Research Method To Understand Brain Function

This essay will focus on the strengths and weaknesses of three research methods that cognitive neuroscientists use when looking to understand brain function, the biological bases of behaviour and mental processing. Two of three research methods to be discussed look at hemodynamic based brain imaging that is Positron Emission Tomography (PET) and functional Magnetic Resonance Imaging (fMRI) (Lystad & Pollard, 2019) Whilst the final method of research to be examined is Magnetoencephalography (MEG), This is an electromagnetic based technique (Horwitz & Poeppel, 2002).

PET scanning is the first method of research to be discussed. PET scans are an invasive way of measuring glucose consumption, blood flow and brain metabolism when there's increased neural activity (Martin & Carlson, 2019). PET scanners function by detecting radiation given off by a substance injected into your arm called a radiotracer. This is often a form of glucose called fluorodeoxyglucose (Schelling et al., 2000). PET allows cognitive neuroscientists to understand mental processing by the amount of radiotracer that is consumed in specific brain regions or by blood flow that travels to neurons. This is due to the radioactive nature of the glucose that emits positrons that can be detected by PET (Martin & Carlson, 2019)

Moreover, PET provides neuroscientists with high-quality images. This is because of the good spatial resolution it possesses (Lystad & Pollard, 2009). For example, a contrast resolution better than ten percent in a period of less than one minute (Ter-Pogossian, 1982). This is useful for cognitive neuroscientists and is a clear strength of PET as it allows neuroscientists to analyse brain regions that consume the radiotracer, through high-quality coloured images of the brain that are active and inactive when completing short tasks. Such as the right dorsolateral and ventrolateral prefrontal cortices when researching prospective memory (Okuda et al., 1998).

Despite this key strength that PET provides to cognitive neuroscientists, PET has limitations which reduce its effectiveness. A first weakness of PET is that it has a poor temporal resolution at sixty seconds (Varvatsoulias, 2013). Thirty seconds for the radiotracer to reach the brain and an additional thirty seconds for radiation to peak (Benaron et al., 2000). Due to this negative, PET cannot assess rapid changes in brain activity that are associated with cognitive processing and cannot imply to cognitive neuroscientists which brain areas were active at specific moments in time.

Furthermore, an added flaw with PET is the invasive nature of the radiotracer that causes harm to certain participants in psychological research, conducted by cognitive neuroscientists. Thus making these participants exempt from research. Premenopausal women and children are excluded from PET research (Martin & Carlson, 2019) which inhibits the investigation of brain function during the early development of those who suffer from this condition.

Now focusing the attention onto fMRI. This form of research method is an indirect, non-invasive way of studying deoxygenated levels of haemoglobin in the blood, in certain brain regions which provides researchers with blood oxygen level-dependent signals (BOLD) (Varvatsoulias, 2013). BOLD signals are transferred into a visual unit called 'voxels' with each image produced containing between forty thousand and fifty thousand voxels (Martin & Carlson, 2019). Voxels

are put together and a three-dimensional image of neural activity is produced.

Due to the non-invasive nature of this method, this is a strength and is useful for cognitive neuroscientists as all varieties of participants can take part in fMRI research (Melzer et al., 2001). For example, a sample of seven-year-olds when researching self - regulatory control on a Stroop performance task (Marsh et al., 2006). This allows researchers to examine brain function in young children or those who suffer from disabilities from early years of brain development. As previously discussed, PET does not have this ability which gives fMRI an advantage over its counterpart.

Following on from this, another positive of fMRI is that the same of PET in which it has a good spatial resolution at 1mm (Lazar, 2009). Recent studies have shown that advancements in fMRI technology have led to fMRI having the best spatial resolution amongst all functional neuroimaging techniques (Lystad & Pollard, 2009). Therefore producing high-quality three-dimensional images for neuroscientists to evaluate and conclude which brain areas are functioning when performing cognitive tasks. Such as increased blood flow to the ventral striatum in subjects attempting to delay gratification when performing ‘go/no go’ tasks (Casey et al., 2011)

On the other hand, a weakness of fMRI is that results and conclusions made by neuroscientists for data produced by fMRI can be false or misleading due to excessive acoustic noise that is created by these scanners (Moelker & Pattynama, 2003). This can, therefore, disrupt the concentration of the participant when performing cognitive tasks and increase the load on an individual’s working memory (Tomasi, Caparelli, Chang & Ernst, 2005). Ultimately leading to inaccurate measures of brain activity, brain function and false conclusions made by neuroscientists.

In addition to this, it has been previously discussed that PET scanners have poor temporal resolution. Similarly, fMRI also has a poor temporal resolution at four to five seconds (Lystad & Pollard, 2009). This is due to the process that fMRI takes to produce an image. fMRI uses a process of averaging and subtraction, by which several scans are taken of a brain region every three seconds and an average image is produced (Martin & Carlson, 2019). Therefore, neuroscientists cannot accurately determine neural activity at precise moments in time.

Now turning the attention to an electromagnetic based approach in the form of MEG, this method of research is a more contemporary neuroimaging technique (Stam, 2010). By definition; MEG is a direct, non - invasive functional imaging procedure that records the magnetic field produced by electrical brain activity, which is associated with electrical currents in activated sets of neurons (Wheless et al., 2004). The magnetic field is measured from the surface of the head via a machine called a superconducting quantum interference device (SQUID). This is often combined with Magnetic Resonance Imaging (MRI) to form a Magnetic Source Image (MSI) of the brain activity and functioning processes (Singh, 2014)

With regards to the positives that MEG possesses, one strength of this method is that it has an excellent temporal resolution, in the region of milliseconds (Cornelissen et al., 2009). For instance, in right-handed individuals, the left superior-temporal areas became active just 136ms after an elicit word was spoken (Pulvermuller, Shtyrov & Ilmoniemi, 2003). Therefore, this evidence illustrates how cognitive neuroscientists can study neural activity to the nearest millisecond, because of the excellent temporal resolution that MEG provides. Thus leading to

much-improved conclusions about brain function.

In comparison to previous methods of research that have been discussed, MEG has an added strength by which it also has good spatial resolution along with excellent temporal resolution (Singh, 2014), rather than compensating one for the other such as PET or FMRI. MEG takes advantage of neuromagnetic signals being able to penetrate the skull easily (Wheless et al., 2004). The MSI is then produced when the MEG data is superimposed onto a MRI. Depending on signal quality, spatial resolution of MEG can be in the range of millimeters (Braeutigam, 2013). Combining excellent temporal resolution with good spatial resolution allows for neuroscientists to trace the fastest of neuronal processes (Brauetigam, 2013), with good quality images to analyse.

On the other hand, despite the strengths that MEG brings when researching neuronal activity and brain function, one disadvantage of the method is that it’s very expensive and costs a vast amount of money to operate and maintain (Martin, 2006). This is because of the small magnetic fields that are generated by the brain. And to achieve sensitivity to measure them, conventional MEG systems must employ SQUID that is housed in liquid helium (Boto et al., 2019). Consequently, this means that conventional MEG systems are large and expensive with the cost of one piece of MEG equipment coming to two million dollars and the operating costs coming to six hundred dollars (Lystad & Pollard, 2009). Ultimately, this portrays that to gain the advantages of having a research method that has excellent temporal resolution, good spatial resolution, is non invasive and is a direct measurement of neural activity, cognitive neuroscientists have to pay and fund large amounts of money to produce high quality data.

In conclusion, this essay has discussed a brief overview of three research methods and their strengths and weaknesses that cognitive neuroscientists have to consider when analysing the biological basis of behaviour, mental processing, and brain function. Two of three (PET and fMRI) research methods focused on hemodynamic based brain imaging, whilst the final method (MEG) focused on an electromagnetic technique. Each method has its positives and negatives, such as poor temporal resolution but the excellent spatial resolution in fMRI, or excellent temporal resolution but being very expensive such as MEG. Overall, when the correct research method is chosen, each method has been beneficial to cognitive neuroscientists in one way or another, to study brain function and localisation.