# Neuroethics: a methodological reflection

Delio José Kipper

**Abstract**

Neuroethics: a methodological reflection

This article introduces a personal reflection on neuroethics by describing some of the technologies that led to emerging of the topic, targeted to brain stimulation and mapping.. It relates the current possibilities of using these technologies and the main ethical, legal, and social challenges connected to them. Next, it presents the main definitions of neuroethics in the fruitful literature in this field, which is still under construction, pointing out the central topics of the main discussions, dealing with technological advances and deriving ethical challenges.

**Key words:** Neurosciences. Neuroethics. Challenges.

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*Human society is the society of human brains. Of course those brains are enclosed in, affected by, and dependent on the rest of the body, but our most important interactions are with other people's brains, as manifested through their bodies.*

Henry Greely, Stanford – 2007

The US Congress proclaimed the 1990s as the *Decade of the Brain* with the objective of repeating the Genome Project success, and in an effort to lighten the interior of human brain's black box. Funds derived from this initiative, allied to others, in different parts of the world, encouraged the convergence of disciplines and knowledge in basic and applied neuroscience, and collaboration among experts from several areas of knowledge, namely neuroscientist, bioethicist, and philosopher of the mind [1-3].

Science is propelled by technological innovations and perhaps in any other branch of knowledge this is so visible as in neuroscience[4]. Technological advances, in addition to its clinic-surgical applications for the diagnosis, treatment, and prevention of diseases led to a burst of studies in cognitive, affective, and social neuro-science, through use of technology that can visualize brain structure and stimulate and/or record human brain activation [5].

The increase in capability to see the structure, to observe and to interfere in brain activity allowed recording neuro-biological expression of the mind in activity. Efforts are underway to turn these relevant technologies in studying many clinic and mental diseases, and they showed great hopes in the evaluation of normal and pathological brain development, in brain's acute diseases, in functional studies of fetuses' brain blood flow, and in determining patients' level of awareness under vegetative state.

The goal to diagnose, treat and prevent diseases originating in the brain is laudable and relatively protected by ethics rules set out in time. However, this remarkable progress brought in its core huge ethical, legal, and social challenges, mainly due to the unexpected possibilities for application of these technologies. Some of them refer to neuroscience applications and their implications for individuals and society. Others are more philosophical, related to ways about how we think as people, moral agents, and spiritual beings.

Along medicine and cognitive science realms, the legal arena is set as attractive area to explore these technologies in the real world of Courts. Neuroscience applications may have major consequences for the legal system and for the entire society because they have the capability to define neurological changes that can compromise the capability to make decisions, to distinguish truth from lie, real memories from false ones, and the skill to foresee behavior. A relative new of electroencephalogram (EEG) application, for example, allows identifying if the individual has or does not have knowledge of facts or images related to a crime [5].

Neuroscience expanded also in the field of cognitive studies and innovations were applied to acquire new knowledge on motivation, reasoning, and pathological social attitudes changes. This brought in evident social and political implications with studies about lie and misleads (fraud), human cooperation and competition, genetic influences, brain differences in violent individuals, individual variability of images during development, religious experiences, and applications in national security.

Current neuroscience, as genetics, enables monitoring and manipulation human mind with increasingly accuracy by means of a variety of neuroimaging, pharmacological, surgical, electric, or magnetic interventions. It is possible, for the first time, to break human mind's privacy and to judge an individual not just by acts and preferences. If the genome tells us *what we are made of*, the

"*Brainoma*" points toward *who we are* [5]. In this context of progressive discovery and mapping of brain functions, it is expected that soon neuroscience may provide also answers to some older philosophical questioning, bringing light, for example, on the limits of existence and in the meaning of free [5].

Some people question if there is anything related to the human being that is not a feature of his body [6]. Basic neuroscience progress is shedding light on the relationship between mind and the brain – a topic of major philosophical relevance. Changes in brain function in normal people, with the objective to increase the psychological function, is increasingly more possible and, probably, more practiced. One seeks with this the understanding of why people act as they do, what relates closely to law, social moral, and religious beliefs. Neuroscience foresees explanations increasingly more understandable about human behavior in purely physiological terms.

## Instruments of neuroscience production

Despite been possible to divide in many fields neuroscience progress, we shall attain in this introductory article to three of them: neuroimaging (structural and/or functional); brain stimulation (non invasive and invasive); and neuropharmacology, briefly described next. These neuroscience fields corroborate discussions at neuroethics rise.

### Neuroimaging

Computed Tomography (CT), magnetic resonance (MR), electroencephalogram (EEG), magneticencephalography (MEG), *positron emission tomography* (PET), *single photon emission computed tomography* (SPECT), *functional magnetic resonance imaging* (fMRI), *transcranial magnetic stimulation* (TMS), *transcranial direct current stimulation* (tDCS), *deep brain stimulation* (DBS) e *vagus nerves stimulation* (VNS) are some of the acronyms often mentioned to describe studies through images used in research laboratories and clinical practice, aiming at getting brain's structure and functioning [4].

### Structural Imaging

The methods used for structural evaluation of the brain are computed tomography (CT) and magnetic resonance (MR). CT bases itself in the same principles of conventional radiography, according to which tissues with different composition absorb X radiation differently. When crossed by X-rays, denser tissues or with heavier elements absorb more radiation than less dense or lighter tissues. Thus, a CT indicates a quantity of absorbed radiation by each analyzed part of the body, translating these variations in a gray scale, and yielding an image.

With the arrival of imaging by magnetic resonance, CT lost space as structural evaluation exam, due to its lesser anatomic resolution. Thus, currently, is not an exam considered suited for the level of scientific requirement needed in research to define and delimit sub areas in the encephalon that may be altered. The MR exam bases in the principle of magnetization of live tissue when set under the action of intense magnetic field. The equipment can detect the energy produced by live tissues and it allows forming anatomic images. Currently, it is the exam of higher anatomic resolution and the most used toward this end.

### Functional Image

The electroencephalogram (EEG), discovered in 1929 by Hans Berger, showed that it was possible to capture the location and intensity of brain's electric activity by means of electrodes placed in the scalp. It became a widely used technique, non-invasive, well-supported, low cost, with good temporal resolution, but with limited spatial resolution.

In time, other modalities of getting functional images were discovered, such as the electromagnetic activity, the magneto-encephalography, MEG, the metabolic activity, and the brain flow, the positron emission tomography, PET, and the single photon emission tomography, SPECT, and the regional blood oxygenation, the functional magnetic resonance imaging, fMRI, providing different and complex measures of brain activity.

All these technologies have major role in diagnoses and intervention in a variety of neurologic and psychiatric diseases, such as skull trauma, cerebral vascular accident, cancer, convulsions, humor disorders, and the impact of drug abuse, to mention just a few.

Among the different techniques, each has relative advantages and disadvantages. The fRMI, in view of its availability, for been little or not invasive at all, without known risks, and not needing the cyclotron to generate radioactive isotopes like the PET and the SPECT, but just a strong magnetic field, is the most used technique despite its high cost and requirement of experienced physicists for its handling and maintenance [5].

The fRMI sustains itself in the same physical principles of magnetic nuclear resonance, which allows construction of detailed tomographic images of the brain. The evolution of the technology began with the works of Linus Pauling and Charles Coryell[7], who investigated the properties of hemoglobin molecules. In these works, they found that hemoglobin has different magnetic properties, depending on its oxygenation state. Hemoglobin molecule totally deoxygenated has a magnetic susceptibility around 20% higher than hemoglobin completely oxygenated. Objects with magnetic suscepbility cause transversal magnetic decay, with consequent decrease of MR signal.

### Brain stimulation

#### Non- invasive

Contrasting with functional neuroimaging, non-invasive brain stimulation has just two techniques, -

both still experimental: the transcranial magnetic stimulation – TMS, and the *transcranial direct current stimulation* – tDCS. Both techniques are relatively accessible, using small devices, which can be self-applied eventually.

TMS uses an external generator that activates brain functions through magnetic stimulation. A magnetic field, generated by an electric current, induces an electric current inside the skull. Its antidepressant activity is one of its clinical applications. It is considered, normally, as non-invasive and relatively safe, although inadvertently may cause convulsive crises, particularly in more susceptible people.

tDCS works differently from TMS. Although, it cannot produce directly potential retraces, it may influence in the excitedness of individual neurons.

These brain stimulation techniques are used to change people's attitudes and behavior. TMS may be used for interventionist neurophysiology, to modulate brain activity and to stimulate the liberation of neurotransmissor or to induce genes specific focal expression, both with impact in behavior. Depending on TMS parameters, brain cortex activation may be increased or decrease[4].

### Deep brain stimulation (invasive)

Available techniques are deep brain stimulation – DBS, and the vagal neurostimulation– VNS.

DBS involves uni or bilateral implanting of electrodes in specific areas of the brain, through stereotaxic techniques, including RM, physiological mapping and computed surgical navigation. Normally, electrodes are inserted after clinical evaluation and connected, then, to a pulse generator implanted in the infraclavicular region. DBS clinical effects are similar to traditional surgical ablations, with additional benefits of greater safety and reversibility. It is an effective neurosurgical intervention and approved by the Food and Drug Administration (FDA), for motor disorders such as Parkinson's disease, and essential tremors. It can be effective also in treating several psychiatric diseases like depression refractory to clinical treatment and for compulsive obsessive disorder. It is an expensive and invasive procedure. Other non-motor indications are under study, such as chronic pain and multiple sclerosis [8].

### Neuropharmacology

The advances in cognition neuroscience and neuropharmacology are providing promising treatments for neurological diseases. Recently, we saw the introduction of antidepressant and anxiolytic with less side effects. In addition to humor, several other vegetative functions – like sleep, hunger, and libido –may be influenced pharmacologically. This coadunate with the objective of medicine that, respecting the limits of clinical and pathological indexes, considers the quality of life as parameter for therapeutical institutions. This seems reasonable, as what one aims from a treatment, particularly in chronic diseases, is to improve the quality of life [9].

Many of these treatments may be used also in people without disease, improving body, and brain functions, modulating the motor, cognitive, and affective systems. An improved tolerability to these drugs, sided by better public understanding of mental diseases and the aggressive marketing by the pharmaceutical industry with physicians and patients, led to an intensive use of the psychopharmaco by people who were not considered as sick a few years ago.

These interventions, which may increase the quality of life, involve ethical questioning related to the individual and to society [10]. Despite that, some advocate that they are desirable and that physicians certainly will find easily consumers seeking happiness, memory and executive function increase, and even those who want to free themselves from undesirable remembering.

The purpose of medicine is, recognizing the limits of clinical and pathological indexes, to improve its patients' quality of life, been reasonable to prescribe appropriate medicines for such end. However, as quality of life is not always directly proportional to clinical-pathological indexes, why not considering biological interventions to improve individuals' quality of life, either sick or not? This is the questioning that Chetterjee's [9] does.

The distinction between treating and increasing the quality of life repeats itself between treating and increasing motor, cognitive, or affective capability. Many people, if not all, agree that therapy is desirable. In contrast, many will doubt about improving those considered as normal. He suggests that the public power should restrict researches to improve the quality of life for normal people through intervention in the central nervous system. However, it is difficult to separate research to treat or to increase capacity, because often they mix. It is difficult also to define clearly the threshold between normality and disease [11].

If society is concerned in knowing if a will is true, it is even more concerning is to know if a behavior is true. Any other topic of neuroscience challenges so much the issue of authenticity as the cognitive increase, independently of which drug is used for this or that function, as the issue remains the same: the pharmacological control over the neurocognitive function [12].

## Neuroethics

Illes and Bird presented Eric Kandel's testimony, a psychiatrist and geneticist born in Germany and migrated to the United States of America (USA) one year before the Austrian invasion by Hitler, which seems appropriated for the ethical discussion of a science that places itself in the limits of scientific knowledge: *When we think about the ethical values of science, we are tempted to assume that these values are obvious, that they are implicit in what we do. It was in this context that I remembered recently, when I wrote about my personal and professional life that it was not always like that. Even scientists who seem to themselves as well-intentioned and, sometimes, for other also, may lead a path that, imperceptibly for them, becomes totally unethical* [11].

Kandel, quoted by Illes e Bird [11], reminds that at the beginning of the 20th Century almost every geneticist, even the best intentioned, were eugenists. In 1883, Francis Galton, Darwin's cousin, would have been the first to advocate this idea, and geneticists started considering that one of their functions was to make an improved human race, discouraging the reproduction of the inferiors, and encouraging that of the best fit. Despite its European origin, this idea disseminated itself in the world, and it was very strong in the USA and in the United Kingdom (UK). Eugenics changed, then, from idea into action. Vasectomy was not banned in the USA and UK. In Germany, it was. However, in the former there was a more modern and transparent political system, and this allowed criticism to sterilization, which resulted in its prohibition, while in Germany, with a fragile democracy, there were not these public safeguards and the anti-vasectomy law was overruled with the medical argument that without a radical eugenics program, the German state could have economic and social losses. The eugenics program *evolved* from sterilization to euthanasia, establishing what currently preaches the *skidding slope theory*. Physicians initially well intentioned and reasonable, went from caring to murdering, proposing elimination of individuals genetically compromised, as they could not expose their view to open criticism from a democratic society.

Finally, Kandel, still quoted by Illes and Bird [11], reminds the statement by Reinhold Niebuhr', the great theologist from the University of Columbia, regarding democracy: *The capability of the people to do good makes biological ethics desirable; its capability to do evil turns ethics necessary*! [12].

Neuroscience relates itself with biological fundaments of who we are, with our essence. The relationship of the brain with the notion of itself is more direct than between this notion and the genome[1]. However, until recently, there was little awareness about the ethical aspects yielding from neuroscience. Neuroscientist and a few philosophers, from 2002, began investigating these challenge in the scientific literature, and this field of study got the name of neuroethics – term coined by the journalist William Safire during the meeting, Neuroethics: Mapping the Field Conference [1]. Some of these initiatives reproduce the U.S. Human Genome Project model, which developed the program (Elsi) to study the ethical, legal, and social implications of genetics. Dana Foundation, in the USA, is an example [13].

Several definitions are mentioned for neuroethics. Here are a few: *Neuroethics is the discipline that combines biological knowledge with the* *human values system* [14]. *Neuroethics is the investigation about how we want to deal with the social issues of disease, normality, mortality, life style, and philosophy of living informed through our knowledge of brain mechanisms. It is – or will be – an effort of terms of a life philosophy based on the brain* [15]. *Neuroethics is the analysis of what is right and wrong, good or evil related to treat ment, enhancement or invasion and undesirable manipulation of the human brain* [16]. *Neuroethics is considered as a new bridge between humanities and biological sciences* [17].

The necessity of a new discipline for neuroethics is discussed also. Some authors agree [18] by the simple fact that the origin of the mind is in the brain, an organ that merits a special status. The brain, certainly our most complex organ, is involved in all human activities, what makes it very special. Any other system performs so many roles, and it consists of interaction of many parts, as there are not secluded brain structures: individual parts of the brain never act alone or are involved in one single function. The interconnections of its parts and the natures of its individual structures, capable to exert several tasks at the same time, make that any intervention that does not a single simple consequence, wanted or not. Thus, any structure or activity change involves big cost/benefit questioning and, easily, one can go beyond the desired with the intervention.

The bioethics realm began to be divided in sub specializations in the last decades, in a pragmatic way. It was divided, in some cases, in social domains, such as clinical ethics, ethics of research, and public health ethics. In others, it was subdivided in accordance with methodological approaches, like the principialism, ethics of the virtue, or the narrative ethics. Other subdivisions were made based in medical expertise, such as ethics in pediatrics, in surgery, or in psychiatry. There are trends that are more recent in its subdivision, in terms of new scientific or technological research lines, such as genetics, nanoscience, and neuroscience.

As nobody has infinite energy, needed to consider all aspect of bioethics, to limit the study to the individual to a restrict field may help focusing the attention, because to study the ethical aspects, it is necessary to follow the evolution of science in fields so complex such as genetics, nanoscience, and neuroscience [19]. Nevertheless, this can cause problems also, like to reinvent bioethics or to forget already made progresses. Even in so diverging fields, issues such the highlight of qualities, identity, safety, informed consent, privacy, and access do not change. Another risk is the exaggeration on what scientists can suggest us regarding what they search, think, and do. An example of this occurred with genetics, which not only affects researchers and the media, but bioethicists as well.

It is necessary to recognize that, in order of not forgetting the reflection and the encompassing prerequisite of bioethics or to incur in the lack of excessively particularize a common perspective, there are similarities and differences between ethical challenges derived from genetics and neuroscience, as some ethical issues are relevant for both. Among these, the ethics of access, of consent, of getting unauthorized information of people's genome or of their brain, the implication of ill use of these information, the distributive justice, the probalistic or statistics handling of information on future health, in addition to the difficult issue on how to conceive and identify what is pathological or normal.

As counterpart, even when considering ethics issues related to genes as very important, like, for instance, modifying human genome, which may have repercussions not only for the individual whose genome was changes, but for his future descents as well, and even for the entire human race, one cannot forget that there are questionings peculiar to neuroscience. Three of them refer to awareness, control of decision-making and free will, as well as the understanding of the moral reasoning.

Many of the expectations related to the consequences of researches in genetics did not confirm ever, and currently one talks more on genetic exceptionalism than determinism. Learning genetics should be used in relation to neuroscience. Throughout the learning process with ethics in genetics, it was observed that we should be concerned more with similarities than with difference. It is admitted that perhaps the only difference of neuroscience by imaging is that it changes throughout the day due to the individual's blood flow and humor [17].

Illes and Racine [5] recognized that the phenotype of neuroimaging is extracted from different procedures, techniques, statistics, and ideologies.. Knoppers states that: *imaging is just a phenotype and the interpretation depends on the observer, who often is the researcher and the same fundamental problem of interpretation (sometimes simplistic and self-promotional) exists in both fields, and basically it has nothing to do with the involved scientific discipline, but probably with researchers' personality and with their level of social awareness* [18]. Both genetics and neuroscience require interpretation in scientific as well as in sociocultural level. The main message, for Evers [19], from Illes and Racine is that neuroscience goes beyond genetics because it raises interpretation and application unprecedented difficulties.

There is, according to Evers [20], a topic perhaps even more important: the need of a philosophical analysis of the core notions used by neuroscientists when they describe their results and theories. Bioethics, for the author, in addition to the need of scientific data interpretation under ethical, legal, and social concepts, it needs the concept analysis of key notions. And she highlights that challenges derived from scientific discoveries are of three and not two fields. There should be added to the scientific and sociocultural levels the philosophical interpretation by analyzing the meanings of neuroscientific terms, theories, and relationships with their meaning in other disciplines, particularly in non-scientific speech. In neuroscience case, she completes, this level is largely constituted by the traditional philosophy of the mind and, the state of art, neurophilosophy, founded by Patricia Smith Churchland.

The objective of this new discipline is to understand conceptually mind and brain, using analytical philosophy method, as well as empirically, using neuroscientific methods aiming at developing a unifying theory: that of mind-brain. Neuroethics is an area if the neurophilosophy and it should use this framework [21]. The neuro-philosophical level of interpretation cannot be described as feature of the scientific level of interpretation, because scientists are not equipped with to carry out such conceptual analysis, and philosophers are not prepares to interpret neuroimaging. A clear and explicit emphasis in a philosophical level of interpretation may help to avoid severe confusion, such as to introduce terms with wrong connotations. The quote in Illes and Racine's article exemplifies *brain maps* as equivalent to *maps of thoughts* – which will be very important when discussing privacy.

Evers [21] stresses, still, that many of neuroimaging applications are real and useful, but other mentioned by Illes and Racine are simplistic and they need to be reformulated such as, for example, use of neuroimaging to detect people, in airports, with trend to violence. She concludes with the need of interdisciplinarity, and by stating that ethical analysis should comprise scientific interpretation of data and theories, by philosophical interpretation of core concepts and by ethical interpretation of problems with its application and use.

Buford [22] is another author who evaluates the same Illes and Racine's article. Her analysis focus mainly in the Illes' statement: *the link between the brain and the self is far more direct than the link between genes and personal identity* (...) [Neuroscience] *Will fundamentally alter the dynamic between personal identity, responsibility, and free will in ways that genetics never has. Indeed, neurotechnologies as a whole are challenging to our sense of personhood* (…) [23]. She argues that neuroscience and neurotechnologies do not have moral and metaphysical implications that differ either in gender or in level of implications of the previous sciences and technologies, particularly genetics. She recognizes, however, that these areas of knowledge certainly have ethical implications, but regarding personal identity and personality the metaphysical discussions eill not succumb to these new sciences and technologies.

Other much debated article is that of Fins[24], in which it is questioned if neuroethics is something new and different of ethics practiced in medicine and in research. He quotes the definition of neuroethics by journalist William Safire: ...*investigation of what is right or wrong, good or evil regarding treatment, the enhancement or undesirable invasion or disturbing manipulation of human brain* [25]. Safire's concerns, according to him, are not limited to brain research and enhancement, but also with the context of treatment, which, often, involves brain "manipulation". The key for this definition is the term "disturbing", consideration shared by other authors, which Fins considers as a little exaggerated, making difficult the access to treatment for patients historically marginalized from neuroscience fruits and of its therapeutical possibilities. He considers, as derivation, that neuroethics has, as unplanned consequence, the delay of progress.

Taking neuroimaging as example, as it is a favorite topic of neuroscientists, Fins [24] considers that hyperbolic presumptions surpass by large clinical reality. He states that, if there are legitimate concerns with legal and national security application, it is important as well to be alert so these precautions do not cause losses to clinical applications and to research. He concludes pointing that the balance point between these perspectives should be the crucial responsibility of neuroethicists, but this is developing more as speculative philosophy that founded in clinical reality. The discipline, for him, is not engaged in therapeutics or guided to the needs of patients afflicted by neuropsychiatric diseases, and this can be observed in Gazzaniga, whose definition explicitly exclude the consideration of medical healing

Finally, for Fins, this is explainable because the majority of writers on neuroethics is comprised by non-medical ethicists and philosophers. This theoretical approach, according to him is reminiscent of the beginning of bioethics, when this field of knowledge had focus in abstract principles and streamlined by philosophers ant theologians who embraced it and whom David Rothman, also mentioned by Fins, called of *strangers at bed side* [26].

Lunstroth [27] analyzes Fins' article, where he discusses that the pragmatic values of medicine (the good for the patient) and of science (false hypothesis) have priority over philosophical values regarding neuroscience. He suggests that ethicists and philosophers are strangers that speculate too much on neuroscience, unconnected to the primary reality of clinical relationship. He teaches that the situation classified as "at bed side" was understood just for the social structure by the social justice movement in medicine, and the social determinant movement in public health, and he concludes by stating that if there is still a stranger, he is the patient [27].

Vernillo [28] also analyzes Fins' article and quotes that in Fins understanding, *a neuroethicist should be strongly supported by analytical method, ethically proportional in his opinions on patient's care and not stranger at the bedside* [29]. He sustains that our brain is a sanctuary, repository of our thoughts and emotions, and not equivalent to our liver. It is so that evolution made a hard skull bone to protect it. EAnd that, as in history of medicine, neuroethics has foundations also, partially, in the analytical principles of philosophy applicable to medicine, constituting a dynamic synergy between philosophers, theologians, historians, legislators, physicians, and scientists.

Neuroethics assumes, thus, a cautious and sage stand, not as Fins characterizes it: *a hyperbole that surpasses scientific reality* [30]. Neuroethics, for Vernillo, serves society as a crucial reminder that the application of new and emergent technologies should be tempered with wisdom and ethically proportionate.

Eric Racine [31] criticizes Fins' ideas and his pragmatism in bioethics that he and his colleagues call as clinical pragmatism, related to references of *strangers at bedside*, such as philosophers and theologians. He suggests that we should avoid describing monolithic ideas of historic and current neuroethics, recognizing pluralism. He alerts that we need to reinforce not only physicians' role, but the valuable contributions of other professions in health area as well, and also the multidisciplinary approach. Finally, he reminds that some neurologist and psychiatrists, in the 1930s and 1940s, collaborated with the most infamous and cruel experiments in modern medicine.

Fukushi and Sakura [32] refer that the reality of articles have shown integration between many branches of knowledge, setting a structure for neuroethics, as Fins desires, in his pragmatic view. Jones [33] praises Fins work, who insists in the neuroscientific pragmatism as the basis for neuroethics.

**Final considerations**

Neuroethics advances carry in their core huge ethical challenges. Some of practical nature, such as monitoring and manipulating human mind, break its privacy, improving motor and psychological functions, and understanding the physical bases for decision-making. Others have a more philosophical nature, such as the understanding of mind-brain relationship, religious beliefs, and post humanity. It is urgent that, in order to get the support from human community, a genuine dialogue is established between scientists and society, through the media, without hyperbolic views. From these challenges result the urgent need to develop neuroethics in order to suggest norms and guidelines for the correct use of these technologies.

## Resumen


### Neuroética: una reflexión metodológica

Este artículo introduce una revisión sobre la neuroética, describiendo algunas de las tecnologías que ocasionaron el surgimiento de la disciplina, centradas en el mapeado y la estimulación cerebral. Relaciona las actuales posibilidades de uso de esas tecnologías y los principales desafíos éticos, legales y sociales a ella relacionados. También presenta las principales definiciones de Neuroética encontradas en la literatura de este campo en construcción y resalta los tópicos centrales de las principales discusiones, que se ocupan de los avances tecnológicos y de los desafíos éticos de ellas derivados.



**Palabras-clave:** Neurociencias. Neuroetica. Desafios.


## Resumo


### Neuroética: uma reflexão metodológica

O artigo introduz uma reflexão pessoal sobre a neuroética, descrevendo algumas das tecnologias que ensejaram o surgimento da disciplina, voltadas ao mapeamento e estimulação cerebral. Relaciona as atuais possibilidades de uso dessas tecnologias e os principais desafios éticos, legais e sociais a elas relacionados. Apresenta a seguir as principais definições de neuroética na profícua literatura deste campo em construção, apontando os tópicos centrais das principais discussões, que se ocupam dos avanços tecnológicos e dos desafios éticos deles decorrentes.



**Palavras-chave:** Neurociências. Neuroética. Desafios.


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