Communicating with people in a vegetative state

Have you ever wondered whether your friends are actually conscious? The chances are you think they are because they can follow commands. Ask someone to raise their arm and if they do, you assume they are conscious. This might not be an infallible test of consciousness, ask a dog to raise its paw and, if trained, it will. That might not be conclusive proof of the consciousness of dogs but let's not go there now. Asking a potato to jump might be an attempt to communicate with vegetables and that is something completely different best left to the Prince of Wales.

The problem is that we simply can't tell if someone is conscious by looking at their brain activity. Most patients with acute brain damage who are in a coma often recover over a period of time. They may enter a vegetative state which has been called 'wakeful unawareness'. These patients show waking and sleeping but are unable to communicate with the outside world – they show no signs of conscious perception. Patients in a vegetative state should not be confused with 'locked-in syndrome' - patients who are clearly conscious but so paralysed that they cannot speak. Their main way of communicating with the world is through eye-movements and eye blinks. If you saw the movie 'The Diving Bell and the Butterfly' you'll know all about locked-in syndrome.

However let's consider the problem of communicating with someone in a vegetative state. These people, by definition do not respond to external stimuli; there is no way they can raise their arm when asked to do so but does this necessarily mean they didn't understand the request? Perhaps they are conscious but are trapped in a body that can't respond. This is a really scary possibility. Imagine being completely paralysed but still able to see, hear and understand everything going on around you.

Adrian Owen and his colleagues reported just such a case (Owen, A et al (2006) Detecting awareness in vegetative state. Science 313 1402). A young woman suffered brain damage following a traffic accident. She seemed to be in a vegetative state, but could she actually be conscious? Owen answered this question in a particularly ingenious way. He knew that people who imagine they are doing different things produce different areas of brain activity and this can be seen using fMRI. So, for example, if I imagine I am playing tennis there will be significant activity in a region of my brain called the 'supplementary motor area'. If I imagine I'm visiting all the rooms in my house, the pattern of activity will be concentrated in the parahippocampal gyrus, the posterior parietal cortex and the lateral premotor cortex. Don't worry too much about these different areas; the important thing is that if I were to think either about the tennis game or my home, Owen would know which activity I was thinking about by looking at my brain in the scanner. So what happened when Owen put the vegetative state traffic accident patient in the scanner and asked her to imagine exactly those same activities? Her brain patterns looked exactly like those of a normal person (see http://www.sciencemag.org/content/313/5792/1402.figures-only).

Could this technique be used to communicate with all vegetative state patients? Sadly the answer seems, at present, to be 'No'. Owen and his colleague Martin Coleman have reported that of the 17 patients they have scanned only one other shows this level of awareness (Owen, A. and Coleman, M. (2008) Functional neuroimaging of the vegetative state. Nature Reviews Neuroscience 9 235-243).

The use of fMRI data to determine the wishes of patients in a vegetative state is not without its problems. Currently such patients may be 'allowed to die' with the withdrawal of food and water. The decision to do this may involve family members, doctors or even the courts. Should the patient also be consulted via fMRI? It's not as simple as asking 'Think of playing tennis if you want to die…' What if you didn't remember the question... what if you were asleep at the time… what if the fMRI signals were misinterpreted?

If you're interested in the issues raised here – and in the quest to understand consciousness, then you might like to listen to Adrian Owen talking about this problem and his research:

http://www.youtube.com/watch?feature=player_detailpage&v=lvUvY_JrUgA

If we can work out if a comatose patient is imagining a game of tennis or walking around their home, could we work out what someone is seeing just by looking at the activity in their brain. Research is this area is in an early stage but in 2008 Yukiyasu Kamitani and colleagues reported that they could present a simple figure made up of 100 black or white squares (in an array 10x10) – a bit like a crossword puzzle – and reconstruct the pattern from brain activity, measured with fMRI. (Miyawaki, Y. et al (2008) Visual image reconstruction from human brain activity using a combination of multiscale local image decoders. Neuron 60 915-929). Actually, the results weren't *that* great. Figure 2 in the article shows what they got.

You can hear Kamitani talking about his work on YouTube:

http://www.youtube.com/watch?v=2XtlBrTtUqU&feature=player_detailpage

More recently Jack Gallant and his colleagues have taken this research further by showing subjects movie clips and then trying to reconstruct what they see (Nishimoto et al (2011) Reconstructing visual experiences from brain activity evoked by natural movies. Current Biology 21 1641-1646). You can see Jack Gallant talking about this work – and some of the examples of their reconstructions at:

http://www.youtube.com/watch?feature=player_detailpage&v=6FsH7RK1S2E

Their results might not look brilliant but the fact they can do this at all is amazing, given that fMRI is not good at tracking fast moving changes.

This is a new and fast-moving area of research. How long will it be before we can record your brain activity while you sleep and then play back the movie of your dreams in the morning? Scary, scary stuff!