



Biological Psychology

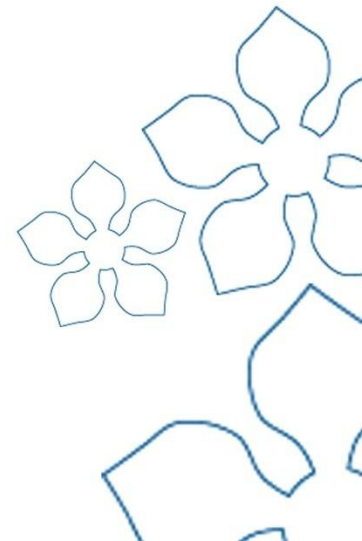
M5X00908 Brain, Behaviour, and Cognition (BBC)

Lecture 6: The Research Methods of Biopsychology

Dr Kate Williams



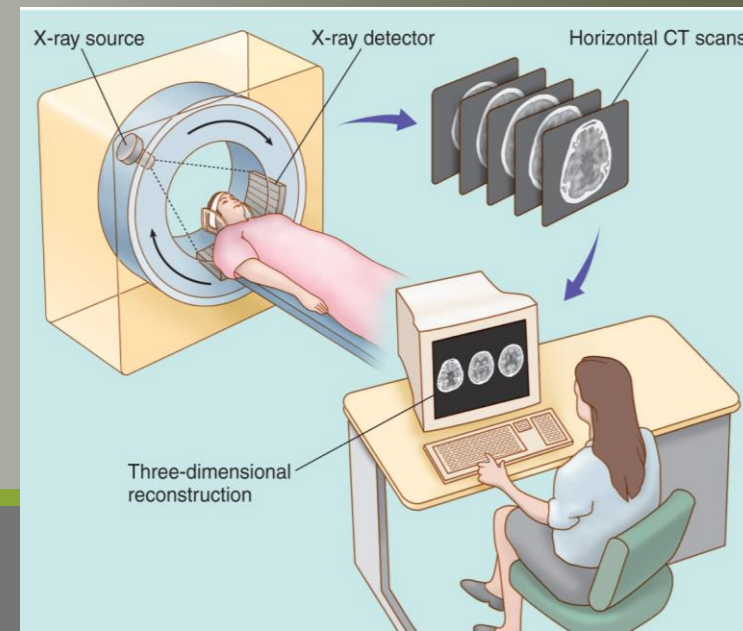
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Methods of Visualising and Stimulating the Living Human Brain



- **Contrast X-rays:** inject something that absorbs X-rays less or more than surrounding tissue
 - Cerebral angiography: uses x-rays & iodine-containing contrast material to produce picture of blood vessels in brain
- **X-Ray computed tomography (CT)**
 - Head placed in cylinder: x-ray tube projects x-ray beam to x-ray detector.
 - Tube & detector rotate & take no. of photographs.
 - Each photograph combined on PC to create a CT scan of horizontal section of the brain.
 - Beam & detector move to another level of brain.
 - Process is repeated until 8/9 horizontal brain sections are obtained & all combined to create a 3D image on a computer.



Methods of Visualising and Stimulating the Living Human Brain



Magnetic resonance imaging (MRI)

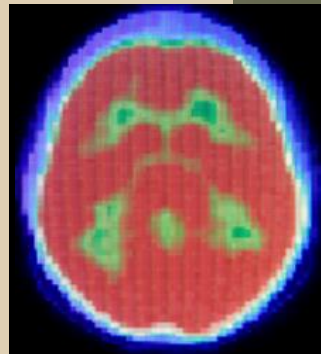
- Uses radio waves to excite atoms in the brain.
- This produces magnetic changes picked up by large round magnet surrounding persons head.
- High resolution digital image made from measurement of waves that atoms emit when activated by radio-frequency waves in a magnetic field.
- Produces clearer images than CT & has high spatial resolution, (i.e., can detect & represent differences in spatial location).
- Can be conducted from no. of angles to show structure of brain, but not functions of the brain.
- Techniques discussed so far have enabled production of structural brain images, a static picture.
- As technology has developed we are now able to produce functional brain images - pictures showing brain activity.

Methods of Visualising and Stimulating the Living Human Brain



Positron emission tomography (PET)

- Involves detection of positrons: atomic particles emitted from radioactive substances.
- Person injected with radioactive glucose, which is taken up by metabolically active cells.
- Radioactive particles emit positrons detected by the scanner.
- Areas of brain high in metabolic activity produce more gamma rays because they take up more glucose.
- This is transformed to a colour coded 3D image indicating regions of increased blood flow.
- Good spatial resolution but not good temporal resolution.
- Only provides indirect measure of neural activity.
- Images produced are not of the brain: only produces coloured map of radioactivity in tiny cubic voxel (a pixelated area) from scan, which is superimposed on image of brain.



Methods of Visualising and Stimulating the Living Human Brain



Functional MRI (fMRI)

- Provides images of brain structure *and* activity.
- As with MRI, uses strong magnetic field
- Two properties of oxygenated blood allow it to work.
 1. Active areas of brain take up more oxygenated blood than actually needed.
 2. Oxygenated blood has magnetic properties through the iron.
- Structure is imaged using waves emitted by hydrogen ions
- Function is imaged using signal created from interaction between oxygen and iron in the blood
 - Blood Oxygenated Level Dependent (BOLD) signal
- Good spatial and temporal resolution
- Produces 3D images of activity over the whole brain.
- But only provides indirect measure of neural activity through BOLD.
- Also, the 2 to 3 seconds to create image is too slow to capture neural responses e.g., action potentials that happen in milliseconds

Methods of Visualising and Stimulating the Living Human Brain



Magnetoencephalography (MEG)

- A measure of neural activity
- Measures changes in magnetic fields on the surface of the scalp produced by underlying patterns of neural activity
- Fast temporal resolution

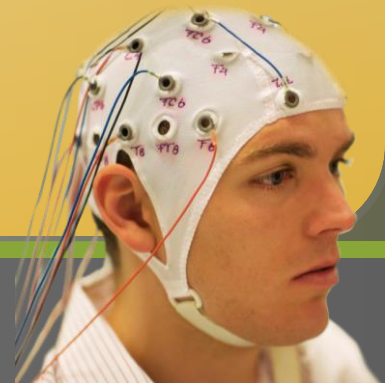
Transcranial magnetic stimulation (TMS)

- NOT a measure of neural activity
- Provides experimental probe to alter neural activity
- Involves placing a figure of 8 coil close to the participants head and then running a brief pulse of current.
- Produces a brief, strong magnetic field that alters neural activity
 - Can either activate or “deactivate” brain structures
 - Observe changes in behavior

Recording Human Psychophysiological Activity



- Techniques discussed so far have involved brain imaging, but we can also use psychophysiological methods to measure the brain:
- **Scalp electroencephalography (EEG)**
 - Measure of gross electrical activity of the brain
 - Including action potentials & postsynaptic potentials.
 - Uses electrodes attached to scalp (individually or in cap)
- **Many techniques of EEG**
 - Wave form assessment (e.g., alpha waves)
 - Event-related potentials (ERPs)
 - Combination of EEG with MRI



Recording Human Psychophysiological Activity



Aroused



Relaxed



Asleep



Deep sleep



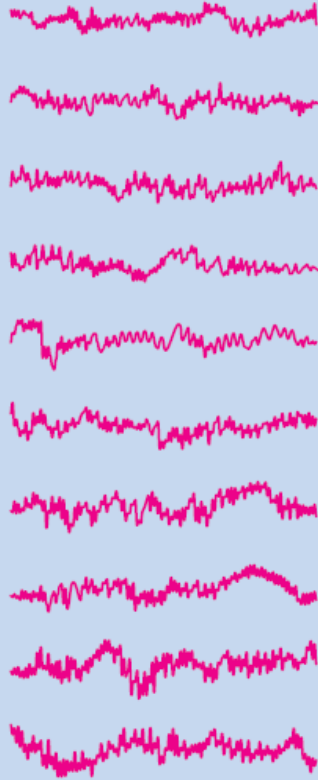
1 second

- **EEG waves are associated with particular states of consciousness.**
- **Some typical EEGs and their psychological correlates.**

Recording Human Psychophysiological Activity



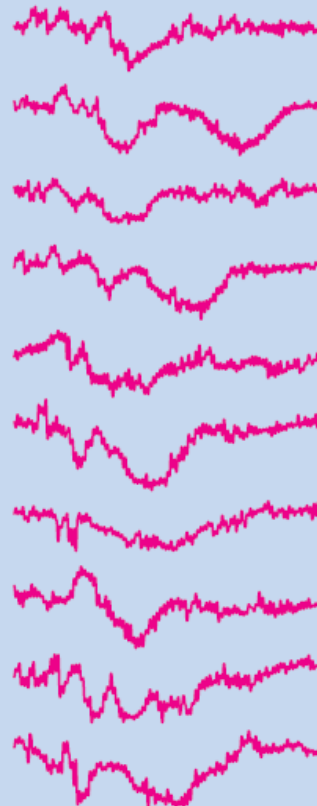
1-second segments
of background EEG



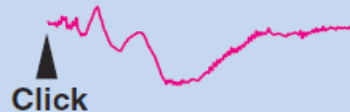
Average
background
EEG



1-second segments
of EEG with evoked
potential



Average
evoked
potential



- Interest in EEG waves accompanying certain event - Event-related potentials (ERPs).
- Same stimulus presented repeatedly & pattern of electrical brain activity recorded by several electrodes & averaged to produce single wave form.
- Allows researchers to work out timings of various cognitive processes.

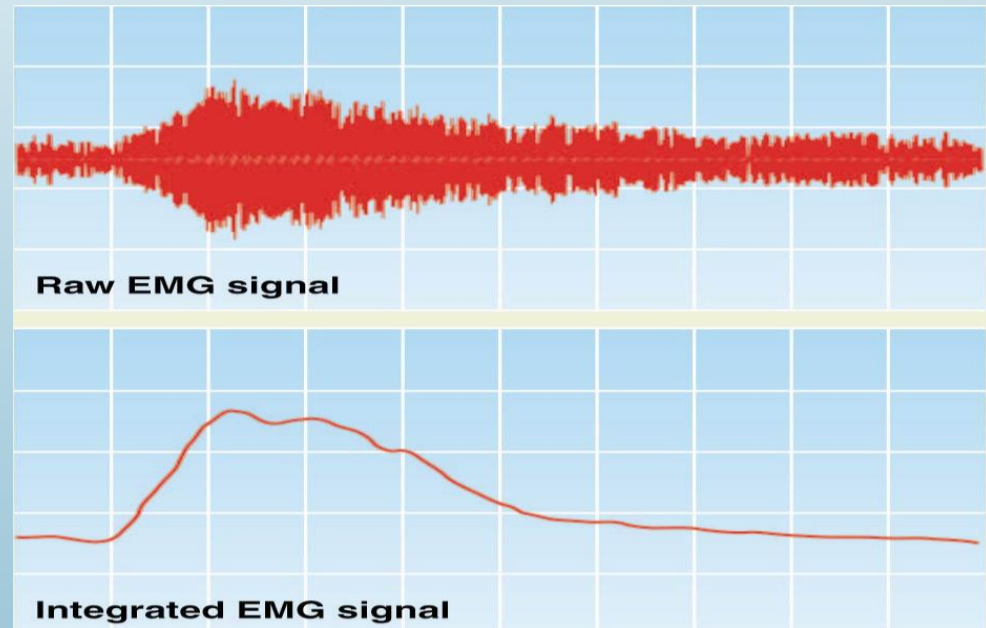
Recording Human Psychophysiological Activity



Psychophysiological measurements can also come from somatic nervous system activity.

Muscle tension

- Electromyography measures electrical activity of muscles
- Electromyogram (EMG) indicates tension of muscles under the skin.
- Gives no. of muscle fibers contracting at any one time.
- Raw signals are converted and calculated as total amount of MEG spiking to produce a smooth curve.



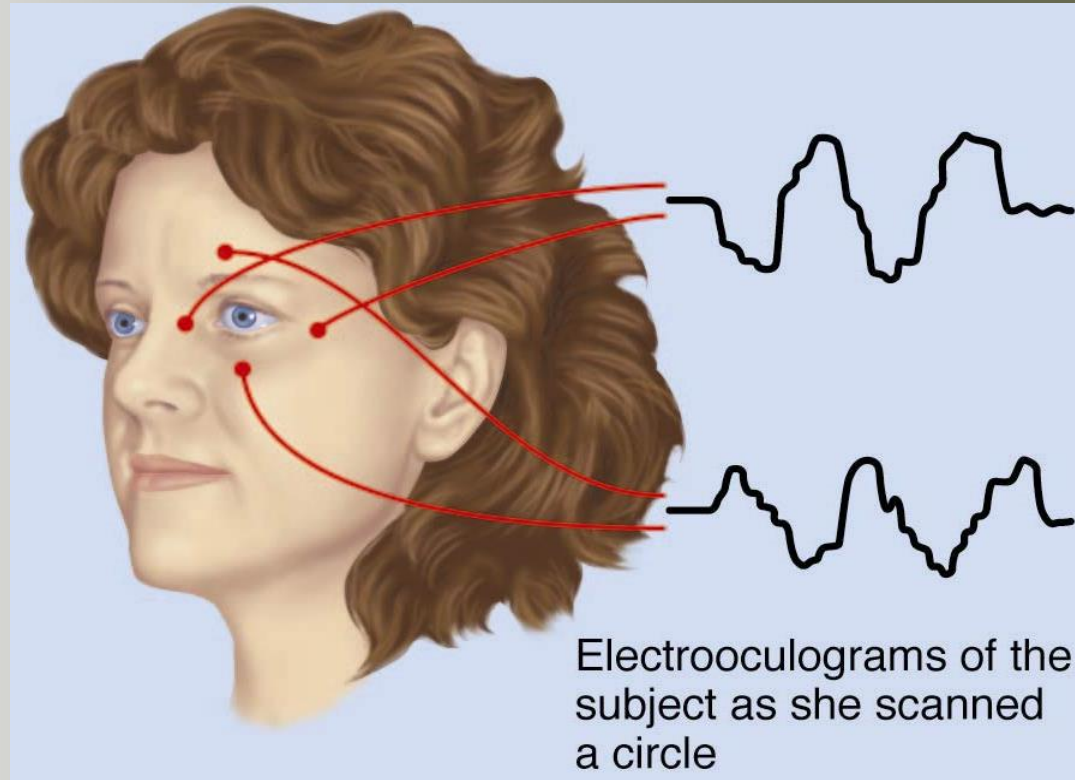
The relation between a raw EMG signal and its integrated version. The subject tensed the muscle beneath the electrodes and then gradually relaxed it.

Recording Human Psychophysiological Activity



Eye movement

- Electrooculography is the technique of recording eye movements
- Electrooculogram (EOG) indicates changes in electrical potential between the front and back of the eyeball



The typical placement of electrodes around the eye for electrooculography. The two electrooculogram traces were recorded as the subject scanned a circle.

Recording Human Psychophysiological Activity



Autonomic nervous system activity

Skin Conductance

- Measures electro dermal activity when we experience something.
- Techniques include measurement of:
 - Skin conductance level (SCL): background level of conductance associated with particular situation
 - Skin conductance response (SCR): transient skin changes associated with discrete experiences.

Cardiovascular Activity

- Often used to link physiological changes with emotional state
- Measures include heart rate (ECG), blood pressure, and blood volume (amount of blood going to particular area of the body).

Invasive Physiological Research Methods



- **Biopsychological research on animals falls in to 3 categories:**
- **Lesioning:** to remove, damage, or inactivate a structure
- **Electrical stimulation:** to “activate” a structure
 - Stimulation of a structure may have opposite effect to that seen with lesioning.
- **Electrophysiological recording**

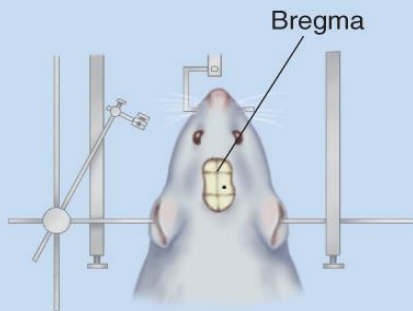
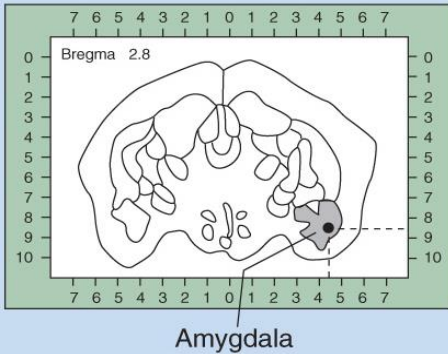
Invasive Physiological Research Methods



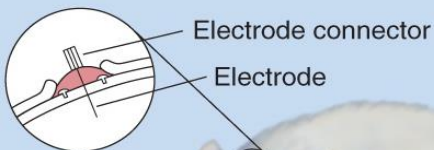
Stereotaxic surgery

- Device positioned in precise place deep in animals brain.
- Involves stereotaxic atlas to locate brain structures in 3D.
- Brain is represented in a stereotaxic atlas by series of individual maps, one per page, each representing structure of single 2D frontal brain slice
- Distance in millimeters from a reference point.
- In some rat atlases the reference point is called bregma (top of the skull).

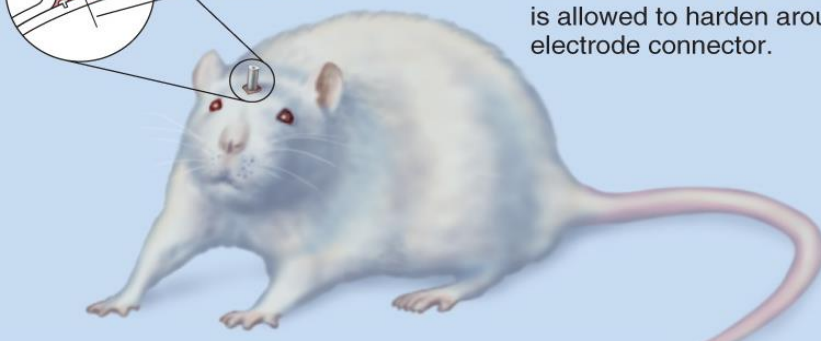
1 The atlas indicates that the amygdala target site is 2.8 mm posterior to bregma, 4.5 mm lateral, and 8.5 mm ventral.



2 A hole is drilled 2.8 mm posterior to bregma and 4.5 mm lateral to it. Then, the electrode holder is positioned over the hole, and the electrode is lowered 8.5 mm through the hole.



3 The electrode is anchored to the skull with several stainless steel screws and dental acrylic that is allowed to harden around the electrode connector.



Stereotaxic surgery: implanting an electrode in the rat amygdala

Invasive Physiological Research Methods



Lesion methods

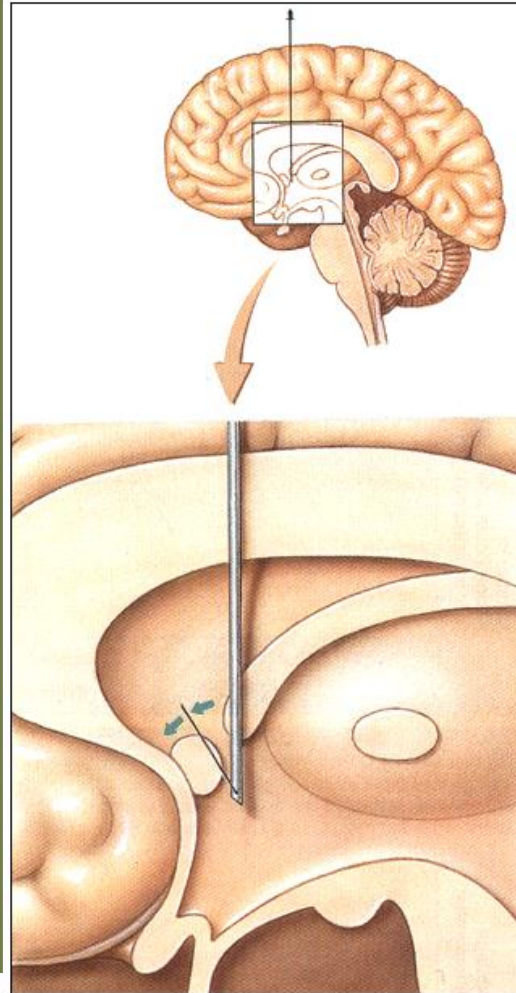
- Can be Bilateral and unilateral
- Four main methods:
 1. **Aspiration:** lesion to area accessible to the eyes and instruments of the surgeon, cortical tissue is drawn off by suction through a glass pipette.
 2. **Radio-frequency lesions:** place radio-frequency current through tissue from an electrode. Heat from current destroys tissue, with size & shape of lesion determined by duration & intensity of current

Invasive Physiological Research Methods

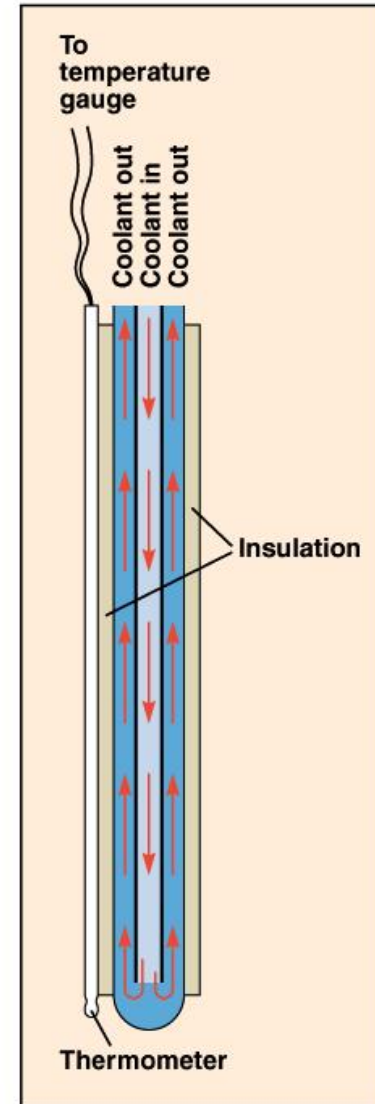


3. **Knife cuts:** cutting nerves or tracts. Blade enters & swivels out to make cut.
4. **Cryogenic blockade:** implanting cryoprobe in brain then pumping coolant through the system. Neurons are cooled to such a degree they stop firing, but temperature is maintained above freezing to avoid structural damage. When tissue warms up, normal neural activity resumes.

► Subcortical Knife Cuts



► A Cryoprobe



Invasive Physiological Research Methods



Invasive electrophysiological recording methods:

- **Intracellular unit recording**
 - Membrane potential of a neuron
- **Extracellular unit recording**
 - Firing of a neuron
- **Multiple-unit recording: involves large electrode tip**
 - Firing of many neurons
- **Invasive EEG recording:**
 - signals recorded through large implanted electrodes in brain rather than scalp. Cortical EEG signals recorded through stainless steel skull screws, while subcortical EEGs are recorded through implanted wire electrodes.

Pharmacological Research Methods



- Administering different drugs that can either increase or decrease effects of a particular neurotransmitter and then observe subsequent behaviour.
- **Routes of drug administration (peripheral)**
 - Fed to subject (swallowing)
 - Injected through a tube into stomach
 - Inject hypodermically into peritoneal cavity of the abdomen, into the fatty tissue beneath the skin, or into a large surface vein of the subject
 - BUT: May not pass blood-brain barrier
- **Selective chemical lesions: inject neurotoxins (neural poison) that destroy only certain neurons**

Measuring Chemical Activity of the Brain



- Two main techniques for measuring chemical activity in the brain.
- **2-deoxyglucose (2-DG) technique**
 - Inject animal with radioactive 2-DG and allow it to engage in behaviour or interest.
 - 2-DG is similar to glucose (brain's main source of energy), so neurons activated whilst animal is under testing will absorb the 2-DG.
 - Brain is sliced to undergo autoradiography to see where radioactivity accumulates in brain
- **Cerebral dialysis:** measures extracellular concentration of specific chemicals in live animals through small tube implanted in the brain. Chemicals go in tube, which is then removed, frozen, and later analysed.



Locating Neurotransmitters and Receptors in the Brain



- Dye or radioactive labels used to visualise protein of interest.
- **Immunocytochemistry:** based on binding of labeled protein-specific antibodies:
 - Inject foreign protein in to animals body
 - Antibodies created to fight infection by binding to it & removing or destroying it.
 - Neurochemists can then locate a particular neuroprotein by labelling the antibody with a dye or radioactive substance.
 - Once brain is sliced, marked location show where particular neurotransmitter or receptor are located.
- **In situ hybridisation** – uses labeled Ribonucleic acid (RNA) to locate neurons with complementary messenger RNA

Genetic Engineering



- **Gene knockout techniques**

- Involves creating an animal that lacks a particular gene to examine what the gene controls.
 - E.g., if gene for synthesizing melanopsin is deleted then mice's circadian rhythms is impaired.
- But difficult to interpret results – most behaviour is controlled by many genes and removing one gene may alter the expression of others, including compensation for missing gene (as above rhythm was impaired not eliminated).

- **Gene replacement techniques**

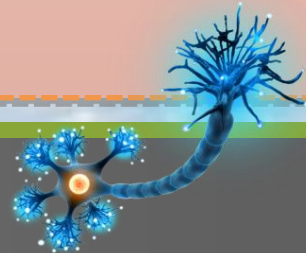
- Insert pathological human genes in mice – e.g., for schizophrenia, to examine behaviour.



Neuropsychological Testing



- **Behavioural methods to examine function of the brain.**
- **Patients suffering from nervous system disorder would see neurologist but neuropsychologist would also be needed to examine other subtle changes in behavior (e.g., emotions or cognitions).**
- **But, this is time-consuming – only conducted on a small portion of those with brain damage**
- **Assists in diagnosing neural disorders**
- **Serves as a basis for counseling/caring**
- **Provides information on effectiveness and side effects of treatment**



Modern Approaches to Neuropsychological Testing



- **Single-test (1950s & before)**
 - Used to differentiate structural brain damage from functional (psychological) causes.
 - But one test not enough.....
- **Standardized-test-battery (1960s)**
 - Same goal as single-test approach but used numerous tests (e.g., Halstead-Reitan test battery)
 - But unable to discriminating between neurological patients (disease of the nervous system) & psychiatric patients (experiencing abnormal thoughts/feelings).....
- **Customized-test-battery (Now predominant)**
 - Characterises nature of psychological deficits

Tests of the Common Neuropsychological Test Battery



- **Intelligence:** Wechsler Adult Intelligence Scale (WAIS)
- **Memory:** Digit span subtest
- **Language: Token Test** – 20 tokens of different shapes, sizes, & colours placed on table & examiner reads set of instructions e.g., touch red square, which patient must follow. Instructions get longer and more complicated. Patient tested on how far they can understand these.
- **Language lateralisation** – used to identify language-dominant hemisphere
 - Sodium amytal – anesthetize one hemisphere then other to examine patients inability to speak
 - Dichotic listening – ear contralateral to dominant hemisphere shows superior hearing ability

Tests of the Common Neuropsychological Test Battery

– Tests of specific function



- **Memory – exploring nature of deficits**
 - Short-term, long-term, or both?
 - Anterograde or retrograde, or both?
 - Semantic or episodic?
 - Explicit or implicit? (repetition priming tests – Purple ; P u _ p _ _) amnesic patients able to do this as well as healthy controls but have no recollection of the words.
- **Language – problems of phonology, syntax, or semantics**
- **Frontal-Lobe Function**
 - Wisconsin Card Sorting Task



Behavioural Methods of Cognitive Neuroscience



- Each complex cognitive process results from the combined activity of simple cognitive processes (**constituent cognitive processes**)
- Each complex cognitive process is mediated by neural activity in a particular area of the brain
- Goal is to identify parts of the brain that mediate various constituent cognitive processes
- Paired-image subtraction technique: compare PET or fMRI images during several different cognitive tasks that only differ on one aspect.
- But should be viewed with caution: brain activity takes places even when sitting still & not engaging in a task (default mode)



Procedures developed for investigating a particular behavioural phenomenon

Assessment of Species-common behaviours:

those displayed by all members of the species: e.g., grooming, eating, building nests, etc.).

- Three main tests

- 1. Open-field test:** place animal in empty chamber & record activity (does it move around or stay close to wall, how much droppings it produces, etc.).

- 2. Tests of Sexual Behaviour**





3. Tests of Aggressive and Defensive Behaviour:

Colony-intruder paradigm: examine no. of combat encounters between dominant alpha male of established colony & smaller male intruder.

- Dominant alpha is aggressive: biting, putting hair upright.
- Intruder is defensive: goes up on back legs to defend from biting & tries to push alpha away with its front paws.
- Elevated plus maze: a maze mounted 50cm from the ground, two arms of maze have sides while other two do not
 - Amount of time rat spends in closed arms rather the open edge arms is compared.
 - Giving rat anti-anxiety drugs increases amount of time spent in open arms of maze: used for understanding usefulness of anti-anxiety drugs in humans?





Traditional Conditioning Paradigms:

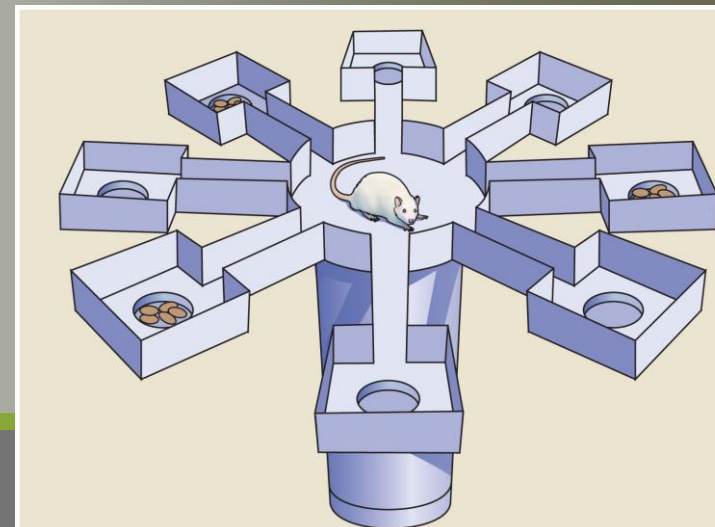
- We can infer about the sensory, motor, motivational, and cognitive state of an animal from its ability to learn and perform various responses.
- Pavlovian conditioning (pairing an unconditioned stimulus with a conditioned stimulus)
- Operant conditioning & reinforcement





Semi-natural Animal Learning Paradigms:

- **Conditioned Taste Aversion:** pairing something that makes an animal ill with their food so they learn to avoid it.
 - This really challenged traditional learning paradigms because taste aversion can be established after a single trial.
- **Radial Arm Maze:** place food at the end of the same arms.
 - Rat learns not to bother looking in the other arms.
 - Shows their spatial ability is good because all the arms look the same, so they have to orientate themselves to the whole room.
 - When the maze is rotated their performance is disrupted.



Biopsychological Paradigms of Animal Behaviour



- **Morris Water Maze:** rat must find hidden escape platform in an opaque pool of water.
 - Even when rat is placed in different places around the pool it quickly learns route, using spatial cues from the room.
 - Brain lesions disrupt this ability and in severe cases the rat can be swimming around in circles for a long time even if they are placed in the same starting point on a trail where they successfully found the platform previously.
- **Conditioned Defensive Burying:** give rat a single aversive stimulus (e.g., a shock/blast of air) delivered from an object.
 - They then spray their bedding/hay) at the object to cover it.
 - Anti-anxiety drugs decrease amount of burying Behaviour.

Next Week...



Brain Damage and Neuroplasticity

Essential Reading...

Pinel: Biopsychology – Chapter 10