

INTO THE GREY ZONE

Neuroscientist **Dr Adrian Owen's** pioneering work uses brain scans to find consciousness in vegetative patients. He speaks to **Daniel Bennett** about his research

What is the 'Grey Zone'?

It's a term I coined to describe a state between being completely awake and aware of who and where you are, and at the other end of the spectrum, a state where you're completely unaware of anything. In my work, this typically means patients in a vegetative state – but it could mean something more familiar, like being under a general anaesthetic.

What typically leaves a patient in this state?

I'm interested in any patient who's had a serious brain injury, and that's two groups: traumatic and non-traumatic injuries. Traumatic injuries typically involve a blow to the head, often in some kind of vehicle accident. But a non-traumatic brain injury might also put you into a vegetative state. That might be an anoxic injury – where the brain is starved of oxygen, as can occur in near-drowning accidents – or a stroke.

What does it feel like to be in the Grey Zone?

Every patient is different. What does it feel like to have your sense of being a person gradually deteriorate to the point that you become detached to the outside world? We're starting to decode what it's like to be minimally conscious, but we still don't know. Every patient who's recovered – and they're rare – has something a little different to say.

Kate, my first patient, described quite harrowing experiences. She talked about a raging thirst that she couldn't alleviate, and at one point she wished she could die. Another patient who made a spectacular recovery was optimistic: he said he always knew that he was going to get out.

How have we viewed patients like this in the past?

When we came into this area 20 years ago, the assumption was that these patients were all the same: they were in a vegetative state with no sense of who or where they were. But through many brain imaging studies over the last 20 years, we've shown that what you see is often *not* what you get. A recent study reported that one in five patients reported as vegetative seem to have some level of awareness.

On the surface, some patients that may not appear

to be entirely responsive may be somewhere in there. That consciousness can take many different forms. It could mean that the patient can understand a little bit of what's going on around them, to full-blown conscious awareness where a patient is trapped inside their head, unable to respond but aware of everything going on around them and every decision made on their behalf. Sometimes they're in that situation for decades.

Where did your research into the Grey Zone start?

I was at working in the Wolfson Brain Imaging Centre at Addenbrookes Hospital in Cambridge, and a colleague brought a patient called Kate to my attention. He said a virus had attacked her brain. ●

“One in five patients reported as vegetative seem to have some level of awareness”



Dr Owen's research has shed new light on the experiences of people in vegetative states

"It was a shock when Kate's brain responded to the faces in the same way our own brains might"

• The two of us cooked up the idea of putting her into the brain scanner – in those days it was known as Positron Emission Tomography or PET scanning. We did it not knowing what the outcome was going to be. Everybody assumed that none of these patients would produce any brain activity in response to stimulation.

We showed her pictures of her friends and family, because I'd been doing some work on face recognition: mapping which parts of the brain were involved in processing faces. We thought if we showed these to Kate, and if there was anything going on in her brain, the part of it involved in recognising faces might light up. We all expected nothing to happen, so it was a shock when Kate's brain responded to the faces in the same way our own brains might. The fact that Kate's brain sprung into life that day really laid the foundation for everything that came afterwards.

Where did you go from there?

In the decade that followed, we started putting together the building blocks of consciousness. We kept trying different things to see whether some patients would respond to them. To some we showed faces, to others we played speech, and the answer at every stage was 'yes'. We'd find a patient who was responsive, but each time we were stuck with this question: does it mean that they are conscious? Maybe the patients' brains were on autopilot. Maybe their brains were just automatically processing language and faces, because these are things we have very little control over.

So I asked the question – and this was really my big 'a-ha!' moment – "What would you have to do to be absolutely sure a patient is conscious?". I realised that you have to go back and think about that scenario that everyone has seen in a medical drama, where the doctor holds the patient's hand and says, "Squeeze my hand if you can hear me." If you say that to a patient and they do it, you know they understand language, you know they can initiate an action; essentially, you know they have some level of awareness. I realised that we had to do the same thing with brain scanning. We had to measure a pattern of brain activity that could not be automatic.

So you asked them to play tennis...

It sounds a bit bizarre, I know, but it's just a way to get patients to do what we want, which is to imagine

moving their arms around. This action activates a part of the brain called the premotor cortex, which is involved in planning and initiating movements. If you think about waving your arms around, the premotor cortex will light up: even if you don't physically move, simply *thinking* about tennis activates the areas involved. If we could get a patient to activate their premotor cortex when we asked them to do so, I knew at that point we would know they were conscious.

So tennis gave you a way to talk to people. How did that work?

We had this signal now, so we could then use that as a response. We'd say to patients: "I'm going to ask you a question. If the answer is yes, please imagine playing tennis." We'd start with simple questions like "Is your name Dan?" and we'd see activity and we knew we'd got a yes. And of course we'd have another signal for no. Then we'd go on to stuff like asking them if they were in pain, or whether they were afraid, and we'd get answers out of patients who were entirely physically non-responsive.

What do you do once you find out they're conscious, but effectively trapped. What if they say they're in pain? What would happen next?

This is exactly why I wrote this book. We don't have this end idea that we work toward until we get there – the whole thing is an evolving process and I can honestly say that, over the 20 years the book covers, I had no idea at the beginning of the journey where it would end up. Indeed, I'm not at the end now, I'm still continuing with this work. I never know what I'm going to find.

One thing that gets us into hot water is when we have a patient in the scanner and they're answering yes and no, and we've asked all the questions we've thought of. What do we do next? Sometimes we're flying by the seat of our pants, and it can bring us quite close to complexities with our ethics committees because we want to do things we don't

Dr Owen's research involves using an fMRI scanner to track activity in the brain – specifically, activity in the premotor cortex

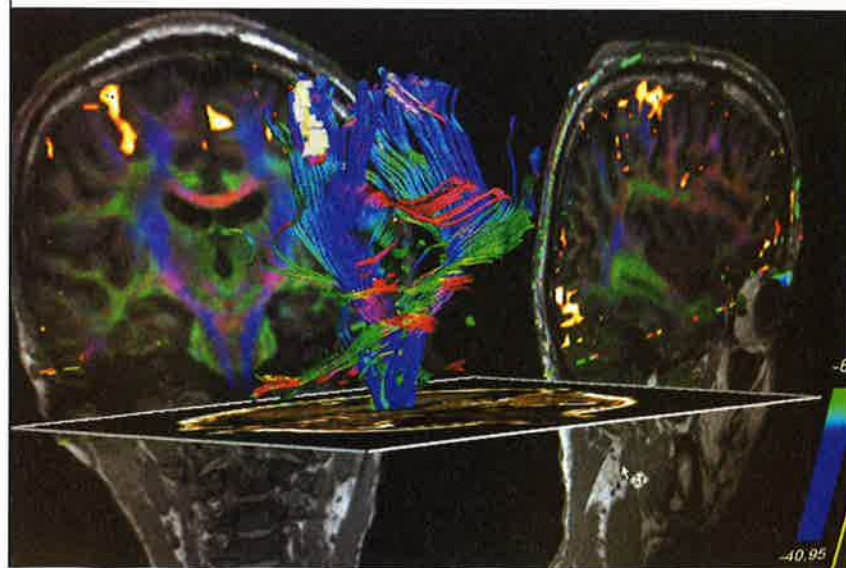
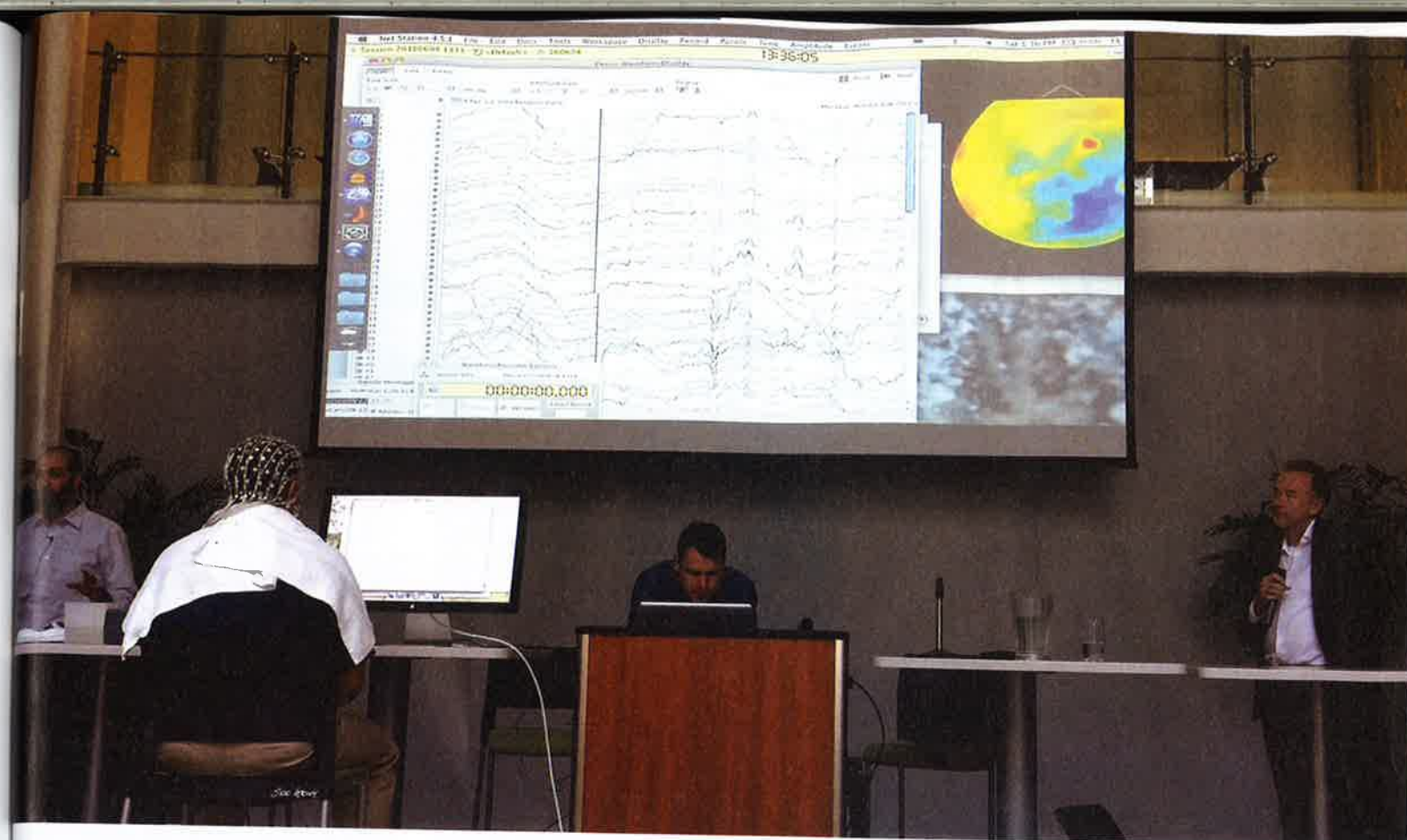


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Dr Owen gives a demonstration of his methods at a meeting of the Canadian Science Writers' Association in 2016

have permission to do. Not because we're not allowed, but because we didn't know just how far we'd get. Suddenly we're thinking, 'Should we ask this patient if they want to live or die?'

What effect did 'finding' these patients have?

Kate, my first patient, told me that the scan "found her". In her own words she said the day we scanned her she became a person again. Now, after 20 years working with these patients, I know exactly what she means. It's very difficult to maintain a sense of a person being somebody when they're totally non-responsive. These patients don't respond, they don't appear to be listening when you talk to them, or when you play them music. It's human nature. It becomes difficult to remember that that person has a personality, attitudes, beliefs and love. Things they like and don't like. The moment you identify that somebody is in there, they become a person again. They have hopes for the future.

What about for the patients – does the act of contact help them?

We know what happens to people in solitary confinement. We know there are benefits of social interaction. Suddenly when we 'find' a patient they get a cascade of attention because their relatives, nurses and often the media become interested in them and they pay them a lot of attention. I'm always careful with this idea, because I'm crossing what is scientifically backed up. But it's tempting to wonder if this has contributed to improvements.

Where does your work go next?

Now, we're communicating on a fairly regular basis with patients in the scanner. Often what happens is

that families want to ask more, but we can't because MRI is expensive, and it's not portable. It's not very convenient. This has pushed me to try and find a way to send somebody home with a piece of technology that will allow these patients to communicate with the outside world for the rest of their life. I don't think it's a long way off.

There's a number of technologies we're exploring. There's a promising technique known as functional near infrared spectroscopy that looks at oxygenated blood in the scalp to understand how active the brain is being; in a sense it's quite similar to MRI, and it can be miniaturised. You simply point the device at the area you're aiming to activate and see if it gives you a response. It's terribly efficient and fast. The work isn't published yet, but we were recently able to communicate with a non-responsive patient with this method.

The book is quite harrowing at times. Has your work affected your own life?

I do think a lot about these people – it's been very important for me, getting to know them. Getting to know their lives and them getting to know mine. As a PhD student I would test and see patients, but I was detached from them as people. My focus was on the scientific question. But now I'm very much more involved in the patients' and the families' lives, which personally is much more satisfying. •



Into The Grey Zone is on sale now and available in all good book stores. Visit intothegrayzone.com for more. You can see Dr Owen speak at the Manchester Science Festival on 26 October: details at manchestersciencefestival.com