**PET Scanning**

PET stands for Positron Emission Tomography. The use of PET as a technique for investigating brain activity is based on the assumptions (1) that brain functioning is *localised*, with different brain areas performing distinct functions; and (2) that brain activity correlates with glucose consumption, higher glucose uptake equating to higher brain activity.

When a PET scan is performed, glucose carrying a short-lived radioactive marker (half-life about 110 minutes) is introduced into the bloodstream. The radioactive glucose spreads around the body, including the brain. Due to metabolic activity, it becomes concentrated in areas of the brain where more glucose is being used. The person is placed inside a scanning machine which can detect the emission of positrons from radioactive decay (hence, *positron emission* tomography). As the radioactive marker in the glucose decays, it emits positrons, more positrons being emitted from where more of the radioactive glucose has concentrated. The emissions are picked up by the scanner and a computer calculates the position from which each positron came. This is then used to build up an image of the brain.

The PET image represents a thin ‘slice’ through the brain. Different colours are used to represent different levels of glucose concentration. By convention, black and blue areas denote low concentration, rising through green, with yellow and then red indicating the highest levels of radioactive glucose and, consequently, the highest levels of brain activity.

From the point of view of the person being scanned, the whole procedure takes two to three hours. On arrival at the scanning facility the health of the participant is assessed. They are then injected with the radiotracer and left for about an hour whilst it becomes distributed around the body. They then lie on a bed which is slowly fed through the scanning apparatus. This might take 15-35 minutes, depending on the equipment being used and the exact nature of the scan. During the scan the participant must remain completely still. Depending on what is being investigated, the person may be asked to complete various kinds of task or to answer some questions during the scan.

**Interpreting the data...**

* In picture A, we can see a comparison between brain activity in a healthy person (1) and a person with schizophrenia (2). The front of the brain is at the top of the picture. How does brain activity differ between the two?
* What does picture D tell us about language processing in the brain?
* One of the brains has suffered a minor stroke. Which one, and how can you tell?

**Questions to think about...**

* What health risks might be associated with PET scans?
* What practical limitations are there on the sorts of things you can investigate with PET?

**MRI Scanning**

MRI stands for Magnetic Resonance Imaging. It is a way of generating images of the internal structures of a living body, including the brain. Because of the way it works, it is highly suited to imaging soft tissues (as opposed to bones, teeth etc.)

When an MRI scan is performed, the volume to be investigated is placed in a very strong magnetic field. This causes the water molecules in the tissues to align themselves with the magnetic field. They are then stimulated with radio waves in a way that causes them to give off signals that can be picked up by a number of detectors (they *resonate* in the magnetic field, hence *magnetic resonance* imaging). The data from the detectors is converted into an image by a computer.

The MRI image represents a thin ‘slice’ through the brain. During the course of a scan data are collected from many different ‘slices’ allowing the whole internal structure of the volume to be examined. Usually, different shades of grey are used to represent different types of tissue. By adjusting the scanner settings, the MRI scanner can differentiate between a wide variety of different tissue types. Sometimes the person is injected with a contrast material that helps the scanner pick out certain types of internal structure but this is not always necessary.

From the point of view of the person being scanned, the procedure takes between 30 minutes and 2 hours. On arrival at the scanning facility the participant completes a questionnaire asking them about any metal that may be present in their body (e.g. surgical implants, artificial joints etc.) They must also remove all jewellery and other metal items from their person, including clothing with metal zippers etc. They are usually given earplugs to wear. The participant lies on a bed during the scan, and this is fed slowly into the MRI machine. The scan takes place in a number of phases, each lasting about 2 minutes. Whilst the scanner is active it makes a very loud banging noise (up to 130 dB). The participant must remain very still during the scan.

**Interpreting the data...**

* Look at scans A and B. One of these people has a brain tumour. Which one, and how do you know?
* Scan E compares the brains of identical twins, one of whom has schizophrenia (the other is mentally healthy). What differences can you detect between them?
* Scan D shows the brain of a person who had a sudden onset of dementia. What seems to be the problem?

**Questions to think about...**

* Why is important to know about all the metal a person has on and in them?
* Why might it be argued that MRI is more useful to doctors than psychologists?

**EEG**

EEG stands for Electro Encephalograph. It is a way of recording activity from groups of neurons in the brain. It relies on the fact that the electrochemical activity of neurons is detectable a short distance away from the neurons themselves.

Action potentials propagating down neurons create an electromagnetic field. The field created by a single neuron is too weak to be detected but groups of neurons active together produce a much stronger field. This is particularly the case when they are all firing in a similar pattern. The fluctuations in the electromagnetic field can be picked up by metal electrodes attached to the scalp. The electrodes convert the electromagnetic field into a voltage, and changes in the voltage over time are recorded by the EEG apparatus.

Each line on an EEG readout depicts the voltages recorded from one electrode over a period of time. Time intervals (usually seconds) are often indicated somewhere on the readout. Different types of brain activity produce different characteristic EEG traces. The trace from an alert, normal brain usually has an irregular form, with a high frequency and low amplitude:



Regular, low frequency, high amplitude waveforms are produced by people in deep sleep. However, they can also be produced by brain areas that are not functioning properly:



Changes in EEG activity can be used to track brain activity changes in different states of consciousness (e.g. waking, sleeping, meditating). Abnormal EEG traces can be used to diagnose and understand brain problems.

From the point of view of the person whose EEG is being taken, the procedure takes between 30 and 90 minutes. On arrival at the EEG facility a technician marks the points on their scalp/forehead where electrodes are to be attached. The electrodes are covered with conducting paste and either taped in place or held in place with an elastic cap. Whilst the EEG recording is being taken the person may be asked simply to relax or they may be given various tasks to perform.

**Interpreting the data...**

* When a person has a measles infection in their brain, the EEG detects this as intermittent ‘spikes’ across large areas of the cerebral cortex. Which EEG suggests a measles infection?
* Trace D shows the EEG of a person having an epileptic seizure. Approximately how long did it last?
* Which other trace shows evidence of an epileptic seizure?

**Questions to think about...**

* Why do you think EEG research is nowadays quite unfashionable?
* Where in the brain can an EEG not ‘reach’?

**Post Mortem Investigation**

‘Post mortem’ means ‘after death. A post mortem investigation of the brain involves removing it from the skull and examining it. The features of the brain after death can be correlated with what was known about the person’s behaviour before they died, giving an insight into how brain structure relates to behaviour.

One level of post mortem examination concerns the large scale characteristics of the brain. At this scale, interesting structural features may be apparent as evidence of physical damage/scarring (‘lesions’) or abnormalities of size (e.g. shrinkage) or other features (e.g. colour) of the brain. Internal structures of the brain may be examined through careful dissection.

Another level of post mortem examination requires that samples of brain tissue are prepared as slides and examined microscopically. This can provide evidence of structural abnormality at a cellular level, for example, a lack of organisation in specific brain tissues, abnormal connectivity between neurons or a higher or lower than expected density of particular types of synapse.

Brain tissue can also be examined chemically, possibly indicating the presence or absence of particular toxins, an excess of a hormone or neurotransmitter or other evidence of unusual (or typical) metabolic activity.

Post mortem examination of the brain may be required by order of a coroner’s court to investigate the causes of a person’s death. If not, and it is conducted for research purposes only then informed consent should be obtained from the next of kin someone empowered to consent in their place. Taking and retaining tissue samples prior to burial or cremation generally also requires consent. Accurate information about the person’s behaviour prior to death e.g. medical records is also necessary for interpretation of most post-mortem data to be made.

**Interpreting the data...**

* Picture A compares a healthy brain with the brain of a person who had Alzheimer’s disease. What are the differences? And which other brain shows evidence of Alzheimer’s?
* Pictures E and F are microscopic close-ups of brain tissue from a healthy person and a person with schizophrenia. Which is which, and why?
* Picture B shows the brain of a patient nicknamed ‘Tan’ who was examined by an early neurologist called Paul Broca. Whilst alive, Tan was unable to speak. What conclusions might Broca have drawn about the relationship between brain structure and language?

**Questions to think about...**

* What sorts of problem might limit the conclusions you can draw by looking at the brains of dead people?
* What can you get from post-mortem studies that no other technique can give you?