

PYB 204 Exam Revision Guide

- 50 multiple-choice questions
- 50% exam

Week 1: Intro

What is cognitive psychology?

- Cognitive psychology = studies mental processes → how the mind is organised to produce intelligent thought and how it is realised in the brain
 - Intelligent thought – how we think, reason, solve problems, remember things, and make decisions
 - Realised in the brain = how neurons, brain regions, and neural networks carry out those mental processes
- Cognitive psychology = re-defining psychology as the science of human information processing
- Looks at the internal processes that influence how we understand and interact with the world
- Understanding the information processing that goes on in the human mind

Why do we study cognitive psychology?

- So we can understand mechanisms governing human thought, which is useful for studying:
 - Why certain thought malfunctions occur (clinical psychology)
 - How people behave with other individuals (social psychology)
 - How financial decisions are made (business and economics)
 - False memory and eyewitness testimony
 - Spatial navigation and the design of autonomous robots/cars
 - Understanding brain disorders = research on navigation systems and Williams Syndrome

Williams syndrome

- loss of 26-28 genes, which affects navigation and processing visuospatial information
- their spatial navigation is not entirely impaired → they can learn repeated routes better than age-matched healthy individuals
- humans have 2 distinct navigation systems: response-based and place-based
- Response-based system is affected

Week 2: Vision

- we can recognise objects reliably in a dynamic and changing environment

light

- for us to see an object it must either emit or reflect light
- light is called electromagnetic radiation, which is generated when an atom emits a photon
- energy of photons = wavelength
- the human eye can only detect light within a narrow range of wavelengths
- different wavelengths = perception of different colours e.g., short wavelength = ultraviolet light

eye movements (saccades)

- eyes constantly move = saccades
- if an image stays in the exact same spot on your retina, your photoreceptors stop sending signals about it, as a result the image seems to fade or disappear even though it is still there
- we all have a stationary blind spot where the optic nerve enters the eye, and we are just unaware of it because our brain fills in the missing details

accommodation – how the eye's lens changes shape to focus on objects at different distances

- lens round (thicker/more curved) = when focusing on near objects e.g., reading a book
 - ciliary muscles contract = lens becomes rounder/thicker
- lens flat (thinner/less curved) = when focusing on far away objects e.g., looking at a mountain
 - ciliary muscles relax = lens flattens
- the ciliary muscles control the shape of the lens to accommodate near or far targets

vergence & stereopsis – how our eyes work together to perceive depth and 3D space

- vergence = the simultaneous movement of both eyes in opposite directions to maintain single vision when focusing on an object
 - convergence and divergence
 - see one clear image instead of double vision
- stereopsis = the brain's ability to perceive depth using the slightly different views from each eye
 - each eye sees the world from a slightly different angle (binocular disparity). The brain combines these images to judge distance and depth

- judge how far away objects are

cones vs rods

Cones	Rods
<ul style="list-style-type: none"> • colour vision • high acuity – can see very fine details • work primarily in bright light – daylight photopic vision 	<ul style="list-style-type: none"> • black and white vision • low acuity – widely spaced • works well at nighttime – scotopic vision

Overview of retinal physiology

- receptor cells synapse with bipolar cells
- bipolar cells synapse with ganglion cells
- horizontal cells connect different receptor or different bipolar cells
- amacrine cells connect different bipolar or different ganglion cells
- these connecting cells allow events at one location to influence events at another
- massive convergence as we move deeper into the retina: on average 126 receptors connect to 1 ganglion cells
- process of information reduction

functional organisation of the retina – how the photoreceptors and retinal neurons work together to process visual information

- ganglion cells – like a lens on part of the visual field, combine points over a small area, like a lens, enhancing contrast and patterns
- the cells are highly interconnected to make vision shaper and more informative
- receptors – raw point of light (rods and cones)
- ganglion cells = act as a lens, capturing an image over an area of the retina
 - can enhance the image in its local area

lateral inhibition

- a process that enhances contrast and sharpens visual signals
- it occurs when activated photoreceptors inhibit the activity of their neighbouring receptors
- as a result, edges and contrasts appear sharper because bright areas suppress the response of adjacent darker areas
- the experiment Hartline, Wagner, Ratliff showed adjacent receptors inhibit each other, so the ganglion cell's response is enhanced for contrast at the edges of the stimulus

lateral geniculate nucleus

- the LGN has a map of your retina
- it responds to spots of light just like retinal ganglion cells
- LGN cells get signals back from the visual cortex. This feedback lets the LGN adjust its responses based on previously processed information

The tectopulvinar system

- Functions = localisation of objects in space, guidance of eye movements, and gross pattern perception
- These structures are located in the tectum
- Cells in the superior colliculi have receptive fields on the retina and receive their input from retinal ganglion cells
- The tectopulvinar system also receives back projections from the cortex
- Cells are organised in topographic maps

Schneider's hamster experiment

- LGN removed = hamster could not recognise patterns (LGN critical for identifying objects)
- Superior colliculi removed = hamsters could recognise patterns but couldn't move accurately towards them (colliculi critical for locating objects in space and guiding movements)
- There are 2 separate visual pathways
 - 1. Focal system = "what" system, involves the LGN (visual cortex). It is responsible for recognising and identifying objects (shape, colour, pattern)
 - 2. Ambient system = "where/how" system, involves the superior colliculi (other brain areas). It is responsible for localisation, movement, and guiding actions towards objects
- Blindsight = some people with damage to the focal system (visual cortex) cannot consciously see objects, but can still react to them
 - E.g., they might point to a light without being aware of seeing it
 - Shows the ambient system can still function

The visual cortex

- LGN cells send their visual signals to V1, the first area in the occipital lobe at the back of the brain where visual information is processed
- Layer IV = basic light/contrast detection
- Other layers = more complex feature detection e.g., edges, orientation, motion

Feature detectors in the primary visual cortex

- There are special neurons in the visual cortex that respond to specific aspects of a visual scene, helping the brain detect shapes, edges, and patterns
- Simple cells = respond to bars or lines of a specific orientation, don't care about movement – just the angle of the line
- Complex cells = respond to bars or edges of a certain orientation that are moving across their receptive fields, some are direction sensitive
- Hypercomplex cells

Beyond V1

- After V1, the visual signal travels along 2 separate pathways
 - Dorsal stream = travels up the parietal lobe, concerned with motion perception and spatial awareness 'where'
 - Ventral stream = travels to the temporal lobe, concerned with object recognition 'what'

Adaptation and constancy

- Adaption = your visual system adjusts to constant or repeated stimuli, so you stop noticing it as strongly over time
- Constancy = even when sensory input changes, we perceive objects as stable e.g., a car looks the same size even as it drives away

Week 3: Hearing

the nature of sound

- Sound is caused by changes in air pressure
- These pressure waves are characterised by amplitude, frequency, and phase
 - Amplitude = loudness
 - Frequency = pitch
 - Phase = position within cycle
- Human hearing range = 20-20000 Hz

- Complex sounds = built from sine waves of varying amplitude, frequency, and phase
- Fourier analysis = used to decompose complex sounds into sine wave components
- Fundamental = the lowest frequency component of a complex sound
- Many complex sounds are made up of harmonics – integer multiples of the fundamental e.g., fundamental = 440Hz, 2nd harmonic = 880Hz, 3rd harmonic = 1320 Hz

The outer ear

- Pinna = increases sound amplitude, helps determine direction of sound
- External auditory canal = provides protection, increases the sound amplitude
- Eardrum (tympanic membrane) = vibrates in response to sound waves, moves bones in the middle ear

The middle ear

- Ossicles = consists of malleus, incus, and stapes
- Smallest bones
- The ossicles transmit the vibration of the eardrum into the cochlea
- Provide protection against high amplitude sounds (muscles attached to the ossicles restrict the bones movements)

Inner ear

- Cochlea = contains auditory sensory receptors, filled with a watery liquid, that turn sound vibrations into electrical signals, which are then sent to the brain through the auditory nerve, allowing us to hear
 - 3 canals in the cochlea = vestibular canal, tympanic canal, cochlear duct
 - These canals are separated by Reissner's membrane, Basilar membrane – these membranes vibrate in response to vibrations of the oval window
 - When the basilar membrane vibrates, hair cells are also set in motion – converting the vibrations into neural signals
- Oval window = membrane covering an opening in the cochlea

Central auditory pathways

How sound signals travel to the brain

1. Sound starts in the cochlea (Inner ear), where vibrations are turned into nerve signals
2. These signals travel along nerve fibres and make stops at several key points before reaching the auditory cortex (where sound is processed)

The main stops along the way

1. Cochlear nucleus – first stop, receives the signal directly from the ear
 2. Superior olivary nucleus – helps compare sounds from both ears to figure out where a sound is coming from
 3. Inferior colliculus – processes and integrates sound information
 4. Medial geniculate nucleus – final relay in the thalamus before the signal reaches the primary auditory cortex
- Each side of your brain processes sounds from both ears

The auditory cortex

- Many animal studies have shown that auditory tasks can be performed without the auditory cortex being present e.g.,
 - responding to the onset of sound
 - changes in sound intensity
 - changes in sound frequency
- Other tasks cannot be performed without the cortex
 - Discriminating the pattern of several tones
 - Discriminating the duration of sounds
 - Localising sounds in space
- The cortex deals with more complex auditory tasks
- Speech perception requires structures beyond the primary auditory cortex

Frequency coding

- Sounds = made up of sine wave components
- The auditory system isolates and identifies the frequencies of these components, as the travelling waves move along the basilar membrane and peak at different points depending on the frequency of the sound
- The location of a peak thus identifies the frequency of a sound
- When people have damage to a specific part of the cochlea, they tend to suffer from frequency-specific hearing loss
- Stimulating different parts of the cochlea makes us hear different pitches e.g., one area makes us hear high sounds

- Hair cells are tuned to different ranges of frequency according to the location along the basilar membrane
- The auditory neurons are arranged orderly
 - organised throughout all auditory pathways
 - tonotopic maps present in auditory system (different parts of the brain respond to different sound frequencies)
 -

pitch perception

- Binaural pitch encoding = both ears work together to help the brain understand pitch, it is not just handled by the cochlea

Loudness perception

- When we hear sounds, how loud something seems depends on how strongly and how many neurons in the auditory system fire. There are 2 main mechanisms involved:
 1. Overall firing rates = faster the firing, the louder the sound is perceived
 2. Range of firing/number of neurons firing = louder sound = more neurons activate
- Factors that affect loudness perception
 - Sound duration – longer sounds perceived as louder
 - Frequency – high-frequency sounds are perceived to be louder
- Amplitude = the size or strength of a sound wave, higher amplitude = louder sound

Auditory space perception – how we locate sounds

- When we hear a sound, the brain uses several cues to figure out where it is in space
- You try to determine a sounds:
 - Horizontal direction (azimuth) – time and level difference between ears
 - Vertical – spectral cues from the outer ear
 - Distance – loudness & reverberation
- However, vision provides the most precise information about an object's location

Why can we auditorily localise sounds (perceive where a sound is coming from in space)

- Your ear on its own cannot tell where a sound is
- Your brain compares what each ear hears (time and loudness difference) to figure out where the sound is coming from/the horizontal direction of the sound (azimuth)
 - The basilar membrane in the cochlea tells us pitch (frequency) and intensity, but it doesn't tell the brain where a sound is coming from, so we compare inputs from both ears

- Interaural time difference (ITD) = the difference in time it takes for a sound to reach each ear (onset difference)
 - Detected by a simple 'delay line' mechanism in the brain
 - Useful for locating/localising low-frequency sounds
- Interaural intensity difference (ILLD)/Level Difference = the difference in loudness of a sound between the two ears
 - Same sound should be more intense at an ear that is closer to the sound source
 - The head works as a barrier that reduces the intensity of the sound (sound shadow)
 - more obvious for locating high-frequency sounds
- neither cue works for pure tones in the middle range

role of head movements

- by changing the position of the ear, you can experience changes in interaural time/intensity differences

horizontal vs vertical direction

- humans perceive horizontal directions better through auditory cues
- ears are positioned horizontally and a greater range of head movement is possible horizontally

limits of auditory localisation

- most auditory localisation cues depend on the distance between a sound and ears
- if 2 different sound sources are the same distance from one ear, they can produce very similar auditory cues (like time and intensity differences). This makes it hard for your brain to tell exactly where the sound is coming from
- cone of confusion – any sound located somewhere on that cone will sound like it is coming from the same direction to that ear, even though, it is a different location
 - brain sometimes needs head movements, reflections, or other cues to resolve this ambiguity

auditory distance perception – the ability to judge how far away a sound source is using hearing alone. Distance is harder to determine as cues are more subtle

main cues for distance perception

1. loudness (intensity) – louder sounds are closer, quieter sounds are farther. Loudness can only give a relative estimate as the loudness depends on both the distance and the original intensity of the source

2. energy ratio of direct vs reverberant sound – direct sound = travel straight to ear vs reverberant sound = sounds that bounces off walls, floors, and other surfaces before reaching your ear
 - a. only useful in rooms or spaces with reflective surfaces
 - b. in open spaces e.g., a field, reverberation is minimal, so the cue doesn't work well

visual capture

- when we can visually see where a sound 'should be' coming from it overrides our auditory localisation
- when we have some visual information about how a stimulus 'should' sound, it strongly affects how we hear the stimulus
 - the McGurk effect = what we see affects what we hear, shows that what we see can override what we hear

don't think vision always dominates

- we give more weight to the sense we believe is more reliable e.g., vision = excellent for spatial information, where things are, audition (hearing), excellent for temporal information, timing, sequence, rhythm
- sometimes, auditory and visual information conflict, and our perception can be altered – because hearing is more precise for timing, a sound can change what we see if the visual information is ambiguous