SCIENCE AND SOCIETY

Neurotalk: improving the communication of neuroscience research

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Abstract | There is increasing pressure for neuroscientists to communicate their research and the societal implications of their findings to the public. Communicating science is challenging, and the transformation of communication by digital and interactive media increases the complexity of the challenge. To facilitate dialogue with the public in this new media landscape, we suggest three courses of action for the neuroscience community: a cultural shift that explicitly recognizes and rewards public outreach, the identification and development of neuroscience communication experts, and ongoing empirical research on the public communication of neuroscience.

"That science has become more difficult for non-specialists to understand is a truth universally acknowledged."[1]

Neuroscientists are faced with an important challenge. With the development of powerful new research tools, they are gaining a better understanding of the biology of the brain every day. At the same time, this progress is prompting many questions about the personal, social, moral and spiritual choices that humans make. These factors conspire to place increasing pressure on neuroscientists to discuss both their scientific research and the ethical implications of their findings. The interactions between neuroscience and society, and the debates triggered by the social implications of neuroscience findings, can ultimately inform public policy[2,3].

Although translating and disseminating new knowledge is a fundamental responsibility for all scientists, neuroscience is among several scientific disciplines that are particularly prone to misinformation and inaccurate reporting. Sensational media headlines that evoke mind reading, a neurogenetic basis for fidelity or voting patterns, memory boosters for the healthy, and miracle cures for sensory and movement disorders are but a few examples. Without accurate and sufficient background information or context, the public — who are naturally interested in diseases and cures, especially with regard to common and serious brain disorders — may accept these simplistic messages uncritically[4]. The power of brain imaging techniques, such as functional MRI, further feeds into this problem, with the potential for brain scan images to create biases in the laboratory, the clinic and the courtroom[5–7].

The interest in the neurological basis of individual and social behaviour has also generated a considerable number of 'neurologisms' — new terms for the complex and varied phenomena arising at the intersection of brain science and society — including neuroethics, neuromyths, neurorealism, neuromarketing and neurotalk. Some of these terms, such as neurotalk and neuroethics, bring ideas for a dedicated new practical and scholarly effort to the foreground. Others, such as neurorealism[8] and neuromyths[9], highlight how the seductive allure of neuroscience explanations can confer an unwarranted sense of objectivity based on the general hype that surrounds contemporary science and technology[10].

Not all science in the public domain is treated equally. Like the science behind genetically modified foods and nanotechnology, neuroscience combines high public relevance with rapidly advancing technologies. Everyone has a stake in understanding how the brain works. Neuroscientists, as members of academic and professional organizations, recipients of public funds and beneficiaries of scientific advances, have a stake in public outreach. Many are already actively engaged in furthering public understanding of the brain. However, the growing emphasis on social accountability in science, along with the interest of the public in the brain, creates a clear need for more efficient and accessible approaches to communication of neuroscience by neuroscientists and the participation of scientists in public debates about societal norms and social policy.

As outlined in BOX 1, there are substantial challenges facing the communication of neuroscience[11,12]. How can neuroscientists successfully tackle these challenges at the same time as achieving their research programme goals? Over the past decade, science communication has expanded beyond unidirectional efforts that aim to convey accurate messages about new scientific findings to the public, although this remains an important goal. The expectation of the public for meaningful engagement and dialogue on ethical and social issues that are generated by science has led to more interactive and multidirectional communication approaches[13]. The public expects to provide input on the direction of scientific research, and neuroscientists themselves are often apprehensive about society's response to the potential of new knowledge and tools. In this regard, there has been a recent wave of calls to increase the direct interaction of scientists with journalists and the public[14–17]. However, for individual scientists, the time required for such successful science communication efforts is considerable. This is especially the case if, as in this article, communication is

Box 1 | **Specific challenges for neuroscience communication**

Complexity of the brain
Conveying information about intricate molecular pathways, their interactions and their impact as understanding about the brain continues to emerge from varied neuroscience subspecialities.

Personal, philosophical and religious salience to mind and body
Advancing scientific inquiry into brain function and biology-based causes of behaviour that challenges the nature of 'belief', leading to new definitions of normal behaviour, increased understanding of how humans think and learn, and potentially socially charged attributions of moral responsibility.

Burden of CNS disease and impact on public health
Addressing the overwhelming personal and societal impact of diseases of the CNS, which engenders high awareness of, unfettered hope for and unsubstantiated hype around neuroscientific discoveries relating to diagnoses, treatments and cures.

Stigma of neurological and mental health disorders
Navigating negative social perceptions that persist about the causes of, and reasons for, mental health disorders and make meaningful public discussions about these conditions difficult if not impossible.

considered to include both the dissemination of accurate accounts of neuroscience to the layperson and public engagement activities that tend to be two-way forums for debate and dialogue.

In this article, we suggest advances on several fronts that will initiate a sustainable long-term change for individual scientists and the broader research community. Our recommendations aim to support the goals of neuroscience literacy (understanding the science) and public engagement in discussions about what this science can tell us about ourselves (ethical and societal issues). These recommendations can facilitate public engagement with knowledge from neuroscience that is used in everyday life, including how we make decisions, how we understand common diseases such as depression and Alzheimer's disease, how we deal with addictions and how we conceptualize mind, body and soul. The science and the ethics cannot be separated because the science itself presents new ethical questions. As neuroscientists better understand brain activity, definitions of normal behaviour will be newly debated, our understanding of how humans think and learn will increase, and questions will be raised about personal identity, individual privacy and privacy of thought.

We suggest three courses of action that should be implemented to address the challenges outlined above: a cultural shift within the scientific community, the creation of a cohort of neuroscience communication specialists and the growth of empirically driven research on science communication. The recommendations presented take into account the communication challenges that are specific to neuroscience in the new era of digital and interactive media.

Communication challenges

Trust, reciprocity and transparency. A climate of trust, reciprocity and transparency is essential for any science that depends on the public for funding and for public participation in research[18,19]. Creating and maintaining such a climate poses several challenges for neuroscience. A record of misrepresentative or sweeping claims, for example, can jeopardize trust and raise false expectations[20]. Neuroscience may be particularly vulnerable to exaggerated claims, such as 'God spots in the brain', because its findings can challenge widely held assumptions about sensitive social and behavioural phenomena.

There is also great potential for misunderstanding arising from the inherent complexity of neuroscience. As the number of neuroscience specializations — such as neuroeconomics (focusing on the neurobiology of decision making) or neurolaw (aiming to discover how neuroscience can inform questions about justice) — grows, we gain new knowledge. However, each additional specialization produces a new set of complex terms and concepts[1]. The challenge is to create a climate of trust and transparency while being aware of the need to distil complex new knowledge into an accessible form when presenting it to the public. To begin to achieve this, especially when scientific inquiry is directly related to personal and intangible human phenomena such as identity or individuality, communication about the evolving science should begin before any specific findings are relayed. This would demystify the science by keeping the focus on progress and away, for example, from fear-provoking notions about 'forbidden knowledge' or the reduction of people to neurons. Even with many studies of this nature already published or underway[21], it is not too late to work towards narrowing the gap between the complexity of data and public understanding; now is better than never.

Openness about the potential and limitations of the research can also provide a framework in which to engage the public on ethical questions. Although this may mean that neuroscientists could be constrained in the short term, public input on research direction is likely to produce larger long-term gains. The research community needs to embrace the outcomes of scientifically informed debate, trusting that it will lead to good policy decisions based on empirical evidence. To this end, multidirectional communication and mutual learning are crucial objectives[8,22].

Academic rewards for communication and outreach. Another challenge facing neuroscience communication is its emergent status in academic culture. Over the past 30 years, several successful strategies to improve the science–media relationship have been implemented. These include the development of guidelines for researchers on how to interact with the media and training workshops to prepare scientists for contact with journalists. One study of more than 1,300 researchers in 5 countries[23] reported a high rate of interaction between biomedical scientists and journalists and a high level of satisfaction with these interactions. These initiatives reflect an increased willingness in the scientific community to engage in public dialogue about research. However, there is room for improvement: academic recognition and merit systems provide little or no credit for endeavours to communicate science to the public, such as writing opinion editorials and books for the general public, giving media interviews or public lectures and volunteering in local classrooms. Efforts to popularize science can sometimes stigmatize a researcher and even compromise professional credibility[24,25]. Even when this sentiment is absent, many scientists may feel that their outreach and media work will not be considered a comparable accomplishment to a publication or grant. Some neuroscientists experience frustration when their results are reported in sound bites, and journalists are often frustrated by scientists' reluctance to speak candidly about their findings and lack of skills in doing so[26].

New social and interactive media. The new digital era presents both a challenge and an opportunity for all science communication. New ways of communicating using

social network platforms that fall into the category of Web 2.0 (for example, Facebook and YouTube) have flourished in recent years. People under the age of 21 receive and absorb the bulk of their information through television and the internet. Indeed, 40 million people in in the United States now rely on the internet as their primary source for science news and information[27]. Although most of these users are reasonably wealthy and educated, with 40% possessing college degrees and another 32% having completed at least some college coursework, the internet is used as a source of information by individuals from many walks of life (Demographics of Internet Users, Pew Internet and American Life Project; see Further information). Obtaining medical, health and current events information is the sixth most popular use of the internet (Internet Activities, Pew Internet and American Life Project; see Further information). Twitter, a tool that permits only telegraphic-type messaging, is one of the latest technologies to be embraced by young adults (Twitter and status updating, Pew Internet and American Life Project; see Further information). The rapid changes introduced by interactive media are dramatically affecting traditional forms of journalism and means of communication. Although these digital tools open up new and creative ways of communicating neuroscience directly and interactively to the public (TABLE 1), their advantages and limitations have not been fully explored. In particular, it is not yet clear how neuroscientists are adjusting to the diverse new forms of media. Should neuroscientists be paying attention to these new tools? To reach today's generation on a global scale[14], it would seem that the answer to this question is yes.

Table 1 | **Advantages and disadvantages of interactive media for neuroscience communication**

Description	Advantages	Disadvantages
Podcast		
An audio or video broadcast that can be downloaded to a computer, PDA (personal digital assistant) or mobile phone	• Can convey a great deal of information in a form that is brief and easily understood • Room for creativity in explanations (graphics, sound effects and humour) • Ubiquitous to the Web • Likely to increase in popularity within the next 5 years • Technically easy to distribute, via iTunes, YouTube, blip.tv and many more channels	• Requires some technical skill to produce • Short length is challenging for the complexity inherent to neuroscience information • Requires some marketing and partnership for promotion
Blog		
A website used to log activities, thoughts, events, and other media such as pictures and videos; similar to an online daily column	• A contemporary mainstream format for news • Can be updated easily, quickly and frequently • Can include all types of media (photos, illustrations and interactive graphics) • The current gap in the 'blogosphere' for good, accessible neuroscience is a growth opportunity	• Current neuroscience blogs tend to be exclusive, written by and for experts using expert language that is inaccessible to the public • Requires some technical knowledge of back-end interfaces • Requires good partnerships with known brands and excellent marketing to reach the mainstream public
Twitter		
Text-based posts of up to 140 characters; updates are displayed by followers	• Extremely easy interface • Can be easily and frequently updated • Feeds can be updated by numerous people • Feeds are public and do not require subscription or membership • Dynamic owing to interactive messaging • Growing audience base • Few feeds are currently focused on neuroscience and there is therefore growth opportunity	• Launch of a Twitter feed requires some technical knowledge • Must be updated daily to keep audience engaged • Brevity is a given, so communication of complex topics is limited
Online discussion forum		
Public conversation through the World Wide Web	• Available to the global community • A topic thread can be ongoing • Hyperlinks to brain images and other neuroscience sites augment text-based discussions • Archived for future referencing • Driven by both neuroscientists and non-experts, who can suggest topics	• Requires a curator to ensure accurate and meaningful dissemination of information and prevent the propagation of 'neuromyths'
Salon		
An informal panel discussion in which a host presents topics for debate among panelists and an audience	• Provide opportunities to meet neuroscientists • Moderator can facilitate communication between scientists and the public • Can be webcasted live and recorded for later use • Clarifications can be made in real-time	• Limited to local community • Topics controlled by moderator • Often a one-time event
Café scientifique		
A public lecture and discussion, usually in a coffee house or other informal public setting	• Opportunities for neuroscientists and the public to interact in a casual setting • 'Neuromyths' can be corrected in real-time	• Limited to local community • Requires comfort and skill in speaking with public extemporaneously

Neurotalk recommendations

Against the backdrop of the communication challenges described above and existing initiatives to promote communication (TABLE 2), we present three recommendations to improve the communication of new neuroscience knowledge in a socially accountable way (TABLE 3). The aim of these recommendations is to equip a new generation of neuroscientists with the tools to communicate their findings in two interconnected ways. One aims to advance neuroscience literacy — the science itself. The other aims to engage the public, in parallel with scientific research itself, in broader dialogues about neuroscience and society. These communication goals are connected because ethical issues often arise when new empirical data trigger the reconsideration of individual and social norms (BOX 2).

Promote a cultural shift. Owing to the increasing relevance of neuroscience to society, the communication of neuroscience research needs to be made a priority in the professional community, similar to protecting the rights of human subjects and ensuring appropriate animal care in research. Institutional support, which is required to advance this goal, begins with explicitly valuing the effort. Developing a process for valuing communication will be no less complex than the composite metrics that are used today, for example, for valuing productivity in peer-reviewed publications from a combination of raw numbers of papers, journal impact factor and individual publication impact. However, journal impact factor and individual publication impact cannot be applied to science communication products. We propose that audience size and evaluations, and local, national and international reach can serve as first proxy measures of impact. These measures must ultimately be factored into the evaluation of junior researchers for promotion and of more senior researchers for advancement. Awards that recognize excellence in communication, such as the Society for Neuroscience Science Educator Award and the Wellcome Trust Broadcast Development Awards, are important signals of commitment and success. Other long-term rewards should take the form of time off from teaching, research or administration. These changes will entail costs, both financially and in personal effort. Nevertheless, those who are already skilled in neuroscience communication must step forward to help achieve these goals with mentorship and action.

Table 2 | **Examples of professional programmes for training and public engagement**

Programme or resource	Description
Society for Neuroscience (SfN)	
Guide to Public Advocacy	• A resource for individuals interested in communicating the importance of biomedical research to elected officials, the press and the general public • Provides tools, information and tips on how to be an effective advocate
Brain Facts	• A comprehensive and accessible introduction to neuroscience, designed for lay audiences and school students
Neuroscience Wikipedia Initiative	• Aims to improve the accuracy, breadth and accessibility of neuroscience content available to the public and to facilitate society members participating in public communication activities • Members are encouraged to review and update Wikipedia's neuroscience content and there are plans to engage trainees in the efforts as part of their coursework
Neuroscience Education Resources Virtual Encycloportal (NERVE)	• A dynamic online gateway providing easy access to over 300 reliable educational resources in neuroscience
Dana Alliance for Brain Initiatives (DABI)	
Brain Awareness Week (BAW)	• An annual celebration of the brain, uniting the efforts of universities, hospitals, patient advocacy groups, professional associations, government agencies, service organizations and primary and secondary schools around the world
Brainy Kids	• Online science resources for students, teachers and parents
Brain Expert Directory	• Provides members of the media access to DABI members, more than 280 leading experts in neuroscience who are willing to assist in the reporting of neuroscience news
International Brain Research Organization (IBRO)	
The Brain Campaign	• Provides small grants to assist groups in organizing public education events to promote understanding of the brain in IBRO's African, Latin American and Asian/Pacific regions • Supporting resources on how to design, organize and advertise events and interact with the press
The Banff Centre	
Science Communications Program	• A career-development summer residency for scientists, journalists, public- and private-sector communications professionals and educators responsible for communicating about science
AAAS Center for Public Engagement with Science and Technology	
Communicating Science: Tools for Scientists and Engineers	• Science communication workshops and online resources including 'webinars', how-to tips for media interviews, strategies for identifying public-outreach opportunities, and links to articles, books and other websites
Wellcome Trust Fund	
Science Media Production Internships	• Studentships offering financial support for practising biomedical scientists to undertake a postgraduate qualification in science media production at Imperial College London and to then use these skills in a 6-month internship working in the broadcast industry

Some steps towards the cultural shift can be immediately implemented, such as increasing the professional value of delivering public lectures, media work and the development of training activities designed specifically for neuroscientists. Other actions, such as the full integration of communication training into neuroscience curricula and graduate training, will require longer-range planning and a more fundamental culture shift, given already heavily laden schedules. For neuroscientists, the overall continued development of specialized training sessions, online course modules and 'boot camps' at professional meetings or local institutions will help to achieve this culture shift.

Indeed, some actions have been taken and investments made towards this goal. For example, the American Association for the Advancement of Science (AAAS) sponsors a summer internship programme that places graduate and postgraduate students studying science, engineering and mathematics at media organizations nationwide; participants "come in knowing the importance of translating their work for the public, but they leave with the tools and the know-how to accomplish this important goal" (The AAAS Mass Media Science & Engineering Fellows Program; see Further information). An intensive science communication programme for scientists, journalists and communications professionals takes place each year at the Banff Centre in Alberta, Canada. This immersive residency programme encourages mid-career professionals to initiate creative science communication projects, with the goal of fostering a broad,

Table 3 | **Recommendations and action for improving neuroscience communication**

Individual neuroscientists	Academic institutions	Professional organizations	Research sponsors
Introduce and promote a shift in academic culture			
• Give public lectures; participate in public discussions and debates • Support the efforts of trainees and junior faculty to lead interactive public events • Explore and become familiar with uses of new media • Organize local training opportunities, including interactions with experienced communicators and journalists • Participate in ongoing research, including the identification of the needs and priorities as well as the qualities of good neuroscience communicators	• Develop metrics for valuing neuroscience communication towards career advancement • Invest in opportunities for internships and attendance by trainees and faculty at communication programmes • Provide financial and staff resources for faculty and trainee-led public events • Provide time off from teaching, research and administration for neuroscience communication • Attribute awards for outstanding public-communication accomplishments • Integrate neuroscience communication into graduate training curricula • Consider neuroscience communication accomplishments in the evaluation of faculty for promotion and advancement	• Build on existing programmes to create customized communication programmes for neuroscience • Proactively encourage academic institutions to include neuroscience communication activities in faculty career advancement	• Support neuroscience communication in requests for proposals and open competitions • Develop funding opportunities for public engagement activities and collaboration
Train and support communication specialists in neuroscience			
• Volunteer to serve as neuroscience communicators and knowledge brokers • Pursue specialized training experiences for all aspects of neuroscience communication: basic, clinical, ethical and societal • Provide mentorship to junior faculty and develop relevant curricula • Master new forms of communication tools such as podcasts and webcasts • Actively attend to neuroscience in the news and be available to clarify and comment • Develop relationships with trusted journalists and disseminate potentially newsworthy results	• Send trainees and faculty who self-identify and who exhibit potential excellence in neuroscience communication to specialized programmes • Identify excellent communicators and nurture them with academic currency • Develop cross-disciplinary academic programmes that will yield Master's- and PhD-level experts in neuroscience communication	• Create new programmes for neuroscience communication and public engagement • Provide material and resources for quotes and easy fact checking in press coverage • Enable journalists to acquire specialized training in neuroscience	• Create funding opportunities for training in neuroscience communication
Develop and carry out research in communication and public engagement			
• Develop and participate in research on science communication and public engagement • Explore and embrace relevant new research approaches and methods to support evidence-based practices • Engage in the development, implementation and testing of new initiatives on public neuroscience literacy • Encourage trainees showing interest in an alternative career in science to pursue research on communication and public and engagement	• Seed in-house pilot research on neuroscience communication and public engagement • Create metrics for the outcome and impact of communication and public engagement • Encourage the evaluation of public events and recognize excellence • Value interdisciplinary collaboration and grant funding in neuroscience communication • Encourage flexibility in training curricula to take into account new empirical data on neuroscience communication	• Update existing tools and create new programmes based on emerging empirical data.	• Develop dedicated research funding opportunities in the area of neuroscience communication and public engagement

Box 2 | **Impact of recommendations on neuroscience communication**

The overall aim of these recommendations is to substantially improve the essential conversations between the public and neuroscientists about the science and the ethical, social and policy implications of ongoing research.

Promote a cultural shift

- Investment and professional incentives that promote communication and engagement with the public.
- Interaction of neuroscientists at all career stages with the public.
- Venues and opportunities for the public to learn directly from neuroscientists and to share views about advances in neuroscience.

Create communication specialists

- Neuroscience communication specialists who are skilled in engaging and interacting with the public.
- Legitimized efforts of neuroscientists who are keen to engage with the public.
- New partnerships between science journalists and public-relations professionals and the neuroscience community.

Enable research on neuroscience communication

- New methods for communicating neuroscience to the public, based on empirical data.
- Identification of gaps in, and barriers to, neuroscience communication.
- Responsiveness to public desire and the need for knowledge based on scientific evidence.

ethical and more engaging role for science in public culture. Both of these programmes cater to all scientific disciplines. We recommend that these initiatives be extended directly to neuroscience to create focused communication internships for trainees or mid-career researchers and opportunities to be immersed as neuroscience communication experts. Organizations that already have communication development programmes should customize new ones for neuroscience and use their experience to guide others who wish to embark on new initiatives.

Some programmes aimed specifically at neuroscience led, for example, by the International Brain Research Organization, the Dana Alliance for Brain Initiatives, the Federation of European Neuroscience Societies and the Society for Neuroscience, already have prominence. For example, the Society for Neuroscience has endorsed public education as a key component of its strategic plan and published Neuroscience Core Concepts[28], a document for use by both elementary school and secondary school educators and the general public that lays out fundamental principles about the brain and nervous system. Another excellent resource, The Brain from Top to Bottom, has been created by the Canadian Institute of Neuroscience, Mental Health and Addiction (see Further information). The neuroscience research community can support the further development, awareness and uptake of these resources by increasing the prominence of communication in the community and the accountability of the individuals on the task.

A commitment to culture shift will also urge funders of neuroscience research to encourage or even require information on plans for knowledge translation, public engagement and outreach. For example, the National Science Foundation, which funds basic research across all disciplines, including behavioural and neurobiological sciences, already has a requirement for a societal impact review. In Canada, many requests for applications and proposals have explicit requirements for knowledge translation. Funding agencies that primarily support neuroscience research could adopt this approach by similarly requiring the inclusion of societal impact in submitted proposals and funding opportunities for knowledge translation and public engagement. Although the current economic climate presents difficulties, the prevailing view in science policy is that investment in the future of science and the research and development workforce through education is needed. Indeed, the 2009 American Recovery and Reinvestment Act included provisions for science, technology, engineering and mathematics education at all levels, as did the earlier American Competitiveness Act of 2007.

Neuroscience trainees and neuroscience training curricula should be at the core of the culture shift in communication education and funding. It is important to train doctoral students not just to be experts in a specific field or subfield but also to uphold the integrity of their discipline and to commit to generating new knowledge and critically evaluating that knowledge. This will help them to understand and appreciate how their work fits into the larger intellectual framework and social landscape as well as to communicate information clearly and effectively to a broad range of audiences[29]. Communications internships can become required components of traditional training curricula. Accreditation and certification for participation are legitimate goals and are measurable. Rigorous interdisciplinary Master's level and Ph.D. programmes that span schools of journalism and faculties that include neuroscience programmes can be developed, making use of the expertise that is available in these different domains. The leadership of those who are more senior in their careers is vital, but a new flexibility that promotes engagement in communication will be most effective if focused on the younger generation — the next stewards of the neuroscience discipline.

Support neuroscience communication specialists. Specialized training of journalists, editors and neuroscientists is needed to promote effective communication of important neuroscience findings and considerations of their ethical, social and policy impact. We propose that specialists from both the academic and non-academic neuroscience community who can serve as specialists or ambassadors in neuroscience communication should be identified and should bring their interests to the attention of their supervisors, faculty heads and deans. Neuroscientists are not generally trained in communications or in emerging new media and, among those who are, skills are variable. It is not reasonable to assume that all scientists will be able to acquire the specialized skills needed to communicate effectively in any medium, even with the heightened level of exposure to science communication training and activity we suggest above. Although all neuroscientists need to be aware of the public discussions surrounding neuroscience and the increasingly diverse means by which it is circulated through online, print, television and radio sources, a cohort of skilled neuroscience ambassadors who are involved in neuroscience research programmes could become experts in new communication tools. These individuals would work with each other, other science communication experts at institutional press offices, journalists and their own colleagues and students to foster the communication of accurate and contextualized information. They could become neuroscience 'knowledge brokers' by linking the creators of new knowledge with

recipients, and could increase the quantity and calibre of communications activity by providing education about and access to new knowledge[30]. They could explore creative uses of new media tools and develop strategic communications for engaging the public using new media platforms. An investment in specialized programmes, such as expert workshops in which neuroscientists and journalists exchange knowledge and know-how, will be an additional powerful tool in achieving this goal.

The need for such experts is further amplified by the rapid flow of information through continually emerging non-peer reviewed, non-curated publications and Web postings. Organizations and researchers can disseminate their own information directly to the public through blogs and websites. Filtering and discerning high-quality information in this new landscape is time consuming and will require dedicated and reliable specialists who can provide services for the wider community.

Enable research on neuroscience communication. More empirical data are needed on neuroscience communication. It is imperative to understand the receptivity to, motivation for and barriers to communication of both neuroscience findings and their social impact. The complexities of commercialization and partnerships between academia and industry, including conflicts of interest and intellectual property and risks to the privacy of brain data, expand this imperative[17,31]. In parallel, the opportunity also exists to gather data about public engagement activities in the neuroscience field, to improve these activities and to re-engage the communicators. These initiatives will require seed funding for pilot projects from within institutions and funding from research sponsors. This could take the form of funding that is specifically allocated to meet this objective, as well as support for a communication component of projects that are not specifically focused on communication.

To understand the willingness of scientists to engage in discussions about ethical and social issues in neuroscience, including science communication, large-scale studies of researchers whose work involves neuroimaging, neurodegenerative disease or both have been conducted. More than 600 neuroimagers, for example, reported considerable interest in these topics, motivated both by internal factors (because it is personally the right thing to do) and by external factors (to respond to the public's right to know)[32]. This study also elucidated barriers to communication, including lack of time, lack of sufficient expertise and lack of opportunity for collaboration with ethicists and other scholars from the humanities. We hope that communication opportunities will arise from the information that these data provide, alongside past data on the positive and negative effects of media reports on neuroscience literacy[33].

Powerful methods from social science can be harnessed for this research. Although the neuroscience community may currently be unfamiliar with these methods, they provide ways to immediately start engaging the public in research processes. Appreciative inquiry[34] is a model programme from the business community that has been used to evaluate and reshape practices. In contrast to standard evaluative models that recommend changes by focusing on failures, appreciative inquiry seeks to highlight successes of the past and bring members of a community into dialogue about what should be done in the future. It relies on genuine engagement rather than on rigid principles. Consistent with the idea that science communication should involve a common understanding and set of goals[13] and a pragmatic approach to the task[35], such an approach acknowledges that collective interests are unlikely to remain fixed during rapid technological change. It also recognizes that deciding how to act, and what policies ought to be adopted, can best be achieved through a negotiated scientific-social decision process[36]. In this way, the input of neuroscientists will be fully integrated into any future product. When this approach is applied in interviews, focus groups and to online professional user group discussions, rich perspectives from investigators on their experiences and priorities will emerge[37,38].

It is also important to understand what the public knows, what is of interest and how much science non-scientists can absorb, especially in this age when traditional journalistic reporting meets the worlds of arts, electronic media and entertainment. Whereas we do have detailed audience profiles for print, radio, television and arts media, the same information is not yet available for the conflation of these forms on the internet. For example, we can gather statistical data on the behaviour of visitors to a website, but at present the intent of the visitors can only be inferred: we can tell if someone uses a search engine to find an article on depression, but we do not know the motivation or goal for that search. We do not understand how viewers are engaged with the data and how they make use of it in everyday life. We do not understand how Web-based information shapes public dialogue and participation in events. Empirical research in science communication that draws on quantitative and qualitative data in the internet age can provide a foundation for well-informed strategies. This can include appropriate and rigorous evaluations of current and emerging mechanisms that are designed to improve the public understanding of neuroscience, as well as the effectiveness of public dialogue and engagement activities.

Public deliberation is being used to explore public concerns and desires in the context of the development of biobanks[39] and the adoption of new health technologies[40]. Given the need for scientists to listen to the public and the public's interest in learning about science, these approaches can be used to understand the depth of public knowledge, to create opportunities for expanded literacy about the brain and to engage in meaningful exchanges on complex issues. These approaches reflect the values of trust, reciprocity and transparency by engaging non-experts and acknowledging that they have a right to be involved in the conduct of science. These tools also provide richer data than the 'snapshot' views that are available through traditional methods such as opinion surveys. However, their use calls for enhanced training of neuroscientists and a willingness to engage in less conventional approaches. Empirical research throughout the process of public engagement is an integral part of this training. Measuring outcomes and impact will be an essential step in the new cycle of knowledge that feeds back in a dynamic system to improve communication skills. However, it should not delay the immediate and increasing encouragement of outreach and engagement through lectures, café scientifiques and the use of evolving media forms that enable the proactive dissemination of scientifically accurate information.

Conclusions

Neuroscience communication requires scientists to articulate new scientific knowledge and the implications of that knowledge. The community of scientists and scholars with interests in neuroethics[21,41–43] — a mixed composition of experts in neuroscience, social science, law and philosophy whose multidisciplinary interests lie at the intersection of neuroscience and its impact on people and society — offer a compelling starting point for advancing communication in neuroscience. It is from this community that this article emerges.

We have recommended three areas of initial focus to advance public understanding of neuroscience and public engagement in the ethical issues it provokes in the rapidly changing world of science communication. First, although many neuroscientists are motivated to be responsive to the public, they need to be supported by the academic and research culture in which they work. Second, specialized communicators are needed to ensure that communication and outreach activities are of high quality and are well integrated with scientific research programmes. The public is being exposed to new ways of thinking about neuroscience and society[44], and skill is needed to negotiate the promise and hype, the ties between academia and industry, the occasional disputes among neuroscientists themselves about the legitimacy of results[45,46], and the routes for reporting results[47,48]. This need for specialists feeds into the third recommendation and a call for ongoing research and empirical data. Research approaches that are used in the social sciences can be used to shape public engagement. Given the different stakeholders that are involved and their respective challenges and expectations, specialized knowledge in communication will be required.

The climate for communicating neuroscience that can be created through initiatives such as those proposed here could have a considerable influence on the way that the public is engaged with the information and with emergent ethical and policy debates. With an even stronger commitment to communication, the neuroscience community and its partners will mitigate or avoid the public backlash and funding freezes that have taken other areas of science by surprise — including stem cell research, genetic testing and population screening[49,50]. From a long-term scientific and ethical standpoint, the future development of the relatively young field of neuroscience must occur with public debate and transparency. This will empower neuroscience researchers, enhance our understanding of brain health and support the translation of fundamental knowledge into better care for individuals and societies.

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Data sets from Pew Internet and American Life Project: http://www.pewinternet.org/Data-Tools/Download-Data/Trend-Data.aspx
Demographics of Internet Users, Pew Internet and American Life Project: http://www.pewinternet.org/Data-Tools/Download-Data/~/media/Infographics/Trend%20Data/January%202009%20updates/Demographics%20of%20Internet%20Users%201%206%2009.jpg
FASEB Washington Update: http://opa.faseb.org/pages/WashingtonUpdate/Sept0409/page2.htm#6
Internet Activities, Pew Internet and American Life Project: http://www.pewinternet.org/Data-Tools/Download-Data/~/media/Infographics/Trend%20Data/January%202009%20updates/Internet%20Activities%20-%20all%20-%201%206%2009.jpg
Society for Neuroscience Science Educator Award: http://www.sfn.org/index.cfm?pagename=fellowshipandawards_edu_sea
The Brain from Top to Bottom: http://thebrain.mcgill.ca/flash/index_a.html
Twitter and status updating, Pew Internet and American Life Project: http://www.pewinternet.org/Experts/~/link.aspx?_id=2CB2AFA2A1484EFB9CE986F0A4F67EC5&_z=z
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