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# The Neuroscience Revolution

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# In Brief

## The Neuroscience Revolution

While the world's attention has been diverted by the drama of the Human Genome Project, neuroscience has been quietly creating a revolution with implications every bit as profound as those of genetics. Neuroimaging advances, psychopharmaceuticals with enormous potential for clinical use, neural-technological interfaces, brain stimulation technologies, and organic implants such as fetal cell therapy are transforming our ability to understand and intervene in the brain. Along the way, they are also challenging accepted standards for the proper limits of technology, possibly giving criminal justice some revolutionary and troubling new tools, redefining our sense of selfhood and brain-body relations, and raising a host of other ethical and social questions. And all this without a multi-billion dollar, public-private juggernaut like the Human Genome Project to drive it forward.

Ethicists are only now beginning to take note of these developments. Two recent conferences, one on each coast, have raised a call to ethicists by highlighting the astonishing scientific advances in neurosciences and the oft-times novel ethical challenges they present.

The first conference, funded by the Greenwall and Medtronic Foundations and hosted in February 2000 by the University of Pennsylvania's Center for Bioethics and Center for Cognitive Neuroscience, was the culmination of a series of meetings of ethicists and neuroscientists in early 2000. A larger, more ambitious conference took place in San Francisco in May, sponsored by the Dana Foundation and hosted jointly by Stanford and the University of California at San Francisco. Promising to kick-start the "new field of neuroethics," the conference included leaders in neuro-

science, law, social science, and ethics—and William Safire as master of ceremonies. The two conferences explored issues such as the proper use of psychopharmaceuticals, the proper role of physicians in dispensing neuroactive drugs, the nature of human rights and responsibilities, the proper use of neurodiagnostics (for example, for predicting a child's susceptibility to a late-onset disease like Alzheimers), public discourse and social policy, and the proper nature and limits to the practice of science.

The increasing attention to neuroscience is not surprising given the novel problems of these technologies. Neuroimaging studies are beginning to demonstrate an ability to correlate mental states and traits to detectable brain patterns or structures. Research has shown, for example, that a history of depression, or addiction, leaves identifiable brain sequelae even if the disease is in remission. In some cases, neuroimaging may be able to detect racist ideation, to differentiate false and true memories, and to discover mood states (even when they are preconscious in the subject), intentional prevarication, and even the content of thought (to discover whether someone is thinking of a face or a chair, for example). While these studies are preliminary and their powers of prediction so far modest, they portend a time when the criminal justice system, employers, schools, and other institutions may want to use imaging to detect or refute other kinds of evidence about people's aptitudes, honesty, or history.

In addition to these diagnostic or scanning technologies, new psychopharmaceuticals are promising to redefine how we conceive of disease, treatment, and professional privilege. Drugs like Prozac, Viagra, and soon perhaps modafinil (which fights fatigue without

the side effects of amphetamines), are being used by people without any diagnosable pathology, and are often prescribed by physicians upon request. Drugs are being developed that can enhance memory, confidence, and other aspects of normal functioning and will likely be as freely available as Viagra, which can now be purchased on the web with at best a transparent nod to diagnostic and prescriptive requirements. As the power and specificity of these drugs increase, so will the ability of the average person to manage his daily life pharmacologically, adding a host of mood and cognitive enhancers to the morning cup of coffee and the after-work cocktail.

Neuroimaging and psychopharmaceuticals are only the tip of the neuroscience iceberg. Implantable computer "brain chips" are allowing the blind to see, the deaf to hear, and monkeys to control cursors on computer screens entirely with their minds. Trans-cranial magnetic stimulation can temporarily turn specific areas of the brain off by sending electric charges through the skull. Electrode implantation has allowed scientists to create "robo-rats" whose travels are controlled by the joysticks of scientists, and monkeys whose thought processes can control mechanical arms thousands of miles away.

Clearly the influence of these technologies on everyday life is only years away, rather than decades, as in the case of genetic technologies. Bioethicists are coming to the game a bit late, and often underprepared, but the issues are real and complex, and the neuroscientists are not waiting for the ethical groundwork to be laid.

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