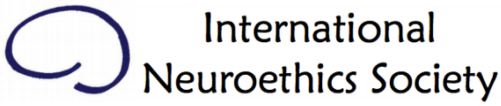
Neuroethics as a Field: How much has it grown, about what, and by whom?



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I. Introduction and executive summary:

The purpose of this survey was to examine the field of neuroethics as it has developed over the last 12 years, through the following questions:

1) How has its level of coverage in academic journals and books changed over time?
2) What topics in neuroethics have been most popular?
3) What have been the most common professional backgrounds of journal article authors?

To answer these questions, we looked at books as well as journal articles as the two major print sources for the academic discussion of neuroethics. It is common to date the "birth" of neuroethics as a field to 2002, when several conferences gathered representatives from organizations such as the American Association for the Advancement of Science, the journal *Neuron,* the University of Pennsylvania Centers for Bioethics and Cognitive Neuroscience, Stanford University, the Royal Society of London and the Dana Foundation to map out major concerns for the field. Thus to capture the full trajectory of the growth of neuroethics, including preceding years that laid the foundation for the 2002 meetings, we looked at books and articles published from the year 2000 on.

Based on our initial results, we can arrive at the following tentative answers:

1. Coverage of neuroethics has increased, as indicated by consistent positive trends for both the number of journal articles and the number of books published each year

2. Among journal articles, the five most popular topics were (in descending order) enhancement; moral philosophy/psychology; disorders of consciousness; responsibility, free will and the brain; and brain stimulation. Among books, the five most popular topics were (in descending order) neuroethics as a field; the neuroscience of ethics; the role of imaging; neurotechnology; and enhancement.

3. The three most common professional backgrounds of authors for neuroethics journal

articles were, first to third, neuroscience/medicine, bioethics and philosophy.

II. Methodology

For academic articles, we narrowed our search to journals that focus on neuroethics as a field or are broadly prominent in the neuroscience literature. Based on this criteria, we chose the following 12 journals: *Neuroethics, AJOB Neuroscience, Nature Reviews Neuroscience, Annual Review of Neuroscience, Behavioral and Brain Sciences, Molecular Psychiatry, Nature Neuroscience, Neuron, Trends in Neurosciences, Frontiers in Neuroendocrinology, Annals of Neurology and Progress in Neurobiology*. We then looked at every issue of these journals published between 2000 and 2012 to select articles for the survey. For *Neuroethics* and *AJOB Neuroscience,* we included all articles that presented original research, excluding secondary material like peer commentaries and book reviews. Looking at the other 10 journals, we included every article that examined ethical issues specific to neuroscience, excluding neuroscience papers that did not address ethical questions as a central topic.

To develop a list of books, we entered the search term "neuroethics" into Amazon.com's book catalogue. Amazon's search algorithm returns books that merely cite or contain the search term, so we also assessed whether each result was relevant. Books focusing on purely philosophical issues — without touching on the corresponding issues in neuroscience — were excluded from the survey. For those we chose to include, we coded topic and author names with respect to the entire volume if it focuses on a single topic, or by chapter, in the case of edited books that examine multiple topics within the field.

To answer our initial three questions, we organized the data across three corresponding dimensions: a count of articles or books published each year, a count of topics addressed, and a count of author backgrounds based on eight professional categories determined after collecting data on the journal articles. Data for the books and journal articles were analyzed separately.

III. Journal article results:

2000	0	**2007**	0
2001	1	**2008**	19 (15)
2002	6	**2009**	15 (13)
2003	5	**2010**	32 (25)
2004	6	**2011**	71 (63)
2005	5	**2012** (through August)	41 (39)
2006	4	**Total:**	205

- **A. By year:**

The numbers in parentheses indicate how many articles in a given year came from either *Neuroethics* or

AJOB Neuroscience, to give a sense for the proportion of articles coming from the two primary publications that cover neuroethics. For example, in 2011, 63 of the 71 total articles we found published on neuroethics came from *Neuroethics* or *AJOB Neuroscience. Neuroethics* was founded in 2008 and *AJOB Neuroscience* in 2010, meaning the results from 10 journals are counted in the 2000-2007 interval, results from 11 journals are counted 2008-2009, and results from 12 journals are counted 2010-2012.

There is a clear upward trend in journal articles on neuroethics. We have no explanation for the lack of articles published in 2007 but suggest it results from general year-to-year variation, as well as the restricted set of journals examined.

This chart allows us to crudely visualize the increase in number of neuroethics articles published in our 12 journals of interest. We used the raw count of articles (ignoring the figures in parentheses). Because our search only continued through August of 2012, we projected the total article count for that year based on the output of the first 8 months (transforming the raw count of 41 to 61.5, which was rounded to 62). Spikes at 2008 and 2010 may reflect the founding of two journals specializing in neuroethics: *Neuroethics* and *AJOB Neuroscience.*

- **B. By topic**

TOPIC	**COUNT**
Addiction	10 (5, 1)
Animals	3
Brain-computer interface (BCI)	5
Brain stimulation	23 (12, 1)
Disorders of consciousness	17
Enhancement	26
Folk psychology	11 (7, 1)
Gender differences	12
Memory blunting/erasure	3
Mind-reading/prediction	4
Moral philosophy/psychology	21 (5, 2)
Neurodevelopment	3
Neuroeducation	8 (4, 1)
Neuroethics as a field	9
Neurolaw	10 (1, 1)
Neuropolitics/neurosecurity	3
Neuroscience in popular culture (including sports)	5
Neuroscience of ethics (brain processes underlying ethics)	2
Psychiatry	8

Regulation, commercial issues, conflicts of interest	5
Responsibility, free will, brain (philosophical side of neurolaw)	21 (8, 2)
Role of imaging	7
Selfhood	4
Stem cells, chimera, genetic engineering	4

Topic categories for journal articles in this survey were determined prior to our review, based on expert knowledge of the most commonly discussed issues in the field. This list was slightly modified during the review to include unanticipated topics, such as neuroscience in popular culture. Twenty-one of the 205 articles (10.2%) were judged as equally covering two topics, each of which was counted independently. As a result, the total count for topics exceeds the total count for articles by year.

As with the annual count of neuroethics journal articles, this topic-based count is imperfect because not all journals in the field were sampled. Additionally, this count was complicated by "special issues" of some of the journals — issues that focused entirely on one topic within neuroethics. These special cases are indicated by the extra counts in parentheses, which represent the number of articles on that topic that came out of a certain number of special issues. For example, the "8, 2" shown for the "Responsibility, free will, brain" category indicates that 8 of the 21 total articles on this topic were published in 2 special issues that focused solely on responsibility, free will and the brain. These figures are worth noting in case some special issues inflate the apparent prevalence of a topic in the field of neuroethics (e.g. the case of folk psychology, which was covered heavily in a special *Neuroethics* issue about delusions but otherwise was not one of the most commonly found topics).

This chart shows the prevalence of the five most popular topics across our sample of journal articles. The "adjusted count," represented in blue, was used to rank the top five, starting with enhancement and ending with brain stimulation. The adjusted count can be calculated from the table by subtracting the first number in parentheses from the number outside the parentheses, then adding this difference to the second number in parentheses. This total is the equivalent of adding the number of special issues given to a topic to the number of independent or stand-alone articles published on that topic. We used this count to avoid skew from special issues (for example, 12 of the articles on brain stimulation came from a single special issue). "Gender differences" also had an adjusted count of 12, but brain stimulation was ranked higher because of its greater raw count.

C. By author's professional background

Our last factor of interest in this survey was which professional disciplines are most heavily represented in the neuroethics literature. To address this question, we recorded the professional background of all individual authors for each journal article and then sorted the authors into categories. We determined the

categories after collecting information on author background for every journal, so that the labels would best reflect the range we found in our search. Though many of these fields overlap, most authors have built their career around one or two in particular, which we identified by examining their institutional appointments and academic backgrounds. Authors could count toward multiple categories, which usually meant up to two. Counts were determined this way so that our analysis would continue to center on the literature and answer our primary question about author background: Which disciplines are most commonly brought to bear on issues in neuroethics? In this context, we felt it matters if an author has a background in both law and psychology, as that person may be applying both a legal and psychological perspective to the topic at hand.
Psychology was separated out from the rest of the social sciences because of its more direct relevance to neuroethics, compared to fields like anthropology and education studies. As its name implies, the miscellaneous category contains two authors whose work did not fit into the other categories: one professor in mathematics and gender in mathematics, and one professor in the fine arts.

FIELD	**COUNT**
Neuroscience/Medicine	181
Bioethics	115
Philosophy	95
Psychology	46
Law	26
Social sciences	18
Cognitive science	16
Miscellaneous	2

This chart shows the prevalence of different disciplines in the neuroethics literature. Perhaps unsurprisingly, it is dominated by authors with neuroscience/medicine, bioethics and philosophy backgrounds.

IV. Book results

We counted both single author books and edited volumes. Books that consistently reflect the work of the same authors and focus on one topic throughout were counted as a single publication. Any chapter within an edited book that covers a distinct topic within the field of neuroethics, and/or is written by a distinct set of authors, is treated as an independent publication in the year and topic tables. This means a book with 15 distinct chapters would count 15 times, rather than once. We counted this way because such chapters could stand alone as independent articles in other publications, a factor that becomes particularly relevant when we count topic frequency.

- **By year**

YEAR	COUNT
2000	0
2001	0
2002	0
2003	0
2004	1
2005	1
2006	22 (19, 1)
2007	3
2008	3
2009	12 (8, 1)
2010	32 (25, 1)
2011	23 (16, 1)
2012 (through August)	53 (48, 4)

The figures in parentheses indicate how many counts are in fact chapters coming from a certain number of books. For example, the "19, 1" figure listed for 2006 indicates that 19 out of the 22 counted book publications are chapters from 1 edited book. Note that our Amazon.com search yielded no books published before 2004.

The graph starts at 2004, as our results contained no books published before that year. In setting the y-axis, we ignored the number of chapters and counted the "pure" number of books as determined by a manual count (these numbers can be verified in the above table by subtracting the first number in parentheses from the number outside the parentheses, and then adding that difference — which represents the number of books that were only counted as 'one' to begin with — to the second number in parentheses, which represents the number of books that were counted by number of chapters). We thought it would be more useful to visualize the trend in neuroethics books using the "pure" number of books because chapter counts could skew the data; for example, 2008 might have a large spike simply because one volume published that year happened to contain a high number of shorter articles.

- **By topic**

TOPIC	COUNT
Addiction	18 (17, 1)
Animals	1
Brain stimulation	2
Disorders of consciousness	3
Enhancement	17 (15, 3)

Folk psychology	2
Gender differences	11 (11, 1)
Memory blunting	3 (2, 1)
Mind-reading/prediction	7 (6, 2)
Neuroeducation	3
Neuroethics as a field	9
Neurolaw	15 (13, 2)
Neuroscience in popular culture	4 (2, 1)
Neuroscience of ethics	8 (2, 1)
Neuroscience of religion	1
Neurotechnology	27 (24, 2)
Psychiatry	11 (11, 2)
Regulation, commercial issues, conflicts of inter	2 (2, 1)
Responsibility, free will, brain	4
Role of imaging	21 (17, 2)
Selfhood	8 (4, 1)
Stem cells, chimera, genetics	3

Again, figures in parentheses indicate how many counts were chapters from a certain number of books. For example, "Addiction – 18 (17, 1)" means that 17 of the 18 total counts were chapters from 1 book, which in this case focused on the neuroethics of understanding and treating addiction.

As with the journal articles, any book or book chapter that focused equally on two topics contributed two counts in the topics table. Thus the total for this table is higher than the total for the counts by year.

This chart shows the prevalence of the five most popular topics across our sample of books. The "adjusted count," shown in red, was used to rank the top five starting with neuroethics as a field and ending with the neuroscience of ethics. Counts were calculated in the same manner as for the topic-based journal article analysis: the adjusted count is obtained from the table by subtracting the first number in parentheses from the number outside the parentheses, then adding this difference to the second number in parentheses. This total gives the number of single books that address a given topic, without taking into account chapter numbers. As with the chart of books published by year, we did not want chapter counts to skew the presentation of data.