The Big Questions: Do we have free will?

18 November 2006
NewScientist.com news service
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In 2003, the *Archives of Neurology* carried a startling clinical report. A middle-aged Virginian man with no history of any misdemeanour began to stash child pornography and sexually molest his 8-year-old stepdaughter. Placed in the court system, his sexual behaviour became increasingly compulsive. Eventually, after repeatedly complaining of headaches and vertigo, he was sent for a brain scan. It showed a large but benign tumour in the frontal area of his brain, invading the septum and hypothalmus - regions known to regulate sexual behaviour.

After removal of the tumour, his sexual interests returned to normal. Months later, his sexual focus on young girls rekindled, and a new scan revealed that bits of tissue missed in the surgery had grown into a sizeable tumour. Surgery once again restored his behavioural profile to "normal".

This case renders concrete the issue of free will. Did the man have free will? Was he responsible for his behaviour? Can a tumour usurp one's free will? With the tumour, he had powerful, but atypical desires; he was not himself. Even so, the case reminds us that most adults also have powerful, albeit typical, sexual desires - desires that are sometimes more powerful than the need for food or the fear of pain. These sexual desires are regulated by hormones that act on neurons in the septum and connected brain areas. How different, then, are normal humans from the Virginia man where free will is concerned?

Neuroscience, and behavioural biology more generally, are gradually revealing the mechanisms that make us who we are: how we make decisions and control our impulses, how our genes shape our social desires and how our reward system adapts in response to satisfying experiences. We know for example that maternal-offspring attachment in mammals is mediated by the peptide oxytocin, released in the brains of both mother and child during lactation and cuddling. Oxytocin binds to neurons, and the reward pathways record and reinforce the interaction. Mate attachment in females is also mediated by oxytocin, and in males by a similar peptide, vasopressin. In non-human mammals, the density of peptide binding sites in the brain predicts whether the species is monogamous or polygamous. Male prairie voles with lots of vasopressin binding sites are monogamous while montane voles, with few, are promiscuous. What determines the density of binding sites? Genes. Granting the effects of cultural complexity, something similar probably holds for humans too.

As neuroscience uncovers these and other mechanisms regulating choices and social behaviour, we cannot help but wonder whether anyone truly chooses anything (though see "Is the universe deterministic?"). As a result, profound questions about responsibility are inescapable, not just regarding criminal justice, but in the day-to-day business of life. Given that, I suggest that free will, as traditionally understood, needs modification. Because of its importance in society, any description of free will updated to fit what we know about the nervous system must also reflect our social need for a working concept of responsibility.

Think about what we mean by "free will". As with all concepts, we learn the meaning of this from examples. We learn what to count as fair, or mean-spirited, or voluntary by being given sterling examples of people doing things that are fair, or mean-spirited or voluntary. Consequently, we tend to agree that Chamberlain's choice to appease Hitler was a free, if unwise choice. Our understanding is balanced by contrasting cases - actions that are obviously not freely chosen: a dreaming man who strangles his wife, the toddler who wets his pants, a startle response to a thunderclap, or a coerced confession. From such prototypes, brains manage to extract a common enough meaning so that we can talk about free will tolerably well.

As well as prototypical cases, there are outlying cases beset with ambiguity, daunting complexity and background cultural differences. Here, the status of an action - freely chosen or not - has no clear answer, and such cases often come before the courts. Andrea Yates, the Texas mother who drowned her five children in a bathtub, was unquestionably psychotic, though her actions were methodical and purposeful, unlike the erratic movements of someone suffering an epileptic seizure. She understood that her actions were against the law, and telephoned the police to say so. Outside of our usual ken, this sort of case divides opinion. The way we currently think about free will, there may be no right answer as to whether she exercised it.

A rigid philosophical tradition claims that no choice is free unless it is uncaused; that is, unless the "will" is exercised independently of all causal influences - in a causal vacuum. In some unexplained fashion, the will - a thing that allegedly stands aloof from brain-based causality - makes an unconstrained choice. The problem is that choices are made by brains, and brains operate causally; that is, they go from one state to the next as a function of antecedent conditions. Moreover, though brains make decisions, there is no discrete brain structure or neural network which qualifies as "the will" let alone a neural structure operating in a causal vacuum. The unavoidable conclusion is that a philosophy dedicated to uncaused choice is as unrealistic as a philosophy dedicated to a flat Earth.

To begin to update our ideas of free will, I suggest we first shift the debate away from the puzzling metaphysics of causal vacuums to the neurobiology of self-control. The nature of self-control and the ways it can be compromised may be a more fruitful avenue to understand cases such as the Virginian man and Andrea Yates than trying to force the issue of "freely chosen or not".

Self-control can come in many degrees, shades, and styles. We have little direct control over autonomic functions such as blood pressure, heart rate and digestion, but vastly more control over behaviour that is organised by the cortex of the brain. Self-control is mediated by pathways in the prefrontal cortex, shaped by structures regulating emotions and drives, and it matures as the organism develops. The individual learns to inhibit self-defeating impulses, such as biting the mother when it should suck, grasping a burning ember or harvesting honey when the bees are hostile. Once bitten, twice shy. Many aspects of self-control become automatic as habits are entrenched, so that a toddler is less likely to have messy pants six months after toilet training that one week after.

Unlike free will, self-control is a concept that we can usefully apply to other animals. This is consistent with the overwhelming similarity in brain structures across all mammals. Our larger prefrontal cortex probably means we have more neurons that allow us to exercise greater self control than that displayed by baboons or chimps. Through reinforcement, my dog has learned to lie quietly when the local squirrel taps the screen door for peanuts; a hungry chimpanzee will reach for a banana only if he knows the alpha male cannot see it, but will suppress the desire otherwise. Ulysses famously bound himself to the mast of his ship to avoid seduction by the sirens, and monkeys will deviate from a direct route to avoid a temptation known to be troublesome. This is the prefrontal cortex using cognition for impulse control.

Self-control also allows us to make sense of difficult cases where free will is unhelpful. Self-control may be diminished in persons with brain lesions or tumours. Self-control is also diminished during an epileptic seizure, while intoxicated or under anaesthesia. Other kinds of syndromes implicating compromised self-control include obsessive-compulsive disorder, where a patient has impaired ability to resist endlessly repeating some self-costly action such as hand-washing; and severe Tourette's syndrome, where the person finds it almost impossible to inhibit particular ticking movements.

How do neural networks achieve these effects that we call self-control, and what is different in the brain when self-control functions are impaired? Although little is known so far about the exact nature of the mechanisms, relevant experimental details have begun to pour in from many directions: on the properties of neurons sensitive to reward and punishment, on the generation of fear responses by neurons in the amygdala, and on the response profiles of "decision" neurons in parietal regions of cortex when the animal makes a choice after accumulating evidence. Riskier but more profitable exploratory decisions probably depend heavily on the prefrontal pole of the cortex, while safer but less profitable decisions depend more on ventromedial prefrontal regions.

These sorts of discoveries promise that eventually we will understand, at least in general terms, the neurobiological profile of a brain that has normal levels of control, and how it differs from a brain that has compromised control.

So is anyone ever responsible for anything? Civil life requires it be so. Very briefly, the crux of the matter is this: we are social animals and our ability to flourish depends on the behaviour of others. Biologically realistic models show how traits of cooperation and social orderliness can spread through a population; how moral virtues can be a benefit, cheating a cost and punishment of the socially dangerous a necessity.

From an evolutionary perspective, punishment is justified by the value all individuals place on their social life, and by the limits on behaviour needed to maintain that value. The issue of competent control arises when, given a social harm, we need to determine whether punishment is appropriate. Part of cultural evolution consists in figuring out more suitable and effective ways of limiting violent or otherwise antisocial behaviour. So yes, we must hold individuals responsible for their actions.

But what is the "self" of self-control? What am I? In essence, the self is a construction of the brain; a real, but brain-dependent organisational network for monitoring body states, setting priorities and, within the brain itself, creating the separation between inner world and outer world. In its functionality, it is a bit like a utility on your computer, though one that has evolved to grow and develop.

Complex brains are good at that sort of thing - creating high-level neural patterns to make sense of the world. We lack a word to describe this function, but instances abound. A simpler example is our normal three-dimensional visual perception. Here, a network of neurons in the visual cortex compares the slightly offset two-dimensional inputs it gets from each eye. The comparison is used to create an image of a three-dimensional world. Thus we literally see - and not merely infer - real depth.

The brain constructs a range of make-sense-of-the-world neurotools; one is the future, one is the past and one is self. Does that mean my self is not real? On the contrary. It is every bit as real as the three-dimensional world we see, or the future we prepare for, or the past we remember. It is a tool tuned, in varying degrees, to the reality of brain and world; like other tools, it can malfunction, for example, in schizophrenia.

Essentially, it is high-level tools like this which allow us to do the amazing things we humans do, including thinking of oneself as a self. Is one cheapened by this neuroscientific knowledge? I think not. Self-esteem and self-worth are wholly compatible with realising that brains make us what we are. As for self-esteem, we do know that it is highly dependent on successful social interactions: on respect, love, accomplishment, but also on temperament, hormones and serotonin. Moreover, the beauty, intricacy and sophistication of the neurobiological machine that makes me "me" is vastly more fascinating and infinitely more awesome than the philosophical conception of the brain-free soul that somehow, despite the laws of physics, exercises its free will in a causal vacuum. Each of us is a work of art, sculpted first by evolution, and second by experience in the world. With experience and reflection one's social perception matures, and so also does the level of autonomy. Aristotle called it wisdom.

From issue 2578 of New Scientist magazine, 18 November 2006, page 42-45