

Brain-imaging techniques for cognitive functions analysis



**ASSIGN
BUSTER**

Using examples of fMRI, explain how researchers use brain-imaging techniques and discuss what, if anything, these techniques can tell us about cognitive functions.

Here is introduced the method of fMRI, how imaging data is gained and at what cost is involved in getting it. Further to this the experimental designs are discussed and how these might add to the toolbox available to the experimental psychologist. A study will be looked at, which has used fMRI imaging to add to the existing knowledge and psychological theories that exist around memory. Last of all some areas of concern are looked at as the structure-function data will continue to grow and expand.

Before the use of imaging methods, such as that of fMRI and PET scanning, as Naish (2010) points out, it was possible to discover whether certain parts of the brain were responsible for certain cognitive functions. There were problems with this, often relying on accidental lesions meant the more than one function could be damaged or it produced inconsistent findings. Lack of clear resolution resulted in the patient being tested through their life to only discover the underlying neurological damage after death. Kaye (2010) highlights a common critique that the current use of imaging techniques does not provide cognitive psychologists with much. The simple structure-to-function mapping does not improve our understanding of cognitive theories. This has been challenged in Henson's (2005) review of Tulving (1985) 'remember' or 'know' memory experiment with the use of fMRI methods. Still, it is important to explore the way that imaging methods work for continuing psychological understanding.

MRI and to an extent also PET imaging works based on the idea that when a cognitive task is being undertaken both glucose and oxygen will be carried to those area(s) of the brain, which requires it significantly over than that of resting or less activate areas (Johnsrude and Hauk 2010). The imaging technique is sensitive to that increased blood flow and that according to Johnsrude and Hauk (2010) this is used to study the functioning of the brain. This is often known as regional cerebral blood flow (rCBF): alongside this the level of oxygen that is left in blood can also be looked at known as the blood oxygen level dependent (BOLD) contrast, as deoxyhaemoglobin and oxyhaemoglobin produce different magnetic fields (Johnsrude and Hauk, 2010). Although there are some methodological problems with this, such as the lag between neural processing and increased blood flow, it is argued that with the correct design and computer analysis such problems can be dealt with (Henson, 2005). Functional MRI over PET is less intrusive in the sense that more participants can be involved, be studied over a longer time and it is generally easier to maintain. This is due to PET requiring the participant being injected with a radioactive substance which because of health issues rules out who can take part and how many times each participant can undergo PET imaging (Johnsrude and Hauk, 2010). Functional MRI has become the choice of many experimental psychologists.

Johnsrude and Hauk (2010) also highlight other issues that make fMRI difficult, but not impossible, the first that the machine itself makes a lot of noise to the extent it can cause hearing damage, it can be constricting and participants cannot move their heads while imaging is taking place. Those with anxiety issues, for example, will find fMRI studies very difficult to take

part in but when participants move their heads computers can adjust the images to match up with earlier ones and ear plugs can be worn. Johnsrude and Hauk (2010) present two types of experimental design.

Subtractive designs such as that used by Klein et al (1995, cited and explored by Johnsrude and Hauk 2010) is based on the assumption that [cognitive] tasks can be broken down and by adding an additional task between two tasks, the extra load can be subtracted from the two tasks. This allows the extra task to be measured and Klein et al (1995) followed this design. Using native English speakers who later in life learned French, these participants were asked in either language to either repeat the heard word or create a synonym for that word. Speech perception and production would always have to be used, but when asked to create a synonym it would also involve semantic association and word retrieval (cited by Johnsrude and Hauk, 2010). Klein et al (1995) subtracted speech perception and production, allowing them to solely study semantic association and retrieval. They found activation in the prefrontal cortex, perhaps indicating the importance of this region in processing word meaning and response selection. Further to this activation in the basal ganglia in the French synonym task which is linked to motor action a previous known process.

The second type of design is that of correlations which Johnsrude and Hauk (2010) highlight as examining the relationship between a presented stimulus or behavioural response along with the associated brain activity. They are relatively simpler than subtractive designs avoiding the interpretation or subtraction of tasks. For example, cognitive states can be examined so signal change in one area can be predictive of activity somewhere else in the <https://assignbuster.com/brain-imaging-techniques-for-cognitive-functions-analysis/>

brain. If the two areas correlate it could be assumed they are part of the same neural network for the cognitive function either directly or through another region. In this case it is not simple structure-to-function but rather exploring the areas of the brain that are required to perform one cognitive task. Adding or reducing theoretical components to such cognitive tasks. It could be argued that subtractive designs look for differences within known theoretical connected functions, whereas correlational designs look for explorative patterns without assuming such a strong known function-to-structure relationship.

Henson (2005) distinguishes between two types of imaging inferences the first function-to-structure deduction and the other structure-to-function induction. The first inference is that of deduction, if one condition activates area one and the second condition activates area two it would be possible to assume that these two different conditions activate different areas within the brain. It does not matter which areas of the brain are activated only that there is a qualitative difference. In terms of function-structure mapping at the psychological function level according to Henson (2005) the only assumption is that the same psychological function (or task) will not give rise to different activation patterns within the brain.

For function-to-structure induction the areas of the brain activated are important for each presented condition. Henson (2005) goes on to explain for each presented condition the same area of the brain is activated which can lead to experiments which conditions use the same area of the brain to explain that a certain area of the brain has more than one function but can operate differently depending on the processing task. Rather than there
<https://assignbuster.com/brain-imaging-techniques-for-cognitive-functions-analysis/>

being a disassociation that you would find in deduction there is an association, Henson (2005) argues that in most cases the null hypothesis, therefore has to be accepted, although at the same time this could suggest the abilities and/or limitations of that area of the brain thus results in limitations of that cognitive ability and task.

Through psychological manipulations it can be shown that there is a reliable regional dissociations (Henson, 2005). One experiment as mentioned above is that of the remember/know memory experiment that also uses function-structure deduction. The importance of this fMRI study is that it takes psychological theory and determines what the processes are occurring. This experiment presented by Henson (2005) and others is based around the argument that there is either a single-process model such as that presented by Donaldson (1996, cited by Henson, 2005) or a dual-process. Using Tulving (1985, cited by Henson, 2005) participants are asked to indicate if they have seen a stimulus previously and whether they think this because they remember the encounter (remember) or they just think the stimulus seems familiar (know). It was found that within the remember condition the left hemisphere was more responsive while the in the know condition other regions such as the right prefrontal cortex were more activated. The conclusion is that the imaging data support a dual-processing model over the single-process model. Functional MRI imaging was helpful here as behavioural findings could not agree and the debate was in part helped by imaging data.

Both deduction and induction results in the function-structure mapping according to Henson (2005). It is important to follow the logic of Henson that <https://assignbuster.com/brain-imaging-techniques-for-cognitive-functions-analysis/>

imaging data is useful within itself for providing another dependent variable, such is the case if reaction time is being recorded alongside imaging data, that imaging data would provide additional information such as right/left activation of the motor cortex (Henson, 2005). This might not be relevant in all contexts, still it can provide information which could be necessary to the research if that research included or required such information. This is described as function-structure mapping.

Henson (2005) argues that the systematic function-structure is an assumption, for deductive areas of the brain to perform certain functions whereas for induction a strong sense of systematicity is necessary. In this case there may be a function that depends on co-activation with at least one, perhaps more regions. In this case a network is what is being observed activated within a condition. Through subtraction analysis, it allows for this test of a 'neural network' and McIntosh (1999, cited in Henson, 2005) the function of the area or region of the brain depends on its interaction with other regions (Henson, 2005, referred to this as hot-wiring). Adding to this there might be an activation of a region or area which does produce suppression of other areas or regions. Nelson (2005) calls for the redundancy of networks, to summarize this within a brain damaged patient, it might be that although the function-structure mapping is incorrect for this person. There might be a different function-structure mapping present.

Henson (2005) counter-argues for this position to say that if through trial to trial or from many experiments, it would not be observed that there are reliable or reproducible activations. Most psychologists are also content with the idea that there is a hierarchy of abstraction of functions. For example, <https://assignbuster.com/brain-imaging-techniques-for-cognitive-functions-analysis/>

visual perception occurs within a region which is divisible into sub-functions. Where colour, form perception and motion perception can occur (Nelson, 2005). However, there is agreement that there needs to be a one-to-one mapping or function-mapping before one can infer structure to function. Henson (2005) calls this the structure-to-function induction, the usefulness of this approach or paradigm will have to stand up by its success or failure.

Henson (2005) further argues the fMRI is a recent invention, the computer mapping even so, with such new areas of technology it has to prove itself to be of benefit. So even if mapping critics have a point it will perhaps be years before the value of imaging technique come to be very useful. Currently they can be useful, though by using existing completing cognitive theories which can be settled using imaging data with caution. For Henson (2005) imaging data simply comprise another dependent variable along with behavioural data that can be used to test competing theories. Imaging can determine the circumstance under which a tactile stimulus produces activity in the visual cortex give clues about the mechanisms of sensory integration that are not provided by behavioural data alone (Henson, 2005).

There are criticisms of using imaging data, one produced by Coltheart (2004, cited in Henson, 2005) that understanding the hardware does not mean that we then reach an understanding of the neuro software. Henson (2005) argues that it does provide information on performance and on the distribution of the processes while the software is performing. To finally say that once you have the performance data, through behavioural data, the knowledge of the hardware this then can tell you something about software (Henson, 2005). Henson (2005) argues that neuroimaging data can be <https://assignbuster.com/brain-imaging-techniques-for-cognitive-functions-analysis/>

informative to the experimental psychologist, although there is perhaps too much excitement around such data. No other technique comes close to this ideal of measuring brain activity, if we assume that ideal is measuring activity simultaneously the activity of many individual neurons, we currently are not there but MRI is the best that we currently have. This is still a developing technology, it may in future years with advances it can become something quite special.

Functional MRI is a relatively safe method and it can be used to replace the more traditional method in the Neuropsychology of relying on accidental brain lesions to discover the link between psychological function and structure. The two methods mentioned above, that of subtractive and correlational designs allows for the more traditional dissociations along with associations of areas or regions of the brain. Although fMRI does not study the neural activity directly it is currently one of the best methods for studying activity at levels of relatively high resolution. Still fMRI is relatively new and the computing software more so, so it is likely that in years to come these technologies will improve. This is not to say that such imaging should be a replacement for more traditional methods, above the example of the Remember/Know experiment imaging extends or made clear the already present psychological models. The mainstay of cognitive psychology is behavioural data and imaging should be used alongside. To what Henson argued that imaging data as another dependent variable. This is to say that it won't always be appropriate to use imaging data still there is excitement about imaging data and as it improves it will become yet another useful tool in the experimental psychologist toolbox.

Word count: 2204

References:

Naish, P. (2010) *Perceptual Processes* in: Kaye (2010) 'Cognitive psychology' ed, The Open University, Milton Keynes

Kaye, H. (2010) *Foundations of cognitive psychology* in Kaye (2010) 'Cognitive Psychology' ed, The Open University, Milton Keynes.

Johnsrude, I. S. and Hauk, O. (2010) *Neuroimaging: techniques for examining human brain function*, ed in: Kaye (2010) 'Cognitive psychology: methods companion', The Open University, Milton Keynes.

Henson, R. (2005) *What can functional neuroimaging tell us the experimental psychologist?* *The quarterly journal of experimental psychology*, Issue 58A, pp. 193-233

- Lewis Karl Flood