The Economist

The ethics of brain science

Open your mind

Genetics may yet threaten privacy, kill autonomy, make society homogeneous and gut the concept of human nature. But neuroscience could do all of these things first

May 23rd 2002 | From the print edition

IN THE genetically engineered world portrayed in “Gattaca”, a movie made in 1997, the hero and heroine attend a concert in which a pianist performs a concerto that can be played only by a person with six fingers on each hand. This is a society in which genetic perfectionists have had their way. The concert-goers have been altered before birth to be free of such ailments as baldness, obesity and diabetes, and to be tall, good-looking and intelligent. In that room, improbable as it may seem, only Ethan Hawke has lived a life free of genetic enhancement; he alone has had to take his chances with the genetic lottery of natural conception.

Compare this scene to one in which the effects of neurotechnology (technology that makes it possible to manipulate the brain) are pervasive. The old man on the left of the aisle is being saved from Alzheimer's disease by an implant that bathes his brain cells in a healthy broth of chemicals. The little girl in the circle, vows her doctor, has a cortex that will one day win her a Nobel prize in physics—if she keeps up the correct regime of “cogniceuticals”, of course. As a condition of their employment, the security guards posted at the entrance had to undergo brain scans to demonstrate that they were free of propensities to uncontrollable rage. The musicians on stage are on drugs that speed their reflexes, heighten their hearing and assuage their performance anxiety. Not that different from “Gattaca”, is it?

The mind's eye

Although often overlooked, advances in neurotechnology raise ethical and legal questions of the same nature and gravity as advances in genetics. Concerns about genetic technology fall into three main categories: first, how much screening should be allowed for certain genetic traits; second, who should have access to such information; and third, what will happen when those traits can be modified at will, possibly in ways that challenge the very idea of what it is to be human.

Neuroscientists may soon be able to screen people's brains to assess their mental health

Concerns about neurotechnology fall into the same three groups. Neuroscientists may soon be able to screen people's brains to assess their mental health; to distribute that information, possibly accidentally, to employers or insurers; and to "fix" faulty personality traits with drugs or implants on demand. They may also, according to some philosophers, expose fallacies in philosophical thinking that go to the heart of human nature by showing how the brain actually makes decisions.

Until recently, neurobiologists have been constrained in their research by the consideration that most kinds of experiment with the human brain are seen as unethical. Tradition has it that they must sit around with their fingers crossed, hoping that a patient will walk through the door sporting a tumour or other injury in a part of the brain whose function is not yet understood. Ideally, this patient will show some odd behaviour—say, being able to multiply but not add, or mistreating cats but not dogs—that can be tied to the injured area. Thus, painstakingly, a map of which parts of the brain do what can be built up.

Over the past decade, however, machines for measuring brain activity have proliferated. There are now half a dozen such technologies, ranging from old favourites, such as electro-encephalography, to new-fangled methods including magneto-encephalography, which measures the brain's magnetic fields, and single-photon-emission computerised tomography, which tracks radioactively tagged chemicals around the organ. One of the most important new techniques is functional magnetic-resonance imaging (fMRI), which employs powerful magnetic fields to monitor the rate of blood flow in the brain, and thus to determine which parts are particularly active.

With the help of fMRI, researchers can observe which brain areas are involved when somebody performs a particular task or thinks along particular lines. That could be a boon. It could, for example, identify children whose brains are not maturing normally—making possible early intervention with, say, special lessons.

Researchers can observe which brain areas are involved when somebody performs a particular task or thinks along particular lines

A study to be published shortly in *Neuroimage* shows how this might work. Vinod Menon and his colleagues at Stanford University have been using fMRI to investigate how people's brains behave when they are subjected to the Stroop colour-word interference task. The Stroop task is a well-established psychological test that presents subjects with the names of colours printed in ink that does not match the colour named. The subjects have to name the colour of the ink, not the word that has been printed.

As people mature, their brains get better at coping with the challenge the task poses. Dr Menon has found that children, adolescents and adults show progressively different patterns of brain activity which appear to reflect this improvement. He has discovered that a child

whose brain is not maturing normally will show an unusual pattern of brain activation when performing the test. That reveals problems with brain development that an ordinary questionnaire-based psychological evaluation does not.

Nobody could object to such a worthy enterprise. But what about the following idea? Greg Siegle and his colleagues at the University of Pittsburgh are studying depression. In a paper published in this month's issue of *Biological Psychiatry*, they report that when depressed individuals are read a list of depressing words, they show a different response in a region of the brain called the amygdala from that displayed by "normal" individuals. The amygdalas of the depressed hum away for as long as 25 seconds after hearing a depressing word. Those of individuals who have never been depressed stop showing activity after ten seconds. Dr Siegle suggests that the depressed subjects ruminate on, or think repeatedly about, sad words, while the undepressed subjects simply move on.

Since the amygdala is known to be involved in processing emotion, that is not altogether startling. Suppose, though, that job-recruiting agencies were fitted with fMRI machines (unlikely at the moment, given their expense, but not unimaginable). An individual who wished to conceal evidence of depression from possible employers would have a much harder time doing so in the face of fMRI, than in the face of a little light form-filling.

Just as genetic markers can be associated with physical states, so features of brain scans will surely be linked to a wide variety of mental states

And that may only be the start. Just as genetic markers can be associated with physical states, so features of brain scans will surely be linked to a wide variety of mental states. fMRI screening might, for example, become a foolproof method of lie detection—one that could catch out even "astute liars" who pretend to have impaired memories when put under pressure by an interrogator. Other personality traits, such as tendencies to aggression or risk-aversion, could also yield their secrets to fMRI's probing glance.

Steal your face

Medical privacy is another area that brain scanning could compromise. One of the most immediate threats is a little-considered side-effect of the scanning process: that what is scanned and recorded is actually the head, and not merely the brain. In other words, a magnetic scan of a brain also contains enough information about the front of the skull to recreate a recognisable depiction of the scanned subject. The result is that, unlike a genetic profile, which does not, by itself, tell you who has been profiled, no magnetic-resonance image is inherently anonymous.

Neuroscientists are already building up databases of brain scans for research purposes. In

2000 John Van Horn and Michael Gazzaniga, two cognitive neuroscientists at Dartmouth College in Hanover, New Hampshire, launched a database called the fMRI Data Centre, to help disseminate fMRI studies among scientists. They hope that it will spur discoveries in neuroscience in the same way that GenBank, a public database of gene sequences, has spurred discoveries in genetics. The fMRI Data Centre makes raw data from such studies available to researchers, and will soon organise the data so that interesting features can be extracted from it systematically. So far, says Dr Gazzaniga, roughly 400 researchers around the world have requested data from the centre. Those data are shipped to them on compact discs to do with as they please.

One answer to the lack of anonymity of magnetic-resonance images is to scramble the picture in the part of the image that contains facial information. The managers of the Dartmouth database do just that. Such scrambling, however, makes the data useless for some sorts of analysis. It is therefore questionable whether the operators of other databases of neuro-images (several are planned) will follow suit.

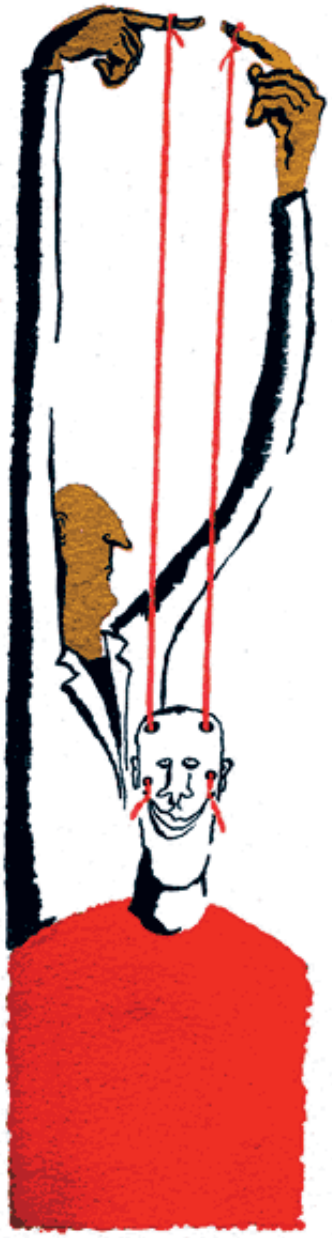
Pictures of perfection

Just as with genetics, however, the spectre that most terrifies many of those who fear the advance of neurotechnology is that it will one day be capable of "enhancing" human beings. Some worry that this may blunt the differences between individuals, turning society into one homogeneous mass. Others see the opposite risk—a Gattacesque division between the privileged and the unenhanced.

Potential dystopias always make good press. But drawing the line between necessary therapy and discretionary enhancement is genuinely difficult. Some argue that society accepted the idea of so-called "cosmetic psychopharmacology" when people first began using recreational drugs. Who has not perceived himself to be wittier and more attractive than normal when under the influence of alcohol—or, indeed, seen wit and attractiveness in others in the same circumstances?

Another argument is that drugs for the brain are simply one more step down a road taken by orthodontics, face lifts, Viagra and other medical extras. That may be so. But it could be a step in seven-league boots, for pharmaceutical companies are only just beginning to mine the spectrum of psychological ailments that flesh is heir to. Drugs to combat shyness, forgetfulness, sleepiness and stress are now in or close to clinical trials, not to mention better versions of drugs that have already swept society—what Arthur Caplan, a bioethicist at the University of Pennsylvania, calls "super-Prozacs".

One example of the trend towards making the normal treatable is research into "mild cognitive impairment", the kind of slight deterioration in memory that goes with getting old.



Or that does for now, anyway. Many companies are hunting for drugs to fend off this sort of memory loss. Researchers at Cortex Pharmaceuticals in Irvine, California, for example, are exploring molecules known as ampakines. These attach themselves to nerve-cell proteins called AMPA receptors. That serves to amplify the transmission of signals from one nerve cell to another. In particular, it amplifies the effect of a second protein, the NMDA receptor, which is known to be associated with learning. Meanwhile, Targacept, a firm based in Winston-Salem, North Carolina, is looking at another group of nerve-cell proteins, the nicotinergic receptors, whose activation has been shown to increase alertness and may fend off cognitive decline.

Another technology, known as transcranial magnetic stimulation (TMS), also holds out the promise of enhancement. Since nerve cells use electrical signals, and magnetic fields can induce and disrupt such signals, a strong, well-aimed magnetic stimulation can affect the brain's operation. By holding a magnetic coil over somebody's skull, a researcher can affect the activity of the piece of cortex beneath, while causing no pain to the subject. Sending repeated magnetic pulses disrupts neural transmission in that area, in effect creating a small lesion on demand. Although nobody is quite sure how it works, there is evidence to suggest that certain kinds of TMS improve performance in memory and reasoning tasks.

The death of free will?

Screening, privacy and enhancement are all important issues, to be sure. For many critics, though, they are side-shows. The really uncomfortable questions raised by brain science are those that go to the heart of what it is to be human. Or, more specifically, what philosophers and theologians have claimed is the heart of what it is to be human.

In the West, at least, that defining quality is the concept of “free will”. Although some philosophers see free will as an illusion that helps people to interact with one another, others think it is genuine—in other words, that an individual faced with a particular set of circumstances really could take any one of a range of actions. That, however, sits uncomfortably with the idea that mental decisions are purely the consequence of electrochemical interactions in the brain, since the output of such interactions might be expected to be an inevitable consequence of the input. It also sits uncomfortably with the

separate, but parallel, argument that correct moral choices are the result of a sort of biological decision-making programme, shaped by evolution, rather than being arrived at by abstract reasoning.

There are already cases where neurotechnology may have a practical effect on people's moral development

Whatever the philosophical arcana of the field, there are already cases where neurotechnology may have a practical effect on people's moral development. Erik Parens of the Hastings Centre, a think-tank in Garrison, New York, is concerned that it could, for example, “reduce the number of ways acceptable to be a person”.

To illustrate this point he says that the act of giving a normal, healthy child Ritalin, a drug used to treat so-called hyperactivity, is really “a substantive moral choice”, because it tells that child that he needs to change to be acceptable. If forgetfulness, xenophobia and a whole host of the other eccentricities that make up a person's character become optional traits rather than inevitable ones, people will be more inclined to discriminate against the bearers of those traits.

Discoveries in neuroscience may also have profound legal implications. Most courts, for example, accept a claim of insanity as a defence in certain criminal cases. If a propensity towards aggression or violence is shown to have a biological basis in the brain, a lawyer may argue that his client could not control his violent urges. Courts may be asked to treat brain-image data as exculpatory evidence, which shows that a suspect is not really guilty of a crime he has committed.

Donald Kennedy, a neuroscientist who is also editor of *Science*, says it is likely that “some extension of the domain of exculpatory conditions” will be made as a result of neuroscientific advances. In any case, each jurisdiction treats insanity claims in its own way, so they may well disagree over whether brain-image data are exculpatory. In Texas, for example, all that a prosecutor needs to demonstrate is that a suspect knew “the difference between right and wrong” at the time of the crime. Even individuals who are clearly insane can be found guilty if they meet this test.

Soul-searching questions

In many ways, therefore, thinkers who are wrestling with questions of free will, the soul and human nature are seeing the terms of their debate altered by modern brain science. But the history of the debate may offer consolation to those who fear that neurotechnology is a hair's breadth from catapulting society into a “post-human future”, as Francis Fukuyama termed it in the title of a recent book. The human soul—or its physiological equivalent—has proved

surprisingly elusive.

René Descartes was a philosopher who believed that he had found the exact point in the brain where the body and soul meet. Rather unromantically, the structure he chose was the humble pineal gland. As the author of a popular textbook on the subject dryly notes, however, “this now seems unlikely because pineal tumours do not cause the changes one would expect to find associated with distortion of the soul.” There is a deal of searching to do yet before human nature gives up its secrets.

From the print edition: Science and technology