THE HUMAN PROSPECT(S) OF NEUROSCIENCE AND NEURO-TECHNOLOGY: DOMAINS OF INFLUENCE AND THE NECESSITY – AND QUESTIONS - OF NEUROETHICS

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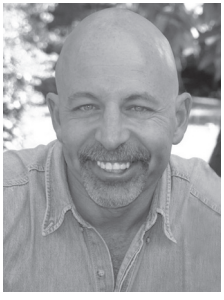

ABSTRACT:
Neuroscience and the technologies it develops and employs have become a profound international force, exerting effects upon the scope and tenor of healthcare, socio-cultures, economics, and global relations. In this essay, I provide an overview of neuroscientific and neurotechnological approaches to assessing and accessing the brain, and explicate how neuroscience exerts influence in the metaphysical, epistemic, anthropological and ethical domains. I posit that when taken together, these domains of effect establish the substance and work of the field of neuroethics.

Herein, I describe key issues and fundamental questions that are the foci of neuroethics. To address these issues and questions, I offer that the field and practice of neuroethics will must engage ongoing discourse, formulation of methods and protocols, and establishment of standards and guidelines that realistically reflect – and respond to - specific developments and trajectories of neuroscience. Through such address – and dedicated educational efforts - neuroethics can define and direct the ways that neuroscience will influence the human prospect upon the 21st century world stage.

KEY WORDS: NEUROETHICS; NEUROTECHNOLOGY; NEUROSCIENCE; CULTURE

NEUROSCIENCE AND NEUROTECHNOLOGY – A GENERATION OF PROGRESS

Through a deepened and broadened focus upon the structure and functions of nervous systems and the brain, neuroscience is addressing perdurable questions about the "bases" of consciousness, cognition, and action, and concepts of self-determination, morality, and the "nature" of mind and being. Built upon the groundwork provided by research of the late 19th and 20th centuries, and propelled by various governmental and commercial programs of support since 1990, the field has had a surge in activity, reflected, for example, by a greater than 70% growth during the 10 year period from 2000-2010, as evidenced by the increased number of studies reporting basic and translational research and various clinical applications.[2] Today, neuroS/T can be viewed not as separate dimensions, but rather as a singular, reciprocal – and inextricably inter-reliant – enterprise, entailing iterative heuristic progress that employs extant tools to establish theory, which then prompts the development and use of more capable and precise tools with which to both (a) address, adapt and/or confirm theories anew, and (b) afford information and instruments that can be translated into knowledge and applications in medicine, public life, and various spheres of human activity and relations (an overview of extant categories and types of neurotechnologies is provided in Table I).

Table I. Categories of Neurotechnologies

Assessment Neurotechnologies
Imaging Approaches
Computed Tomography (CT)
Positron Emission Tomography (PET)
Single Photon Emission Computed Tomography (SPECT)
Magnetic Resonance Imaging (MRI)
Functional Magnetic Resonance Imaging (fMRI)
Functional Near Infrared Spectroscopy (fNIRS)
Diffusion Tensor Imaging (DTI)
Physiological Recording Approaches
Electroencephalography (EEG)
Quantitative Electroencephalography (qEEG)
Magneto-encephalography (MEG)
Genomic, Genetic and Proteomic Analyses
Neurochemical Biomarker Analyses
Interventional Neurotechnologies
Neuro-psychopharmaceuticals
Transcranial Magnetic and Electrical Stimulation
In-dwelling (Deep) Brain Stimulation
Peripheral/Cranial Nerve Stimulation
Genetic Modification
Tissue and Gene Transplants
Brain-Machine Interface Devices (Neuroprosthetics)

For overview and address of neuroethico-legal issues generated by the use or misuse of specific neurotechnologies, see: *Neurotechnology: Premises, Potential, and Problems*, edited by James Giordano, Boca Raton: CRC Press; 2012.

Contemporary brain science is advancing on an international and multi-dimensional scale through projects such as the European Union's *Human Brain Project*, and the newly announced *Brain Research through Advancing Innovative Neurotechnologies (BRAIN)* initiative in the United States.[3] At present, the interval needed to translate concept to construct, and theory to tools is estimated at 60 to 90 months.[4] Without doubt, there is much that neuroS/T has achieved, and can achieve, but there is much that remains unknown, and which remains yet unaccomplished – if not untenable. This cresting of scientific and technological capability has prompted considerable speculation about the current and future potential of neuroS/T, and has spawned attendant hopes and fears about the ways that such techniques and technologies might be used, and the means and ends they will effect. In this light, it becomes important to parse fact from fiction, and reality from fantasy when examining what can and should be done with the knowledge and capabilities we possess, and what should be done *about* the information and abilities we lack. Perhaps more importantly, an undergirding question is whether we - as individuals, communities, and publics - will be able to tell the difference between the knowns and unknowns, facts and fictions, and exert appropriate judgement and control in the ways that neuroS/T is used.

NEUROS/T: DOMAINS OF EFFECT AND NEUROETHICAL ISSUES

In the main, advances in neuroS/T engage four interactive domains:

The metaphysical - Neuroscience is based upon a naturalistic view of the known universe and its events. Brains and their functions entail processes that are consistent with a current understanding of nature. Of course, the fund of information, and thus any understanding of the known realties of the natural universe will change as a consequence of new approaches in scientific investigation. This speaks to the epistemological domain as discussed below. As well, the naturalistic metaphysics of neuroscience establishes certain parameters of the anthropological and ethical domains, in that it grounds any speculations about, and undertakings of the human being and human action to natural explanations.[5]

The epistemological - Namely, the naturalistic methodology of neuro-

scientific inquiry, outcomes it obtains and the limits of such methods, inquiries and knowledge. From this is an accounting of what and how this information contributes to other domains of human knowledge, and how this knowledge informs and in some cases influences longstanding philosophical questions about the nature of consciousness, the person, self, free will - and if such terms can and/or should even be used, or if a new lexicon needs to be developed.

The anthropological - NeuroS/T is a human endeavor, developed by humans, for use by humans to affect the human condition (including our relationship to each other and the natural world), the human predicament (of pain, suffering, disease, injury and the finitude of life), human nature, and the being that is the human. Here we must address and examine those ways that current and future developments in neuroS/T can (a) define both common and variant aspects of human structure and function, and (b) *realistically* affect these variables to alter humans and other organisms, and our interactions (with each other, the technologies we create, and the world).

The ethical - NeuroS/T, like any science - is employed to advance human knowledge and capability so as to fortify survival, and perhaps more appropriately, flourishing. If flourishing is defined as strivings for the good(s) of life, it then becomes important to address and examine how such goods are defined by various individuals, groups and societies, how neuroS/T can, are and should (or should not) be employed to obtain such goods. This then situates any consideration of neuroS/T research and application squarely within the realm of the field and practices of neuroethics

Neuroethics, as a field, is devoted to two main tasks: (1) the study of neurobiological functions that are operative in proto-moral, moral and ethical cognition, emotions and actions; and (2) those ethical issues fostered by neuroscientific research and uses in medicine, public life and national security, intelligence and defense.[6]

At present, key neuroethical issues include:

(1) The validity and relative value of using various forms of assessment neuroS/T (such as neuroimaging, neurogenetics, biomarker evaluation) to define, describe, and/or predict patterns, and types of thought, emotionality and behaviors.

This incurs consequences in medicine and public health (as relates to predicting dispositions to potential neurological and/or psychiatric disorders), law (as regards using neuroS/T to define capability and culpability) and socio-political standards and actions (by using neurocentric criteria to establish norms and then basing social, economic and politico-legal treatment of individuals upon these definitions and distinctions).

NeuroS/T-based assessments have been shown to be useful in experimental, and certain clinical and social applications, by illustrating particular functional and dysfunctional parameters of brain structure and activity. However, these approaches also incur a number of potentially controversial issues and questions, based, at least in part, upon the capabilities and limitations of the techniques themselves. For example, neuroimaging technologies and techniques (e.g.-positron emission tomography (PET), functional magnetic resonance imaging (fMRI), diffusion tensor imaging (DTI)) tend to have rather good spatial resolution, but less than optimal temporal resolution. In contrast, physiological measures (e.g.- quantitative encephalography (qEEG) and magnetoencephalography (MEG)) have very good temporal resolution, but generally restricted spatial precision. Genomic and genetic assessments may be viable in assessing certain predispositions to patterns of neural structure and function, but direct prediction of resulting phenotypes can be difficult (if not impossible) given the diversity of interacting biological and environmental factors affecting physical expression. If used together (in what is being developed as a paradigmatic approach, called Advanced Integrative Scientific Convergence, AISC), many of these constraints can be de-limited.[7] But while creating opportunities for technical embellishment and diminished constraints, convergence may also increase the questions and problems generated by the use of multiple techniques.

I posit that the utility - and applicability - of these approaches are credible if and only if the relative constraints and underlying assumptions (and misassumptions) are acknowledged and accounted for in any and all attempts to apply said techniques - especially in situations beyond the research or restricted clinical realm (such as social norming and/or law).Can we "scan brains to read minds", or "plot genes to predict future thoughts and actions"? No; at least not to the degree entertained in popular media, and fictional accounts that tend to prompt public fears. Are we on a path to such possibilities? Perhaps, and here we encounter something of a paradox: Given (a) trends in, and relative speed of neuroS/T advancement, and (b) recent

events of social violence in Columbine, Oslo, Phoenix, Newtown and Boston (if not those of 9/11), there is a pervasive- if not increasingly strong - call from the public (as well as certain government sectors) to «do something» and employ imaging and genetic neurotechnologies to define, describe and predict who will be most likely to commit acts of aggression or violence.

At the same time, there is an equally strong fear that such neurotechnologies will be used to probe the sanctity of consciousness and usurp privacy and autonomy. How can a balance be struck between calls for protection and equivocal calls for privacy? What concerns me is that we might lose insight to the capabilities and limitations of these technologies and techniques, and imprudently begin to increasingly employ them in inapt ways (e.g.,- for legal inference or determinations of culpability or even disposition to certain patterns of thought and action, beyond the pale of actual current technological capabilities).[8] Moreover, given the growing availability of, and reliance upon neuroS/T, might the use of such tools for assessment then instigate (a more widespread) employment of neuroS/T for cognitive, emotional and/or behavioral control?

(2) The potential use and misuse of interventional neuroS/T (such as novel drugs, transcranial and direct brain stimulation, implantable devices and gene and tissue transplants and implants, and brain-machine interfacing) to affect fundamental aspects of personality or "the self" as defined in first, second- or third-person perspectives.

Might neuroS/T be used to change the subjective experience of being by altering mental representations of past and present, so as to affect thought, feelings and actions in the future? Recent work in deep brain stimulation (DBS), transcranial magnetic stimulation (TMS), and optogenetics is impressive, and can be seen as an ardent step toward affecting cognitive functions to alter emotional reactivity and behavior. These studies are indeed important, but we must be cautious against spinning hype from fact.

Let's bear in mind that there are a lot of ways to "manipulate' memories, thoughts and the emotions that are yoked to them. These range from the rather crude to the extremely sophisticated. Altering brain activity to change cognitive and emotional states relative and relevant to situational responses is not a new approach, even in the brain sciences. What *is* new is the specificity and precision that state-of-the-art techniques and technologies enable.

For example, the use of selective pharmacological agents (such as certain types of benzodiazepine derivatives, such as midazolam), transcranial magnetic or electrical stimulation, and deep brain stimulation are all currently possible (although it'd be hard to picture these being covertly employed). There is also building impetus to employ interventional neuroS/T to augment cognitive, emotional, and decisional abilities, and in this way, affect performance in learning and memory, acquisition of knowledge and skill, and to alter "talent", "sensitivity" and perhaps "morality" (however defined). But what – and whose - criteria will provide the yardstick(s) of need, value or desirability? On one hand, such applications of neuroS/T can be seen as providing new vistas – and means - for self-improvement. On the other, these same approaches can be leveraged to enforce medico-legal and political standards and norms. In both scenarios, economics play a role in shaping how - and to whom - various techniques and technologies would be provided.

I offer that at the core, what generates unease is not the cutting-edge or even the covert nature of such techniques, but rather the question of using science and technology to probe and change thoughts and emotions. Arguably, this too is not new, although the mode(s), extent, and directness of such evaluation and change are certainly novel. This harkens a bit of sci-fi, (think here of the Hollywood films *Terminal Man*, *A Clockwork Orange*, *Eternal Sunshine of the Spotless Mind*, and *Limitless)*, and these depictions are reflective of public sentiment, at least to some extent.[9] Without doubt, there are situations that might sustain the use of neuroS/T to alter if not eradicate memories (eg.- traumatic events, profoundly sad or disturbing experiences, etc), and change cognitions and emotions (e.g.- depressive disorder; post-traumatic stress syndrome, and florid psychopathy) and these can be seen in a positive, therapeutic light. However, this same capability could also be used in ways that might - and perhaps should - be viewed as more controversial and provocative, such as in interrogations, intelligence operations, and even certain contexts of what is construed to be "public safety".

But let's say that we were somehow able to constrain the use of neuroS/T to the clinical milieu; we must still consider, for example, how «informed» consent can really be, given the newness of these techniques and technologies. Does this mitigate further research and use in practice? Indeed not, as the only way to fortify determinations of benefits, burdens, risks and harms is through ongoing research. And since most of the contestable issues regard-

ing the use of neuroS/T centers upon the assessment and control of human mental function, animal research will likely be insufficient, thereby necessitating human trials. Of course, many potential side and adverse effects will be reduced through the careful design and conduct of any such studies. Yet, the fact that this research employs and investigates heretofore unknown interactions between technologies and the brain creates strong probability that unanticipated outcomes can and will occur. How will responsibilities for unintended consequences be addressed and managed? Will the financial structure of medicine be revised to accommodate the trend and trajectories of cutting edge neuroS/T and its translations into clinical contexts?

As well, one need only to look at recent history to recognize that limiting neuroS/T to the clinical arena is unlikely (examples of this "spill-over" effect include cosmetic surgery, psychopharmacology; erectogenic drugs; and as explicitly apropos to this discussion, the extra-clinical use of neurotechnologies such as EEG-based neurofeedback, and transcranial electrical stimulation).[10] To what extent can - and should - these approaches be used to alter and augment human thought, intellect, mood and emotion, personality, belief and/or action? What type or extent of interventions constitute treatment (of "abnormalities", for example, if said norms are neuroscientifically defined), versus enhancements (and how far can and should brain functions and human performance be enhanced)? Might there be some "middle ground" - such as socially sanctioned and justifiable "enablement" (a term developed by our group) in which key individuals in select professions (eg.- peace officers, fire fighters, physicians, soldiers, et al) might receive neuroS/T augmentation of those capabilities that are deemed important and/or necessary to upholding their social status as protectors of the polis? What professions might be appropriate? Would it not be of benefit to augment the performance of other professionals, for example, lawyers, pilots, and even clergy? What about a cadre of augmented engineers to design and create ever improved technologies to enable human flourishing? And what happens if these individuals can no longer perform such duties, or are no longer in such jobs; should thy then be "dis-enabled", or will their augmented/altered capabilities render them misfit for other aspects of society? How will these "dis-enabled" individuals be cared for? Who decides? Who pays?

(3) The commercialization and global leveraging of neuroS/T.

Recent reports estimate that neuroS/T generated over $150 billion in rev-

enues, and in excess of 5% total market growth in 2011-12.[11] Furthermore, current predictions posit a greater than 60% increase neuroS/T research, development and translational application(s) within the next 10 years, with Asian, and South American efforts becoming equal to, if not surpassing US and European output.[12] This establishes brain science as a major economic factor and force affecting power distributions upon the world stage of the forthcoming decade. The strong market-pull for those neurotechnologies that may be viewed (via communicated popular/consumer beliefs) or intentionally construed (via advertising) to be of high value (e.g.- for cognitive, emotional or behavioral augmentation), may generate potential for inapt use as a consequence of commodification of neurotechnology into the consumer sphere and as a result, a default to relying upon *caveat emptor* as an undergirding ethico-legal precept.

This will likely incur social control by manipulating aspects of both economic and biological states through the use of neuroscience and technology (i.e.- in form(s) of what philosopher Michel Foucault referred to as "bio-power" and "bio-politics").[13] Thus it will become important - and necessary - to consider and acknowledge the needs and values of other, non-Western nations and groups when examining and articulating neuroethical issues and their possible resolution(s). It will no longer be adequate - or appropriate - to base international discussion, guidelines, treaties, policies, and laws upon solely Western ethics when attempting to address and govern neuroS/T research and use. What constitutes equitable distribution of the techniques, technologies and goods afforded by these approaches? How will neuroS/T affect global cultures, and what ways will neuroS/T be used to leverage national and international norms, lifestyles and qualities of life, laws, relationships, economics and politics?

Such leveraging of brain science is not limited to the portfolios of international economics; rather it is also crucial to consider the use of neuroS/T in military operations. The formal definition of a weapon as "a means of contending against an other"[14] would warrant more accurate insight to the ways that neuroS/T might be employed to foster improved understanding and insight to precipitating factors that spawn cognitive and emotional precipitants of aggression and violence.[15] In an optimistic, but nonetheless pragmatic view, I have argued that neuroS/T could be employed in such ways to defer conflict. But human history and contemporary events prompt re-examination of the viability of weaponizable neuroS/T to incur sickness

and death, and to negatively impact local, national and international public health.[16]

NEUROETHICAL QUESTIONS

I posit that from these arise three major - and I believe inter-related – neuroethical questions and debates:

First is what we - as individuals, communities, organizations, nations and perhaps even a species - will do *with* the information and capability conferred by neurotechnology, and what we will do *about* the capability and information we lack (and by extension, whether we will be insightful and exercise sufficient judgment to know the difference). In other words, will we be (a) sufficiently *pragmatic* in our assessment of neuroscience and neurotechnology to recognize the actual strengths and limitations of these approaches, and (b) sufficiently *prudent* in the ways we use and limit the outcomes and products of these approaches to leverage medical, social, economic, legal and even political effects and power.

Second is whether neurotechnologies developed and articulated under current funding initiatives will be translated into clinical care, and/or publicly viable - and sound - use within a reasonable window of time, or whether these approaches are so nascent as to remain little more than incipient drops in the proverbial bucket that will be required to evoke the sea change of effect necessary to realize brain science as a viable public good. This is a double-edged sword; while we must be concerned about *not* translating neurotechnological research into clinical care, we must be equally concerned about the ampliative claims and under-estimated potential adverse effects that prompt over-expedience in moving novel technologies to the clinical forefront.

Third is how assessment and interventional neurotechnologies can, should and/or should not be used to define, predict and change the cognitive, emotional and behavioral states, conditions and manifestations that are associated with various brain structures and functions. Of course, this incurs a host of derivative issues, questions and problems, including if and how neurotechnologically-based or -derived information might be used to establish neurocentric criteria for normality and abnormality, what thresholds

(of both neurotechnological accuracy and neurobiological function) will be employed to initiate medical, socio-legal and/or political actions, and if and how various neurotechnologies will be utilized to execute such actions (by changing thought, emotions, beliefs, and actions).

Under this rubric we also confront the use - and potential misuse- of neurotechnology in dual-use agendas, both by intent and by co-optation. Surely, public safety and national security use of neurotechnology are not inherently capricious, nefarious or problematic. As noted above, such applications are often directed at discerning and mitigating risks of violence that could affect the population, and increasing the effectiveness of military medicine to prevent or reduce the burden of neuropsychiatric insult and trauma. Despite this, neurotechnology can - and I believe - will be used to effect great purchase in national defense, military and political spheres, both as weaponized techniques and technologies, and perhaps more subtly, but none the less potently, to effect new economic balances of power upon the ever more diversified world-stage that is contingent upon the market space occupied by cutting edge neurotechnoloigies (in medical, public life, and of course, defense uses). The question is how such neurotechnolgical research and applications will be assessed, surveyed, guided and governed, and what types of organizations will bear the responsibility of such ethico-legal stewardship on the international stage?

THE CHALLENGE - AND OPPORTUNITY - OF GUIDING NEUROS/T AS HUMAN PROSPECT

In assuming a path forward it will be essential to create equilibrium between postures of assertivism and precautionism. Toward this end, I have advocated more of a preparatory stance, wherein the neuroethical tasks will be to 1) *realistically* assess the science and technology that will be executable at present and in the near future, 2) model trajectories for use, misuse and effect, and thereupon 3) develop guidelines and approaches that will be necessary to identify, address and either prevent problems, or resolve them at their inception or early in their development.[17]

I believe that such a preparatory posture is necessary because adherence to a frank precautionary principle is untenable for two principal reasons: First is the momentum of progress; these paths of neurotechnological development can and likely will occur, at least in some form. Second is that the progres-

sion of neurotechnological research and its applications are increasing, not least due to investments like *BRAIN* in the United States, as well as other national and international agendas, and therefore a "wait and see" attitude toward addressing neuroethico-legal and social issues created by neuroS/T, or an attempt to constrain neurotechnological development is ingenuous, if not downright foolish.[18] Rather, I re-iterate that it will be wiser to take genuine stock of what areas and types of neuroS/T are being subsidized, fortified and advanced, assess how such technological developments will affect local, regional, national, and global societies, economics and politics, and employ neuroethics in an empirical, predictive and preparatory way so as to afford both readiness for, and guidance of neurotechnological use (and its effects) in various domains of global culture.

We have opined that the internationalization of neuroS/T necessitates a move away from older, exclusively Western philosophy and ethics. A contemporary neuroethics can only be meaningful and applicable upon the 21st century world-stage if the socio-cultural contingencies and exigencies of various stake- and share-holders in neuroS/T are taken into accord. In light of this, we have advocated a cosmopolitan approach that can be articulated within particular communitarian contexts through adapting certain existing principles and the development of others. While hypothetical and tentative, we maintain that this construct, while not without problems (such as potential tensions arising from inter-communitarian engagement), affords promise as a methodological paradigm for a "globalizable" neuroethics.[19]

As a work-in-progress, the field will require dedicated efforts toward formation of working groups, ongoing discourse, formulation of methods and protocols, and establishment of standards and guidelines. I propose that (like the Human Genome Project) 2-3% of the total *BRAIN* budget be allocated to addressing specific neuroethical, legal and social issues (NELSI) arising in and from its funded scientific projects. To wit, I advocate a non-agnostic approach, in which there is targeted address of the NELSI that could likely be generated by the science that would be conducted under particular requests for proposals (RFPs). As well, I would hope that there would be equivalent investment by the private and commercial sectors in establishing well-conceived and precise NELSI projects that reflect and are aligned with the direction, scope and activities of these groups' respective endeavors in neurotechnological research and its translation. Clearly these issues and question loom large on the forefront of neuroscientific research and use. I

am very much encouraged by the proactive engagement of groups such as the Nuffield Council of Bioethics (in the UK), President's Commission for the Study of Bioethical Issues, and Defense Advanced Research Projects Agency's (DARPA) Neuroscience Ethics' Legal and Social Issues Panel (in the USA) in the explicit dedication to these issues, both in acknowledgment of neuroS/T progress to date, and in advance of major incentivized programs in brain research.[20]

Moreover, I think that the importance of educating professionals (in a variety of fields, including the sciences, humanities, law and politics) as well as the general public about what neuroS/T can and cannot do cannot be overemphasized, given the current level and planned courses of research, development and use, and the neuroethical, legal and social issues likely to be spawned by the realistic employment of neuroS/T in medicine, public life an d international relations. Without doubt, neuroS/T can and will affect if not change the human predicament of suffering and pain, will affect the human condition, and may alter the human being - and conceptualizations of what it means to be human or a person. Learning must precede positive change, and absent this learning, change can evoke false hopes and fear, and give rise to misdirected action - often with dire consequences.

These undertakings need not be disparate; to the contrary, it might be of great benefit - and maximum effect - if monies were aggregated to support the formation of a network of neuroethics' centers (both in and outside of academia) that would serve as interactive, governmentally independent, scholarly resources and think tanks that could conjoin multi-disciplinary scholars and practitioners to focus upon key issues - and domains of issues - germane to major areas of neuroscientific and neurotechnological investment, development and articulation affecting various spheres of society (e.g.- medicine, public life, the military, etc).

That neuroS/T becomes a salient and powerful reality –and force – that will affect the human prospect of the 21st century society is inevitable. How this force is to be realized remains to be determined…and is subject to our insight, pragmatism and prudence.

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Notes and References

1. James Giordano. Neuroethics: Traditions, tasks and values. *Human Prospect*, 1(1): 2-8 (2011).

2. James Giordano. Neurotechnology as deimurgical force: Avoiding Icarus' folly. In: *Neurotechnology: Premises, Potential and Problems*, edited by James Giordano. 1-14; Boca Raton: CRC Press, 2012.

3. For additional information on the European Union Human Brain Project, see: https://www.humanbrainproject.eu; For further information about the United States' Brain Research through Advancing Innovative Neurotechnologies initiative, see: https://www.whitehouse.gov/share/brain-initiative.

4. Misti Anderson and James Giordano. *Aequilibrium prudentis*: On the necessity for ethics and policy studies in the scientific and technological education of medical professionals. *BMC Med Education*. 19(4): (2013).

5. See: Robert Almeder. *Harmless Naturalism*, Chicago: Open

Court, 1998, for a discussion of limits of scientism, and varieties of naturalism, apropos Paul Kurtz's notion of skeptical inquiry. Note also that such a naturalistic metaphysics need not exclude or denigrate notions of the transcendent, or spiritual and/or religious views, beliefs and practices. The so-called "hard questions or problems' of neuroscience, namely how "mind" occurs in brain, leaves open the issue of whether the brain is a generator of consciousness, an antenna (to aggregate physical forces that coalesce into consciousness within the structural conditions of a neural network) or both. This comports with a number of naturalistically oriented religious perspectives of the universe, matter and being (such as that of Bernard Lonergan, Karl Rahner, and Pierre Teilhard de Chardin, for example), and/or views toward a syncretic or synthetic philosophy, such as that proposed by Herbert Spencer (see, for, the contemporary examples, the works of Carol Rausch Albright, James Ashbrook, Arthur Clarke, Paul Davies, Martin Gardner). Counterpoint is provided by authors such as Richard Dawkins, Daniel Dennett, and Sam Harris; and Richard Feynman, Stephen Jay Gould, and Matt Young (for example) offer more mid-ground positions of science and religion as non-overlapping, but nonetheless important, meaningful, and valuable doxa. A complete discussion of the tensions, conflict and potential conciliation of science and religion is well beyond the scope of this essay. For a reasonable, balanced overview, the reader is referred to: *Science and Religion: Are They Compatible*, edited by Paul Kurtz (with assistance of Barry Karr and Ranjit Sandhu), NY: Prometheus Press, 2003.

6. Adina Roskies. Neuroethics for a new millennium. *Neuron* 35:21-23 (2002); for overviews, see: Judy Illes (editor) *Neuroethics: Defining the Issues in Theory, Practice and Policy.* Oxford: Oxford University Press, 2006; James Giordano and Bert Gordijn (editors) *Scientific and Philosophical Perspectives in Neuroethics.* Cambridge: Cambridge University Press, 2010; and Eric Racine, *Pragmatic Neuroethics.* Cambridge: MIT Press, 2010.

7. James Giordano, Integrative convergence in neuroscience: trajectories, problems and the need for a progressive neurobioethics. In: *Technological Innovation in Sensing and Detecting Chemical, Biological, Radiological, Nuclear Threats and Ecological Terrorism,*

edited by Ashok Vaseashta, E. Braman and Philip Sussman. 155-185; NY: Springer, 2012.

8. James Giordano, Anvita Kulkarni and James Farwell. Deliver us from evil? The temptation, realities and neuroethico-legal issues of employing assessment neurotechnology in public safety initiatives. *Theoretical Medicine and Bioethics* (in press, 2014).

9. The use of purposive, identified fictional accounts to depict both possible manifestations of science and technology, as well as public effects and sentiment(s) is a form of artistic endeavour that is referred to (in the classical Greek literature) as *Eidóla.* For address of neuroscience-fiction as *Eidóla,* see: Rachel Wurzman and James Giordano. Neuroscience fiction as *Eidóla:* On the Neuroethical role and responsibilities of representations of neuroscience (Presented at the annual meeting of the International Society for Neuroethics, San Diego, CA, November 8, 2013), and to be published in *AJOB -Neuroscience,* 2014.

10. James Giordano and Donald DuRousseau. Toward right and good use of brain-machine interfacing neurotechnologies: Ethical issues and implications for guidelines and policy. *Cog. Technol.* 15 (2): 5-10 (2011); see also: Herbert Plischke, Donald Du Rousseau, and James Giordano, EEG-based neurofeedback: The promise of neurotechnology and need for neuroethically-informed guidelines and policies. *J. Ethics Biol Engineer Med* 4(2): 7-18, (2012)

11. NeuroInsights Report. Accessed online at: http://www.. neuroinsights.com; 20. November, 2013.

12. P. Sabocki, I. Lekander, S. Berwick, et al. Resource allocation to brain research in Europe – a full report. *European Journal of Neurosciences*, 24(10) 1-24 (2006).

13. Michel Foucault. *The Birth of the Clinic: An Archaeology of Medical Perception*. NY: Pantheon, 1973.

14. Merriam Webster's Dictionary. NY: Merriam-Webster, 1976.

15. Ibidem, note 8. See also: Fabrice Jotterand and James Giordano. Real-time functional magnetic resonance imaging and brain-

computer interfacing in the assessment and treatment of psychopathy: Potential and challenges. In: *Springer Handbook of Neuroethics*, edited by Jens Claussen, NY: Springer (2013).

16. James Giordano and Rachel Wurzman. Neurotechnology as weapons in national intelligence and defense. *Synesis: A Journal of Science, Technology, Ethics and Policy;* 2: 138-151 (2011). For overview, see: James Giordano (editor) *Neurotechnology in National Security: Practical Considerations, Neuroethical Concerns.* Boca Raton: CRC Press, 2014; and for an excellent review of the historicity – and predictions - of neuroscience and its technologies in military operations, see: Jonathan Moreno, *Mind Wars: Brain Science and the Military in the 21st Century.* NY: Bellevue Press.

17. James Giordano and Roland Benedikter. An early - and necessary - flight of the Owl of Minerva: Neuroscience, neurotechnology, human socio-cultural boundaries, and the importance of neuroethics. *J. Evolution and Technol.* 22(1): 14-25. (2012); James Giordano. Neuroethical issues in neurogenetics and neurotransplantation technology – the need for pragmatism and preparedness in practice and policy. *Studies Ethics, Law Technol.* 5(1) (2011); James Giordano and James Olds. On the interfluence of neuroscience, neuroethics and legal and social issues: The need for (N)ELSI. *AJOB-Neuroscience* 2(2): 13-15 (2010).

18. Ibidem, note 2.

19. Roland Benedikter and James Giordano. Neurotechnology: New frontiers for European policy. *Pan Euro Network Sci Tech*.3: 204-207 (2012); James Giordano. Neuroethics- two interacting traditions as a viable meta-ethics? *AJOB-Neuroscience* 3(1); 23-25 (2011). See also: John Shook and James Giordano. Toward a principled and cosmopolitan neuroethics – considerations for international relevance. *Philosophy, Ethics, and Humanities in Medicine* 8 (2014).

20. For additional information regarding the activities of the United Kingdom's Nuffield Council on Bioethics studies on neurotechnology, see: www.nuffieldbioethics.org, and for information regarding activities of the US' President's Commission for the Studies of Bieothical Issues dedicated to the forthcoming BRAIN

initiative, see www.bioethics.gov/node/2224. Information about the Defense Advanced Research Projects Agency's Neuroscience Ethics Legal and Social Issues Panel can be found at: www.darpa.mil.