Social Science & Medicine 71 (2010) 725–733

Contents lists available at ScienceDirect

Social Science & Medicine

journal homepage: www.elsevier.com/locate/socscimed

Contemporary neuroscience in the media

Eric Racine [a,b,c,d,e,f,*], Sarah Waldman [g,h], Jarett Rosenberg [i], Judy Illes [g,j,k]

[a] Neuroethics Research Unit, Institut de recherches cliniques de Montréal, 110 avenue des Pins Ouest, Montréal, Québec H2W 1R7, Canada
[b] Department of Neurology and Neurosurgery, McGill University, 3801 University Street, Montréal, Québec H3A 2B4, Canada
[c] Department of Medicine (Division of Experimental Medicine), McGill University, 1110 avenue des Pins Ouest, Montréal, Québec H3A 1A3, Canada
[d] Biomedical Ethics Unit, McGill University, 3647 Peel Street, Montréal, Québec H3A 1X1, Canada
[e] Department of Medicine, Université de Montréal, C.P. 6128, Succ. Centre-Ville, Montréal, Québec H3T 3J7, Canada
[f] Department of Preventive and Social Medicine, Université de Montréal, C.P. 6128, Succursale Centre-ville, Montréal, Québec H3C 3J7, Canada
[g] Stanford Center for Biomedical Ethics, Stanford University, 1215 Welch Road, Stanford, CA 94305-5417, USA
[h] HB-Rex Program, Program in Human Biology, Stanford University, 450 Serra Mall, Stanford, CA 94305-2160, USA
[i] Department of Radiology, Stanford University, 300 Pasteur Drive, Stanford, CA 94305-5105, USA
[j] Department of Pediatrics, Stanford University, 300 Pasteur Drive, Stanford, CA 94305-5208, USA
[k] National Core for Neuroethics, University of British Columbia Hospital, 2211 Wesbrook Mall, Vancouver, BC V6T 2B5, Canada

ARTICLE INFO

Article history:
Available online 4 June 2010

Keywords:
Neuroscience
Print media
Neuroimaging
Ethics
Functional magnetic resonance imaging
Neurostimulation
Psychiatry
USA
UK

ABSTRACT

Technological innovations in neuroscience have opened new windows to the understanding of brain function and the neuronal underpinnings of brain activity in neuropsychiatric disorders and social behavior. Public interest and support for neuroscience research through initiatives like the Decade of the Brain project and increasingly diverse brain-related initiatives have created new interfaces between neuroscience and society. Against this backdrop of dynamic innovation, we set out to examine how different features of neuroscience are depicted in print media. We used the 'guided news' function of the LexisNexis Academic database with keyword searches to find news articles published between 1995 and 2004 in major U.S. and U.K. English-language news sources. We performed searches on headlines, lead paragraphs, and body terms to maximize search yields. All articles were coded for overall tone of coverage, details on reported studies, presence of ethical, legal, and social discussion as well as the emerging interpretations of neuroscience – in the form of neuro-essentialism, neuro-realism, and neuro-policy. We found that print media coverage of the use of neurotechnology for diagnosis or therapy in neuropsychiatric disorders was generally optimistic. We also found that, even within articles that were identified as research reports, many did not provide details about research studies. We also gained additional insights into the previously identified phenomena of neuro-essentialism, neuro-realism, and neuro-policy showing some profound impacts of neuroscience on personal identity and policy-making. Our results highlight the implications of transfer of neuroscience knowledge to society given the substantial and authoritative weight ascribed to neuroscience knowledge in defining who we are. We also discuss the impact of these findings on neuroscience and on the respective contributions of the social sciences and the biological sciences in contemporary psychiatry and mental health policy.

Introduction

Technological innovations in neuroscience have opened new windows to the understanding of brain function and the neuronal underpinnings of brain activity in neuropsychiatric disorders and social behavior using methods like functional Magnetic Resonance Imaging (fMRI) (Hsu, Anen, & Quartz, 2008; Young & Saxe, 2008). Possibilities for clinical interventions that modulate brain function have surfaced with the refinement of techniques like deep brain stimulation (DBS) (Larson, 2008; Weaver et al., 2009). Public interest and support for neuroscience research through initiatives like the Decade of the Brain project sponsored by the Library of Congress and the National Institutes of Health, combined with the burgeoning of neuroscience research, have created new interfaces between neuroscience and society (Frazzetto & Anker, 2009). Neuroscience advances in areas like DBS and fMRI could provoke shifts regarding the respective role of biological sciences and of the humanities and social sciences in understanding social behavior and mental health (Hyman, 2007). An early representation of this trend can be found in (then US president) George H.W. Bush's declaration launching the Decade of the Brain stating that the brain

* Corresponding author. Tel.: +1 514 987 5723; fax: +1 514 987 5763.
E-mail address: eric.racine@ircm.qc.ca (E. Racine).

0277-9536/$ – see front matter © 2010 Elsevier Ltd. All rights reserved.
doi:10.1016/j.socscimed.2010.05.017

is: “the seat of human intelligence, interpreter of senses, and controller of movement,” and that “[r]esearch may also prove valuable in our war on drugs” (Bush, 1990). This project spanned the 1990s and involved the US Library of Congress and the National Institute of Mental Health (NIHM) of the National Institutes of Health (NIH). In the public domain, this declaration met with growing enthusiasm for attributing the very essence of the self to the brain, along with promises of improvements in brain well-being and healthcare for diseases for the central nervous system (Racine, Bar-Ilan, & Illes, 2006).

The public interest for the brain and the potential profound implications of neuroscience on philosophical and social issues – in its contemporary form – was foreshadowed as early as the 1980s. The writings of neurobiologist Jean-Pierre Changeux in Europe (Changeux, 1983) and of philosopher Patricia Churchland in North America (Churchland, 1986) provided some of the historical impetus for contemporary discussions on the implications of neuroscience for culture and society. For example, Changeux argued that neuroscience would have broad anthropological implications and, in fact, yielded a new vision of man, i.e., the “neuronal man”. Churchland developed a consolidated philosophical and neuroscientific perspective on the nature of cognitive function and the mind. She also argued for stronger ties between the humanities and neuroscience, calling for a renewal of philosophy and the humanities. Currently, the philosophical, theoretical, and social implications of neuroscience constitute the object of several specific interdisciplinary endeavors such as social neuroscience and affective neuroscience. In tandem, the emergence of the field of neuroethics signaled a new response to the profound impact of neuroscience on mental health, policy, education, moral responsibility, and, more generally, on the methods of the humanities and the social sciences (Marcus, 2002; Racine, 2010a). Against this backdrop of technological neuroscience innovation and of scholarly and public interest in extending the frontiers of neuroscience, public discourses on neuroscience represent an area to explore and examine in order to gain insights into the forces that have led to current debates – a context that some have called the “neuroscience revolution” (Wolpe, 2002, 8).

Media coverage of neuroscience innovation could have potential desirable and less desirable consequences. Examples of the former are expectations that a more biologically-informed approach to mental health would help to reduce stigma associated with mental health by reinforcing the medical model of psychiatric disorders (Grey, 2002; Hyman, 2007). Potentially less desirable consequences include the impact of enthusiasm about neuroscience innovation on unrealistic expectations that undermine informed consent for patients or suggest capabilities of neuroscience such as mind-reading (Liacoboni, Freedman, Kaplan, Hall, & Freedman, 2007), which are far beyond what can be achieved. For example, enthusiastic depictions of neuroscience innovation and high expectations for revolutionary outcomes and deliverables of neuroscience research may create pressures for the hasty translation of technologies in healthcare and in other sectors of society (Huttson, 2007; Illes et al., 2009; Racine, Bell, & Illes, 2010). Neuroscientists themselves have voiced concerns regarding the simplified depiction of complex tools like fMRI as a powerful diagnostic tool and even a “mind-reading” device (Dudai, 2004; Farah, 2009). In spite of cautionary arguments (Greely & Illes, 2009; Wolpe, Foster, & Langleben, 2005), fMRI, for example, has moved into the public sphere for lie-detection (No lie MRI, 2010). Controversial legal uses are illustrated by a case in India where a woman was convicted of having killed her fiancé based on functional neuroimaging evidence – although not based specifically on fMRI in this case (Giridharadas, 2008). Similarly, media coverage of techniques like DBS (Racine, Waldman, Palmour, Risse, & Illes, 2007) may fuel high patient expectations and inform patient responses to these technologies (Bell, Mathieu, & Racine, 2009; Bell, Maxwell, McAndrews, Sadikot, & Racine, 2010). In sum, the public’s understanding and appreciation of neuroscience and neurotechnologies may shape debates about the ethical use of neuroscience in healthcare as well as the future of academic disciplines like psychiatry, psychology, and economics.

Progress has been made in understanding some aspects of media coverage of neuroscience, especially in its connection with discussion of ethical and social aspects of neuroscience (Racine, Bar-Ilan, & Illes, 2005; Racine, DuRousseau, & Illes, 2007; Racine et al., 2006; Racine, 2010b). However, previous research would benefit from larger-scale studies to confirm or refute earlier results and provide additional insights into the features of media coverage of neuroscience. For that reason, we set out to examine how different forms of neuroscience innovation like DBS and fMRI were depicted in US and UK print media. We were particularly interested in examining the overall tone of media coverage, details reported about studies, presence of ethical, legal, and social discussion as well as the emerging interpretations of neuroscience – in the form of neuro-essentialism, neuro-realism and neuro-policy (Racine et al., 2005). We expected that the data yielded would help us understand the implications of media coverage of neuroscience on beliefs about the contribution of biological approaches to mental health and mental health policies, as well as the nature of discussions on the ethical and social aspects of neuroscience in the public sphere.

Methods

Keyword searches reflected scientific terminology used to describe different techniques. Key word searches were carried out using the LexixNexis truncation operator (!): gen! test! & brain; gen! test! & nervous system; Positron Emission Tomography & brain; SPECT or Single Photon Emission Computerized Tomography; fMRI or functional Magnetic Resonance Imaging; EEG & brain, electroencephalography; deep brain stimulation, neurostimulation; neural stimulation; brain–machine interface; brain–computer interface; neural prosthes!, transcranial magnetic stimulation (TMS); TMS & brain; TMS and neuroscience; neural implant; cortical implant. We performed searches on headlines, lead paragraphs, and body terms to maximize search yields. Articles that did not minimally discuss featured neuroscience techniques were discarded from the sample. We also eliminated news sources not available for the full decade under study from the sample.

All articles were coded systematically by two independent coders (S.W. and E.R.) based on the instructions contained in a coding guide. The guide was developed for this specific study based on our research objectives and previous print media studies of neuroscience, genetics and other areas of biomedical research (Mountcastle-Shah et al., 2003; Racine et al., 2005; Racine, Gareau, et al., 2006). The coding structure included the identification of the: 1) type of technology featured (e.g., electroencephalography [EEG]; fMRI); 2) explanation of the technology (none; simple; elaborate); 3) level of focus on science reporting on the described neurotechnology (none; moderate; high); 4) authorship (e.g., journalist, press agency, unidentified author); 5) type of research reported (clinical or non-clinical); 6) specific health conditions investigated or to which the neurotechnology was applied (World Health Organization, 2005); 7) specific non-clinical areas investigated or to which the neurotechnology was applied (e.g., cognition; integrated cognition); 8) cohort to which featured neurotechnology is applied (e.g., humans, animals); 9) clinical benefits (e.g., improving treatment, improving diagnosis); 10) non-clinical benefits (e.g., contributing to the economy; improving education or social policy); 11) scientific and medical issues (e.g., reliability, validity, safety and side-effects); 12) ethical, legal and social issues (e.g., confidentiality and privacy; justice and resource allocation; discrimination and stigma); 13) sources of quotation (e.g., researchers in public sector; researcher in private sector; physicians and other healthcare providers); and 14) overall tone (optimistic, neutral, balanced or critical). The content of articles that fit in more than one category was captured in all relevant codes (rich coding strategy).

To gain further insight about the reporting of studies, we further coded articles identified as featuring a high level of science reporting based on previously used coding approaches (Bubela & Caulfield, 2004; Bucchi & Mazzolini, 2003; Mountcastle-Shah et al., 2003; Schwartz, Woloshin, & Baczek, 2002; Woloshin & Schwartz, 2006). We examined the identification of: the institution of the investigators; the name of the investigators; the source of the data (e.g., a scientific journal, an abstract published at a scientific meeting); the number of research subjects; presence of control or comparison groups; observations on the need for replication of the reported study source(s) of funding; and stated conflicts of interest. Personal testimonials were also recorded. We performed a blind reliability test on a sub-sample of 100 articles with a yield of a 0.94 inter-coder agreement. We used descriptive statistics to characterize the composition and properties of the sample and used Fisher's exact tests (with a significance level of 0.001) to identify significant differences.

Table 1
Sources of quotation for articles on neurotechnology.

Sources of quotation	%
Scientists with a public sector affiliation	42
Physicians and other healthcare providers	14
Patients, family members, and research volunteers	11
Patient interest groups and lobby groups	5
Humanities and social science scholars	5
Politicians	4
Governmental bodies	4
Scientists working in the private sector	4
Representatives from a private company	3

Results

We identified 1256 articles featuring neurotechnology published from 1995 to 2004. Our sample is composed of 335 articles featuring PET and/or SPECT; 284 for EEG; 235 for neurostimulation techniques; 223 for fMRI and 179 for neurogenetics (See Fig. 1). Of the total, 875 (70%) originated from the U.S. and 381 (30%) from the U.K. The vast majority of articles ($N = 1233$; 98%) reported the use of neurotechnology in humans (See Supplementary data).

Eighty-four percent of the articles in the sample were reports written by identifiable journalists $N = 1053$). The remainder were reports produced by press agencies ($N = 139$; 11%), editorials and columns ($N = 14$; 1%) or articles written by authors whose positions were unclear ($N = 144$; 11%). Scientists with a university or other public sector affiliation ($N = 524$; 42%) were cited most frequently (See Table 1).

Clinical research and clinical applications, i.e., involving identifiable neurological or psychiatric disorders were reported in 868 articles (69%), non-clinical research and applications in 504 articles (40%); 126 articles (10%) featured both types of research and applications. Within clinical research and applications, diseases of the nervous system (ICD-10, G00-G99) were targets in 445 articles (35%); mental and behavioral conditions (ICD-10, F00-F99) in 353 articles (28%). The most frequently cited sets of conditions were organic dementias; extrapyramidal and movement disorders such as Parkinson's disease; degenerative diseases of the nervous system such as Alzheimer's disease; episodic and paroxysmal disorders such as epilepsy; and mood disorders such as depression (see Supplementary data for additional details). Non-clinical research and applications (Illes, Kirschen, & Gabrieli, 2003) most frequently dealt with basic and higher-order cognitive phenomena as well as emotions and social behavior (see Supplementary data).

Overall, 68% of articles ($N = 853$) presented at least one clinical or non-clinical benefit and 28% of articles ($N = 352$) presented one scientific or ethical issue. The breakdown data in Table 2 yield a profile for each set of neuroscience innovation relative to benefits and issues. For example, the table shows that neurogenetic testing is more frequently associated with ethical issues than other neurotechnologies. Neuroimaging techniques such as fMRI and PET are more often associated to issues of validity. Issues related to commercialization and conflicts of interest were the most frequent across technologies.

Tone varied in different neurotechnology reports (Fig. 2a) with more frequently balanced ($p \leq 0.001$) and critical articles ($p \leq 0.001$) in coverage of neurogenetic testing in comparison to the other forms of neuroscience innovation. Overall, the tone of media coverage was optimistic (featuring benefits of research and its applications) or neutral (no mention of benefits, risks or challenging issues). Except for articles about neurostimulation, the majority did not provide explanation about the technology per se

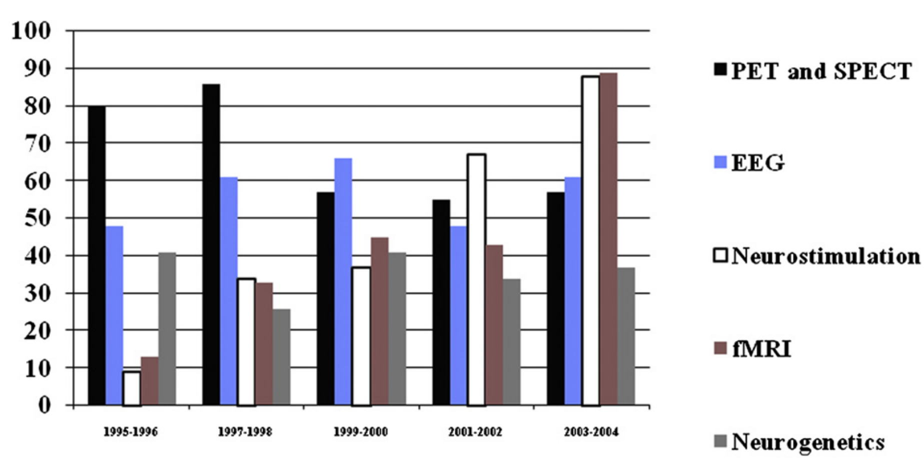

Fig. 1. Print media coverage of neurotechnology (1995–2004).

Table 2
Percentage of benefits and issues featured in print media coverage of neurotechnology.

	Benefits/issues	All	PET	EEG	NStim	fMRI	NGen
Clinical benefits	At least one clinical benefit*	**60.0**	**47.5**	**67.6**	**79.1**	**30.5**	**81.0**
	Therapy*	28.7	20.9	13.4	76.6	19.7	16.2
	Diagnosis*	26.1	27.8	41.2	0.9	6.3	60.0
	Monitoring*	10.3	14.3	20.8	0.0	7.6	2.8
	Prevention*	4.6	2.7	0.0	1.7	0.4	24.6
	Surgery*	2.9	4.8	1.8	3.0	3.6	0.6
Non-clinical benefits	At least one non-clinical benefit*	**19.0**	**14.0**	**21.5**	**23.4**	**20.6**	**16.8**
	Research and technology design*	6.7	1.5	11.6	11.9	4.0	5.0
	Economy	4.5	3.3	5.3	4.3	4.5	5.6
	Moral and spiritual	3.6	2.7	3.2	6.0	0.9	6.1
	Social and educational*	2.7	3.0	2.5	0.0	6.7	1.1
	Legal*	2.9	4.2	2.5	0.0	6.7	0.0
	Political*	1.0	0.3	0.0	5.1	0.0	0.0
Scientific and medical issues	At least one scientific or medical issue	**16.8**	**20.0**	**18.3**	**15.7**	**17.0**	**9.5**
	Validity*	7.6	9.0	11.3	1.3	12.6	1.1
	Interpretation and misunderstanding*	5.4	8.7	5.6	0.0	6.3	5.0
	Safety and side-effects*	4.6	2.7	2.5	15.3	1.8	1.1
	Readiness	2.5	3.6	3.2	0.0	3.6	1.1
	Reliability*	2.0	3.6	1.8	0.0	0.4	3.9
Ethical. legal and social issues	At least one ethical, legal or social issue*	**17.5**	**15.2**	**11.3**	**14.0**	**9.4**	**46.4**
	Commercialization and conflicts of interest	5.7	8.1	3.9	3.0	2.2	12.3
	Discrimination and stigma*	4.8	1.5	0.0	0.0	0.9	29.6
	Meaning of research*	3.8	5.4	1.1	2.1	4.5	6.7
	Privacy and confidentiality	3.3	0.9	3.2	0.9	2.7	11.7
	Consent and autonomy*	2.6	0.9	1.8	5.1	4.0	2.2
	Justice and resource allocation*	1.4	2.4	1.8	1.7	0.0	0.0
	Duty and responsibility	1.0	0.0	1.1	0.4	0.4	4.5
	Policy and public involvement	1.0	0.6	0.4	0.0	0.0	5.0
	Dignity and integrity	0.6	0.3	0.7	1.3	0.0	0.6
	Enhancement	0.5	0.0	0.0	1.7	0.0	1.1
	Artificial selection and eugenics	0.5	0.3	0.0	0.0	0.0	2.8
	Animal rights*	0.4	0.0	0.0	2.1	0.0	0.0

PET: Positron Emission Tomography and SPECT (Single Photon Emission Computed Tomography); EEG: Electroencephalography; NStim: Neurostimulation techniques; fMRI: functional Magnetic Resonance Imaging; NGen: Neurogenetic testing.
*Fisher's exact test $p \leq 0.001$ indicating significant overall variability among neurotechnologies.

(Fig. 2a). Articles dealing with neurostimulation techniques included more simple (2–3 lines) or elaborate (>3 line) explanations ($p \leq 0.001$).

In the subset of articles with a high level of science reporting ($N = 435$; 35%), we identified how information about the study was reported (Table 3).

The three emerging trends of neuro-essentialism, neuro-realism, and neuro-policy, first identified in a previous study of the print media coverage of fMRI (Racine et al., 2005) were only found in print media coverage of neuroimaging techniques (EEG, PET, fMRI); none were found in coverage of neurostimulation techniques and neurogenetic testing. We present our findings on these trends in the following sections of the results.

Neuro-essentialism

Neuro-essentialism designates interpretations that the brain is the self-defining essence of a person, a secular equivalent to the soul (Racine et al., 2005). Neuro-essentialism describes that the concept of the brain becomes short hand for other concepts (e.g., the person, the self) that may serve to express features of the individual not ordinarily found in the concept of the brain. In our sample, neuro-essentialism was present in 4% of EEG articles; 12% of PET articles, and 13% of fMRI articles. Neuro-essentialism was a combination of biological reductionism and enthusiasm for neuroscience research. The reductionist component took the form of equating brain and personhood, for the localization of personality traits or illness or for the subtle replacement of grammatical subjects by the brain (Table 4).

Enthusiasm for the “secrets” that neuroscience could reveal about ourselves was tightly associated with the various forms of neuro-essentialism. For example, according to print media, neuroimaging technologies allow for the exploration of “the secret, uncharted areas of the brain,” and the identification of “the individual sources of all our thoughts, actions and behaviour” (Dobson, 1997). The brain was also portrayed as “the mystery we still can't penetrate” (Hall, 2001), an “enigma” (Connor, 1995) and the “terra incognita that lies between our ears” where one can find “the keys to the kingdoms of memory, of thought, of desire, of fear, of the habits and skills that add up to who we each are” (Hall, 1999). Accordingly, neuroscience was therefore depicted as revealing “life's ultimate mystery: our conscious inner selves” (Connor, 1995) and was presented as science “gone in search of the soul” (Hellmore, 1998).

Neuro-realism

The concept of neuro-realism gathers interpretations that neuroimaging research yields direct data on brain function despite the complexities of data acquisition and image processing involved (Racine et al., 2005). Observed brain activation patterns are, as a result, portrayed as the ultimate proof that a phenomenon is real, objective, and effective (e.g., in the case of health interventions such as hypnosis and acupuncture). Instances of neuro-realism were found in 3% of EEG articles, 8% of PET articles and 18% of fMRI articles using various metaphors. Table 5 presents print media examples of various forms of neuro-realist interpretations attributing mind-reading powers to neuroimaging. These examples

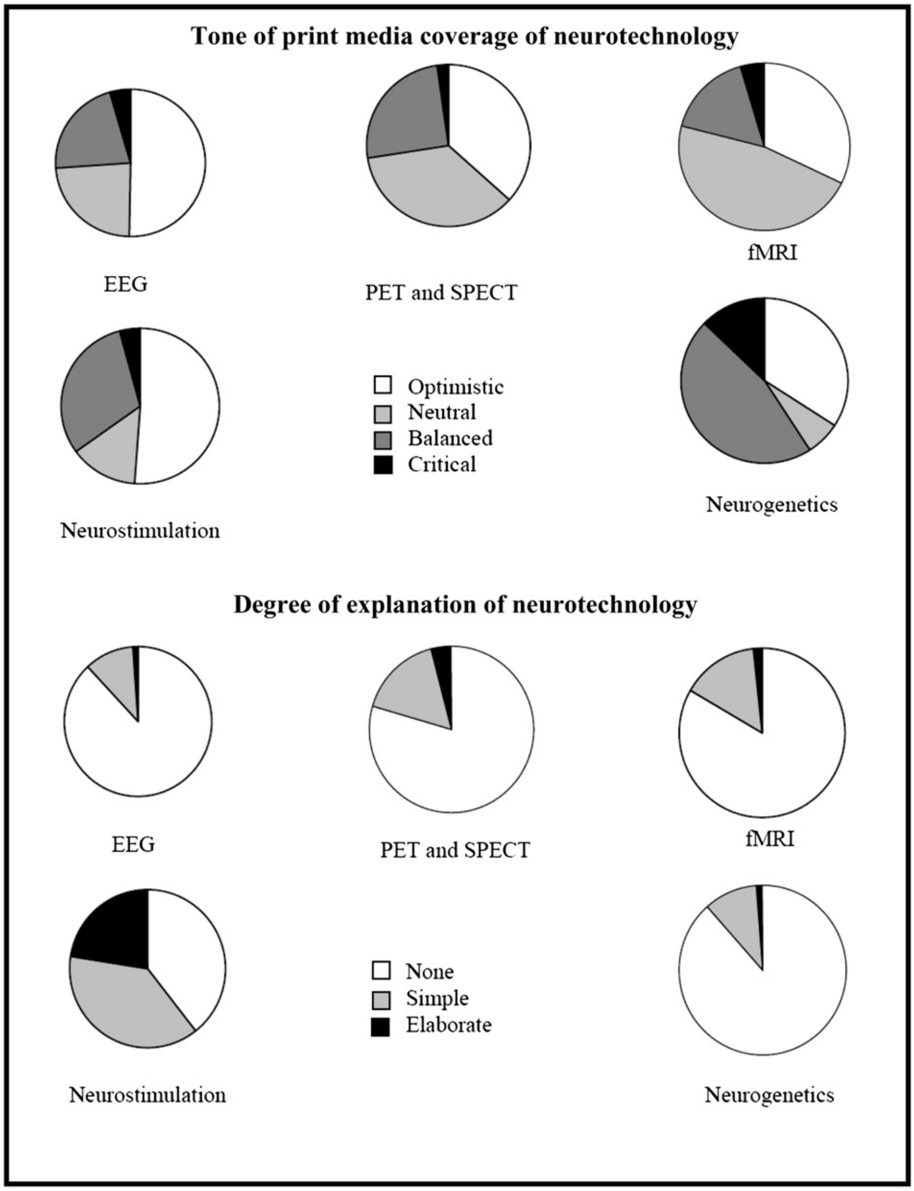

Fig. 2. Tone (%) and degree of explanation (%) of neurotechnology in print media coverage. (a) Tone of print media coverage of neurotechnology. (b) Degree of explanation of neurotechnology.

suggest that neuroimaging can provide a "visual proof" or give insight into the true nature of a phenomenon, describe neuroimaging as a "window into the brain" or a tool, and produces pictures and movies of the brain "at work."

Table 3
Reporting practices in subset of articles with a high level of research reporting.

Identification of:	%
Institution in which research was conducted	89
Investigators	83
Where data was published	65
Number of patients or subjects involved	56
Control or comparison groups	27
Personal interest feature	24
Need for replication of results	11
Funding sources	8
Conflicts of interest	4

Neuro-policy

Neuro-policy describes that the rapid transfer of neuroscience research is particularly appealing when neuroscience is described in neuro-essentialist and neuro-realist ways (Racine et al., 2005). In our sample neuro-policy occurred in 2% of EEG articles, 5% of PET articles and 6% of fMRI articles. Our qualitative data shows that education and healthcare are key targets of neuro-policy, including claims that neuroimaging results (1) inform policies and social practices and (2) provide insight on the conduct of one's life (see Table 6).

Discussion

Our content analysis of U.S. and U.K. print media coverage of neurotechnology provides insights into different aspects of public discourse about neuroscience. We found that certain techniques like fMRI and neurostimulation were gaining more coverage (see Fig. 1) and that most of media coverage was optimistic or neutral,

Table 4
Examples of neuro-essentialist interpretations in print media coverage of neurotechnology.

Neuro-essentialism$_1$: Neuroscience reveals our "essence", who we are

"With more powerful imaging devices and new genetic information, scientists are exploring the secrets of the organ that makes humans unique" (Colburn, 1999).

"The most mysterious, complex system in the universe is perched inside the skull at the top of your neck. The brain holds your memories, your emotions, your hopes, dreams and understanding. (…) It holds "you" – the private you, not the public you that others see. It's so private that even you don't know the "you" that resides inside" (Hall, 2001).

Neuro-essentialism$_2$: Neuroscience reveals the neuronal basis of personality traits or illness

"Looking for that brain wave called love: humanities experts use M.R.I.'s to scan the mind for the locus of the finer feelings"[a] (Eakin, 2000).

"Scientists spot the site of addictive craving in brain [a] (…) Childress can peer into brains and literally see the seat of desire, the wanting-place inside addicts that orders them to abandon jobs, children and spouses to hunt for mind-spiraling products" (Lubrano, 1997 p. A35).

"One of the most striking findings came in 1997, when a team of researchers from the University of California at San Diego found what they called the "God module" in the brain" (Cook, 2001).

"If your child has trouble reading, the problem may indeed be all in his head" (Hall, 1999).

"Are you guilty? It's all in the mind: A new test is being used to detect memories in suspects" [a] (Spinney, 2001).

"Optimists owe it all to the brain"[a] (Henderson, 2001).

Neuro-essentialism$_3$: Brain implicitly becomes a grammatical subject

"As any good movie director or roller coaster designer knows, people love surprises. Now, it seems, at the most basic level, the brain does too" (Nagourney, 2001).

"There have always been strong hints that the brain can use separate brain regions for first and second languages" (Blakeslee, 1997).

"Researchers found that as the brain struggled to decipher the code of the English language" (Davis, 1998).

[a] Example featured in headline.

Table 5
Examples of neuro-realist metaphors and interpretations in print media coverage of neurotechnology.

Neuro-realism$_1$: Neuroimaging as "mind-reading"

"We know what you are thinking. The nature of things: Spin doctors are delving deeper into our grey matter "[a] (Derrington, 1998).

"Reading the brain: New imaging technique lets doctors see inside, but some question how it is used "[a] (Blakeslee, 2000).

"Brain scan can catch a lie"[a] (Anonymous, 2004).

"Hi-tech hairnet that reads minds"[a] (Macdermid, 1997).

Neuro-realism$_2$: Neuroimaging provides a "visual proof" or reveals the true nature of cognitive phenomena

"Plourd showed the jury a PET scan that depicted the damaged section of his brain. The jury voted for life imprisonment. "A PET scan is very helpful," says Plourd. "The jury … can accept it more readily than just words or the testimony of an expert"" (Terry, 2000).

"But the fact that pain, like blood pressure or body temperature, can now be measured (…) will help convince doctors that patients' pain is very real" (Noble, 1999).

"It's hard to fight an enemy (mental illness) you can't see (…). This will make it as easy to see sickness in the mind as it is to see a broken bone in the body" (Anonymous, 1999).

"Hypnosis really does turn red into white[a] (…) Scientists have shown that hypnosis produces changes in the brain, the first conclusive proof that the practice works. Brain scans have revealed beyond doubt that people who are hypnotized are not simply humouring their interviewers but that they see the world differently while in a trance" (Henderson, 2002).

Neuro-realism$_3$: Neuroimaging provides a "window into the brain'; pictures or movies of the "brain in action"

"The fMRI gives us a window into the human brain" (Fackelmann, 2001).

"In an illustration of how the kind of "photography" known as brain imaging has come of age, scientists Tuesday announced findings that could affect the understanding and treatment of schizophrenia, drug addiction and post-traumatic stress disorder. (…) "We now have remarkable tools to see the living, feeling, thinking human brain at work" (Vedantam, 1996).

"How to get inside the thinking brain[a] (…) Recently, in a darkened lecture theatre, I watched on a flickering screen a slow-motion video of a brain actually thinking" (Charlton, 1996).

"In their study, 36 women played the non-zero-sum game "Prisoner's Dilemma" while getting functional magnetic resonance imaging scans, a new type of MRI that shows a movie of brain activity" (Wahlberg, 2002).

In a quiet laboratory, Andrew Newberg takes photographs of what believers call the presence of God" (Cook, 2001).

[a] Example featured in headline.

with few critical articles exception made for neurogenetics where much more critical coverage was encountered (see Fig. 2a). Print media coverage of neurotechnology as a diagnostic or therapeutic tool for neurological and neuropsychiatric disorders was generally not associated with risks or ethical and social concerns. Reporting of benefits varied across different forms of neuroscience innovation, but even rather experimental techniques like fMRI were associated with clinical benefits in almost one third of articles. Benefits were featured in a large majority of articles featuring neurogenetic testing (Table 2). Scientific issues like validity were more frequently associated with neuroimaging techniques while side-effects were prominent in neurostimulation (Table 2). We also found that, within articles focused on science reporting, many did not provide important specifications regarding research design like the number of patients or subjects involved as well as the funding sources (Table 3). Overall, researchers with public and academic affiliations and physicians and other healthcare providers were featured more often that all other groups combined (Table 1). In our discussion, we focus on two major challenges informed by our study related to (1) the implications of "transfer" of neuroscience knowledge to society and (2) the impact of neuroscience on the nature of psychiatry and mental health.

There are important limitations to this study that need to be acknowledged. The sample is based on major news sources of the U.S. and the U.K. and it covers only a specific ten year time period. In addition, this study does not provide any data on public understanding *per se* but instead on the content available to readers. Investigating the public's understanding of this content requires different research strategies. In spite of these constraints, the size of the sample is sufficiently large to support discussion of media coverage of contemporary neuroscience innovation.

Challenges in the transfer of neuroscience knowledge to society

Our first discussion point concerns science reporting and the inherent challenges in the "transfer" of neuroscience knowledge to society, suggesting that this process is not straightforward or as unidirectional as often assumed. For example, even in the articles focused on reporting specific protocols, we found that information about the number of participants in studies, the need for replication, and details on funding sources were included in not even half of the articles. We also found that less than half of the articles provided any relevant explanation of the featured neurotechnologies. These gaps can have an impact on the public's understanding and potential use of neurotechnologies. For example, neuroimaging studies most often involve small subject samples and there is, in many cases, a need for further consolidation and replication of protocols before extending the results to a broader population and real-world use (Bennett & Miller, 2010; Desmond & Chen, 2002).

Previous research has identified related sets of challenges in knowledge transfer from the media such as the publication of non-peer reviewed findings presented by researchers at scientific meetings and the dissemination of hype (Bubela & Caulfield, 2004;

Table 6
Examples of neuro-policy in print media coverage of neurotechnology.

Neuro-policy$_1$: Neuroimaging informs policies and social practices
"Neuroscientists, mainly in the US, have started using a technique known as functional magnetic resonance imaging to study the responses of teenagers to particular situations. (…) These research findings have profound implications for policy-makers, teachers, parents and, most of all, for teenagers" (Johnstone, 2004).
"Zak says fMRI stands to make a big impact in what has been dubbed "neuro-marketing". As an example of how fMRI might be used, Zak proposes a company that wants to increase its sales of milk. One way it might is to gather a group of people who like milk and scan them as they drink a glass. Some of the regions of the brain that buzz with activity might be triggered by any drink, but others may be triggered only by milk" (Sample & Adam, 2003).
"After monitoring brain activity with functional magnetic resonance imaging, Just and colleagues concluded that people can't effectively drive a vehicle and talk on a cell phone, or with a passenger, at the same time. The brain, it seems, has its limits. The findings interested many, including Bob and Jeff, radio hosts in Sydney, Australia; legislators and police nationwide; great numbers of science writers; the Discovery Channel, which aired a 15-min special; CBS News anchor Dan Rather, whose report worked its way into Just's presentations; and the legislator who authored New York's new "hands free" cell phone law" (Mendenhall, 2002).
"The breakthroughs are so rich in insights for parents and so pregnant with possibilities for health care and public policy that the nation has become absorbed with the scientific intricacies of what happens inside a baby's head. News magazines spew articles replete with heart-melting images of babies and mind-boggling diagrams of their brains. TV specials draw us into the arcane world of synapse formation. Parents contemplate reading Shakespeare to their infants" (Cummins, 1997).
Neuropolicy$_2$: Neuroimaging informs lifestyle, everyday activities and provides a new wisdom in the conduct of one's life
"Serious scientific research efforts have been going on in this area for many years now, and recent successes may have enormous implications for the lifestyle of the future" (Mcnaught, 1996).
"Get a good night's sleep. Evidence suggests that sleep deprivation can impair memory. Studies also point to sleep as an important way for the brain to consolidate what it has learned during the day. Exercise. Physical activity helps the brain as well as the body by improving circulation, lowering blood pressure and increasing blood oxygen levels" (Squires, 1999).
"Overall, a woman's brain, like her body, is 10 percent to 15 percent smaller than a man's, yet the regions dedicated to higher cognitive functions such as language are more densely packed with neurons. (…) recognizing some of these differences can make a difference in our daily lives" (Hales, 1998).
"The findings do not mean that people can't perform more than one task, but suggest that they ought to master each individually" (Stein, 1997).

Caulfield, 2004; Zuckerman, 2003). Our study therefore confirms that general issues related to media coverage of biomedical research (Bucchi, 2004; Einsiedel, 2008) occur in media coverage of different forms of neuroscience innovation.

Current science reporting practices, including that of neuroscience innovation, provide a basis for concern especially since, once published, media articles become publicly available sources of information that are used to support claims and practices that inform patient behavior. For example, newspaper articles feed back into commercial activities and practices such as online direct-to-consumer advertising (DTCA) of neuroimaging products. One study found that many neuroimaging facilities that sell brain scans directly (without physician referral) via internet websites and those that promote dietary neurosupplements used favorable neuroscience media coverage to support their marketing strategies (Racine, Van der Loos, & Illes, 2007). Further, Zuckerman has specifically identified cases in which research is not intended to expand knowledge per se, or even benefit humanity, but instead is undertaken to support the sale of products to the public. She concludes that, "[m]uch of the media coverage of health news stories is based on public relations efforts on behalf of the companies that sell the products, including pharmaceutical companies, diet clinics, or doctors selling new techniques" (Zuckerman, 2003, 383). Some of these practices involve payment to physicians and other experts to speak favorably about the featured product. The situation has been judged serious enough by the Ethics, Law, and Humanities Committee of the American Academy of Neurology to warrant the development of a specific practice guideline on physician involvement in direct-to-consumer advertising (Ethics, Law, and Humanities Committee of the American Academy of Neurology, 2001). These examples show the potential real-world consequences of overly enthusiastic media coverage of neuroscience innovation on healthcare providers as well as patient behaviors, patient information, and patient expectations.

Impact of neuroimaging on the nature of psychiatry and mental health policies

A leading figure of contemporary psychiatry, the Nobel laureate Eric Kandel, has argued for a constructive conceptual framework for psychiatry in which both biological and non-biological approaches complement each other (Kandel, 1998). In contrast to this balanced stance taken by Kandel and others working at the intersection of psychiatry and the humanities, like Brendel (2006); Fulford and Hope (1994) and Sider (1984) to name a few, claims for clinical benefits of neurotechnology in media coverage, especially for the treatment and diagnosis of psychiatric disorders, as well as instances of neuro-essentialism and neuro-realism strongly support biological approaches. A previous study of fMRI in the print media had suggested that media coverage and interpretations of fMRI could influence the public's understanding of mind–body relationships and attitudes toward non-biological understandings of human behavior (Racine, Bar-Ilan, et al., 2006). Taken together, these data suggest that current trends in media portrayal of certain aspects of neuroscience could undermine the potential complementary of biological and social approaches to behavior and disease.

There are no doubt benefits to the biological approaches in psychiatry. Media coverage of neuroscience innovation represents an important endeavor to bring advances in biological psychiatry to the public. As we noted, some have convincingly agued for the benefits of an enhanced and balanced appreciation of the biological aspects of mental health. However media coverage interacts with other aspects of a larger unfavorable context regarding non-biological approaches in mental health. In *Healing Psychiatry*, David Brendel (2006) underlines the challenges associated with the biological turn in psychiatry, such as the proper reimbursement of psychotherapy and the recognition of the current limits of biological approaches for patient care in the American context. At stake are, potentially, the credibility and availability of non-biological therapies and therefore long-term patient well-being. The statements we found in the media, as well as the early claims for clinical benefits, could shape the evolution of public attitudes toward biology-based and away from mind-based approaches in psychiatry. As Dorothy Nelkin states: "[t]hrough the selection of news, journalists help to set the agenda for public policy. Through the information they convey about risks, they may affect stock market prices and influence product sales. And through the presentation of science news, the media influence public attitudes toward science" (Nelkin, 2001, 205).

Similarly, attitudes toward the nature, remedies to, and the policies toward mental disorders could be influenced by media coverage of neurotechnology. Enthusiastic neuroscience media coverage may contribute to undermining a fair appreciation of non-biological understandings and approaches to mental and behavioral disorders. What role can bioethics, as an interdisciplinary field, play to enrich public understanding and foster informed debates and healthcare decision-making? According to bioethicist

Daniel Callahan, one of the main tasks of bioethics is to avoid "disciplinary reductionism", i.e., the reduction of the world to the perspective of one scientific discipline, to capture and promote a global view on the patient as a person (Callahan, 1976). Our results indicate that media coverage encourages reductionist views of psychiatric disorders and the brain, giving rise to neuro-essentialism, neuro-realism, and neuro-policy. One of the crucial tasks of bioethics should therefore be to unveil different forms of reductionism and bring awareness to the inherent complexity of research and patient care.

Conclusion

Our study of media content and neurotechnology highlights some important challenges in the transfer of neuroscience to society and its impact on academic and clinical disciplines like psychiatry. First, we noted important challenges that replicate other findings on general media coverage of biomedical science. Some important details regarding the use of neuroimaging techniques like PET and fMRI are infrequently reported while speculative benefits associated with these techniques are frequently featured. Measures to proactively correct and enhance the accuracy of content are therefore desirable (Illes et al., 2009). Second, we noted that neuro-realist and neuro-essentialist interpretations of neuroscience led us to consider how unbridled the optimism for neurotechnology could shape public expectations regarding the future evolution of psychiatry, as both a mind-based and a brain-based discipline. This discussion pointed to the far-reaching health and policy implications of strong commitments to neuro-policy and neuro-essentialism that further research should address in specific contexts like healthcare and education. Consequently, future discussions about the ethical and social implications of neuroscience should pay close attention to the evolution of media coverage. This is particularly relevant given the existence of debatable and uncorrected epistemological and ethical assumptions of neuroscience innovation disseminated in the media. At stake, ultimately, are also some common assumptions about the role of the media in liberal democracies and the role of the press in creating an informed public. As the professor of journalism, John Trebel wrote in the sixties, "[i]n the end, one supposes, public enlightenment and responsibility will transcend private interest only if the public demands it" (Trebel, 1966, 85).

Acknowledgements

The authors would like to acknowledge the help of Zoë Costa-von Aesch, Ofek Bar-Ilan, Stacey Kallem, and Allyson Mackey. This study was supported by the Institut de recherches cliniques de Montréal (E.R.), FRSQ (E.R.), SSHRC (E.R.), NIH/NINDS R01 #NS045831 (J.I.), and CIHR (E.R).

Appendix. Supplementary material

Supplementary data associated with this article can be found in the online version, at doi:10.1016/j.socscimed.2010.05.017.

References

Anonymous. (1999). Laser device offers peek at brain breakthrough may help in diagnosis of Alzheimer's patients. *Omaha World Herald*. March 15.
Anonymous. (2004). Brain scan can catch a lie. *The Houston Chronicle*. November 30, p. 10.
Bell, E., Mathieu, G., & Racine, E. (2009). Preparing the ethical future of deep brain stimulation. *Surgical Neurology, 72*(6), 577–586.
Bell, E., Maxwell, B., McAndrews, M. P., Sadikot, A., & Racine, E. (2010). Hope and patient expectation in deep brain stimulation: healthcare provider perspectives and approaches. *Journal of Clinical Ethics, 21*(2), 113–125.
Bennett, C. M., & Miller, M. M. (2010). How reliable are the results from functional magnetic resonance imaging. *Annals of the New York Academy of Sciences, 1191*, 133–155, The year in Cognitive Neuroscience.
Blakeslee, S. (1997). How brain stores languages. *Plain Dealer*. July 27, p. 2J.
Blakeslee, S. (2000). Reading the brain: new imaging technique lets doctors see inside, but some question hot it is used. *Plain Dealer*. March 20, p. 1F.
Brendel, D. H. (2006). *Healing psychiatry: Bridging the science/humanism divide*. Cambridge, MA: MIT Press.
Bubela, T. M., & Caulfield, T. (2004). Do the print media "hype" genetic research? A comparison of newspaper stories and peer-reviewed research papers. *Canadian Medical Association Journal, 170*(9), 1399–1407.
Bucchi, M. (2004). *Science in society: An introduction to social studies of science*. London: Routledge.
Bucchi, M., & Mazzolini, R. G. (2003). Big science, little news: science coverage in the Italian daily press, 1946–1997. *Public Understanding of Science, 12*(1), 7–24.
Bush, G. H. W. (1990). *Presidential proclamation 6158, decade of the brain project*. Library of Congress. http://www.loc.gov/loc/brain/proclaim.html July 17.
Callahan, D. (1976). Bioethics as a discipline. In J. Humber, & R. F. Almeder (Eds.), *Biomedical ethics and the law* (pp. 1–11). New York: Plenum Press.
Caulfield, T. (2004). The commercialisation of medical and scientific reporting. *PLoS Medicine, 1*(3), e38.
Changeux, J.-P. (1983). *L'homme neuronal*. Paris: Hachette.
Charlton, B. (1996). How to get inside the thinking brain. *The Times*. February 5.
Churchland, P. S. (1986). *Neurophilosophy: Toward a unified science of the mind-brain*. Cambridge, MA: Bradford Book/MIT Press.
Colburn, D. (1999). The infinite brain; people used to think the brain was static and inevitably declined with age. *The Washington Post*. Washington, September 28, p. Z12.
Connor, S. (1995). Science; The last great frontier; the brain is the ultimate enigma. *The Independent*. May 21, p. 52.
Cook, G. (2001). Plumbing the mystery of prayer with the instruments of science. *The Boston Globe*. Boston, May 3, p. A2.
Cummins, H. J. (1997). What's on baby's mind? Researchers studying how an infant's brain develops are intrigued by what's going on in the heads of their tiny subjects. *Star Tribune*. Minneapolis, August 27, p. 6A.
Davis, R. (1998). Brain 'map' raises hope of finding better ways to teach dyslexics to read. *USA Today*. March 3, p. 6D.
Derrington, A. (1998). We know what you are thinking: the nature of things: spin doctors are delving deeper into our grey matter. *Financial Times*. London, January 3, p. 2.
Desmond, J. E., & Chen, S. H. A. (2002). Ethical issues in the clinical application of fMRI: factors affecting the validity and interpretation of activations. *Brain and Cognition, 50*(3), 482–497.
Dobson, R. (1997). Navigating the maps of the mind; the latest advancements in mind mapping will bring us closer to solving the age-old mysteries of the brain. *The Independent*. London, March 9, p. 40.
Dudai, Y. (2004). The neurosciences: the danger that we think that we have understood it all. In D. Rees, & S. Rose (Eds.), *The new brain sciences: Perils and prospects* (pp. 167–180). Cambridge: Cambridge University Press.
Eakin, E. (2000). Looking for that brain wave called love; humanities experts use M.R.I.'s to scan the mind for the locus of the finer feelings. *The New York Times*. New York, October 28, p. 11.
Einsiedel, E. F. (2008). Public engagement and dialogue: a research review. In M. Bucchi, & B. Smart (Eds.), *Handbook of public communication on science and technology* (pp. 173–184). London: Routledge.
Ethics, Law, and Humanities Committee of the American Academy of Neurology. (2001). Practice advisory: participation of neurologists in direct-to-consumer advertising. *Neurology, 56*(8), 995–996.
Fackelmann, K. (2001). $3 million brain scanner is new weapon in drug fight. *USA Today*. February 1, p. 9D.
Farah, M. J. (2009). A picture is worth a thousand dollars. *Journal of Cognitive Neuroscience, 21*(4), 623–624.
Frazzetto, G., & Anker, S. (2009). Neuroculture. *Nature Reviews Neuroscience, 10*(11), 815–821.
Fulford, K. W. M., & Hope, T. (1994). Psychiatric ethics: a bioethical ugly duckling? In R. Gillon (Ed.), *Principles of healthcare ethics* (pp. 681–695) New York: Wiley.
Giridharadas, A. (2008). India's novel use of brain scans in courts is debated. *The New York Times*. September 14, p. A10.
Gray, A. J. (2002). Stigma in psychiatry. *Journal of the Royal Society of Medicine, 95*(2), 72–76.
Greely, H. T., & Illes, J. (2009). Neuroscience-based lie detection: the urgent need for regulation. *American Journal of Law and Medicine, 33*(2–3), 377–431.
Hales, D. (1998). Gray matters. *Columbus Dispatch*. July 29, p. 1G.
Hall, C. T. (2001). Fib detector; study shows brain scan detects patterns of neural activity when someone lies. *The San Francisco Chronicle*. November 26, p. A10.
Hall, S. S. (1999). Journey to the center of my mind. *The New York Times*. June 6, p. 122.
Hellmore, E. (1998). She thinks she believes in God. In fact, it's just chemical reactions taking place in the neurons of her temporal lobes; Science has gone in search of the soul. *The Observer*. May 3, p. 20.
Henderson, M. (2001). Optimists owe it all to the brain. *The Times*. February 5.
Henderson, M. (2002). Hypnosis really does turn red into white. *The Times*. February 18.
Hsu, M., Anen, C., & Quartz, S. R. (2008). The right and the good: distributive justice and neural encoding of equity and efficiency. *Science, 320*(5879), 1092–1095.

Huttson, M. (2007). Neurorealism. *New York Times Magazine*. December 9, p. 84.
Hyman, S. E. (2007). The neurobiology of addiction: implications for voluntary control of behavior. *American Journal of Bioethics, 7*(1), 8–11.
Illes, J., Kirschen, M. P., & Gabrieli, J. D. (2003). From neuroimaging to neuroethics. *Nature Neuroscience, 6*(3), 205.
Illes, J., Moser, M. A., McCormick, J. B., Racine, E., Blakeslee, S., Caplan, A., et al. (2009). Neurotalk: improving the communication of neuroscience research. *Nature Reviews Neuroscience, 11*(1), 61–69.
Johnstone, A. (2004). A glimpse inside; it's what many parents and teachers have long suspected: teenagers may actually go temporarily insane on the path to maturity. *The Herald*. November 23, p. 2.
Kandel, E. R. (1998). A new intellectual framework for psychiatry. *American Journal of Psychiatry, 155*(4), 457–469.
Larson, P. S. (2008). Deep brain stimulation for psychiatric disorders. *Neurotherapeutics, 5*(1), 50–58.
Liacoboni, M., Freedman, J., Kaplan, J., Hall, K., & Freedman, T. (2007). This is your brain on politics. *The New York Times*. November 11.
Lubrano, A. (1997). *Scientists spot site of addictive craving in the brain*. New Orleans: Times-Picayune. December 7.
Macdermid, A. (1997). Hi-tech hairnet that reads minds. *The Glasgow Herald*. January 23, p. 24.
Marcus, S. J. (Ed.). (2002). *Neuroethics: Mapping the field, conference proceedings*. New York, NY: The Dana Foundation.
Mcnaught, A. (1996). Brain waves. *The Scotsman*. May 6, p. 11.
Mendenhall, D. (2002). Marcel Just: discovering why the brain can't do two things at once. *Pittsburgh Post-Gazette*. January 1, p. D-3.
Mountcastle-Shah, E., Tambor, E., Bernhardt, B. A., Geller, G., Karaliukas, R., Rodgers, J. E., et al. (2003). Assessing mass media reporting of disease-related genetic discoveries. *Science Communication, 24*(4), 458–478.
Nagourney, E. (2001). Vital signs: patterns; surprise! Brain likes thrill of unknown. *The New York Times*. April 17, p. 6.
Nelkin, D. (2001). Beyond risk: reporting about genetics in the post-Asilomar press. *Perspectives in Biology and Medicine, 44*(2), 199–207.
Noble, H. B. (1999). Pain at work: startling images and new hope. *The New York Times*. August 10, p. F1.
No lie MRI. (2010). http://noliemri.com June 9.
Racine, E. (2010a). Neuroscience and the media: ethical challenges and opportunities. In: J. Illes and B. Sahakian. *Oxford handbook of neuroethics*. Oxford. Oxford University Press, in press.
Racine, E. (2010b). *Pragmatic neuroethics: Improving understanding and treatment of the mind–brain*. Cambridge, MA: MIT Press.
Racine, E., Bar-Ilan, O., & Illes, J. (2005). fMRI in the public eye. *Nature Reviews Neuroscience, 6*(2), 159–164.
Racine, E., Bar-Ilan, O., & Illes, J. (2006). Brain imaging: a decade of coverage in the print media. *Science Communication, 28*(1), 122–142.
Racine, E., Bell, E., & Illes, J. (2010). Can we read minds? Ethical challenges and responsibilities in the use of neuroimaging research. In J. Girodano, & B. Gordijn (Eds.), *Neuroethics: Scientific, philosophical, and ethical perspectives* (pp. 240–266). Cambridge: Cambridge University Press.
Racine, E., DuRousseau, D., & Illes, J. (2007). From the bench to headlines: ethical issues in performance-enhancing technologies. *Technology, 11*(1), 37–54.
Racine, E., Gareau, I., Doucet, H., Laudy, D., Jobin, G., & Schraedley-Desmond, P. (2006). Hyped biomedical science or uncritical reporting? Press coverage of genomics (1992–2001) in Québec. *Social Science & Medicine, 62*(5), 1278–1290.
Racine, E., Van der Loos, H. Z. A., & Illes, J. (2007). Internet marketing of neuroproducts: new practices and healthcare policy challenges. *Cambridge Quarterly of Healthcare Ethics, 16*(2), 181–194.
Racine, E., Waldman, S., Palmour, N., Risse, D., & Illes, J. (2007). "Currents of hope": neurostimulation techniques in U.S. and U.K. print media. *Cambridge Quarterly of Healthcare Ethics, 16*(3), 312–316.
Sample, I., & Adam, D. (2003). The brain can't lie: brain scans reveal how you think and feel and even how you might behave. No wonder CIA and big businesses are interested. *The Guardian*. November 20, p. 4.
Schwartz, L. M., Woloshin, S., & Baczek, L. (2002). Media coverage of scientific meetings: too much, too soon? *The Journal of the American Medical Association, 287*(21), 2859–2863.
Sider, R. C. (1984). The ethics of therapeutic modality choice. *American Journal of Psychiatry, 141*(3), 390–394.
Spinney, L. (2001). Science: are you guilty? It's all in the mind: a new test is being used to detect guilt memories in suspects. *The Independent*. January 12, p. 8.
Squires, S. (1999). You must remember this… as time goes by, scientists learn more about how the brain creates memories. And sometimes loses them. *The Washington Post*. December 14, p. Z10.
Stein, R. (1997). Neurobiology: 'multitasking' seems to tax learning. *The Washington Post*. August 11, p. A02.
Terry, S. (2000). 'Brain' defense tests notions of guilt. *Christian Science Monitor*. Boston, July 10, p. 1.
Trebel, J. (1966). Journalism: public enlightenment or private interest? *Annals of the American Academy of Political and Social Science, 363*(1), 79–86.
Vedantam, S. (1996). Imaging techniques illuminate the brain. *The Houston Chronicle*. May 9, p. A15.
Wahlberg, D. (2002). Why cooperate? It's a pleasure, says Emory study. *The Atlanta Journal-Constitution*. July 18, p. 1C.
Weaver, F. M., Follett, K., Stern, M., Hur, K., Harris, C., Marks, W. J., Jr., et al. (2009). Bilateral deep brain stimulation vs best medical therapy for patients with advanced Parkinson disease: a randomized controlled trial. *Journal of American Medical Association, 301*(1), 63–73.
Woloshin, S., & Schwartz, L. M. (2006). Media reporting on research presented at scientific meetings: more caution needed. *The Medical Journal of Australia, 184*(11), 576–580.
Wolpe, P. R. (2002). The neuroscience revolution. *Hastings Center Report, 32*(4), 8.
Wolpe, P. R., Foster, K. R., & Langleben, D. D. (2005). Emerging neurotechnologies for lie-detection: promises and perils. *American Journal of Bioethics, 5*(2), 39–49.
World Health Organization. (2005). International classification of diseases (ICD-10). http://www3.who.int/icd/vol1htm2003/fr-icd.htm Available at ICD-10.
Young, L., & Saxe, R. (2008). The neural basis of belief encoding and integration in moral judgment. *Neuroimage, 40*(4), 1912–1920.
Zuckerman, D. (2003). Hype in health reporting: "checkbook science" buys distortion of medical news. *International Journal of Health Services, 33*(2), 383–389.