WEEK 2 BRAIN AND COGNITION- visual perception

Is the physical world the same thing as our visual experience- no BERKELEY + EINSTEIN

'your physical skull is beyond the experienced dome of the sky'- VELMANS 2009

VISUAL ILLUSIONS- show the rules that the brain uses to construct visual experience eg KANISZA TRIANGLE – the visual brain is constructing things that aren't three [see Bertamini's psych 309]

The brain only sees in 2D and so it interprets the retinal image and creates a representation= *the interpretation* – its always looking for a 3D representation

Sensations inform perception- our visual and sensory experiences can be described as 'percepts' – sensations are more basic elements which are elaborated into precepts by visual parts of the brain.

Top down and Bottom up contributions*

General properties of sensory systems

Vision is just one sensory modality (e.g. sound, taste) … the visual system responds to light, auditory systems responds to vibrations, olfactory systems responds to chemicals in nose and gustatory systems to chemicals in the mouth, tactile receptors respond to mechanical deformation of skin. WE DON'T JUST HAVE 5 SYSTEMS- we have nociception responding to skin damage and vestibular system responding to gravity and acceleration of the head.

EXTEROCEPTION AND INTEROCEPTION.

Exteroception provides brain with signals about energies in the outside world, interoception provides the brain with signals of what's going on inside the bodyProprioception is the main example of interoception – it provides signals about the contraction of muscles and the angles of our joints (allows you to know your current posture in a totally dark room). The brain is also bombarded with interoceptive signals about heart rate, breathing, gut dilation, blood sugar concentrations and so on… Emotional states are intimately linked to interoception (James, 1890).

Sensory systems are 'bounded'- very limited window on the physical world with narrow boundaries. WHY… **TRANSDUCTION-** The conversion of physical energy into action potentials

The psychophysics approach- a part of psychology that plots lawful relationships between physical world and subjective experience.

*What is the minimum strength of stimulus we can detect? [*through the narrow window] eg what is too quiet to hear and what can we just about hear. We like to determine **JNDs** (just noticeable differences) eg applied pressure = pedestal stimulus and slightly harder pressure= test stimulus

JND increases with stimulus intensity- WEBERS LAW--- 'Imagine you are poor and have one pound, and you get another pound. That would change your life quite a lot. Imagine you are rich and have million pounds, and you get another pound. That would hardly change your life at all.'

Scaling- Steven's power law is a more refined version of Weber Fechner type scaling. The relationship between physical stimulus and sensation often non-linear.

Gestalt psychology (modern)- WERHEIMER, KOFFKA and KOHLER

They correctly noted that percepts are 'wholes' made an arrangement of parts, but can't be reduced to the sum of their parts= arrangement matters

Grouping principles- features are often perceptually grouped together and that grouping in lawful rather than arbitrary.

Figure ground segmentation- gestalt psychologists were also interested in the way we segment the scene into figure and ground- the figure owns the borders; the ground doesn't own the borders and its shapeless.

Bi stability= seeing 2 objects alternating in one – the duck-rabbit

Depth- the third dimension

The retinal image projected onto the eye is essentially 2D and the rays do not tell us how far they have travelled from the source yet we still estimate the depth using various cues;

MONOCULAR CUES- occlusion (near things generally cover far things), linear perspective- parallel lines converge on a vanishing point. Texture gradients- becomes less detailed further away. Motion parallax (near things move faster when looking out a train where as things in the distance do not) and of course familiar size- we assume the size of an object based on previous experiences.

BINOCULAR CUES- binocular disparity creates a felt compelling sense of depth. It works over a few 10's of meters- the difference in relative position on left and right eyes increases as we get closer to an object. 3D cinemas present different images to each eye = artificial disparity meaning we think we can reach into space

OTHER CUES- accommodation- we can focus on objects near or far by changing shape of lens. And **Vergence** is how turned in the eyes need to be focus.

'VISION' by MARR 1982

David Marr introduced several crucial ideas showing how we could think of representations being constructed by applying operations to the image- he said to understand any system, we should understand it at computational, algorithmic and implementational levels.

BIEDERMANS GEONS proposed that object representations in the brain are made of an alphabet of 36 primitive shapes, called 'geons'- even the most complex objects can be coded as an aggregate of geons.

FACE PERCEPTION- we are good at distinguishing between faces- but not when they are upside down= the fusiform face area (FFA) was found to be more active when we were seeing faces in the Rubin Face/Vase illusion- HASSON 2001

The phenomena of pareidolia suggests the FFA is over-excitable and gets activated by any face-like configuration (this explains the recurring tabloid story about 'Jesus in a piece of toast', and the great excitement about 'extraterrestrial' face on mars in 1976). **FFA damage causes prosopagnosia** (face blindness).

GALTON 1870- research into criminal faces found the average face is 'attractive'

THE COGNITIVE NEUROSCIENCE OF VISUAL PERCEPTION

The eye and the retina- the eye has a curved transparent surface (cornea) and behind is a pinhole. The retina is 'back to front' in that photo receptors face the brain and the wiring comes forward which then turn around to pierce a hole in the retina creating a visual blind spot.

Transduction (converting light into neural firing) occurs in the retina through photoreceptors cells, there are 2 types; RODS which are concerned with brightness and work best in dim light. And CONES which are concerned with colour- working best in daytime conditions.

We have around *128 million photoreceptors per eye* – 120 mil rods and 8 mil cones- the cones are mainly in the fovea (centre of the retina) rods are dispersed around the edge- the periphery.

WAVE CONES-

Short wave cones- have photo-pigments that respond to light with a wavelength of about 420 nanometres- this is experienced by blue

Medium cones are sensitive to light around 530 nm waves- experienced as green.

Long cones have pigments responding to 600nm wanes- experienced as red.

Hence why it is more likely to be colour-blind of red-green pigment.

Different retinal cells- **BIPOLAR** – synapse with retinal ganglion cells which leaves through the optic nerve. **HORIZONTAL** and **AMACRINE** cells form lateral connections within the retina

CELLULAR PATHWAYS-

Magno cellular pathway take input from rods in the peripheral area

Parvo cellular pathway tale input from cones in central retina

THE OPTIC NERVE- axons of the M and P cells for the optic nerve and leave the retina through the blind spot- then they cross over at the optic chiasm (left visual field projects to right side of brain etc.). Optic radiations go from the LGN to primary visual cortex

Parallel and Hierarchical processing-***

V1 – the primary visual cortex

V1 neurons have retinotopically organised receptive fields- this is one of the most fundamental things to understand… = its like the retina

Orientation sensitivity in V1- HUBEL AND WIESEL cat study

Hyper columns go through the 6 layers of V1. A hyper column is a cluster of cells with the same receptive field. But within a column, we have regions taking input from the left eye or right eye, and cells with orientation sensitivity. In layers 2/3 we have blob and inter-blob regions. Blob regions are particularly concerned with color specialized processing.

THE VENTRAL AND DORSAL STREAMS

V2 is a general relay station that sends parvocellular inputs along the ventral stream and magnocellular inputs along the dorsal stream. The dorsal stream gets magnocellular inputs and generates unconscious representations of object location and motion- this is for rapid action control for example returning a tennis serve. MILNER + GOODALE 1995 – dorsal and ventral stream lesions

DORSAL STREAM- begins with magnocellular inputs and goes into the parietal lobe- motion is well coded. Neurons in V5 regions is particular sensitive to motion

VENTRAL STREAM- area V4 is an early part of the ventral pathway and is sensitive to colour and shape- the inferotemporal cortex is higher up the ventral pathway and is concerned with recognising objects

Some wavelengths are emitted by the illuminant. These are either absorbed or reflected when they hit surfaces. The wavelengths reflected from a surface are determined by the properties of the incident light source, and properties the surface. The cones in the retina, and cells in V1, fire when particular wavelengths are present in their receptive field. They do not know whether these wavelengths are because of the light source reflectance properties of surfaces

V4 cells can code the color of surfaces semi independently of the color of the light source. In other words, V4 achieves *color constancy*. This is computationally difficult. V4 seems to be sensitive to the relative difference between all surfaces in the scene, and subtract the color of the light source.

VENTRAL STREAM INFEROTEMPORAL CORTEX- prosopagnosia is blindness to faces caused by damage to the FFA in the inferotemporal cortex

OBJECT RECOGNITION

Inferotemporal neurons sometimes fire in response to a particular object. BOOTH AND ROLLS 1998 found some neurons are view invariant- respond to an object independently of view angle.