



**Mind reading? How
neuroscientists study your
brain.**

Key Stage 5

Biology, Chemistry,
Mathematics, Physics, and
Psychology.



Resource One

Model Answers

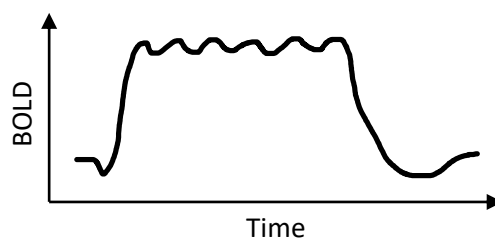
- Answers**
1. Two strengths of EEG and MEG are that they have high temporal resolution and they directly measure electrical activity. Two weaknesses are they have low spatial resolution and can only measure the electrical activity of superficial cells.
 2. Two strengths of MRI is that it has high spatial resolution and can measure activity from the whole brain. Two weaknesses are that MRI has low temporal resolution and can cannot measure brain activity directly.
 3. T_2^* relaxation times are shorter than T_2 relaxation times because the presence of inhomogeneities in the magnetic field (such as deoxygenated haemoglobin) increase the rates at which spins dephase (become out of phase).
 4. Magnetic resonance imaging, because the region of the brain is small, therefore a high spatial resolution is needed, and because it is deep in the brain.
 5. The region with oxygen bound to two heme groups would have a greater difference between T_2 and T_2^* . This is because a haemoglobin molecule that is bound to two molecules of oxygen will be more paramagnetic than a haemoglobin molecule bound to three molecules of oxygen. Therefore there will be two iron molecules not bound to oxygen molecules, compared to haemoglobin bound to three molecules of oxygen who will only have one free iron molecule.. Thus there will be one more pair of free electrons for each molecule of haemoglobin, which increases the inhomogeneity of the magnetic field.



Resource Two

Model Answers

- Answers**
1. Neuronal cells are primarily involved in communicating via nerve impulses, while glial cells support the activity of neuronal cells
 2. The peripheral nervous system produces sensory impulses, the central nervous system integrates inputs.
 3. Items found in grey matter: Neuronal cell bodies, unmyelinated axons, glial cells, capillaries. Items found in white matter: Myelinated axons, oligodendrocyte processes.
 4. The brain uses approximately 20% of the body's energy demand, and makes up approximately 2% of its mass, therefore it requires 10 times more energy relative to its volume.
 5. Yes the haemodynamic response may be representative of neuronal activity, because as activity increases the demand for energy may also increase and thus more oxygen would be needed for respiration. Therefore, blood flow would need to increase. However, it may also not be representative of neuronal activity as we cannot be sure that the increase in blood flow is proportional to the increase neuronal activity, or if it is an increase in neuronal activity that even causes an increase in blood flow.
 6. Some brain regions may have a more comprehensive vascular network that can adapt to changes in blood flow demands more rapidly than other regions, while other regions may take longer to adapt to demands. Therefore these regions would have differently shaped haemodynamic responses.





Resource Three

Model Answers

- Answers**
1. Functional magnetic resonance imaging measures changes in blood flow, while magnetic resonance spectroscopy measures the concentrations of different metabolites in the brain
 2. The protons in molecule B has the most diamagnetic shielding, followed by the protons of molecule A, and the protons of molecule C have the least diamagnetic shielding. This is because molecule B requires the least amount of energy to flip its protons from the α spin state to the β spin state, while protons in molecule C require the most amount of energy.
 3. Expressing resonance frequency in parts per million (using chemical shift, δ) means that resonance frequencies are consistent across different magnetic field strengths. However, the resonance frequency of a molecule when expressed in hertz is dependent on the strength of the magnetic field.
 4. Measuring functional change in metabolite concentrations is restricted by the repetition time of the MRI scanner which is the time taken to measure a single sample, and also by the number of samples that the MRS spectra is averaged over.



Resource Four

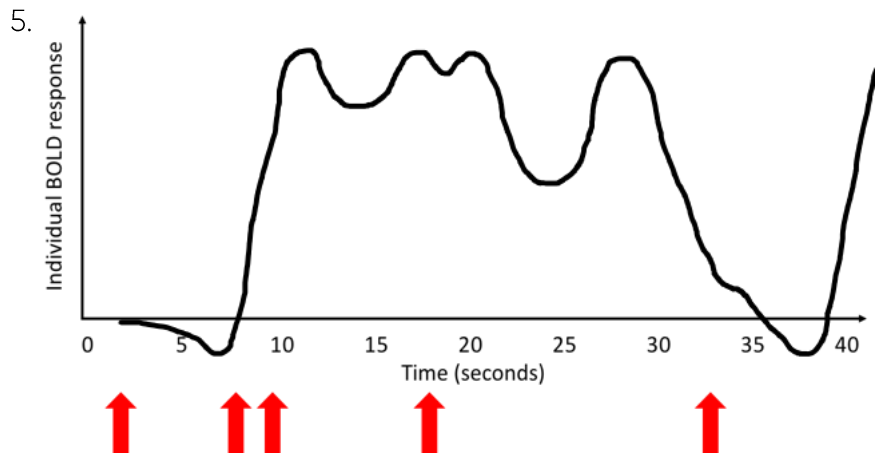
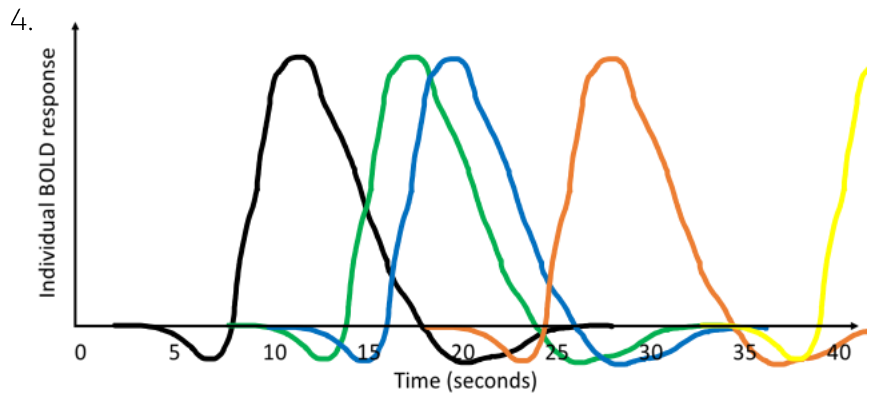
Model Answers

- Answers**
1. Independent variables can also be thought of as the experimental manipulations. Meanwhile, dependent variables are variables that cannot be controlled by the experimenter, and their value can change on the basis of the experimental design.
 2. For a hypothesis to be falsifiable it should be written in a way such that it could be disproved on the basis of evidence collected in a study. A falsifiable hypothesis would be that 'there are more brown eyed people in the United Kingdom than blue eyed people' because eye colour is measurable. A hypothesis that is not falsifiable from Freud's psychodynamic theory is that 'traumatic experiences in childhood has a negative impact on our subconscious, which can cause problems in our adult life'. This is not falsifiable since there is no empirical way the impact of an experience our subconscious.
 3. Event related designs and block designs. Benefit of event related designs are that the haemodynamic response can be estimated for each stimulus presentation, and a limitation is how the sampling frequency (repetition time) limits the speed of event presentation. A benefit of the block design is the sum of the haemodynamic response is relatively easy, while a limitation is that the shape of the haemodynamic response for each stimulus presentation cannot always be identified.



Resource Four Model Answers

Answers



6. Changing the onset of BOLD sampling relative to stimulus presentation for event related designs allows you to sample from more points along the haemodynamic response, thus increasing the accuracy in determining the shape of the haemodynamic response to stimuli.



Resource Five

Model Answers

- Answers**
1. Convolution is a process that combines the onset of stimulus presentations with a model of the hemodynamic response to create an estimation of the shape of the BOLD response created by the presentation of stimuli.
 2. Absolute brain activity cannot be measured as statistical tests always consider the activation in one condition in reference to the activation in another condition.
 3. Clusterwise thresholding and false discovery rate correction. Correcting for multiple comparisons is important to ensure the type 1 error rate is not inflated. If the type 1 error rate were inflated then the likelihood of spurious results would be increased.
 4. Bonferroni correction is a very conservative method for multiple comparisons, since the significance threshold is divided by the number of tests that need to be run. Because a large number of tests need to be run when analysis fMRI data, using the Bonferroni correction would increase the likelihood of type 2 error.
 5. PPI, because PPI analysis identifies other brain regions that are functionally connected with the seed region during certain conditions but not during other conditions.
 6. MVPA, because MVPA can detect how different patterns of neural activity are related to the presentation of different stimuli, thus decoding the response to different objects.



Resource Six

Model Answers

- Answers**
1. The core principle of open science is that science should be open and available to all members of humanity.
 2. 97% of the original studies had statistically significant results, 36% of the replications had statistically significant results. There may be a difference in these numbers because the original study did not describe the methods or analysis in sufficient detail for the results to be replicated. Alternatively, the difference could exist because there is a bias in scientific publishing, where there is a disproportionate focus on publishing significant results, but not results from studies that are non-significant.
 3. Reproducible results use the same analysis method on the same data as the original publication, replicable results use the same analysis method on a different set of data to the original publication.
 4. Open science aims to improve the credibility of scientific research through the use of preregistration/registered reports to clearly separate confirmatory findings from exploratory findings, and by encouraging the sharing of research data with the FAIR principles describing how data should be shared correctly. *Please note, whether this is sufficient or not is a matter of personal opinion and therefore there is no model answer.*
 5. *Please note, what would make someone more or less sceptical about the findings of scientific research is a matter of personal opinion, and therefore there is no model answer.*
 6. It is problematic that journals mainly publish significant findings because it paints an unrepresentative picture of the scientific literature. Many more studies are run than are published, and those studies with non-significant findings are generally not accessible to other researchers.



Resource Six

Model Answers

Answers 6. (Continued)

Not publishing non-significant results could restrict theory and hypothesis generation. If non-significant results were published then there would be a more accurate picture of scientific research in the literature, plus the time and resources of researchers could be saved. Time and resources could be saved because if there are multiple studies published that show an experiment has no significant results then a researcher would know not to run that study again. However if these studies are not published, then a researcher could think they are the first person to run a study because they are not aware that other people have done so before and found no significant effects.



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