

3.2 Risks

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Background

The rapid advances in neuroscience of the past decades, and those that can be anticipated in the near and mid-future, bring with them not merely new knowledge of how the brain works, with profound implications for humanity's understanding of itself, but also actual and potential technologies with associated benefits and risks. Both have been widely discussed in the media. This section is concerned to balance the risks against the perceived benefits discussed more extensively in other sections (see eg Section 3.1).

Is increased knowledge of the brain itself hazardous?

Some argue that increasing knowledge of brain mechanisms and their relationship to such deeply personal and private characteristics as memory, cognition, emotion and even consciousness, risks diminishing our sense of having independent agency and free will. We will be nothing other than neuronal machines, driven by the complex firing patterns of the cells in our brains, themselves the inevitable product of the interplay between genes and environment during our development.

This interpretation is itself vigorously contested among philosophers and neuroscientists—compare for instance, the views of Singer on the one hand (see

Section 2.4) with Chan and Harris on the other in this volume (see Section 3.3). Some distinguished neuroscientists celebrate such a reduction of mind to brain (eg Crick 1994) whilst some philosophers view it with foreboding (eg Habermas 2003). I take neither view. Instead I would argue that any genuine increase in knowledge of brain processes and their pre- and post-natal development can only enrich our understanding of ourselves. Nor can such increased knowledge replace or diminish the insights into what it is to be human that come from philosophy, the social sciences or the humanities—although these disciplines will need to take the findings of neuroscience into account, just as neuroscience will need to respect these other perspectives and understandings. Here, therefore, there should only be benefits, providing one can pick one's way through the 'over-hyping' of apparent neuroscientific claims and the attendant prophesies of doom that so attract media attention.

Neurotechnoscience

Technosciences involve research enterprises in which the old distinctions between science and technology have broken down. It is not just that one cannot say where the science stops and the technology begins, but that the two are inseparable, each both driving forward and being driven by the other. And it is as a technoscience that the risks and benefits

of advances in the study of the brain may be seen as more finely balanced. To judge these requires reflecting not merely on the potential of developments discussed in the previous sections, but also on the intentions and goals of those who fund them—primarily the State, pharmaceutical companies, medical charities, supranational organisations such as the European Commission, and the military. In awarding funds each organisation will have specific ends in view, and these must be taken into account as we consider their implications (see also Section 3.4).

Policy issues

Neurogenetics and the pharmaceutical industry

Many neurological and psychiatric disorders run in families, and in some cases genes have been identified that increase the probability of a person having a particular disorder (see also Section 3.1). Huntington's disease (HD), which results in increasing motor and mental incapacity in middle life, is a single gene disorder where both the gene and its biochemical and cellular consequences are well known and predictable. The same is true for rare forms of Alzheimer's disease (AD), which strike in mid-life rather than, as in most cases, older age. There are also known genetic risk factors for the more common forms of the disease, but these are probabilistic rather than predictive.

The situation is less clear for the common psychiatric disorders such as depression or schizophrenia, whose mode of transmission is obscure and for which, despite decades of research, no

unequivocal and replicable genetic markers have been identified. Rather, the modern techniques of genome wide association studies (GWAS) suggest that there may be tens or even hundreds of genes which, individually or in combination and varying from individual to individual, may affect the risk for the disorder. Under these circumstances, the benefits of genetic testing of an individual for the predisposition may well be outweighed by the risks of false diagnosis (either positive or negative) with its consequent implications for how a person plans his/her life. Even when a relatively certain genetic diagnosis can be made, as in the case of HD, experience has shown that many of those known to be at risk of the disease decline the test, preferring uncertainty, especially where there is no effective treatment, as is still the case for HD.

Some commercial companies offer tests for one of the genetic risk factors for AD, the gene *ApoE4*, but this practice worries both genetic counsellors and ethicists, as a positive result is indicative only of a potential risk factor and provides little guidance as to how one should live one's life, whilst adding to a person's burden of anxiety such that every small slip in memory may be taken as a warning of the impending onset of the disease. Nonetheless in an unregulated or only lightly regulated biotechnological economy, the availability of such tests is likely to increase substantially in the coming years (see eg Collins 2010).

One of the major goals for neuropharmacology must be to develop

drugs to treat or alleviate these conditions. Both the record and the prospects are mixed. In the case of AD, even though the triggering events for the disease are unknown, the biochemical cascade that leads to the accumulation of plaques and tangles and the death of neurons is well understood, providing many potential targets for drug action. Whilst the present generation of drugs is not very effective, there are several promising new developments. Most such drugs are aimed at slowing the cognitive decline characteristic of AD. In this sense the drugs are cognitive enhancers (see also Section 2.2, 3.1 and Box 2). The benefits of such drugs—at the least in enabling AD sufferers to maintain a longer period of independent living—are clear. However, as they do not prevent the inexorable neurodegeneration that the disease entails, some have questioned whether living with the knowledge of that fate rather than benign neglect is always beneficial.

There is some evidence that drugs like the statins, used to control cholesterol levels, and folic acid may be marginally neuroprotective, as are ‘brain exercises’ on the ‘use it or lose it’ principle (see also Section 3.1). There have also been very recent claims to have identified a ‘marker’ molecule, present in cerebrospinal fluid that can predict the onset of the disease before any behavioural indications of its onset. The benefits that would accrue from developing a truly protective agent against neurodegeneration would be enormous, even when set against the risks of the widespread prophylactic drug taking over many years.

For psychiatric diagnoses such as schizophrenia and depression, the situation is less optimistic. Despite earlier hopes and claims, the newer generation of selective serotonin reuptake inhibitor drugs (SSRIs) to treat depression have turned out, when widely prescribed, to be little more effective than the earlier ones in treating what the World Health Organization has categorised as a worldwide epidemic of depression. However, people’s responses to the drugs are very variable, and one hope, though not yet realised, is that GWAS might make it possible to identify subsets of the population who could benefit most from any of the different classes of drugs that are available. Nonetheless, it is perhaps in recognition of these difficulties, and the sheer seeming intractability of the problem that, as mentioned by Robbins and Sahakian (see Sections 2.2 and 3.1), several of the major pharmaceutical companies have abandoned their drug discovery programmes for these disorders, whilst retaining those for frank neurological conditions such as AD or Parkinson’s Disease (Miller 2010).

Drugs for social control?

The US Diagnostic and Statistical Manual (DSMIV), regarded as the psychiatrists’ bible, is currently undergoing revision, but a category of disorders that is likely to remain in one form or another is that which relates not to relatively clear-cut psychiatric conditions but those concerned with an individual’s behaviour—conditions such as (in the current classifications), conduct disorder, oppositional defiance

disorder and, attention deficit hyperactivity disorder (ADHD).

The frequency with which such diagnoses are being made has increased dramatically over the past two decades. ADHD (then called minimal brain dysfunction), considered to affect no more than one in several hundred children in the UK in the 1980s, is now estimated to be present in from 1–5% of children—mainly boys—between 6 and teenage. The diagnosis is based primarily around a child’s unruly, disobedient or inattentive behaviour at school and home. There are no unequivocal neurological or neurochemical markers to correlate with the diagnosis. There are, however, pharmaceutical approaches to correcting or modifying these behaviours, most notably the amphetamine-like drug methylphenidate (Ritalin).

Ritalin prescriptions in the UK have increased from around 2000 a year in the early 1990s to approaching 600,000 a year today, though with very marked regional variations. Ritalin and related drugs certainly make a child calmer in class, less troublesome to teachers and parents. However, the long-term effects of the drug, on a growing child’s brain and behaviour, have not been fully assessed.

An unanswered question is why a disorder considered rare several decades ago should now be diagnosed with such frequency. Did it exist unrecognised earlier, with children being called naughty or delinquent rather than as having a brain disorder? (The increase in autism diagnoses over the decades is a comparable example). Have society’s

criteria for what is or is not acceptable changed? Or might the problem lie less in the brain of the child and more in the parenting practices or social environment?

There is a more general issue at stake here, and that is the use of drugs as a means of social control. Whilst there are undoubtedly children who could benefit from the drugs, such medicalisation of behaviours regarded as outside the norm, to use Chan and Harris’ term (See Section 3.3), may turn out to be an example of what Stirling categorises as missed opportunity or forced tramlines (see Section 3.4). By focussing on the individual and positing that the source of his or her distress lies in some molecular disorder in the brain, we may miss the broader social public health context (from economic insecurity to poor schooling or inadequate parenting) that affects the brain and makes the distress manifest. In focussing on ‘a pill for every ill’ do we risk moving towards what a neurophysiologist once referred to (approvingly) as a ‘psychocivilised society’—and what, less approvingly, Aldous Huxley wrote about in *Brave New World*?

More immediately, in the US, where the use of Ritalin has been more widespread for far longer than in the UK, the FDA has called attention to the extent to which it is being widely traded amongst schoolchildren on the grounds that its attention-enhancing effects are an aid to study and preparing for exams. As discussed by Robbins (see Section 2.2), a number of respondents—predominantly from the US—to a survey conducted by *Nature* amongst its readers as to whether they use cognitive enhancers also reported

that they had or currently still used Ritalin in this way.

Ritalin is of course not the only drug to be considered as a cognitive enhancer (see Section 2.2 and Box 2). A wide variety of agents with very different mechanisms of action have been proposed, mainly on the basis of animal experiments and often without good evidence as to their effects in humans, to act as cognitive enhancers, giving rise to much ethical debate (see Section 3.3) and media speculation. Concern has been expressed over whether the use of such drugs outside a medical context confers an unfair advantage on their users in competitive examinations. Should such 'steroids for the brain' be regulated as in sport? Even if it were possible—and the wide availability of Ritalin for purchase via the web suggests that it would be difficult—would it be appropriate? How different, ethically, is the deliberate and voluntary taking of a cognitive enhancer to employing a tutor or enjoying the educational advantages that, in a profoundly unequal society such as Britain, come with class and income (Rose, 2002)?

Imaging and neural interfaces

As discussed by Rees (see Section 2.1), once they had moved beyond the experimental province of physicists, virtually all modern neuroimaging techniques were developed with diagnostic aims in mind: Computed Axial Tomography (CAT or CT), Positron Emission Tomography (PET), Magnetic Resonance Imaging (MRI) and functional MRI (fMRI) are examples. Perhaps the

exception is magnetoencephalography (MEG). Barring the usual problems with all scanning techniques—of both false positives and false negatives—the clinical benefits to neurosurgery and neurology scarcely need stressing. The only risk seems to be the general one: that modern medicine and clinical practice sometimes seem to substitute diagnosis for treatment—as for instance in the use of MRI scans to detect spinal disc injury as a substitute for, or addition to, clinical judgement even when surgical intervention is not contemplated.

Similarly, at first glance the neural interfaces discussed by Tracey (see Section 2.3 and Box 3) would seem only beneficial, in their potential to compensate for loss of sensory or motor abilities—though their military applications are more disturbing. However, the science fiction possibilities of such prostheses—as described for example by Gibson (2000)—open the prospect of a dystopic world of cyberpeople: part human, part engineered, reflecting in fiction Habermas's concerns (see also Section 3.3).

There are, however, two main areas in which developments in imaging techniques raise immediate social concerns. Both relate to the consequences of living in an increasingly security- and surveillance-obsessed society. Could brain imaging be a further step down the path pioneered by the ubiquitous CCTV cameras and national DNA databases—that is, as a further restriction on an individual's privacy? Might brain imaging provide an internal surveillance of our thoughts, emotions and intentions to add

to the external surveillance of the cameras? Not *Brave New World* but *1984* updated?

Claims that brain imaging ('Brain Fingerprinting') could serve as an updated form of lie detection have been treated with some scepticism by the imaging community (See Box 1), but a number of commercial companies now offer devices claiming to do just this, mainly based on the measurement of evoked response potentials—an application of the electroencephalography (EEG) technique discussed by Rees (see Section 2.1). The company websites suggest their use to detect whether someone 'is a terrorist' or has visited 'terrorist training camps' as well as in the courts to help determine guilt or innocence. The use of such techniques has been admitted into trials in India and the US, though not so far in the UK (Rose 2006). These issues will be addressed in more detail in Module 4 of the *Brain Waves* project on neuroscience, responsibility and the law.

Of at least as great concern are the suggestions that brain imaging can provide a prospective diagnosis of a person's potential for criminal activity or psychopathic violence. There have been claims that MRI or fMRI could detect characteristic differences in brain structures or neural activity between incarcerated men convicted of murder or other violent crimes and either non-violent criminals or 'normal' people. However a major problem with such studies is that they are post-hoc. The violent murderers studied have been in prison, often for long periods of time, have a history of the use

of both legal and illegal drugs, and many other potentially relevant experiences. Although there have been claims that it is possible to detect propensity to psychopathy, based on psychological and even biological measures in young children, whether useful predictive brain differences could be found prior to crime, conviction and imprisonment is simply not known. Furthermore, even if such predictions could reliably be made, it is a cardinal principle of law that intentions or predispositions in the absence of acts are not crimes—unless we are truly to move towards a 1984-type category of 'thought crime.' The argument that individuals 'at risk' should be scanned and subjected to an appropriate remedial or control regime, and the individual could choose whether to be subject to it rather than coerced, fails on the grounds both that any such brain findings are likely to include many false positives, and a lack of knowledge about just what would constitute an appropriate remedial regime. It is doubtful whether there would be any added value provided by a brain scan above that given by standard psychiatric evaluation.

More directly interventive are the expanding applications of transcranial magnetic stimulation (TMS) (see Box 4). TMS has been proposed as a potential therapeutic approach to mitigate the effects of neurological conditions such as Parkinson's, to alleviate depression, or as an alternative or adjunct to cognitive behaviour therapy in obsessive/compulsive disorders. In these senses it would seem to carry a similar balance of benefits and possible risks as do pharmacological interventions. However,

the declared interest of the US military (see below) in exploring the uses of TMS as a method of thought and behaviour control, though still in the realm of basic research and even science fiction, raises the same issues of privacy versus social control and manipulation discussed above.

The military and neurotechnoscience

Military interest in neurotechnoscience is directed towards two general goals: improving the efficiency of one's own forces, and diminishing that of an enemy. Most available information comes from the US, where the military and its research organisations such as the Defence Advanced Research Projects Agency (DARPA) have a long record of funding work in this area, and where information is much more freely available than in other more secretive states. Current concerns centre on two areas: psychoactive chemicals; and behaviour modification via brain stimulation. These issues will be addressed as part of Module 3 of the *Brain Waves* project on neuroscience, conflict and security.

Psychoactive chemicals: Pharmaceuticals to improve the performance or motivation of one's own military have a long history (from hashish to marijuana and amphetamine) and widespread use. For example during recent conflicts it is reported that US pilots were supplied with Modafinil to improve alertness and concentration during long flights (see also Section 2.2).

The use of any toxic chemical, including neuroactive chemicals such as nerve gasses, as weapons of warfare is prohibited in international law by the Chemical Weapons Convention. However, the Convention allows for the use of long-standing 'riot control agents' — 'tear gasses' such as CN and CS that cause local irritation of skin and mucous membranes — for 'law enforcement including domestic riot control'. It is into this grey area between 'police' and 'military' deployment that some countries have sought to introduce incapacitating chemical weapons with central effects on the brain to induce unconsciousness or sedation. The first use of incapacitating chemical weapons was in Moscow in 2002 when Russian Special Forces stormed a theatre to release hostages taken by Chechen militants. A derivative of the opioid fentanyl was pumped into the theatre with the intention of incapacitating the militants before the troops stormed the building — but the drug killed over 120 of the hostages (Davison 2009). Concerns have been raised of the risk such weapons' development poses to the international ban on chemical weapons (see also Section 2.2).

Physical methods: Other basic research efforts aim to investigate the potential for affecting the brain and central nervous system using different powers, frequencies, and pulses of electromagnetic radiation. These would join emerging directed energy weapons, including lasers and the so called 'Active Denial System', a new weapon that projects a millimetre wave beam of radiation to heat the skin with the aim of causing a burning

sensation without permanent damage (Davison 2009). This weapon has recently been installed on trial in a Los Angeles prison. Whether one judges the availability of such techniques as a benefit or a risk depends on whether one sees them as preventing unwanted social disorder or increasing the power of a militarised State to control citizens.

Of more direct military significance has been the research conducted over several decades under DARPA contracts to develop 'distance' methods to control or manipulate brain and thought processes, in the past by high intensity microwave beams and more recently by magnetic pulses through TMS (Rose 2006). Despite the claims by some groups in the US that they have been unwittingly subject to such experiments by the military, the evidence is that at present the available technology requires that the individual be placed directly into the appropriate equipment. Thought control at a distance remains in the realm of science fiction.

Conclusion

Many of both the benefits and the risks of advances in neuroscience still lie in the future. Some we can anticipate, others will be unintended or unforeseen. Much neuroscience is still 'upstream' of application. However the time to consider and make choices about the directions in

which neuroscience could or should be pursued is now, whilst policy makers and society at large still have time to consider the potential developments and how, and to what extent, they may be directed or controlled (see also Section 3.4). The further 'downstream' the technologies have moved, the harder such choices will be.

References and further reading

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