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## **Reith Lectures 2003: The Emerging Mind**

### **Lecture 5: Neuroscience - The New Philosophy**

The main theme of our lectures so far has been the idea that the study of patients with neurological disorders has implications far beyond the confines of medical neurology, implications even for the humanities, for philosophy, maybe even for aesthetics and art. Today I'd like to continue this theme and take up the challenge of mental illness. The boundary between neurology and psychiatry is becoming increasingly blurred and it's only a matter of time before psychiatry becomes just another branch of neurology. I'll also touch on a few philosophical issues like free will and the nature of self.

Now if you look at ideas on mental illness, there've been traditionally two different approaches to mental illness. The first one tries to identify chemical imbalances, changes in transmitters and receptors in the brain - and attempts to correct these changes using drugs. And this approach has revolutionised psychiatry. It's been phenomenally successful. Patients who used to be put in straight jackets or locked up can now lead relatively normal lives. The second approach we can loosely characterise as the so-called Freudian approach. It assumes that most mental illness arises from your upbringing - maybe your mother. In this lecture what I'd like to do is propose a third approach which is radically different from either of these but in a sense complements them.

My point is if you really want to understand the origins of mental illness it's not enough to merely say that some transmitter has changed in the brain. You want to know how the change in the transmitter produces the bizarre symptoms that it does - why patients have those specific symptoms which you see and why the symptoms are different for different types of mental illness. That's our agenda here. And what I'd like to do is to try and explain the symptoms you see in mental illness in terms of the known function and the known anatomy and neural structures in the brain. And that will be the goal of this lecture. And I'll suggest that many of these symptoms and disorders will seem less bizarre when viewed from an evolutionary standpoint, that is from a Darwinian perspective. So let's give this discipline a new name - and I'd like to call this discipline evolutionary neuro-psychiatry.

Let's take the classic example of what people think of as a purely mental disorder, psychological disturbance - hysteria. Now I'm using the word here in the strictly medical sense, not somebody becoming hysterical and shouting and screaming. In the strictly medical sense, the word means that here is a patient who suddenly develops a paralysis of an arm or a leg, but if you examine this patient neurologically there are no deficits, brain MR scan reveals that the brain is apparently completely normal, there are no identifiable lesions, there's no damage. So the symptoms are dismissed as being purely psychological in origin.

But recent brain-imaging studies using PET scans and functional Magnetic Resonance imaging have dramatically changed our understanding of hysteria. Using PET scans and NMR, we can now find what parts of the brain are active or inactive, for example

when a patient does some specific action or some mental process. And you can find out what parts of the brain light up when he does it - for example when you do arithmetic, mental arithmetic, what part of the brain lights up? (It's usually the left angular gyrus, it turns out). Or when I prick you with a needle and there's pain, what part of the brain lights up, what are the pathways involved? And this tells you that that particular pathway that's lighting up is somehow involved in mediating that function.

If I take anyone of you here and ask you to wiggle your finger and I do a PET scan to see what parts of the brain light up (and Kornhuber and Libet actually did this some decades ago) what I find is that two areas light up in the brain. One is called the motor cortex, which is actually sending messages to execute the appropriate sequence of muscle twitches to wiggle your finger. But also another area in front of it called the pre-frontal cortex that prepares you to move your finger. So there's an initial area which prepares you to move your finger and then there's the motor cortex that executes the motor programmes to make you wiggle your finger.

OK, fine. But what if you now try this experiment on an hysterical patient, who's hysterically paralysed? He says his arm isn't moving but there are no neurological abnormalities. What if you did a PET scan in his brain and you asked him to move his so-called paralysed arm. He says, No I can't do it. You say, Try anyway - and do a PET scan. And this was done by Chris Frith and Frackowiak and Peter Halligan and John Marshall and others. And what they found was when a person with hysterical paralysis tries to move his arm, again the pre-motor area lights up. And this means he's not faking it. He's intending to move the arm. But in addition to that there's another area that lights up. And that is the anterior cingulate and the ventromedial frontal lobes, parts of the frontal cortex. This means he has every intention of moving it, but the anterior cingulate and parts of the frontal lobes are inhibiting or vetoing this attempt to move the arm in the hysterical patient. And this makes sense because the anterior cingulate and parts of the frontal lobes are intimately linked to the limbic emotional centres in the brain. And we know that hysteria originates from some emotional trauma that's somehow preventing him from moving his arm - and his arm is paralysed.

So we've talked about hysterical patients with hysterical paralysis. Now let's go back to normals and do a PET scan when you're voluntarily moving your finger using your free will. A second to three-fourths of a second prior to moving your finger, I get the EEG potential and it's called the Readiness Potential. It's as though the brain events are kicking in a second prior to your actual finger movement, even though your conscious intention of moving the finger coincides almost exactly with the wiggle of the finger. Why? Why is the mental sensation of willing the finger delayed by a second, coming a second after the brain events kick in as monitored by the EEG? What might the evolutionary rationale be? The answer is, I think, that there is an inevitable neural delay before the signal arising in the brain cascades through the brain and the message arrives to wiggle your finger. There's going to be a delay because of neural processing - just like the satellite interviews on TV which you've all been watching. So natural selection has ensured that the subjective sensation of willing is delayed deliberately to coincide not with the onset of the brain commands but with the actual execution of the command by your finger, so that you feel you're moving it.

And this in turn is telling you something important. It's telling you that the subjective sensations that accompany brain events must have an evolutionary purpose, for if it had no purpose and merely accompanied brain events - like so many philosophers believe (this is called epiphenomenalism) - in other words the subjective sensation of willing is like a shadow that moves with you as you walk but is not causal in making you move, if that's correct then why would evolution bother delaying the signal so that it coincides with your finger movement?

So you see the amazing paradox is that on the one hand the experiment shows that free will is illusory, right? It can't be causing the brain events because the events kick in a second earlier. But on the other hand it has to have some function because if it didn't have a function, why would evolution bother delaying it? But if it does have a function, what could it be other than moving the finger? So maybe our very notion of causation requires a radical revision here as happened in quantum physics. OK, enough of free will. It's all philosophy!

I'd now like to remind you of a syndrome we discussed in my first lecture, the [Capgras delusion](#). So, the patient has been in a head injury, say a car accident. He seems quite normal in most respects, neurologically intact, but suddenly starts saying his mother is an impostor. She's some other woman pretending to be my mother. Now why would this happen, especially after a head injury? Now remember, he's quite normal in all other respects.

Well, it turns out in this patient the wire that goes from the visual areas to the emotional core of the brain, the limbic system and the [amygdala](#), that's been cut by the accident. So he looks at the mother and since the visual areas in the brain concerned with recognising faces is not damaged, he says, Hey it looks just like my mother. But then there is no emotion because that wire taking that information to the emotional centres is cut. So he says, If this is my mother how come I don't experience any emotions? This must be some other strange woman. She's an impostor. Well, how do you test this?

It turns out you can measure the gut-level emotional reaction that someone has to a visual stimulus - or any stimulus - by measuring the extent to which they sweat. Believe it or not, all of you here - if I show you something exciting, emotionally important, you start sweating to dissipate the heat that you're going to generate from exercise, from action. And I can measure the sweating by putting two electrodes in your skin, changes in skin resistance - and if skin resistance falls, this is called the Galvanic Skin Response. So every time anyone of you here looks at tables and chairs, there's no Galvanic Skin Response because you don't get emotionally aroused if you look at a table or a chair. If you look at strangers there's no Galvanic Skin Response. But if you look at lions and tigers and - as it turns out - if you look at your mother, you get a huge, big Galvanic Skin Response. And you don't have to be Jewish, either. Anybody here, looking at your mother, you get a huge, big Galvanic Skin Response when you look at your mother.

Well, what happens to the patient? We've tried this on patients. The patient looks at chairs and tables, nothing happens. But then we show him a picture of his mother on the screen, no Galvanic Skin Response. It's flat - supporting our idea that there's been a disconnection between vision and emotion.

Now the Capgras delusion is bizarre enough, but I'll tell you about an even more bizarre disorder. This is called the [Cotard's syndrome](#), in which the patient starts claiming he is dead. I suggested that this is a bit like Capgras except that instead of vision alone being disconnected from the emotional centres in the brain, all the senses, everything, gets disconnected from the emotional centres. So that nothing he looks at in the world makes any sense, has any emotional significance to this person, whether he sees it or touches it or looks at it. Nothing has any emotional impact. And the only way this patient can interpret this complete emotional desolation is to say, Oh, I'm dead, doctor. However bizarre it seems to you, it's the only interpretation that makes sense to him.

Now Capgras and Cotard are both rare syndromes. But there's another disorder, a sort of mini-Cotard's that's much more commonly seen in clinical practice (those of you here who are psychiatrists know this, or psychologists). It's called Derealisation and Depersonalisation. It's seen in acute anxiety, panic attacks, depression and other dissociative states. Suddenly the world seems completely unreal - like a dream. Or you may feel that you are not real - Doctor, I feel like a zombie. Why does this happen? As I said, it's quite common.

I think it involves the same circuits as Capgras and Cotard's. You've all heard of the phrase, playing possum. An opossum when chased by a predator suddenly loses all muscle tone and plays dead. Why? This is because any movement by the possum will encourage the predatory behaviour of the carnivore - and carnivores also avoid dead infected food. So playing dead is very adaptive for the possum.

Following the lead of Martin Roth and Sierra and Berrios, I suggested Derealisation and Depersonalisation and other dissociative states are an example of playing possum in the emotional realm. And I'll explain. It's an evolutionary adaptive mechanism. Remember the story of Livingstone being mauled by a lion.



*Dr. Livingstone, (picture courtesy of John Murray, Publishers)*

He saw his arm being ripped off but felt no pain or even fear. He felt like he was detached from it all, watching it all happen. The same thing happens, by the way, to soldiers in battle or sometimes even to women being raped. During such dire emergencies, the anterior cingulate in the brain, part of the frontal lobes, becomes extremely active. This inhibits or temporarily shuts down your amygdala and other limbic emotional centres, so you suppress potentially disabling emotions like anxiety

and fear - temporarily. But at the same time, the anterior cingulate makes you extremely alert and vigilant so you can take the appropriate action.

Now of course in an emergency this combination of shutting down emotions and being hyper-vigilant at the same time is useful, keeping you out of harm's way. It's best to do nothing than engage in some sort of erratic behaviour. But what if the same mechanism is accidentally triggered by chemical imbalances or brain disease, when there is no emergency. You look at the world, you're intensely alert, hyper-vigilant, but it's completely devoid of emotional meaning because you've shut down your [limbic system](#). And there are only two ways for you to interpret this dilemma. Either you say the world isn't real - and that's called Derealisation. Or you say, I'm not real, I feel empty - and that's called Depersonalisation.

Epileptic seizures originating in this part of the brain can also produce these dreamy states of Derealisation and Depersonalisation. And, intriguingly, we know that during the actual seizure when the patient is experiencing Derealisation, you can obtain a Galvanic Skin Response and there's no response to anything. But once he comes out of the seizure, fine, he's normal. And all of this supports the hypothesis that I'm proposing.

OK, finally let's talk about another disorder, the one that jumps into people's minds when they think of madness - namely schizophrenia. These are patients who have bizarre symptoms. They hallucinate, often hearing voices. They become delusional, thinking they're Napoleon - or George Bush. Or they're convinced the CIA has planted devices in their brain to control their thoughts and actions. Or that aliens are controlling them.

Psycho-pharmacology has revolutionised our ability to treat schizophrenia, but the question remains: why do they behave the way they do? I'd like to speculate on this based on some work we've done on [anosognosia](#) (denial of illness) - which you see in right-hemisphere lesions - and some very clever speculations by Chris Frith and Sarah Blakemore. Their idea is that unlike normal people, the schizophrenic can't tell the difference between his own internally-generated images and thoughts versus perceptions that are evoked by real things outside.

If anyone of you here conjures up a mental picture of a clown in front of you, you don't confuse it with reality partly because your brain has access to the internal command you gave. You're expecting to visualise a clown, that's why you see it and you don't hallucinate. But if the mechanism in your brain that does this becomes faulty, then all of a sudden you can't tell the difference between a clown you're imagining and a clown you're actually seeing there. In other words, you hallucinate. You can't tell the difference between fantasy and reality.

Similarly, you and I momentarily entertain the thought it would be nice to be Napoleon. But in a schizophrenic this momentary thought becomes a full-blown delusion instead of being vetoed by reality.

What about the other symptoms of schizophrenia - the fact that aliens are controlling you? When you move your finger voluntarily, you know you sent the command, the motor centres in the brain sent the command. So you experience willing the

movement. You don't say, Oh the finger moved on its own. But if the mechanism that performs this comparison is flawed, you no longer experience YOU willing the movement. So you come up with this bizarre interpretation. You say your movements are controlled by aliens or brain implants - and of course that's what paranoid schizophrenics do. How do you test a theory like this?

I want you all now to try an experiment. I mean that. I want you to try an experiment on yourselves. Using your right index finger - all of you try it - tap repeatedly your left index finger, keeping your left index finger steady and inactive. So you're all tapping your left index finger using your right index finger - left index finger is perfectly steady. Now you'll feel the tapping only on the left finger, very little on the right finger. OK, how many of you feel that? Yes, raise your hands. OK, 99 per cent of you. There are a few mutants, but we won't pursue that.

Now why is that? That's because the brain has sent a command from the left hemisphere to the right hand saying, Move. So the brain knows, it's tipped off the sensory areas of the brain, saying, Look you're going to move your right finger up and down so it's going to get some touch signals. But ignore them. It's not important. On the other hand, the left hand is perfectly steady so you feel the sensation only on the left finger, even though the tactile input is exactly the same.

Now try it the other way. Hold the right finger steady. Tap with the left finger. And you should now feel it mostly on the right, not on the left. Now the prediction is, if a schizophrenic tries this experiment, since he does not know the difference between internally generated actions and externally generated sensory stimuli, he will feel the sensations equally in both the fingers. It's a five-minute experiment - nobody's ever tried it.

Another prediction. I can come here and tickle anyone of you and you start laughing. Now interestingly, you can't tickle yourself. Try as hard as you want, you cannot tickle yourself. That's because your brain knows you're sending the command. Prediction: a schizophrenic should be able to tickle himself.

OK, it's time to conclude now. I hope that I've convinced you that even though the behaviour of many patients with mental illness seems bizarre, we can now begin to make sense of the symptoms using our knowledge of basic brain mechanisms. You can think of mental illness as disturbances of consciousness and of self, two words that conceal depths of ignorance. Let me try to summarise in the remaining five or ten minutes what my own view of consciousness is. There are really two problems here - the problem of the subjective sensations or qualia and the problem of the self. The problem of [qualia](#) is the more difficult one.

The question is how does the flux of ions in little bits of jelly in my brain give rise to the redness of red, the flavour of marmite or mattar paneer, or wine. Matter and mind seem so utterly unlike each other. Well one way out of this dilemma is to think of them really as two different ways of describing the world, each of which is complete in itself. Just as we can describe light as made up of particles or waves - and there's no point in asking which is correct, because they're both correct and yet utterly unlike each other. And the same may be true of mental events and physical events in the brain.

But what about the self? The last remaining great mystery in science, it's something that everybody's interested in - and especially if you're from India, like me. Now obviously self and qualia are two sides of the same coin. You can't have free-floating sensations or qualia with no-one to experience it and you can't have a self completely devoid of sensory experiences, memories or emotions. For example as we saw in Cotard's syndrome, sensations and perceptions lose all their significance and meaning - and this leads to a dissolution of self.

What exactly do people mean when they speak of the self? Its defining characteristics are fourfold. First of all, continuity. You've a sense of time, a sense of past, a sense of future. There seems to be a thread running through your personality, through your mind. Second, closely related is the idea of unity or coherence of self. In spite of the diversity of sensory experiences, memories, beliefs and thoughts, you experience yourself as one person, as a unity.

So there's continuity, there's unity. And then there's the sense of embodiment or ownership - yourself as anchored to your body. And fourth is a sense of agency, what we call free will, your sense of being in charge of your own destiny. I moved my finger.

Now as we've seen in my lectures so far, these different aspects of self can be differentially disturbed in brain disease, which leads me to believe that the self really isn't one thing, but many. Just like love or happiness, we have one word but it's actually lumping together many different phenomena. For example, if I stimulate your right parietal cortex with an electrode (you're conscious and awake) you will momentarily feel that you are floating near the ceiling watching your own body down below. You have an out-of-the-body experience. The embodiment of self is abandoned. One of the axiomatic foundations of your Self is temporarily abandoned. And this is true of each of those aspects of self I was talking about. They can be selectively affected in brain disease.

Keeping this in mind, I see three ways in which the problem of self might be tackled by neuroscience. First, maybe the problem of self is a straightforward empirical problem. Maybe there is a single, very elegant, Pythagorean Aha! solution to the problem, just like DNA base-pairing was a solution to the riddle of heredity. I think this is unlikely, but I could be wrong.

Second, given my earlier remarks about the self, the notion of the self as being defined by a set of attributes - embodiment, agency, unity, continuity - maybe we will succeed in explaining each of these attributes individually in terms of what's going on in the brain. Then the problem of what is the self will vanish or recede into the background.

Third, maybe the solution to the problem of the self won't be a straightforward empirical one. It may instead require a radical shift in perspective, the sort of thing that Einstein did when he rejected the assumption that things can move at arbitrarily high velocities. When we finally achieve such a shift in perspective, we may be in for a big surprise and find that the answer was staring at us all along. I don't want to sound like a New Age guru, but there are curious parallels between this idea and the Hindu philosophical view that there is no essential difference between self and others or that the self is an illusion.

Now I have no clue what the solution to the problem of self is, what the shift in perspective might be. If I did I would dash off a paper to *Nature* today, and overnight I'd be the most famous scientist alive. But just for fun let me have a crack at it, at what the solution might look like.

Our brains were essentially model-making machines. We need to construct useful, virtual reality simulations of the world that we can act on. Within the simulation, we need also to construct models of other people's minds because we're intensely social creatures, us primates. We need to do this so we can predict their behaviour. We are, after all, the Machiavellian primate. For example, you want to know what he did a wilful action. In that case he might repeat it. Or was it involuntary in which case it's quite benign. Indeed evolution may have given us the skill even before self-awareness emerged in the brain. But then once this mechanism is in place, you can also apply it to the particular creature who happens to occupy this particular body, called Ramachandran.

At a very rudimentary level this is what happens each time a new-born baby mimics your behaviour. Stick your tongue out next time you see a new-born-baby and the baby will stick its tongue out, mimicking your behaviour, instantly dissolving the boundary, the arbitrary barrier between self and others. And we even know that this is carried out by a specific group of neurons in the brain, in your frontal lobes, called the mirror neurons. The bonus from this might be self-awareness.

With this I'd like to conclude this whole series of lectures. As I said in my first lecture, my goal was not to give you a complete survey of our knowledge of the brain. That would take fifty hours, not five. But I hope I've succeeded in conveying to you the sense of excitement that my colleagues and I experience each time we try to tackle one of these problems, whether you're talking about hysteria, phantom limbs, free will, the meaning of art, denial, or neglect or any one of these syndromes which we talked about in earlier lectures. Second, I hope I've convinced you that by studying these strange cases and asking the right questions, we neuroscientists can begin to answer some of those lofty questions that thinking people have been preoccupied with since the dawn of history. What is free will? What is body image? What is the self? Who am I? - questions that until recently were the province of philosophy. No enterprise is more vital for the wellbeing and survival of the human race. This is just as true now as it was in the past. Remember that politics, colonialism, imperialism and war also originate in the human brain.

Thank you.