

NEUROIMAGING AND NEUROETHICS: IMAGING THE ETHICS IN NEUROSCIENCE

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Abstract: This paper outlines the topics that are on the intersection of neuroethics and neuroimaging domain.

Materials and methods: An extensive search through Medline bibliographic database was performed for a period of 12 years (1997–2009), using a combination of 3 keywords ("ethics", "neuroethics", "neuroimaging"). The search returned 119 indexed articles, of which 102 were found relevant. The articles were classified in two main categories tackling ethical challenges in basic research (55 papers) and applied clinical research and practice (39 papers).

Results and conclusions: For each of the categories, the majority of articles came under one of the following topics – the neural basis of emotion, reasoning and personality (30 papers) and ethics of neuroimaging in disorders of consciousness (15 papers). The appointed topics stand at the very intersection of the neuroethics and neuroimaging domain, evidencing their strong interdependent relationship. Furthermore, the number of topics and corresponding articles has been steadily increasing over the years (minimal in 1997, maximal in 2009). These data are in good accordance with other scientific findings. Also, they correspond to the period of progress in the investigated disciplines, giving rise to the fact that future advances in neuroethics are in strong correlation to the advances of neuroimaging technologies.

Key words: ethical, moral, legal, neuroscience, research.

Introduction

The word "neuroethics" refers to the ethics of neuroscience and the neuroscience of ethics [1]. It is a recent coinage in the vast group of neurolo-

gisms – an ever-expanding group of auto-referential neologisms that use the prefix "neuro". Namely, it emerged two decades ago, but was formally introduced at the beginning of the last decade. The first references in indexed articles were considering the role of the neurologist as a neuroethicist faced with patient care and end-of-life decisions [2], and philosophical perspectives on the brain and the self [3]. However, it was only within the framework of the conference called "Neuroethics: Mapping the Field" that this field was officially established [4]. The further progression of neuroethics was proportional to the advances in neuroimaging technology. This was evidenced in a meta-analysis [5] of nearly 3400 peer-reviewed papers, conducted a decade ago for the preceding decade (1991–2001) in order to examine the applications of fMRI with/without other neuroimaging modalities. Namely, the concluding remarks noted a steady growth in studies with evident ethical and social implications. This is due to the fact that modern neurotechnologies, giving rise to advanced capabilities for understanding and monitoring human thought and behaviour, have brought new issues in neuroethics to the forefront [6]. This paper outlines the topics on the intersection of neuroimaging and neuroethics, thus acknowledging their mutual coexistence in a strong interdependent relationship.

Material and methods

PubMed internet search engine was used to explore the Medline bibliographic database of biomedical scientific journals. The following combinations of keywords were used for selection of articles with relevant titles: "ethics, neuroimaging" and "neuroethics, neuroimaging". The search covered a period of published evidence from the neuroethics domain, namely the years between 1997 and 2009. In the initial phase, 119 titles in indexed, peer-reviewed journals were selected for further processing. During the second phase their abstracts were analysed. The selection process concluded with a complete analysis of a total of 102 papers. According to their contents, all but the review papers were subsequently classified into two main categories: ethical challenges in basic research (55 papers) and ethical challenges in applied clinical research and practice (39 papers). The classification was made for didactic reasons [7] but it returned interesting findings, listed in the following section.

Results

A. Ethical Challenges in Basic Research

Neurophysiologic Applications and Safety of Novel Technologies (2 papers). Articles within this group focus on the latest technological discoveries

such as: transcranial magnetic stimulation, implantable brain chips and diffusion tensor imaging modality. They consider these issues from various perspectives: device safety, informed consent for use, application in large cohort studies and possible health implications.

Legal and Policy Issues in Neuroimaging (23 papers). The selected articles open up new perspectives on the matters of privacy (understood as discretion in the process of collecting information about/from a person) and confidentiality (understood as respect for the wishes of the person in regard to the storage and possible disclosure of such information) [8]. Of all possible issues, two are the most prominent: the need for fundamental reconfiguration of personal identity (caused by the possibility of "direct" insight into our mental processes) and the need for appropriate management of incidental findings.

Neural Basis of Emotion, Reasoning and Personality (30 papers). This group of articles covers a wide array of topics originating in various disciplines such as: philosophy, anthropology, sociology, psychology, biology, neuroscience and the cognitive sciences in general. This is an area of research that shows rapid expansion over the last years, constantly widening the scope of ethical considerations. Currently, there is great advancement in providing answers to the problems of human cooperation/competition, decision-making and moral judgment, but the area also expands to cover the less prominent and more exotic questions about our religious beliefs, social attitudes, deceptions and virtues. Furthermore, it gives rise to new disciplines (such as neuroeconomics and neuromarketing) and extends its application to more distant disciplines such as forensics.

B. Ethical Challenges in Applied Clinical Research

Ethics of Neuroimaging in Neurosurgery (1 paper). Functional neuroimaging can be used as a diagnostic tool to prompt the offering of surgery and as a therapeutic tool in assisting the precise execution of operational procedure. Therefore, adequate interpretations of the data, as well as some alternative explanations are essential for advancement in this field. The issues under general consideration are the questions of reliability and validity of the tool and its data.

Ethics of Neuroimaging in the Prenatal Diagnosis of CNS Anomalies (3 papers). The adequate prediction of the neurodevelopmental outcome in neonates is a main issue for consideration, because it may affect the parental decision-making process, and may be a target of various misuses leaving long-term and irreparable consequences.

Ethics of Neuroimaging in Paediatrics (4 papers). These articles deal with dilemmas, typical of the adult population (on a magnified scale), and specific for the paediatric population (on a proportional scale). They discuss the following issues: informed consent/assent, association/causation of the problem, brain/behaviour dichotomy, and risk/benefit of the outcomes.

Ethics of Neuroimaging in Dementias, Neurological and Psychiatric Disorders (15 papers). The issues that receive special considerations within this group, are new and unforeseen situations such as: the use of neuroimaging tools for predicting subclinical disease in asymptomatic or pre-symptomatic patients.

Ethics of Neuroimaging in Disorders of Consciousness (15 papers). The emphasis is placed upon the vegetative and minimally conscious states. Articles which are of special significance are those exploring the opportunities for diagnostic sub-classification, since it could have tremendous implications on the prognosis of the patient. It should be noted that this area is in great expansion with an explosion of papers, numerous meetings and various projects dedicated to its further exploration. One of the most prominent European initiatives for investigation of the problem is the COST Action BM0605 entitled "Consciousness: A Transdisciplinary Integrated Approach", in which a Macedonian team is taking an active part [9].

Conclusions

Even though relatively new, the field of neuroethics is in steady expansion, constantly flourishing with the advances in modern neurotechnologies. This conclusion has already been anticipated in the earlier meta-analysis [5] but was finally confirmed with this study (Fig. 1). A parallel study [10] resulted in similar findings, serving as a reconfirmation (Fig. 2) of the fact that neuroimaging technologies shed light on topics which were formerly unprecedented in the field of neuroethics.

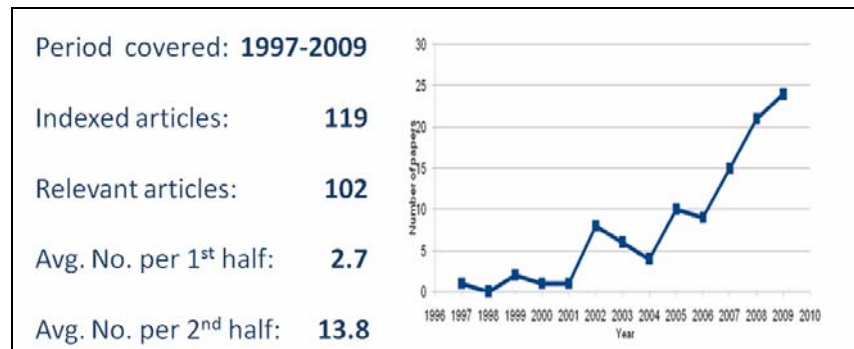


Figure 1 – Dynamics of papers related to neuroimaging and neuroethics in our study

Formally, the topics were arranged in a didactic framework and classified in two categories, but in essence there are no limits to the ethical considerations in neuroscience. At present, the most popular topics are those

standing at the very intersection of the neuroethics and neuroimaging domains. They are exploring the neural bases of emotion, reasoning and personality, delving into the ethical mysteries of consciousness disorders and boldly reaching further into the new territory of neuroethics.

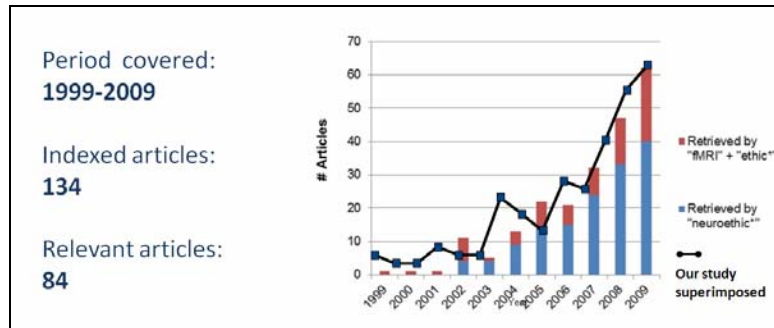


Figure 2 – Dynamics of papers related to neuroimaging and neuroethics in a parallel study superimposed with our findings

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Резиме

НЕВРОИМИЦИНГ И НЕВРОЕТИКА: ПРЕГЛЕД**Ѓонеска Б.**

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Апстракт: Оваа студија дава детален осврт на темите кои се на заедничкиот пресек од две нови дисциплини: невроетика и невроимџинг.

Материјал и методи: За потребите на ова истражување, спроведено е екстензивно пребарување низ библиографска база на податоци "Medline". Пребарувањето е направено за период од 12 години (1997–2009) со комбинација од три збора ("ethics", "neuroethics", "neuroimaging"). Притоа е направен преглед од 119 индексирани публикации, со последователна селекција и детална анализа на 102 релевантни публикации. Истите се класифицирани во две главни категории: етички предизвици во основно научно истражување (55 публикации) и апликативно научно истражување со клиничка практика (39).

Резултати и заклучок: Дополнителната разработка на двете категории поединечно, укажува дека една специфична област се наоѓа во моменталниот фокус за секоја од нив. Во доменот на основното научно истражување тоа се изучувањата на невролошките корелати на емоцијата, когницијата и личноста (30 публикации), додека во доменот на клиничката практика тоа се етичките аспекти од употреба на невроимџинг технологии кај нарушувања на свеста (15 публикации). Наведените теми се наоѓаат на строгата граница меѓу областите од интерес, докажувајќи ја нивната заемна поврзаност. Освен содржинскиот квалитет, во прилог на меѓусебната зависност говори и квантитетот и динамиката на продуцирани публикации (минимален во 1997, а максимален во 2009 година), како и сличните наоди од паралелни научни истражувања.

Клучни зборови: етички, морал, легално, невронаука, истражување.

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