PSYC236 Study Notes (weeks 1-3)

Introduction to vision

The problem

- Sensation is when the sensory organs/receptors are stimulated by a distal stimulus
- Perception is the brain's interpretation and organisation of the information
- Acuity decreases with eccentricity (vision becomes more blurred far away from the point of fixation/centre of vision)
- Distal stimulus = the object emitting the light energy
- Proximal stimulus = image on retina
- Half the brain is involved in perception
- Axon = nerve fibre/neuron which transmits info through neural impulses
- Action potential = electric current with info
- Eccentricity = the angular distance from the centre of the visual field or from the fovea
- Accommodation = making front or back thing in focus (ciliary muscles, lens)

The eye

- Lens = focuses light energy onto the retina
    - Distant vision = ciliary muscles relax, fibres taut and lens skinny
    - Close vision = ciliary muscles contracted, fibres slack and lens rounded/fatter
- Aqueous humour = watery liquid that flows from the ciliary body (pressure is important)
- Vitreous humour = gelatinous substance that keeps the eye's shape
- When light increases the iris constricts and the pupil becomes smaller

The retina

- Image on retina is upside down and two-dimensional
- Retina = light-sensitive layer on back of eye with the photoreceptors
    - Photoreceptors (detect light) > bipolar cells (tells retinal ganglion cell the receptor sees something) > ganglion cell axons carry info from the eye to visual cortex
    - Horizontal cells = point where receptors connect to bipolar cells & amacrine cells = point where bipolar cells connect to ganglion cells
- Reason for "inverted retina" (nerve layer on top) = <u>transduction</u> (turning of light energy into electrochemical energy within the nervous system)
    - Inverted retina also causes "blind spot" (no photoreceptors) in vision

Fovea versus periphery

- Fovea:
    - Tasks of high visual acuity such as reading, fine motor skills or texture recognition almost exclusively in the fovea
    - Half of info sent to cortex from fovea
    - High spatial resolution
    - 2 bipolar cells per receptor
    - Low sensitivity (because mostly cones)
    - Very high receptor density but 1% of cells
    - Macula inside retina

    - Parafoveal vision = surrounding the fovea
- Periphery:
    - Low spatial resolution
    - Many receptor cells per bipolar cells
    - High sensitivity (because mostly rods)
    - low receptor density but 99% of cells

The photoreceptors (rods & cones)

- 2 types of photoreceptors = rods and cones
- Rods:
    - All contain the photo pigment *rhodopsin*
    - Rods respond well to dim light & used at night (more sensitive than cones)
    - When only rods are active = *scotopic,* when too bright for rods to function = *photopic,* when both used = *mesopic*
    - Most sensitive to green light
    - Completely absent from the Fovea, mostly concentrated in the periphery
- Cones:
    - Long (red), middle (green) & blue (short) cones are sensitive to different wavelengths of light and are why we have colour vision
    - Used for most of our daytime vision
    - Most sensitive to yellow light
    - Heavily concentrated in the central area of the retina called the *Fovea*
    - No blue cones in the Fovea
    - Congenitally colour-blind people may be missing their red or green cones

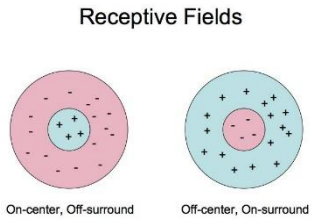
Retinal Ganglion cells

- Each photoreceptor in the retina is connected to its 'own' ganglion cell
- Midget = high spatial resolution
- 3 types of ganglion cells in the retina:
    - Midget (parvo in LGN) cells = 80-90% of all retinal ganglion cells
    - Parasol (magno in LGN) cells = 5-10%
    - Small-bistratified (konio in LGN) = 5-10%
- All cells send their visual signals to the LGN (lateral geniculate nucleus)
- Dendritic trees:
    - Midget = small cells and dendrites
    - Parasol = large and condensed dendrites
    - Small-bistratified = largish dendrites more sparse
- Information type:
    - Midget = carry colour information (green-red on) < small receptive fields > slow
    - Parasol = carry info about movement < large receptive fields < fast
    - Small-bistratified = carry colour information (blue-on) < large receptive fields

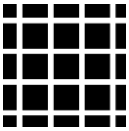
Retinal ganglion cells and receptive fields

- Put electrode near ganglion cell > can hear sound of action potentials firing
- Baseline activity level = low level of spontaneous action potential firing

- Receptive field = area over retina over which the behaviour of the cell can be directly influenced
    - point light on, increase/decrease in action potentials
    - ON region = light increases in firing, OFF region = light decreases firing
    - With ON-centre unit, centre (maximum excitation/has Excitatory input) & Surround (maximum inhibition)
    - Light on centre and surround = cancel out
    - Retinal ganglion cells do not respond to changes in the overall brightening of whole visual field
    - Only interested in edges to make up a picture (ignore Useless information)



Effects of retinal processing



- Ganglion cells have "antagonistic" receptive fields = the surround does the opposite of the centre
- Lateral inhibition = the capacity of an excited neuron to reduce the activity of its neighbours
    - An ON-centre receptive field located at an intersection has much more light in its inhibitory surround, meaning more lateral inhibition, reduces firing. A neighbouring ganglion cell not at an intersection (less light on surround) will be firing faster. The visual system interprets this as being lower brightness and thus why we see the grey spot
    - Reason don't see grey spot when directly looking = receptive fields in fovea are smaller than in the periphery, too small to span the width of the intersection
- Hermann grid = example of lateral inhibition

The optic nerve

- Optic nerves > optic chiasm > optic tract > LGN
- Left-hand nerve fibres carry info from right visual-field

The LGN (relay point on way to cortex)

- Sends info to cortex
- Ipsilateral eye (eye on same side) & contralateral eye (eye on opposite side)
- Has 6 layers = ganglion cell axons from right eye terminating in 3 layers, and ganglion cells axons from the left eye terminating in the other 3
- Retinotopic mapping = ganglion cells adjacent in the retina (also from adjacent directions in the visual world) will project to cells adjacent in the LGN.
    - Forms a map of the visual world where adjacent cells receive info from adjacent parts of the image until all the image is ocvered
    - Each LGN has 6 maps (one in each layer) on top of each other
    - Left LGN = right visual field, right LGN = left visual field
- Small-bistratified between the layers in the LGN
- Parvo = layers 3,4,5,6 & magno = layers 1,2

The Primary visual cortex (V1)

- Located in the occipital lobe, largest of the visual areas
- Has about 140 million neurons (40x of LGN, 140x of the retina)
- Also called "striate cortex" (striped)

- V1and has several overlapping sub maps, such as ocular dominance, orientation preference, colour preference, spatial frequency
- Has stripy appearance because of layers which receive info from different places
- Different ganglion cells project info to different layers in the V1
- Receptive field properties of the ganglion cells change in the V1
    - Crucial stimulus is elongated lines not circles (for each cell the line has to be a particular orientation/angle)
- The left V1 maps the right visual field and vice-versa
- Each cell has its own 'preferred' orientation and within a small area of the cortex there will be a cell for all possible orientations
- Types of cells:
    - Simple cells = receptive fields with discrete ON and OFF regions
    - Complex cells = also responsive to orientated lines but do not show discrete ON and OFF regions. Give same response right across receptive fields (phase insensitive).
    - Hypercomplex cells = reacts to the orientation but also length of the bar
- What causes cell to fire = *trigger feature*

Beyond V1 – the extrastriate areas

- Other areas of the brain involved with vision (30 all up)
- Possible that there are very specific cells which fire because of very specific triggers

Perception

Perception theories

- Constructivism – (top-down approach)
    - Retinal image/info from sensation inadequate
    - Have to construct percepts from the data using assumptions/prior knowledge
    - Flaw = even though we have knowledge of a visual illusion it will still persist
- Direct perception (bottom-up approach)
    - Start at simple analysis of raw data to ever-increasing complexity
    - Environment is visually-rich enough to make sense of the world in a direct way
- Information processing (best)
    - Compares the mind to a computer/we are information processors
    - There are multiple stages of processing

Visual illusions

- Size-after effect = after adapting to a skinny stripes, medium stripes look fatter
- Simultaneous tilt = things different size/angle depending on what surrounds them
- Spatial vision = our ability to resolve or discriminate spatially defined features. The 2 primary measures of spatial vision are acuity and contrast sensitivity