



Introduction

ICS 280: Visual Perception
Aditi Majumder



Perception is taken for granted!





Perception is very complex

- Perceive
- Locate
- Identify/Recognize
 - Different objects
 - Their relationship with each other
 - Qualitative and Quantitative
- Act based on these information

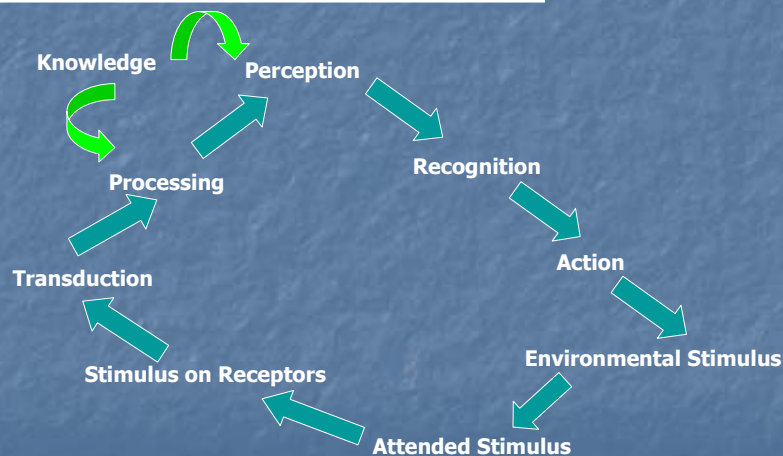
It is a miracle that we do not cause accidents/mistakes every now and then

Slide 3

ICS 280: Visual Perception



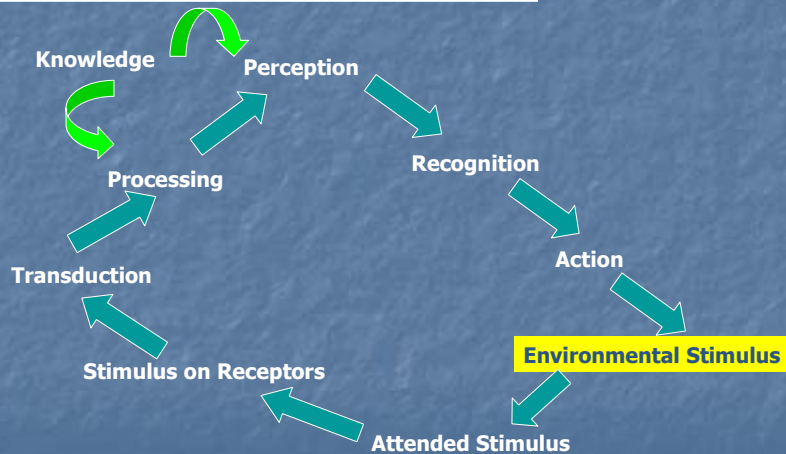
Perceptual Process



Slide 4

ICS 280: Visual Perception

Perceptual Process



Slide 5

ICS 280: Visual Perception

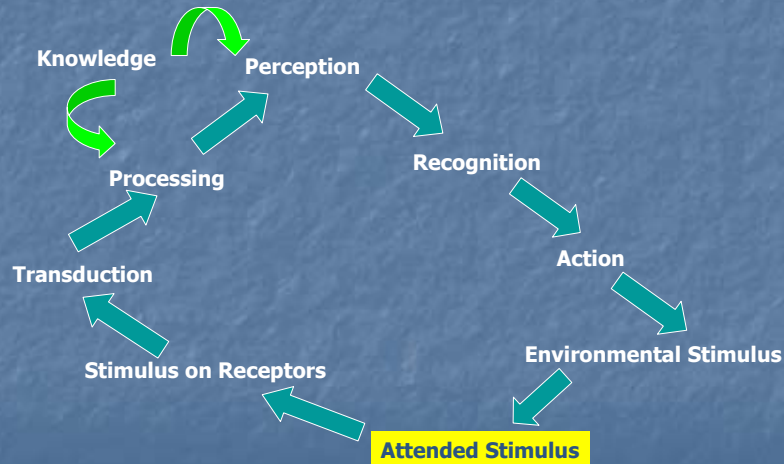
Environmental Stimulus

- Anything in our environment that we can perceive
- Can be anything we can sense
 - See, hear, touch, smell
- Mary goes to circus
 - Takes seats, observes animal in center stage, trapeze on the ceiling, band on the right, clowns in the side
 - Constitutes the environmental stimulus

Slide 6

ICS 280: Visual Perception

Perceptual Process



Slide 7

ICS 280: Visual Perception

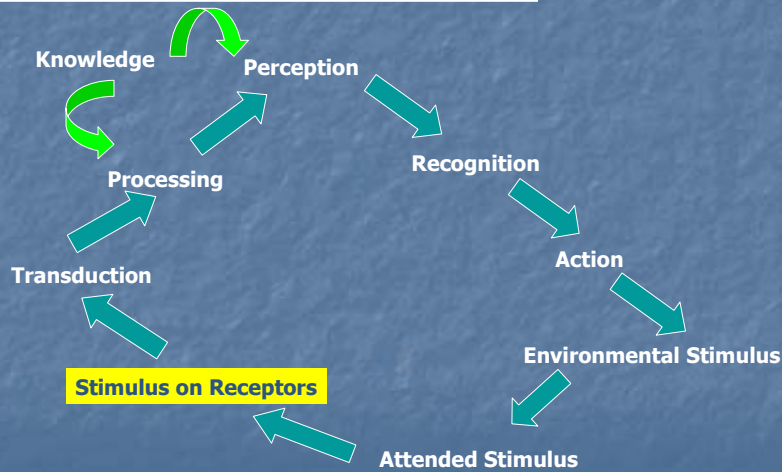
Attended Stimulus

- A part of the environmental stimulus
- Focuses attention on this stimulus
- Mary focus her attention on the center stage animal by looking at it directly

Slide 8

ICS 280: Visual Perception

Perceptual Process



Slide 9

ICS 280: Visual Perception

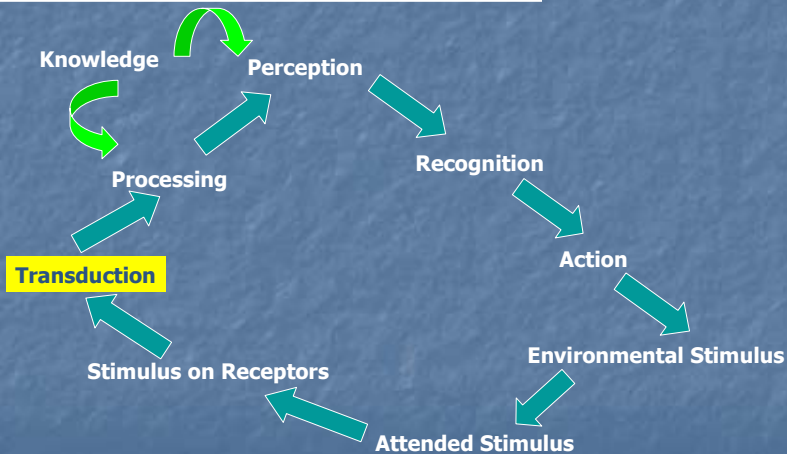
Stimulus on Receptors

- The attended stimuli excites the receptors
- For example
 - Visual stimulus forms a image on the retina
 - Sound changes pressure to affect the ear drum
- Note
 - We do not 'perceive' the image on the retina
 - It is just one of the initial steps of the process

Slide 10

ICS 280: Visual Perception

Perceptual Process



Slide 11

ICS 280: Visual Perception

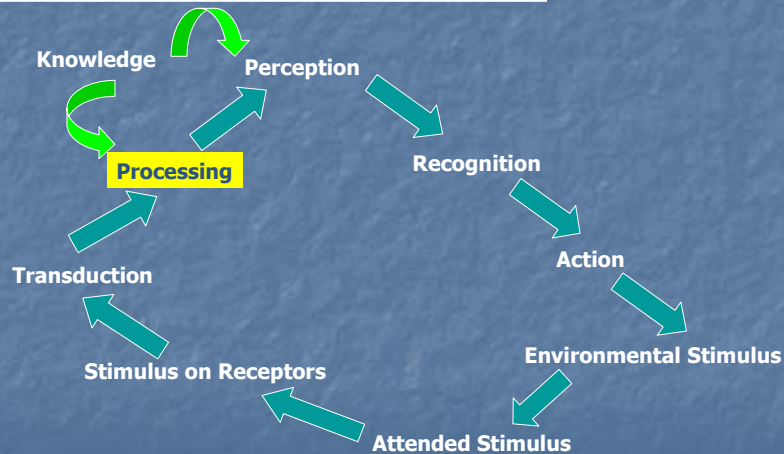
Transduction

- Transformation of one form of energy to other
- Environmental energy transformed to electrical energy
- The image on the retina generates electrical signals in the tens and thousands receptors of the eye

Slide 12

ICS 280: Visual Perception

Perceptual Process



Slide 13

ICS 280: Visual Perception

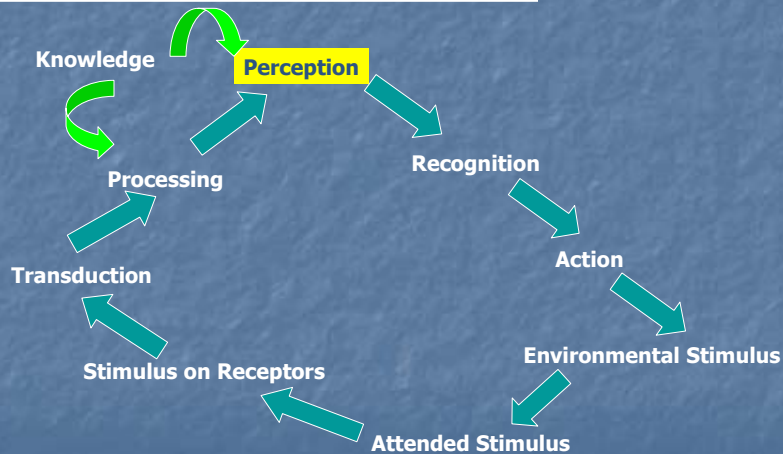
Neural Processing

- Neurons are elements of nervous system
- Interconnected together
- Processing of the electrical energy by the neurons while they travel through them
 - This changes the electrical energy in various ways

Slide 14

ICS 280: Visual Perception

Perceptual Process



Slide 15

ICS 280: Visual Perception

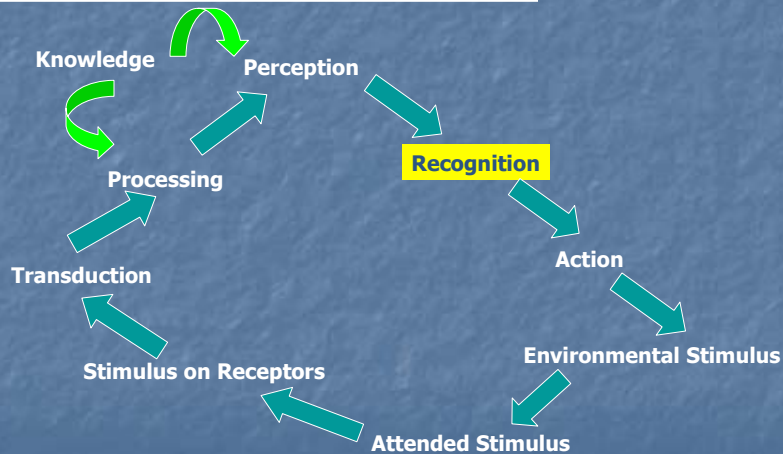
Perception

- Conscious sensory experience
- Electric energy transforms in brain to some experience
- Is this the end of perception?
 - Recognition and action are important outcomes of the perceptual process

Slide 16

ICS 280: Visual Perception

Perceptual Process



Slide 17

ICS 280: Visual Perception

Recognition

- Identifying the experience as something
 - Known
 - Similar to some experience before
- If this fails, people may be in grave trouble
 - Visual form of agnosia

Slide 18

ICS 280: Visual Perception



Visual form of agnosia

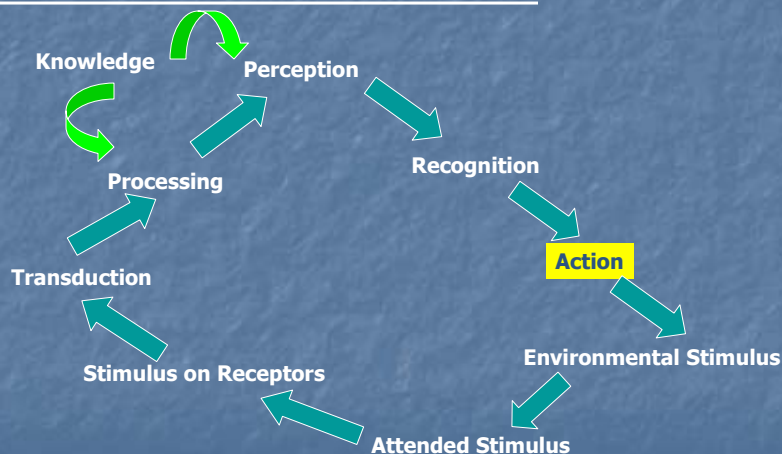
- Dr. P found he cannot recognize students but can tell their name from their voices
- Started conversation with parking meters or expected furniture to talk to him
- Was he blind?
 - Eye examination showed no problem
- Inability to recognize objects due to a tumor in brain
- When show a gloves, he told
 - *a continuous surface, unfolded by itself, with five outpouchings*
 - *Maybe a container or a purse to keep coins to different sizes*
- He can **perceive** an object, identify parts of it, but cannot assemble the parts **perceptually** to recognize it

Slide 19

ICS 280: Visual Perception



Perceptual Process



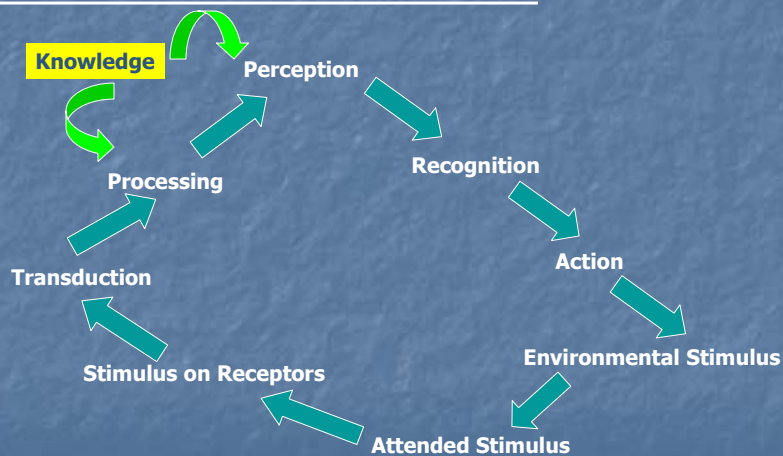
Slide 20

ICS 280: Visual Perception

Action

- Goal of perception is to create action
 - Evolutionary reason for development of perception
- Motor activities
- Response to perception and recognition
- Leads to
 - New attended stimulus
 - Whole cycle repeats

Perceptual Process



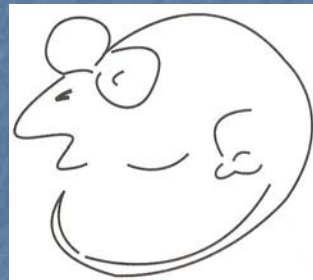
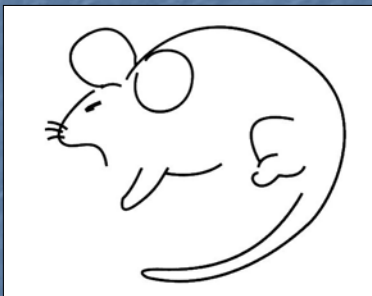
Knowledge

- Affects
 - Processing, Perception, Recognition
- Identification from memory
 - Old knowledge
 - Recent knowledge
- Mary's example
 - Compare the image of tiger with the 'conception' of tiger in her memory
 - Retrieve the name 'tiger' that goes with it

Slide 23

ICS 280: Visual Perception

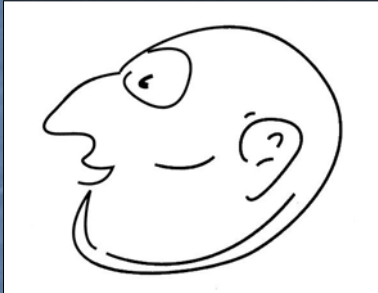
Cognitive Influences on Perception



Slide 24

ICS 280: Visual Perception

Cognitive Influences on Perception



Slide 25

ICS 280: Visual Perception

Visual Perception

- Vision plays preeminent role for humans
- Evolutionary history
 - Vision was developed to aid survival and successful reproduction
 - Used to get nourishing food, safe shelter and strong mates

Slide 26

ICS 280: Visual Perception



Why Vision is so Important?

- Vision is preeminent
- Only sense that provides accurate spatial information from a distance
 - Smell and hearing provides information from a distance but not accurate
 - Touch and taste provide very accurate information but only on contact
- Vision helps us most to keep away from danger
- Vision is a veridical perception
 - *What you see is what you get*

Slide 27

ICS 280: Visual Perception



Studying Perceptual Process

- Levels of Analysis (At different scales)
- Bottom Up
 - Starting from the stimulus towards perception
- Top Down
 - Starting from knowledge
- We will study both and cross refer

Slide 28

ICS 280: Visual Perception



Studying Perceptual Process

- Psychophysical
 - Relationship between stimulus and perception
 - What?
- Physiological
 - Relationship between the processes within a person and perception
 - How?

Slide 29

ICS 280: Visual Perception



Psychophysical Approach

- Description
- Recognition
- Detection
- Magnitude
- Search

Slide 30

ICS 280: Visual Perception



Psychophysical Approach

- Description
- Recognition
 - Qualitative
 - Used by doctors
- Detection
- Magnitude
- Search
 - Quantitative
 - More important for study and research

Slide 31

ICS 280: Visual Perception



Detection

- Absolute threshold
 - Smallest amount of stimulus required to generate detectable perception
- Difference threshold
 - Smallest difference between two stimulus that a person can detect
- Sensitivity = $1/\text{threshold}$

Slide 32

ICS 280: Visual Perception



Absolute threshold

- Is absolute threshold possible?
 - Probably not
- Measured by
 - Method of limits
 - Method of adjustment
 - Method of constant stimuli

Slide 33

ICS 280: Visual Perception



Absolute threshold

- Measured by
 - Method of limits
 - Presents stimuli in ascending or descending order
 - Method of adjustment
 - Method of constant stimuli

Slide 34

ICS 280: Visual Perception

Method of Limits

Intensity	1	2	3	4	5	6	7	8
105	Y						Y	
104	Y		Y		Y		Y	
103	Y		Y		Y		Y	
102	Y		Y		Y		Y	
101	Y		Y		Y		Y	Y
100	Y	Y	Y	Y	Y		Y	Y
99	Y	N	Y	N	Y	Y	Y	Y
98	N	N	Y	N	N	N	N	Y
97		N	N	N		N		N
96		N		N		N		N
95		N		N		N		N
Crossover values	98.5	99.5	97.5	99.5	98.5	98.5	98.5	97.5

Results of using
method of limits

Slide 35

ICS 280: Visual Perception

Absolute threshold

- Measured by
 - Method of limits
 - Presents stimuli in ascending or descending order
 - Method of adjustment
 - Subject controls the strength of stimulus
 - Method of constant stimuli

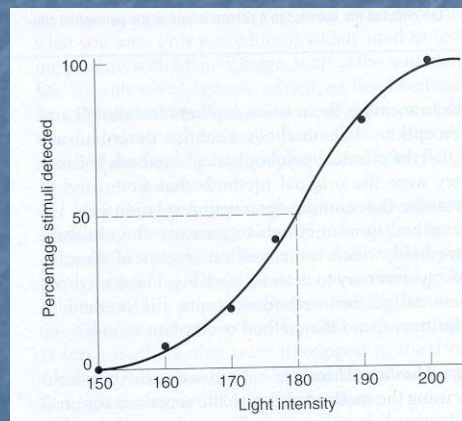
Slide 36

ICS 280: Visual Perception

Absolute threshold

- Measured by
 - Method of limits
 - Presents stimuli in ascending or descending order
 - Method of adjustment
 - Subject controls the strength of stimulus
 - Method of constant stimuli
 - Presents stimuli of random strength in random order

Method of Constant Stimuli





Measuring Absolute Threshold

- Method of limits and adjustment
 - Errors due to anticipation
 - Fast
- Methods of constant stimuli
 - Most reliable
 - Slow
- Is it bias free?
 - How do we eliminate it?

Slide 39

ICS 280: Visual Perception



Difference Threshold

- 'Standard weight' compared with 'comparison weight'
- The 'comparison weight' is increased from 'standard weight' unless the change is detected
- The detectable change is a function of the 'standard weight'

Slide 40

ICS 280: Visual Perception



Weber Law

$$\frac{\text{Difference Threshold}}{\text{Standard Weight}} = K$$

Weber fraction

Slide 41

ICS 280: Visual Perception



Psychophysical Approach

- Description
- Recognition
 - Qualitative
 - Used by doctors
- Detection
- Magnitude
- Search
 - Quantitative
 - More important for study and research

Slide 42

ICS 280: Visual Perception

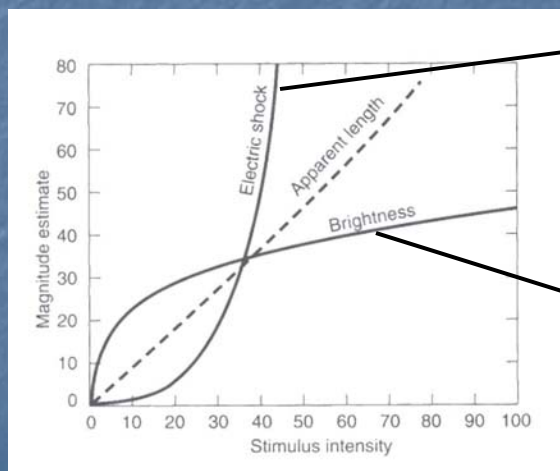
Magnitude

- Threshold measures detectable changes
- How to measure what happens once we are past the threshold?
- Magnitude Estimation
 - Present subjects with different strength of stimuli at random
 - Ask them to number the strength of perception
 - Plot these to estimate the magnitude

Slide 43

ICS 280: Visual Perception

Response



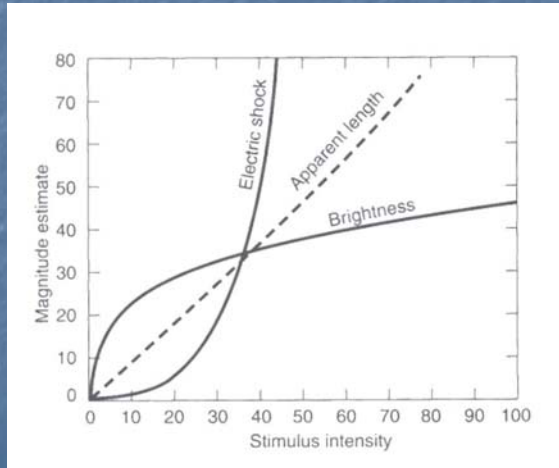
Response
Expansion

Response
Compression

Slide 44

ICS 280: Visual Perception

Steven's Power Law



Slide 45

$$P = KS^n$$

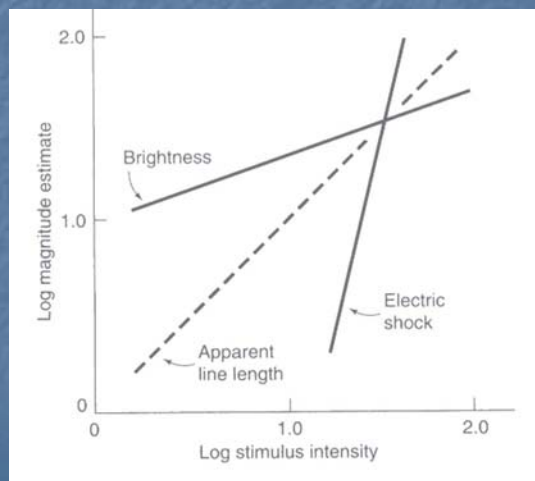
P = Perception
S = Stimulus
Strength

$n > 1.0$ (Expansion)

$n < 1.0$ (Compression)

ICS 280: Visual Perception

Steven's Power Law



Slide 46

$$P = KS^n$$

P = Perception
S = Stimulus
Strength

$n > 1.0$ (Expansion)

$n < 1.0$ (Compression)

ICS 280: Visual Perception



Adapted to Functions of Organisms

- Bright sunlight would not appear very bright since $n=0.6$
- If $n>1.0$
 - Brightness of outdoor scenes would not allow us to see anything inside
 - May even impair our ability to see

Slide 47

ICS 280: Visual Perception



Adapted to Functions of Organisms

- For electric shock, small changes cause large perception of pain
- Acts as a warning mechanism
- So that we can react before much damage is done

Slide 48

ICS 280: Visual Perception



Physiological Approach

- Sensors have receptors that transduce environmental energy to electrical energy
- Nerves carry these signals to the brain
- Processing in brain leads to the experience of perception



Intrigued people for a long time

- Anatomical structures used for operation of mind
 - 384-322 B.C. – Aristotle told that the heart and not the brain is the seat of mind and soul
 - Not many repeated his mistake
- Brain is the seat of mind and soul
- Theories proposed were limited by the technology of the day



Intrigued people for a long time

- 130-200 A.D. : By Greek physician Galen
 - Like aqueducts and sewer system of brain
 - Human health, emotions and thoughts are determined by four fluids flowing from the center of the brain
 - This theory was popular for next 1500 years



Intrigued people for a long time

- In early 1600s
 - By Rene Descartes
 - Human body operated like a machine popular in that era
 - By Johannes Kepler
 - Eye operated like an optical instrument projecting light on to the retina
 - Partially true but did not explain the physiological processes that followed



Intrigued people for a long time

- End of 19th century
 - Showed that electrical energy flows down the nerve
 - Can measure electrical signals in brain to assure brain activity

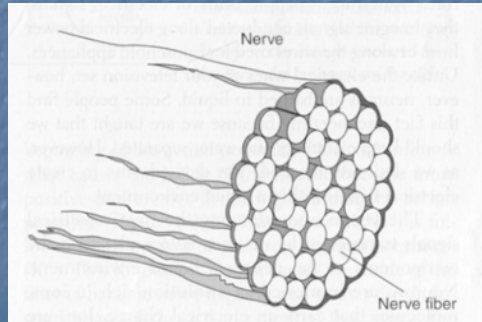


Neurons

- Nerves are made of neurons
- Three parts of a neuron
 - **Cell Body**: Has the elements to keep it alive
 - **Dendrites**: Branches out from cell body to *receive* signals from other neurons
 - **Axon**: Tube filled with fluid that *conducts* the electrical signals

Nerve

- The nerve is formed by a bunch of axons



Perception

- Recording of electrical signal in receptors
- Transmission of signals to the brain
 - Some low level processing occurs at this time
- Processing in brain



Receptor Neuron

- This is a special type of a neuron present in sensors
- Have a receptor (transducer) in place of a cell body

Slide 57

ICS 280: Visual Perception



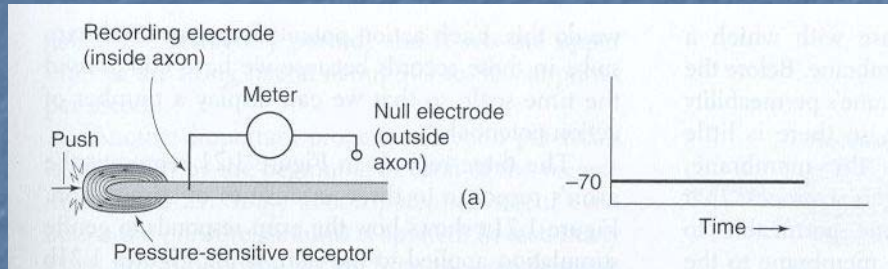
Recording the Electrical Signal

- At the receptor
- Electricity is not carried in the nerves as electricity is carried to our home
- Neurons are immersed in solutions rich in *ions* (molecules carrying electrical charge)
- The solution outside the axon is rich in Na^+
- The solution outside the axon is rich in K^+

Slide 58

ICS 280: Visual Perception

Resting Potential

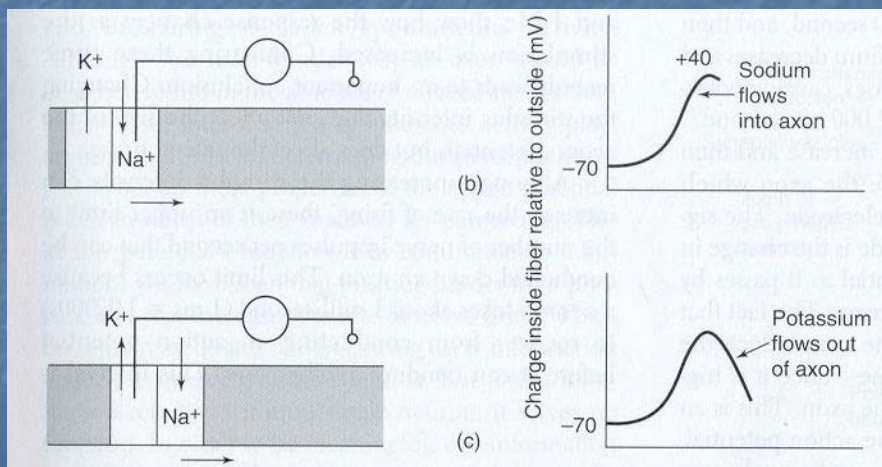


At normal state, the difference of charge is -70 mV

Slide 59

ICS 280: Visual Perception

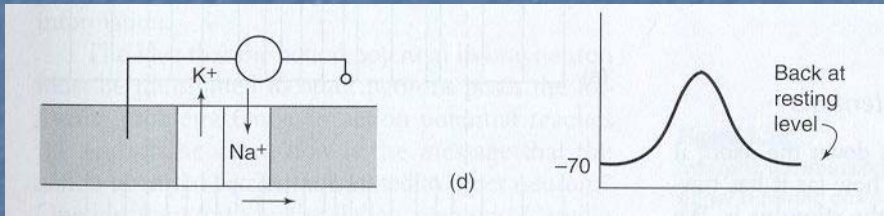
Action Potential (Nerve Impulse)



Slide 60

ICS 280: Visual Perception

Back to Resting Potential



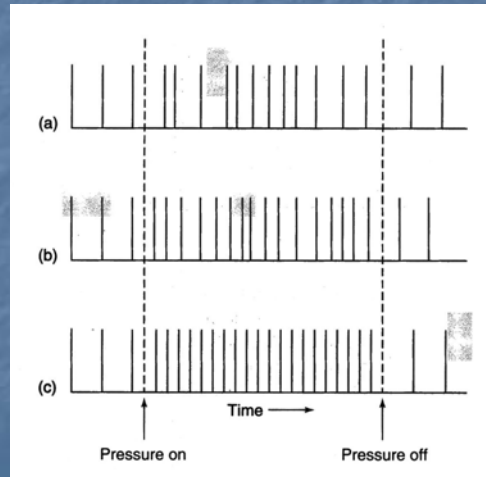
Sodium and potassium ion concentration goes back to normal by a process called **sodium-potassium pump**

How is it caused?

- Change in the permeability of the axon membrane
- Before stimulus, the permeability to sodium and potassium is low
- The receptor when excited triggers a process which increases this permeability
- Everything happens in *1ms*
- **Propagated response:** This action potential travels through the axon

Strength of Signal

- Action potential magnitude is always same
- How is strength of stimulus denoted?
 - Rate of firing



Slide 63

ICS 280: Visual Perception

Rate of Firing

- After every firing there is a *refractory period of 1ms*
- This limits the maximum firing rate to a maximum of 800 pulses per second
- In the normal state, there is some firing called *spontaneous activity*

Slide 64

ICS 280: Visual Perception



Transmission of Electrical Signals

- From one neuron to another
 - End of axon of one neuron to dendrite of another
- No physical contact between neurons
- **Synapse:** Small space between neurons
 - Discovered by Spanish anatomist Santiago Ramon Cajal
 - Won Noble Prize for this in 1906

Slide 65

ICS 280: Visual Perception



Synapse

- Electrical signal triggers a chemical process in the synapse that is instrumental in transmitting the signals
- Presynaptic Neuron: From whom the signal is transmitted
- Postsynaptic Neuron: The one who is receiving the signal

Slide 66

ICS 280: Visual Perception



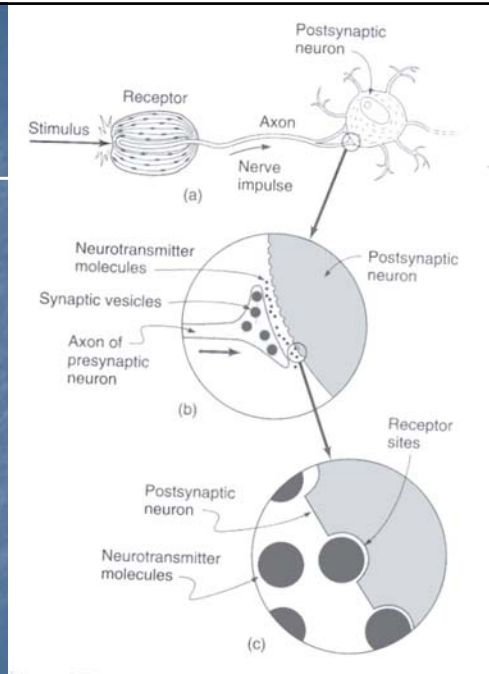
Synapse

- Axons of neurons have *synaptic vesicles* that can release *neurotransmitters*
 - Neurotransmitters can be of different shapes
- Dendrites of neurons have *receptor sites*
 - Receptor sites can be of different shapes too



Synapse

- When electrical energy reaches the end of presynaptic neuron
 - Releases the neurotransmitters
- If the shape matches the receptor site in postsynaptic neuron
 - Generates electric energy again
- Transmission is controlled by the type of neurotransmitters generated



Slide 69

ICS 280: Visual Perception

Synapse

- Electrical signals transmitted may not be identical to the presynaptic neuron
- Can be *excitation* or *inhibition*
- Low level processing while transmission

Slide 70

ICS 280: Visual Perception



Brain

- Cerebral Cortex
 - 2mm thick layer that covers the surface of the brain
 - Used for perception, language, memory and thinking
- Modular organization



Brain

- Primary Receiving Areas
 - First areas in Cerebral Cortex to receive the signals
 - Occipetal lobe: For eye
 - Temporal lobe: For ear
 - Parietal lobe: For skin
- Advanced processing
 - Involves other areas of the brain too

Studying Brain Activity

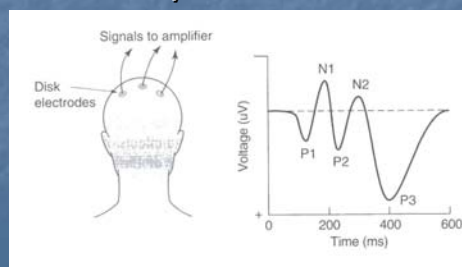
- Neuropsychology
 - Studying the effects of brain damage on behavior
- Microelectrodes on cats and monkeys
 - Intrusive

Slide 73

ICS 280: Visual Perception

Studying Brain Activity

- Now can study on humans by less intrusive disk electrodes
 - Can study *evoked potentials*
 - Record activity of thousands of neurons



Slide 74

ICS 280: Visual Perception

Neuroimaging

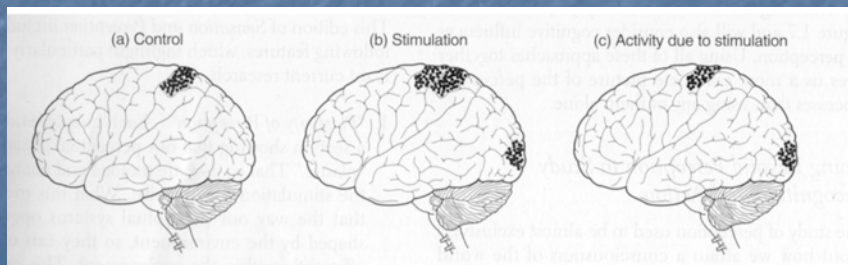
- Using positron emission tomography (PET)
- Person is injected with low activity radioactive tracer (not harmful)
- This tracer indicates volume of blood flow
- Basic concept:
 - Activity in brain is accompanied with changes in the volume of blood flow
 - Monitoring blood flow

Slide 75

ICS 280: Visual Perception

Subtraction technique

- Find state before stimulus
- Find state after stimulus
- Difference gives what was caused by stimulus



Slide 76

ICS 280: Visual Perception



Functional Magnetic Resonance Imaging (fMRI)

- Hemoglobin has iron
- If presented with magnetic field, they line up like tiny magnets to indicate volume of blood flow
- Especially, with activity hemoglobin loses some of its oxygen making it more magnetic
- Popularly called *Brain Scan*