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THE INTERNATIONAL DIMENSIONS OF NEUROETHICS

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Abstract

Neuroethics, in its modern form, investigates the impact of brain science in four basic dimensions: the self, social policy, practice and discourse. In this study, we analyzed a set of 461 peer-reviewed articles with neuroethics content, published by authors from 32 countries. We analyzed the data for: (1) trends in the development of international neuroethics over time, and (2) how challenges at the intersection of ethics and neuroscience are viewed in countries that are considered developed by International Monetary Fund (IMF) standards, and in those that are developing. Our results demonstrate a steady increase in global participation in neuroethics from 1989 to 2005, characterized by an increase in numbers of articles published specifically on neuroethics, journals publishing these articles, and countries contributing to the literature. The focus from all countries was on the practice of brain science and the amelioration of neurological disease. Indicators of technology creation and diffusion in developing countries were specifically correlated with increases in publications concerning policy implications of brain science. Neuroethics is an international endeavor and, as such, should be sensitive to the impact that context has on acceptance and use of technological innovation.

Keywords

neuroethics; ethics; developing world; science; technology; society

INTRODUCTION

Consideration of the ethical implications of modern brain science is becoming increasingly commonplace in today's world. This is a laudable trend, as the products of science and technology 'flow throughout the world and through many domains of social life.'¹ Given the far-reaching impact of science and technology on our lives, ranging from how we understand ourselves and the world around us to how we approach adversity in the medical context, the next question is whether investigation into the ethical, legal and social implications of developments in science and technology is following suit. This study investigates the international development of neuroethics based on publication trends. Our goal was to examine trends in the internationalization of neuroethics as a new discipline with North American origins, and to examine thematic trends in this evolution.

Science in society

Our day-to-day lives are filled with the products of scientific inquiry and technological advances which influence the way we live, act and think. Scholars who investigate the complex relationship between science and society propose that the products of these endeavors are not independent of society. Just as scientists, as members of a community, are influenced by

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contextual values, technology alters the conditions into which it is placed.² Neil Postman states that:

[n]ew technologies alter the structure of our interests: the things we think *about*. They alter the character of our symbols: the things we think *with*. And they alter the nature of community: the arena in which thoughts develop.³

In response to the growth in breadth and influence of scientific innovation, analysis of the ethical practices of scientific inquiry, as well as the effect of innovation on our moral codes, has increased in recent years.

On the world landscape, it is important to consider how different values and perceptions of morality interact with new technology. Anthropologists argue that it is:

[a] given that different cultural systems have different moral codes with different standards [and thus] ... mechanisms that exist in different cultural groups for handling ethically problematic situations are also culturally specific.⁴

Research in international bioethics informs us that 'the ways in which [a medical dilemma] is handled [are] inextricably bound to broad cultural conditions that influence health and illness behavior generally.'⁵ Differences may arise explicitly in research, clinical practice or social policies, or appear as lack of ethical concern. Recognizing differences in how societies define what is acceptable is vital to ensure that the international community reaps the benefits of international science. Never before has this issue been more acute than in neuroscience, where innovations are leading to previously unexplored ways to manipulate the biology of the brain. It is in response to these advancements that neuroethics has grown and continues to increase its sphere of influence.

Neuroethics

Modern neuroethics lies at the intersection between innovation in neuroscience and society.⁶ Examples of modern breakthroughs in brain science with significant ramifications for the public include deep brain stimulation, medication to treat psychiatric disorders, and neurotransplantation of stem cells to treat neurodegenerative diseases. Judy Illes has defined neuroethics as 'a discipline that aligns the exploration and discovery of neurobiological knowledge with human values systems',⁷ and 'intersects with biomedical ethics in that [it] ... is concerned with ethical, legal, and social implications of neuroscience research findings, and with the nature of the research itself.'⁸ Michael Gazzaniga characterizes neuroethics more broadly as the 'examination of how we want to deal with the social issues of disease, normality, mortality, lifestyle, and the philosophy of living *informed by our understanding of underlying brain mechanisms*.'⁹

Neuroethics seeks to give neuroscience what bioethics and the ethical, legal and social implication (ELSI) programs provided for the human genome project: a platform for scientists, lawyers, philosophers, sociologists, other scholars and the general public to interact and discuss the future of neuroscience. The goal of neuroethics research is to empower the scientific process by anticipating ethical challenges and developing methods for the most effective translation of research.

Neuroethics draws upon historical lessons from genetics, but stands apart given the special considerations necessary that arise in dealing with the brain. Although this certainly is not a universal view,¹⁰ generally we consider the brain to be the organ that not only grants the characteristics that we qualify as 'human', but also makes each one of us unique. Adina Roskies explains this as a type of 'neuroessentialism' given 'that our brains define who we are more than do our genes ... in investigating the brain, we investigate the self.'¹¹ This insight, combined with the growing ability of neuroscience to offer a means of manipulation and

alteration of brain states, charges modern neuroethicists with the important task of identifying alternatives to resolve difficult ethical challenges raised by neuroscience. One point of contention is the use of drugs such as propranolol for ‘therapeutic forgetting’. Several scholars claim that memory blunting may have negative social consequences since ‘our identities are formed both by what we do and by what we undergo or suffer’,¹² while others support the use of this family of drugs for therapeutic reasons, such as for post-traumatic stress disorder (PTSD) and prophylactic purposes.¹³

Though the scope of the field is broad, neuroethics has attempted to frame its efforts in terms of four ‘pillars’: brain science and the self, brain science and social policy, ethics and practice of brain science, and brain science and public discourse.¹⁴ Brain science and the self amply borrows from the field of neurophilosophy and focuses on how neuroscience may change our views of ethics and moral responsibility, decision-making, and free will. Patricia Churchland states that philosophers are beginning to understand morality ‘not as a product of supernatural processes ... but of brains.’¹⁵ Brain science and social policy deals with legal and policy issues, including privacy, consequences of behavior, and health care disparities. For example, since our understanding of moral agency informs the legal system, increased knowledge at a mechanistic level may, in turn, translate into policy changes. Ethics and practice of brain science embodies ethical issues in human subjects research and clinical trials spanning competency, informed consent, diagnostics, new therapeutics, and even biomarkers of disease. Brain science and public discourse aims to bridge the gap between scientists, neuroethicists, philosophers and the general public by promoting education and knowledge transfer. There is an overlap between the four pillars, but they provide a useful framework to think about the implications of neuroscience as they unfold in the realm of global societies.

METHODS

Using PubMed, the Science, Social Science and Arts and Humanities Citation Index, and PsychInfo search engines we retrieved peer-reviewed articles in academic journals from 1989, the year in which the term ‘neuroethics’ first appears in the literature,¹⁶ to 2005, the last full year available for study. We used the following search term to achieve the most comprehensive database: neuroethic* OR ((neuro* OR ‘Neurosciences’ [MeSH] OR ‘Neurology’ [MeSH] OR brain* OR CNS OR neuros* OR neuron*) AND ethic*). We limited the search by selecting articles only if the search terms appeared in the title or abstract. Within the unique constraints of each search engine, we made the searches as similar as possible. We limited our analyses to journal articles by removing books, dissertations and other publications that were not peer-reviewed journal articles. Abstracts were also excluded if ‘ethics’ was mentioned only to state approval of the study by a local ethics committee, the ethical concerns explored did not specifically refer to the brain or central nervous system, or the publication was anonymous. If no abstract was provided, we used the entire article and coded it based on the full text.

We coded the abstracts according to the four pillars of neuroethics as described earlier and shown in Table 1.

Sufficiency of the title and abstract as data sources was verified by taking a random sample of 30 articles and coding 50% for full text first and 50% for title and abstract first. The agreement was 90% and 85% respectively.

To establish reliability of coding, we conducted a reproducibility test on a random sample of 80 abstracts. A trained coder not directly involved in the study coded each abstract based on the coding scheme. Agreement with the author’s (SL) coding was achieved in 64 cases (80%; Kappa coefficient 0.76).

We classified countries with market economies and democratic governments that are part of the Organization for Economic Cooperation and Development (OECD) as developed for our study.¹⁷ Developing countries, as defined by the IMF, were countries not considered advanced economies, but also not considered least developed countries (LDCs). In an effort to explore the relationship between development and neuroethics-related publications, we used the Human Development Index (HDI). The HDI is a composite index that takes a wide variety of indicators into consideration before ranking nations based on their development indices in three dimensions: 'a long and healthy life, knowledge and a decent standard of living.'¹⁸ We also used measures indicating investment in creation and diffusion of science and technology as a percentage of gross domestic product (GDP) to explore the relationship between relative investment in science and technology and neuroethics-related themes.

RESULTS

Global trends

Of 1693 articles retrieved, 461 (27%) met our criteria for analysis and contained codeable concerns related to neuroethics. There were 399 authors included in the final database of 461 articles. Thirty-six authors published more than one article ($N = 98$; 25% of the database). Co-authored articles accounted for 43% of the total. Most authors were affiliated with a university medical center (34%), and hospitals or medical centers (17%). A total of 295 journals published articles relating to neuroscience; 66 journals contributed 232 (50%) of the total number of articles. The *Journal of Head Trauma Rehabilitation* published 15 articles (3.3%), the greatest single contribution by any journal.

A total of 32 countries could be identified in the database. In 8.9% ($N = 41$) of the papers, the country of the primary author was not identifiable. The first neuroethics publication occurred between 2002 and 2005 for 34% of the countries. Table 2 shows the year of first neuroethics-related publication by country. Newcomers, those entering the field after 2002, contributed only about 4% of the entire database in terms of number of articles. Of the total, 87% of the articles were published in English, 4% in French, 4% in German, and 5% distributed across Dutch, Italian, Japanese, Portuguese, Spanish and Turkish. Sixty-three percent (63%) of the articles were published in countries where English is an official language.

High-income countries, as defined by the World Bank,¹⁹ are heavily represented in our data set ($N = 23$; 72%), as is the Eurasian continent ($N = 23$; 72%). However, the data set does include upper-middle-income ($N = 6$; 19%), low-middle-income ($N = 1$; 3%) and low-income ($N = 1$; 3%) countries. All continents, except for Antarctica, are represented in the data set to different degrees. Twenty-three countries are in Eurasia (72%), 6 in America (19%), 2 in Oceania (6%), and 1 in Africa (3%).

Trends over time

Publications relating to neuroethics increased between 1989 and 2005 from 13 to 64 – an almost fivefold increase. There has been a relatively steady increase of about 3.9% in these numbers from 1989 to 2002. In 2002, there was a significant increase of 10.4%, and a notable change in publication trends (see Figure 1).

From 1989 to 2001, the number of journals closely follows the number of articles being published and the number of countries participating in neuroethics (Pearson Correlation = 0.974; $p < 0.01$ and Pearson Correlation = 0.580; $p < 0.05$ respectively. See Figure 1).

From 2002 to 2005, there is a clear change in publication trends. First, the number of articles published per year nearly doubled (from 25 to 48) from 2001 to 2002. Second, the number of articles, journals and countries publishing neuroethics-related articles no longer closely follow

each other (see Figure 1). Between 2002 and 2005 the Pearson correlation between the number of articles published and journals included in the database is no longer significant. Journals are therefore publishing more than one neuroethics related article per year. Third, the number of countries from which there are individuals publishing neuroethics-related articles greatly increases in 2002.

Variations in theme

We attributed the code for 'ethics and practice of brain science' to 60% of the publications. The policy issues raised by new knowledge were identified for 21% of the database. The theme for self and personhood was identified in 16% of the articles, and scientists-public discourse in 3%. Using a paired sample t-test of the ratio of practice of brain science articles to all other articles, the difference was statistically significant ($t = 3.066$; $p < 0.05$).

Thirteen countries published more than five articles (1% of the database. See Figure 2). The countries with fewer than five publications ($N = 19$; not shown in Figure 2) published mostly on practice of brain science (74%). The exceptions are Finland, Greece, Singapore, Austria and the Vatican. The first three in this group focused on policy issues while Austria and the Vatican exclusively explored the relationship between the self and advances in neuroscience.

Participation by developing countries

The seven countries present in the database classified as developing were Argentina, Cuba, Mexico, India, Brazil, Saudi Arabia and Singapore²⁰ (25% of all countries). Each had fewer than 5 publications in the database; 4 entered the field after 2002 (see Table 2).

The HDI technology indicators for the developing countries in the database are tightly correlated to the ratio of practice and policy articles (Pearson = -0.970 ; $p < 0.01$, and Pearson = 0.925 ; $p < 0.01$ respectively). The technology diffusion and creation indicator is negatively correlated to the ratio of practice articles (Pearson = -0.970 ; $p < 0.01$). We found a positive Pearson correlation between the technology index and contribution of policy articles (Pearson = 0.925 ; $p < 0.01$). The correlations are significant to a lesser degree for technology indicator and publications related to discourse (Pearson = 0.473 ; $p < 0.05$).

Practice of brain science

Countries with more than ten articles in the practice of the brain science pillar were grouped and the articles further analyzed ($N = 262$ from 8 countries). We specifically examined the populations described in the articles (children, adults, practitioners) coding studies as focusing on adults if the population was not specifically mentioned. Adults were the most frequent focus of coded articles (66%), followed by practitioners (22%) and children (12%). Eighty-six percent (86%) focused on issues in brain disease. Papers focused on intervention²¹ (71%) were more frequent than those focused on discovery (29%; $t = 5.229$; $p < 0.01$).

Limitations

Although this research attempted to gather all publications on neuroethics in the past 17 years, there are limitations to the data collection and analysis. The searches were designed to be as inclusive as possible but there is a risk that not all articles were collected and that results skewed in favor of the Western world. Coding for the four pillars is only one approach to capture trends, among others. Missing data including unidentifiable authors affiliations could also contribute to skewed results. The formal data analysis was completed for the years up to 2005. A rudimentary search using only PubMed and 'neuroethic*' as a keyword through the complete years of 2006 and 2007 yielded 15 and 24 papers for each year respectively. This represents a 7% and 60% increase over previous years and included one developing country.

DISCUSSION

This study demonstrates that countries with different economic strength and technological capabilities contribute to neuroethics-related publications to different degrees. We demonstrated a steep rise in neuroethics publications in 2002, coinciding with the formalization of the modern conceptualization of neuroethics, a correlation between technology related expenditures and policy-related publications in developing countries, and a significant focus on the practice of brain science.

Scholars in the field of Science, Technology and Society (STS) have argued that the role that science plays in society is significant and powerful in influencing how communities go about solving problems on an individual and societal basis.²² Science in general is becoming more international as the number of countries participating increases, as does international scientific cooperation.²³ The pervasive nature of modern neuroscience warrants anticipatory action at an international level before innovations are widely used in society. Our results from the published literature suggest that the professional communities in both developed and developing countries are prepared to embrace such thinking and have begun to take positive action.

The majority of the countries represented in our database are considered high- or upper-middle-income. Only two, Cuba and India, fall under the low-middle- or low-income groupings of the World Bank. Similarly, there is a dominance of Eurasian and American countries. This distribution points to the fact that neuroethics, though becoming a more international field over time, is dominated by scholars from high-income, Western countries.

The greatest thematic contributor to the rise in articles over the time period of this study is the practice of brain science. Since most authors in this data set are affiliated with a university medical center or hospital, it was not surprising that the majority of the articles focused on the ethical issues that this population faces daily: how to apply ethical issues such as respect for persons, justice, beneficence, among others, to clinical care and research. The second most frequently occurring theme was the social policy implications of these discoveries. Within the practice of brain science theme, there was a clear emphasis on problems with any sort of intervention in the brain, for research or therapy, when compared simply to diagnostic measures.

The dominance of neurological disease as a concern within the ethics and practices of brain science pillar mirrors data published regarding prevalence, incidence rates and global burden of disease. The World Health Organization suggests that 450 million people are currently affected by mental, neurological and behavioral disorders worldwide.²⁴ Data published by the Disease Control Priorities Project shows that four of the top six causes of years lived with disabilities are due to neurological disease.²⁵ Higher incidences of neurological disorders are reported in patients with low income and education.²⁶ For example, in Mexico the prevalence of neurological disease for the adult population is 9%,²⁷ whereas in the United Kingdom, neurological disorders are reported to affect about 6% of the population.²⁸ The economic and social costs of neurological disease in developing countries are especially destructive since limited national economic resources can prevent the availability of modern therapies, and limited personal resources can curb access to the therapeutics when available.²⁹ Cultural and religious values can also create barriers to care and even increase the sense of stigma associated with neurological as well as psychiatric disease.

Although the United States is by far the greatest contributor of publications to the field, there is a strong international component in the neuroethics literature. The data from this study show that it is not only developed, and therefore technologically advanced, countries that publish neuroethics-related articles, but that developing countries do so as well. This implies two

characteristics of international neuroethics. First, the scientific community is tightly connected. Advances from one country are easily communicated to other regions of the world, even those relatively less technologically advanced. Thinking about issues raised by a certain technology is not limited to the laboratory, scientific field or country where advances are made. Second, some authors are reacting proactively to the social challenges of neuroscience. Ethical considerations are being explored in parallel to technological development as opposed to as a reaction to already experienced adverse consequences.

For developing countries, the HDI technology indicator is associated with the ratio of practice and policy related articles. The negative correlation between a developing country's technology diffusion and creation indicator and articles within the practice of brain science pillar suggests that as investment in technology creation and diffusion as a percentage of GDP increases, a smaller percentage of the country's publications are about the practice of brain science. The opposite is true for policy related articles. The positive correlation indicates that for developing countries, as the technology index increases, so does the contribution of the country's total number of publications on policy.

CONCLUSION

The results of this study demonstrate that ongoing global development is an important predictor of theme and frequency of publication on neuroethics. This is significant in that the barriers for developing countries to participate in technologically advanced fields such as neuroscience can be prohibitive.³⁰ Nevertheless, some developing countries are publishing articles about the concerns that innovations abroad might have on cultural values at home.³¹ Lack of empirical experience does not bar countries from considering the possible ramifications of technology.

International participation in neuroethics is a reality. It is crucial that policy makers recognize how innovations may be received in different contexts. More importantly, innovators should take these considerations into account when transferring technology to regions where it was not first developed. As a discipline that investigates what is

right and wrong and good and bad about the treatment of, perfection of, or unwelcome invasion of and worrisome manipulation of the human brain ... [neuroethics] deals with our consciousness – our sense of self – and as such is central to our being,³²

neuroethics has a strong cultural component. Participation in the field by countries of different spiritual, economic, scientific and cultural heritages is vital. Promoting local consideration of ethical issues will ensure that the effects of scientific innovation respect cultural practices and societal values. Further research and debate about building contextualized neuroethics capacity is needed to develop the best possible methods of encouraging local consideration of the issues.

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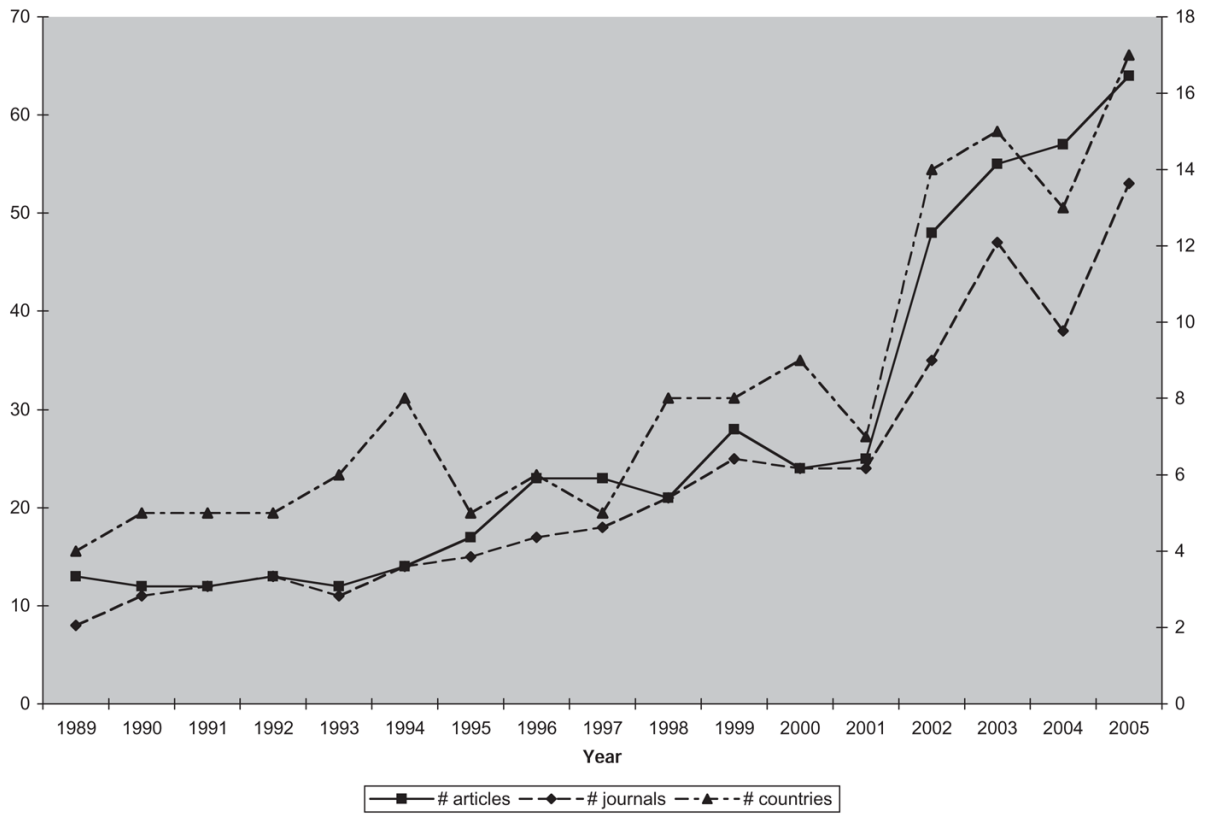


Figure 1.
Trends in Number of Articles, Number of Journals and Number of Countries Publishing over Time.

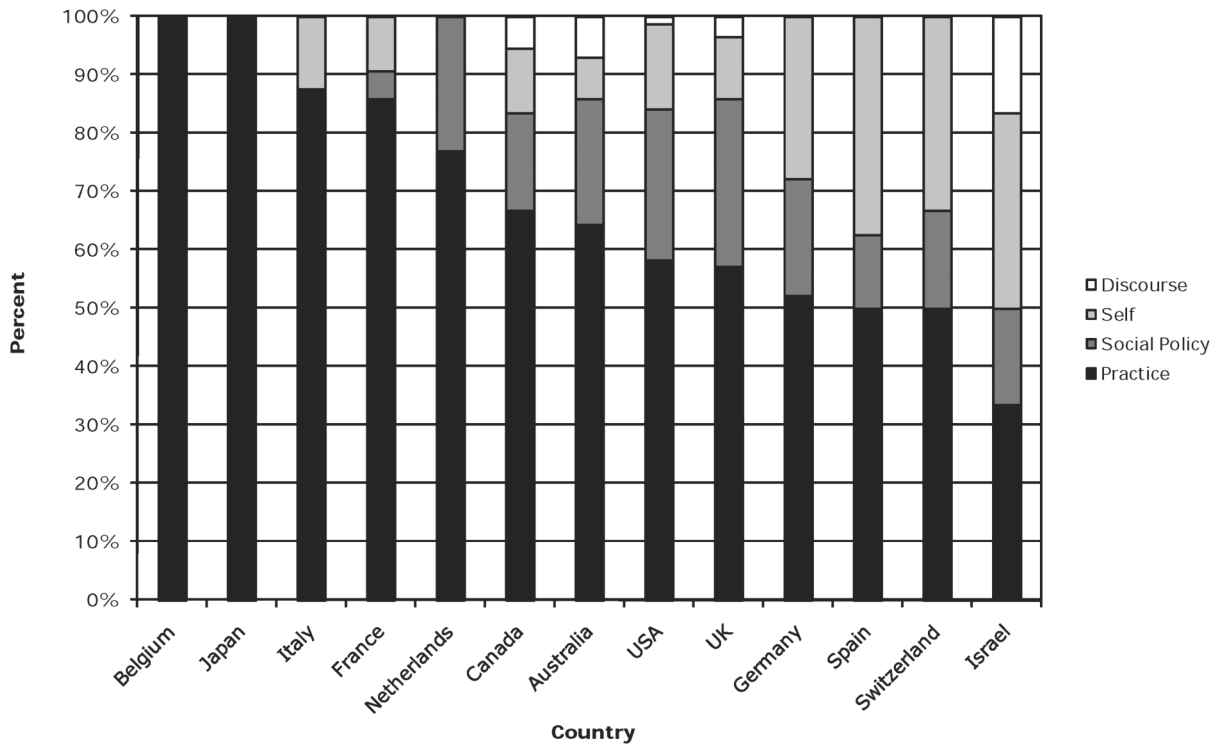


Figure 2. Proportion of Publications by Pillar by Country (>five publications).

Table 1

Coding Scheme and Definition of Codes Used in Neuroethics Database to Code Abstracts

Code	Subcode	Definition
Pillar I: Brain Science and the Self		Discussions of and challenges to moral responsibility, decision-making, and free will as a result of neurotechnological developments.
Pillar II: Brain Science and Social Policy		Legal or policy challenges, including privacy, legal consequences of behavior, unequal access to innovation, or health care disparities.
Pillar III: Ethics and Practice of Brain Science	Research: Discovery	Empirical studies of the human CNS.
	Research: Intervention	Studies of new forms of therapy for disease of the CNS, including drugs, devices and stem cells.
	Clinical: Discovery	Development and testing of new diagnostic procedures.
	Clinical: Intervention	Development and testing of novel therapeutics.
	Beyond Clinical: Discovery	Neurotechnology studies with a non-medical purpose, including lie-detection or neuromarketing.
	Beyond Clinical: Intervention	Pursuit of intervention based on non-research, non-clinical discoveries using neurotechnology.
Pillar IV: Brain Science and Public Discourse		Public understanding of brain science; studies of media coverage and scientists-public interactions.

Table 2

Year of Entry into Neuroethics by Developed and Developing Country

Year of Entry	Developed Country	Developing Country
1989	<i>USA, Australia, Germany, Canada, France, Israel, United Kingdom</i>	—
1991	<i>Japan, Belgium</i>	Saudi Arabia
1992	Russia	—
1993	—	—
1994	Denmark, <i>Netherlands</i> , New Zealand	Mexico
1995	<i>Italy</i>	—
1996	<i>Spain</i>	Brazil
1997	—	—
1998	—	—
1999	<i>Switzerland</i>	—
2000	Finland, Norway	—
2001	—	—
2002	Sweden	Argentina, Cuba, India, Singapore
2003	South Africa, Portugal	—
2004	Austria, Vatican *	—
2005	Greece, Turkey	—

* No development data are available for the Vatican.

Countries shown in *italics* each represented more than 1% of database.