Medical Imaging:
A Hub for the New Field of Neuroethics

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Structural and functional imaging such as plain and tomographic radiological techniques, molecular, magnetic resonance, and optical imaging technologies have had a profound impact on improving human health and reducing human suffering and have been key enabling technologies in discoveries of fundamental human biology for over a century. However, if in 1895 it would have been difficult to predict the sensation around the world that Roentgen's chance observations of the x-rays of his wife's hand would cause (1), it is equally unlikely that he or others would have thought that ethical challenges of medical imaging—beyond ethics for the practicing profession (2,3)—would become compelling. Yet, from a 21st century partnership among disciplines including medical imaging and bioethics, such a movement has emerged. It has been coined "neuroethics," and it has connected the very earliest debates about physiological processes and psychological states dating back to the ancient philosophers to the anatomoclinical approaches to cerebral localization and functional specialization beginning in the 16th and 17th centuries with present-day thinking. The focus of the new field is on advanced capabilities for understanding, monitoring, and modulating human thought and, as we shall see, the myriad of associated ethical, social, and legal challenges that such capabilities pose.

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A BRIEF HISTORY OF NEUROETHICS

The first specific references to "neuroethics" in the literature were made a little over a decade ago to describe the role of the neurologist as a neuroethicist faced with patient care and end-of-life decisions (4) and philosophical perspectives on the brain and the self (5). As a new discipline, the terrain for 21st-century neuroethics was first formally defined in a meeting sponsored by the Dana Foundation called "Neuroethics: Mapping the Field" held in San Francisco in May 2002 (6). Bringing together neuroscientists; scholars in medical imaging, biomedical ethics, and the humanities; lawyers; public policy makers; and representatives from the media, the conference covered four areas: Brain Science and the Self (or, Our View of Ourselves), devoted to issues of free will, the biological basis of personality, decision-making, and consciousness; Brain Science and Social Policy, devoted to issues of personal and criminal responsibility, true and false memory, education and theories of learning, social pathology, privacy, and the prediction of future brain pathology; Ethics and the Practice of Brain Science, spanning topics of pharmacotherapy, surgery, stem cells, gene therapy, and neuroprosthetics; and, Brain Science and Public Discourse, urging the development of broad and informed public discourse, mentoring of young trainees, and responsible reporting in the media. With abundant intersections in this new terrain, it is no surprise that medical imaging has surfaced as a busy hub.

A meeting in June 2003 sponsored by The Lasker Trust and the American Association for the Advancement of Science also placed imaging at the center of the ethical issues surrounding frontier technology. The meeting was focused on the ". . . gray area in which innovation could either be considered research (which is formally regulated) or medical practice (which is governed by profes-

sional and malpractice standards).” It illuminated problems involving both the successes and failures of medical innovations, practice and oversight, and the challenges that innovation poses to the ethical structure of medical practice especially given the moral anxiety, as Don Kennedy and Harold Shapiro remarked, that accompanies the commitment to change and improvement built into our liberal democracy (7). The Forum used four hypothetical cases on which to base its deliberations: assisted reproductive technology, microsurgery, off-label prescribing, and the application of functional MR in neuropsychiatry. While the zone of innovation had more slippery sides than the multidisciplinary group could resolve in a short 1.5 days, the following points were highlighted: (i) whatever thresholds for oversight are established for medical innovation, it should protect patients, benefit clinical practice, draw upon already-existing systems, and take better advantage of little-used outlets such as journals, databases, and information tools; (ii) disclosure is a moral underpinning for all clinical encounters, including the motives and capacities of the physician and the risks and benefits of an approach proposed; and (iii) when there is a departure from standard of care, there is a “duty to learn,” ie, to maximize knowledge by coupling the old knowledge with the new, and to disseminate that information. These conclusions provide a solid basis on which to ground our thinking about where medical imaging and neuroethics will take us next.

SPHERES OF ACTIVITY IN “IMAGING NEUROETHICS”

Issues of neuroethics as applied to medical imaging may not seem as acute as those of stem cells or cloning, but they are equally significant. Given the rapid pace of innovation and expanded applications both within and outside academic medicine (8–9), radiologists must partner with other practitioners and investigators to play a lead role in the following spheres of activity:

- Assuring technical readiness, health benefit versus health risk, and fair access to new technologies balanced against society’s pull for new innovation and the academic push for technology transfer.
- Defining guidelines for managing incidentally detected abnormalities in subjects recruited to studies as healthy controls and patients recruited to clinical studies.
- Examining the role and implications of functional and molecular medicine imaging in regenerative medicine. Imaging is being used increasingly to monitor neural viability by determining whether stem cells marked with reporters are surviving and differentiating into mature cells. What impact will such information have, whether provided by fMRI, optical imaging, or new forms of molecular imaging, on therapy (customizing drug dosages), how patients view their disease and recovery, and patient self-image, especially in cases of xenotransplanted neural material?
- Applying appropriate cautions of interpretation and procedure to brain maps that may predict neurodegeneration in the absence of effective neuroprotection.
- Defining the role of functional imaging in predicting childhood disorders that may affect educational performance such as attention deficit hyperactivity disorder (ADHD), or a propensity to aggression, violence, or suicide.
- Examining the role of functional imaging in informing the therapy-enhancement debate (10–12).
- Examining the role of imaging in improving our understanding of responsibility and autonomy in addiction and criminal behavior.
- Defining parameters for image-guided functional neurosurgery, neurosurgical interventions such as deep brain stimulation, and direct brain interfaces using nanotechnology.
- Applying safeguards in this new era of imaging genomics in which physiological links between functional genetic polymorphisms and information processing have been demonstrated (13).
- Establishing guidelines for transitioning hypnotic (mind–body) interventions for the mediation of pain and anxiety, and accelerated recovery into mainstream interventional radiology (14).
- Providing parameters for predicting developmental outcome from CNS disorders diagnosed with fetal MRI or in prematurely born babies with diffusion tensor imaging (DTI) (15).
- Assuring quality control and appropriate consumer education for body imaging scans and the growing industry of self-referred functional brain imaging services using SPECT.
- Preventing premature uses and overgeneralization of new imaging capabilities in non-medical areas such as law. Whether used to reveal sub-clinical disease, or tried as a new form of lie detection (16–17), radiology should not become the new province of lawyers, judges, and juries.

No doubt, other major new areas of "imaging neuroethics" will surface as quickly as these have.

OUTLOOK AND IMPACT

By all measures—peer-reviewed papers in major journals, recognition of federal research sponsors such as the NIH and NSF, and visibility in the public eye—it would appear that neuroethics is here to stay. For diagnosticians, imaging of abstract phenomena such as moral agency and personhood may not seem to have the same immediate relevance as detecting a cancer or an aneurysm, but for the vulnerable patient who suffers from psychosis or depression, the new and appropriate uses of such knowledge and subsequent treatment may have no less of an impact. To sustain the new field of neuroethics now and fully embrace the momentum it has already captured, greater attention from the radiology community and dedicated funding from major sponsors will be needed. Today, the National Human Genome Research Institute has set aside funding of approximately 5% of its budget for ethical, legal, and social issues (ELSI) primarily dedicated to genetics, and a few individual ELSI-type research grants (RO1s) have been generously funded by other institutes such as the National Institutes of Neurological Disorders and Stroke. The newly established National Institute for Biomedical Imaging and Bioengineering must step up to the plate. Dismissing the ethical and social consequences of biomedical imaging as unscientific is passé. Others, including the Canadian Institutes of Health Research (parallel to the US NIH), have already devoted significant resources to neuroethics, including team grants of $1.5M (CDN) for 5 years. Biomedical ethics should be part of the funding priority of all research sponsors in this country and all large programs, especially as the new NIH roadmap rolls out. We will jeopardize our ability to be at the cutting edge of this important new field unless we have broad support within the imaging community and from all our stakeholders.

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