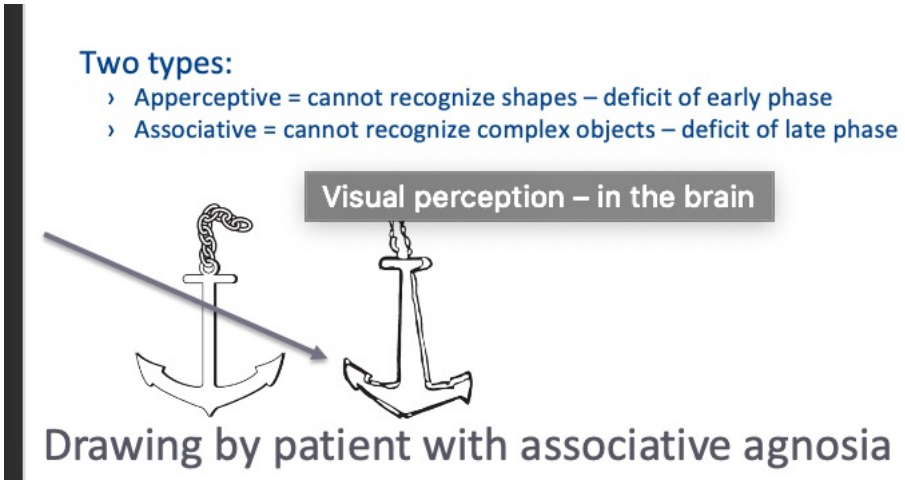
Early




Late

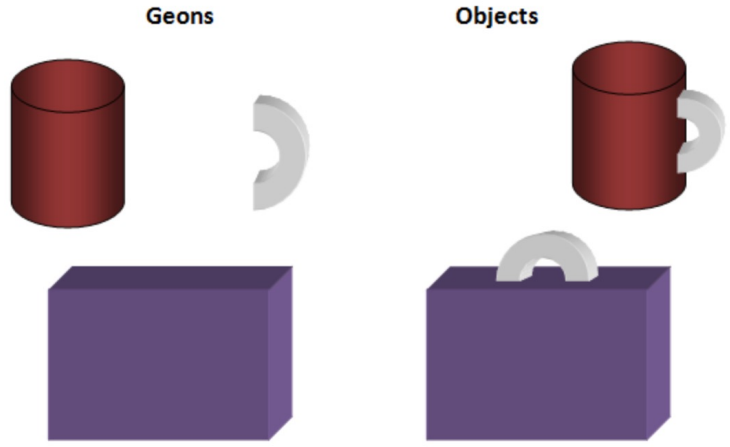
› What is the second type of agnosia?

› ANSWER: Associative agnosia - Cannot recognize complex objects like an anchor. Patient sees individual shapes but not the “big picture”.



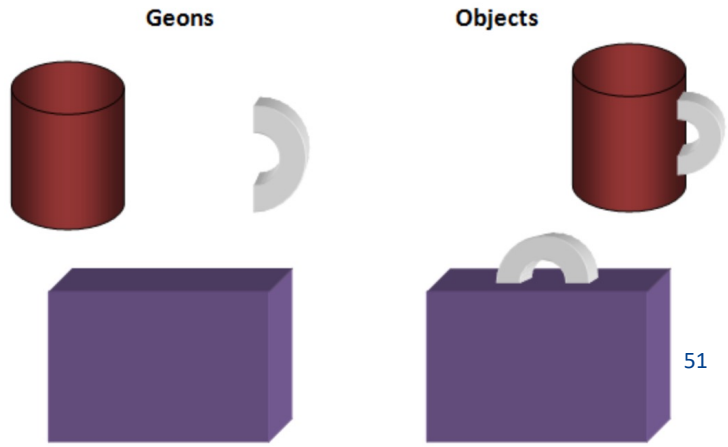
› Explain recognition-by-components theory.

› ANSWER: When recognizing an object, we break it down into parts. We don't just see a mug or suitcase, we recognize a mug by seeing a cylinder and a handle. Biederman called these parts geons, because they are simpler geometric shapes that can be common to multiple objects.



› What is Biederman's critical assumption?

› ANSWER: His critical assumption is that object recognition relies, first, on component recognition. For example, if you don't recognize the semi-circle shape of the handle, then you won't recognize the mug.



- When a neuron is exposed to a stimuli, on of two things can happen, it can de-polarize or hyper-polarize based on the chemical signals from the stimuli, but how do we know how the neuron will react? Are there certain chemicals that elicit de-polarization and others that elicit hyper-polarization?

- ANSWER: The short answer is yes. There are many factors that influence depolarization. This video explains the basic mechanics (starting around 1:14): https://www.youtube.com/watch?v=oa6rvUJlg7o&t=2s

# Bonus

I came across a press release for a new technology that will allow neurons to be observed firing without invasive surgical procedures. So, the possibility exists now, and just needs to be used by enough scientists to make meaningful, replicable observations:

https://news.stanford.edu/2018/12/12/watching-brain-cells-fire-real-time/

## Stanford researchers develop a method to watch as neurons fire without invasive electrodes or chemical modifications

*Brain scientists have plenty of ways to track the activity of individual neurons in the brain, but they're all invasive. Now, Stanford researchers have found a way to literally watch neurons fire – no electrodes or chemical modifications required.*