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High Tech Neuroscience, Neuroethics, and the Precautionary Principle*

Irina Pollard, Ph.D.
Macquarie University
Australia

High Technology—Introduction

We live in a world in which technology plays a significant role in all aspects of our lives, and where existing technologies are constantly being improved, or replaced, by more sophisticated and powerful ones. Technologies, all by-products of science, have redefined how we live, work, fight, relax, and communicate with one another. Modern humans are acquiring ever more sophisticated machinery to serve differing social, economic, and political objectives. On the whole, science is value free because, from the values point of view, science is all about facts. But its application imparts value and, as a consequence, gains socio-ethical significance. Technology is versatile and can be conveniently adapted and applied in ways other than its intended purpose or purposes. In addition, its intended application may have unforeseen risks that carry adverse long-term consequences. Major concerns relating to the development and application of "ground-breaking" technology include damage to the environment, injury to human health, invasion of privacy, issues relating to socio-economics, justice, and equity, and infringement on religious beliefs. To these above concerns we can add those arising from recent developments in high tech neuroscience, where acquaintance with the principles of bioscience ethics and bioethics seems critical.

Bioscience ethics can flexibly facilitate free and accurate information transfer from applied science to applied bioethics. Bioscience ethics' major elements are: increased understanding of biological systems; responsible use of technology; curtailment of ethnocentric debate; and greater awareness of new ecological/medical insights. By reconnecting the traditional disciplines of science and ethics, it becomes possible to incorporate the best of society's traditional/cultural ethical principles, reject misinformation, and bypass fruitless, arcane deliberation (Pollard, 2002).

The Precautionary Principle

The precautionary principle is a rule about handling uncertainty in the assessment and management of risk. This rule recommends that when deciding about actions, a cautious (or precautionary) approach should be taken in the face of uncertainty, particularly when dealing with human health and the environment. The idea behind the principle is that appropriate action should be taken to avoid the risk of serious and irreversible damage to human and environmental health, but it does not mean that no action should take place if there is identifiable risk. The principle ensures that in circumstances where our best predictions turn out to be wrong, it's better to have erred on the side of safety; that is, forgoing potential benefits of a particular technology is better than experiencing harmful consequences from failing to predict the risks.

The precautionary principle emerged in the 1970s, and is currently invoked in numerous international laws, treaties, and protocols in, for example, environmental management, control of toxic chemicals, food standards, fisheries management, species introductions, and wildlife trade. The overarching aim is to support ecologically sustainable development in managing natural resources, and to conserve biodiversity while continuing to develop as an economy. The principle can, however, be equally called upon to assess risk-benefit equations posed by high-tech medical applications.

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The present paper centres on recognized advances in brain-probing technology, and acknowledges that modern neuroscience raises unique ethical questions that demand a cautious (or precautionary) approach in their application.

Mapping the Field

Modern brain imaging began in the 1970s with computed axial tomography (CAT) scans, and many advances have since been made. In the earlier days of neuroimaging, studies focused on structure-function relationships in the brain, and organization of the primary sensors and motor regions of the brain are now particularly well understood. Today, neurological studies probe at our deepest thoughts, define our complex cognitive behaviours, and judge our rational decision-making and consciousness. Neuroimaging reveals the structure of the living brain through technologies such as computer-assisted tomography (CAT) scans or magnetic resonance imaging (MRI). Brain function is revealed through positron emission tomography (PET) scans, single photon emission tomography (SPECT) scans, or functional magnetic resonance imaging (fMRI).

In neural systems of the brain, information is represented by patterns of activity occurring over specific populations of neurons. Different brain regions have evolved to perform different specific tasks, so each region of the brain may perform its computations in different ways. By recording electrochemical activity (neuroimaging) across the brain, it becomes possible to establish normal levels of excitation corresponding to sleep, rest, and various forms of wakefulness. Brain scans can identify early signs of brain disease and risk factors for mental health. Understanding the encoding of information in neural populations is important, both for understanding the fundamental processes underlying brain function and, by learning about normal function, to understand the behaviour of the injured brain suffering from stroke, generative disease, and congenital malformation, for example. In practical terms, knowledge from brain-interpreting science has been applied in neuro-protection (i.e., safeguarding CNS cells from further damage after injury), in neuro-repair (i.e., developing therapies to help the body repair damaged CNS cells), and to develop devices which harness any remaining neural potential to control brain-machine interfaces (i.e., neural prosthetic devices). Future applications will, of course, still concentrate on cure, prevention, and therapy, but they will also focus on reading neural organizations that drive normal and deviant human emotions.

Neuroethics

In response to neuroscience's growing array of technological developments that are capable of monitoring and manipulating the human mind, the emerging field of neuroethics is gathering force. Neuroethics was formally defined in 2002 at the landmark neuroethics conference in San Francisco as, "the study of the ethical, legal and social questions arising when scientific findings about the brain are carried into medical practice, legal interpretations and health and social policy." In practice, neuroethics deals with the pros and cons of research conducted on the brain, as well as the social, legal, and ethical implications of treating or manipulating the mind. When dealing with powerful technologies, questions of need, control, motive, and profit have to be identified and evaluated. For instance, some products such as brain scans, which identify early signs of brain disease and risk factors for mental health, serve obvious medico-*social* benefits, while others, such as technologies created to manipulate human cognition, are less straightforward, and may double as skilfully disguised political tools. Further, when evaluating well-being over the long-term, ethical accountability may require wider forethought, which could include maintaining the well-being of a subsequent generation of children. Thus, in the real world, reaching consensus requires a complex set of interactions among researchers, investors, medical professionals, patients and their families, and the community, at large.

The profit motive may not sit well with, for example, community forethought about what kind of technology is acceptable and what kind is not. But when it comes to high tech research, the money needed to fund these projects is typically out of the range of individuals or small groups, which means financial support is usually made available by governments or multinational companies. Developing new technologies also involves companies legally guarding their research and development through secrecy and patenting. Controlling and monitoring this mix to ensure that society's ethical and legal expectations are met is important, but complex. A sub-sample is described below.

Finger Printing the Human Mind

Current advances in neuroimaging can interpret personality, desires, and may even "see" a state of mind (e.g., racial attitudes) of which one is unaware (Eberhardt, 2005). Future advances will provide insights into individual traits such as intelligence, cognitive abilities, personality characteristics, and genetic predisposition to, for example, violence, addiction, and mental illness. Specific neuroimages may also predict the onset of particular neurodegenerative diseases, such as Alzheimer's and Parkinson's. Other lines of innovative research are already well placed to access the mental processes involved in recalling a memory, whether true or fabricated, and assist neurologists to differentiate between the two. For example, brain fingerprinting techniques can reveal if an individual is lying. But if a truly accurate lie detector were deployed and brain fingerprinting became established as a forensic tool, current privacy guarantees might not provide enough protection against screening requests from courts, the government, the military, or employers. In these circumstances, the precautionary approach is critical because physiological measures, especially brain-based measures, possess illusory accuracy and objectivity. Therefore, instrument accuracy and interpretation needs to be well-established and monitored. Consumers will have to be sufficiently informed to correctly balance advantages (such as prediction of the onset of a particular disease leading to treatment) against disadvantages (such as misdiagnosis, inappropriate treatment, and breaches of privacy). Ongoing advances focus increasingly on ways that basic brain processes can provide useful information about the subtle functions that make us individuals. For example, certain neuroimaging technologies are improving the skill-base for making predictions about an individual's future health. Scientists are learning to read how different image patterns, taken under varying circumstances, correlate with different future conditions or behavioural tendencies.

Since modern neuroimaging faces the common bioethical considerations of privacy, confidentiality, and the misuse of information, the ethical considerations are very similar to those associated with the human genome debate. There are social implications of the availability of personal information, particularly relating to future behaviour, to the wider community. Accountability issues about a patient's medical history are especially relevant here: they extended to include future health prospects, which might involve a wider circle of kin and children. Radiologists who use predictive testing are faced with long-standing ethical issues, particularly in the arena of psychopathology, and it isn't always in a person's best interest to have such information available to others.

Neural Prosthetic Devices

Scientists have uncovered brain functions that would help in the development and application of thought-controlled machines—that is, brain-machine interfaces enabling paralyzed people to move and communicate simply by thinking (Andersen *et al,* 2004a&b; Rizzuto *et al,* 2005). Prosthetics research focuses on recording hand trajectory signals from the brain. Recordings from these cells are "decoded" to control the trajectories of a robotic limb or a cursor on a computer screen. For instance, a patient could navigate a wheelchair or use an LCD interface to type a letter. In pioneering experiments, implants in monkey brains successfully picked up brain signals and sent them to a virtual robotic arm, which, driven only by the monkey's thoughts, carried out reaching and grasping movements on a computer screen (Lebedev *et al* 2005). In other experiments, both humans and monkeys have had their brains wired so they could move cursors on computer screens just by thinking (Sanchez *et al,* 2005). Early research has focused primarily on the identification of specific areas of the brain directly responsible for the control of movement; that is, the primary motor cortex (the brain region that controls voluntary muscle movement). But more recent experiments have identified that the ventrolateral prefrontal cortex, located near our temples, is the region involved in the processing of spatial information related to movements we are about to make (Rizzuto *et al,* 2005). This discovery is important, as it has heightened success opportunities by harnessing the prefrontal cortex for better neural prostheses development. The prefrontal cortex is less hardwired, enabling it to smoothly select appropriate sensory information to achieve the desired objective.

Ongoing experiments significantly advance the effort to devise thought-controlled machines. This technology could greatly benefit people are paralyzed or have lost control over some physical movement.

Post-Traumatic Stress Disorder (PTSD)

Memory gives our lives a sense of continuity and meaning by making it possible for us to learn from experience, to cultivate long-term relationships, and to treasure joyful times. But memory also brings pain. In the extreme, traumatic memories can bring on anxiety states such as post-traumatic stress disorder (PTSD). PTSD is a psychological syndrome that develops in about 20% of individuals after exposure to life-threatening situations such as combat, rape, or natural disaster. The major symptoms include experiencing the event through intrusive recollections, flashbacks, and nightmares, as well as heightened anxiety, emotional numbing, and avoidance of reminders of the trauma. All of these symptoms and their behavioural responses are normal reactions to distressing events, but in the majority of people exposed to trauma, the symptoms subside with time. With PTSD, the symptoms do not fade: rather, they persist indefinitely for years, decades, or a lifetime.

The body's natural tendency to enhance the storage of emotionally-laden memories has important survival value. In dangerous circumstances, we will typically experience emotions such as fear to help us respond appropriately to threats, and avoid similar situations in future. In short: life-threatening situations propel the body and mind to fight for survival by inactivating all non-essential activity and emotions in order to channel the entire available energy to staying alive. This adaptation involves the stress response—the so called "fight or flight" mechanism that is crucial for survival. Stress hormones such as noradrenalin are released from the brain stem and reach the amygdale, which instructs the memory-processing hippocampus to remember that experience clearly. However, in individuals whose stress response is over-reactive or has to be sustained over long periods of time, their hyped up body spells disaster for physical and mental health.

A Pill to Forget

Neurobiologists are working to understand the underlying mechanisms in the brain that encode new memories and store life-sustaining knowledge. They are well placed to appreciate the ways the brain normally keeps unwanted memories at bay (Anderson *et al,* 2004; Ockner, 2004). It looks as if for PTSD sufferers, each recall of the traumatic memory triggers an exaggerated physiological response that further consolidates the traumatic memory by wiring it more strongly into the mind. Because memories run on chemicals, they can be altered by chemicals. Applying this knowledge, researchers are now experimenting with drugs that either weaken the emotional hold of traumatic memories, or prevent newly formed memories from becoming destructive to those with a predisposition for anxiety disorders.

A commonly used class of drugs, the ß-blockers, has the ability to interfere with the way the brain stores memories so that they can be effectively deployed to dampen or eradicate a perceived overreaction to a traumatic event. Administered within about six hours of a traumatic experience, sufferers of traumatic stress disorders can prevent the distress associated with the condition (Giles, 2005). Alternatively, the drug can be administered retrospectively (therapeutic forgetting) to blunt the panic surrounding an existing traumatic memory (Strange & Dolan, 2004). Beta-blockers (short for ß-adrenergic blocking agents) are drugs that interfere with, or "block", the function of certain stress-mediated neurotransmitters in the brain, such as noradrenaline and adrenaline. Because ß-blockers lower blood pressure and the heart rate in general, they have been prescribed to treat high blood pressure and some forms of heart disease. Propranolol and its congeners are ß-blockers commonly used for these conditions.

As described above, the body uses stress-mediated neurotransmitters to initiate emotional reactions that best prepare the body to deal with an emergency, perceived threat, and survive through learned experience. But not all approve of preventing anxiety disorders with drugs, especially when administered before predicted traumatic times. The concern is that memory-erasing medication might risk entrenching antisocial behavior by removing emotions like empathy, remorse, and guilt, which typically curb the excesses of an activated "fight or flight" response. For example, would we want to give soldiers memory-blunting agents on the eve of combat to fortify the extinction of unwanted memories? Would this not risk accelerating atrocities in an environment where killing civilians and children are options? Might this not medicate away shame or guilt that might occur from past misdemeanors, which would otherwise prevent future wrongdoing? Among practical problems, knowing whom to treat is problematic. Potential PTSD victims do not exhibit symptoms at the time of the traumatic event. Would accident witnesses demand prescriptions and thus imperil their future testimony? Some ethicists have even gone so far as to maintain that "bearing traumatic memories is the moral obligation of those who witness atrocities" (Miller, 2004). For example, even if individual Holocaust survivors were to benefit from treatment that weakened the memories of their experiences, society as a whole might be badly served by having no witnesses with unadulterated memories. Our memory is not merely our own; it's part of the society we live in. Somehow, we must preserve the historical record of atrocities without denying individuals the benefits of therapeutic drugs. In the last analysis, it's up to society to determine how far we want to take the technology.

A Pill to Remember

A major research effort is also being directed to the development of memory-enhancing drugs. The effort is primarily aimed at finding treatments for dementia, e.g., for Alzheimer's disease, but it includes developments that could enhance normal memory, particularly in middle and older age, when a degree of increased forgetfulness is normal (Farah, 2004). Memory-enhancing drugs such as Ritalin (methylphenidate) target the molecular mechanisms involved in memory consolidation (see above section for details). In specific terms, memory enhancers exploit the stress-driven adrenergic system that spontaneously becomes overactive in those suffering from anxiety disorders.

The Ethics of Memory Manipulation

Safety concerns, especially regarding the long-term use of neuroactive drugs by healthy individuals, are foremost, but certainly not the only ethical concerns expressed by laypeople and professionals alike (Farah, 2002; Farah & Wolpe, 2004). Enhancement or inhibition of the natural responses of very complex systems, which neuroscientists are only just beginning to understand, invites unforeseeable risks and consequences (Gabrieli, 2004). Nevertheless, scientists who work with patients who suffer from, say, intractable post-traumatic stress disorder see therapeutic forgetting differently. Such scientists go against the current trend in memory research, which is to find a drug or a gene to enhance memory. At any rate, since memory is woven into our individuality, changing the emotional content of memories does effectively dissociate our personal history from our recollections of that history. For example, we gain maturity, social responsibility, and empathy for others from distress, anxiety, and sorrow, as well as from happiness, joy, and contentment. The difficult question is to distinguish what is dysfunctional for an individual from what is dysfunctional for society. Evidently, the technology could be abused. For example, in medicating in order to desensitize combatants or terrorists to commit repugnant acts that, if constrained by guilt, they would never think of doing. On the other hand, when society demands soldiers to participate in warfare, the society also carries the responsibility to help that soldier get through the aftermath of involvement in that horror.

Ethics—Our Evolutionary Heritage

The neurobiological foundations of emotion are attracting mounting interest within the neurosciences due to advances in functional neuroimaging technology. With functional magnetic resonance imaging (fMRI), it is possible to identify patterns of neural activity associated with storing and retrieving sequences of complex events, attitudes, and emotions (Wood *et al,* 2005). Emotion plays a pivotal role in ethical experience by assigning value to events, objects, and actions. Ethical choice depends on our capacity to foresee the results of actions, and includes the acceptance of individual responsibility. Some of the most fundamental questions about our unique evolutionary origins and social relations are centred on issues of altruism and unselfishness (Fehr & Fischbacher, 2003; Fehr & Renninger, 2005). Most academics agree that ethical codes have arisen through the interplay of biology and culture. The human brain—the cortex in particular—is more than an instrument for shaping the environment. In addition to receiving and linking heard, seen, smelled, and felt sensations, there are parts of the cortex's frontal lobe that interpret what is received, and incorporates it into the development of judgment, volition, and consciousness of self and others. From these abstract qualities, it is believed, evolved altruism or seemingly unselfish behavioural characteristics; that is, the willingness to choose cooperative over alternative behavioural options (Pollard, 2003). This opened opportunities for the development of a collective awareness, or ethics, which subsequently gave way to an ethical order of fitness-enhancing behavioural preference, to be used to one's advantage in personal and social relationships (Pollard, 2002).

Converging lines of evidence from evolutionary biology, neuroscience, and experimental psychology have demonstrated that ethics is, indeed, hardwired into our brains—effectively blending modern empirical testing with ancient wisdom. As a consequence, a fresh concordance between secular-based science and spiritual practice has provided new possibilities for the advancement of mental and social well-being (Pollard, 2004). For instance, with the aid of fMRI, Jorge Moll and his colleagues (Moll *et al,* 2002; Moll *et al,* 2003) have shown that subjects viewing scenes suggestive of ethical emotions strongly activated a common network of brain areas that included the prefrontal cortex and temporal regions, the thalamus, hippocampus, amygdale, and hypothalamus. Significantly, when responding to stimuli that evoke ethical or moral emotions, brain activation is consistently more powerful compared with the processing of neutral or unpleasant stimuli (Moll *et al,* 2003).The prefrontal cortex and temporal regions of the brain are critical for higher intellectual functions, social behaviour, perception, and ethical appraisal; the thalamus, hippocampus, amygdale, and hypothalamus are critical working centres of the emotional, or limbic, brain. Together, the intellectual prefrontal cortex and the limbic emotional brain allow us to mingle thoughts and feelings, cognition and emotion, providing an adaptive mix of intellectual and emotional brain power (Pollard, 2004).

Disciplined curiosity is natural and appropriate to the human mind—the sheer desire to learn and the satisfaction of gaining knowledge is Nature's special gift to *Homo sapiens*. It follows that harnessing knowledge to beneficial use in technology and practical skill is a responsibility that arises from the social and benevolent nature of humankind. But since technology is developing at an ever-increasing rate, ethics has to fundamentally change to keep up with this technological expansion. In the next few decades, we will have unprecedented opportunities to improve health and well-being, but also have increasing power to annihilate ourselves and our fellow inhabitants of Earth. Experts have estimated the risk that humankind will be wiped out by some technological disaster—nanotechnology, biological warfare, nuclear technology—at 20-50% in the next century (Savulescu & Foddy, 2005). But such a disaster is already possible with existing technology, so we have to become more resourceful by applying our collective energies from the combined pool of intelligence and sense of adaptive responsibility. In this context, I refer to an elevated awareness conveniently referred to as the emotional intelligence quotient, or EQ. A well developed EQ signals intellectual maturity—one is more responsive to physical and social environments. In closing, I would like to quote from a recent paper by Julian Savulescu and Bennett Foddy (2005):

> There is an urgent need to begin considering how we will face these new challenges to our nature and to our existence. Because technology begets further technological development, there is no halting or avoiding these problems. We must consider radically changing our practical ethics effort away from comparatively less important problems like privacy and reproductive cloning (which will never threaten our nature or existence) to these so critical and so far ignored challenges to humanity in the 21^{st} century.

References

Anderson, M., Ochsner, K., Kuhl, B., Cooper, J., Robertson, E., Gabrieli, S., Glover, G. and Gabrieli, J. 2004. Neural Systems Underlying the Suppression of Unwanted Memories. *Science,Vol. 303,* pp. 232-235.

Andersen R., Musallam, S. and Pesaran, B. 2004a. Selecting the Signals for a Brain-Machine Interface. *Current Opinion in Neurobiology*, Vol. 14, pp. 720-726.

Andersen R., Burdick, J., Musallam, S., Pesaran, B. and Cham, J. 2004b. Cognitive Neural Prosthetics. *Trends in Cognitive Sciences*. Vol. 8, pp. 486-493.

Bioscience-Bioethics Friendship Co-operative Web Portal at http://www.bioscience-bioethics.org/ provides free entry to relevant educational material.

Eberhardt, J. 2005. Imaging Race. *American Psychology*, Vol. 60, pp.181-190.

Farah, M. 2004. Neurocognitive Enhancement: What Can We Do and What Should We Do? *Nature Reviews in Neuroscience*, Vol. 5, pp. 421-425.

Farah, M. 2002. Emerging Ethical Issues in Neuroscience. *Nature Neuroscience,* Vol. 5, pp. 1123-1129.

Farah, M. and Wolpe, P. 2004. Monitoring and Manipulating Brain Function: New Neuroscience Technologies and Their Ethical Implications. *Hastings Center Report, Vol*. 34, pp. 35-45.

Fehr, E. and Renninger, S. 2005. The Samaritan Paradox. *Scientific American Mind,* Vol. 14, pp. 15-21.

Fehr, E. and Fischbacher, U. 2003. The Nature of Human Altruism. *Nature*, Vol. 425, pp. 785-791.

Gabrieli, J. 2004. Memory: Pandora's Hippocampus? *Cerebrum*, Vol. 6, pp. 39-48.

Giles, J. 2005. Beta-blockers Tackle Memories of Horror. *Nature*, Vol. 436, pp. 448-449.

Lebedev, M., Carmena, J., O'Doherty, J., Zacksenhouse, M., Henriquez, C., Principe, J. and Nicolelis, M. 2005. Cortical Ensemble Adaptation to Represent Velocity of an Artificial Actuator Controlled by a Brain-Machine Interface. *Journal of Neuroscience,* Vol. 25, pp. 4681-4693.

Miller, G. 2004. Learning to Forget. *Science*, Vol. 304, pp. 34-36.

Molle, J., de Oliveira-Souza, R. and Eslinger, P.J. 2003. Morals and the Human Brain: A Working Model. *Neuroreport*. Vol. 14, pp. 299-305.

Moll, J., de Oliveira-Souza, R., Eslinger, P., Bramati, I., Mourao-Miranda, J., Andreiuolo, A. and Pessoa, L. 2002. The Neural Correlates of Moral Sensitivity: A Functional Magnetic Resonance Imaging Investigation of Basic and Moral Emotions. *The Journal of Neuroscience,* Vol. 22, pp. 2730-2736.

Ockner, K. 2004. Current Direction in Social Cognitive Neuroscience. *Current Opinion on Neurobiology*. Vol. 14, 2004, pp. 254-258.

Pollard, I. 2003. Choose Between Cooperation and Annihilation: A Mental Mapping Project Towards a More Generously Directed Altruism. *Eubios Journal of Asian & International Bioethics (EJAIB),* Vol. 13, pp. 44-48.

Pollard, I. Meditation and Brain Function: A Review. 2004. *Eubios Journal of Asian & International Bioethics (EJAIB),* Vol. 14, pp. 28-33.

Pollard, I. 2002. *Life, Love and Children: A Practical Introduction to Bioscience Ethics and Bioethics.* Norwell, Kluwer Academic (also freely available on http://www.bioscience-bioethics.org/)

Rizzuto, D., Mamelak, A., Sutherling, W., Fineman, I. and Andersen, R. 2005. Spatial Selectivity in Human Ventrolateral Prefrontal Cortex. *Nature Neuroscience*, Vol. 8, pp. 415-417.

Sanchez, J., Erdogmus, D., Nicolelis, M., Wessberg, J. and Principe, J. 2005. Interpreting Spatial and Temporal Neural Activity Through a Recurrent Neural Network Brain-Machine Interface. *IEEE Trans Neural Systems Rehabilitation Eng*ineering, Vol. 13, pp. 213-219.

Savulescu, J. and Foddy, B. 2005. The New Gods: Ethics in the Next Decades. *Australian Life Scientist,* Vol. 2, pp. 26.

Strange, B. and Dolan, R. 2004. ß-Adrenergic Modulation of Emotional Memory-Evoked Human Amygdala and Hippocampal Responses. *Proceeding National Academy of Science*, Vol.101, pp. 11454-11458.

Wood, J., Knutson, K, and Grafman, J. 2005 Psychological Structure and Neural Correlates of Event Knowledge. *Cerebral Cortex,* Vol. 15, pp. 1155-1161.