



NEUROSCIENCE
2017

SHORT COURSE 3

Neuroethics and Public Engagement: Why, How, and Best Practices

Organizers: Martha Farah, PhD,
Laura Cabrera, PhD,
and Emily Cloyd, MPS



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SHORT COURSE 3

Neuroethics and Public Engagement: Why, How, and Best Practices

Organized by Emily Cloyd, Laura Cabrera, PhD, and Martha Farrah, PhD

Friday, November 10, 2017

1 p.m.–5:30 p.m.

Location: Washington, DC Convention Center • Room: 206

TIME	TOPIC	SPEAKER
12:30 – 1 p.m.	CHECK-IN	
1 – 1:10 p.m.	Opening Remarks	Martha Farah, PhD • University of Pennsylvania
1:10 – 1:45 p.m.	Neuroethics: What It Is and Its Role in Public Engagement	Laura Cabrera, PhD • Michigan State University
1:45 – 1:55 p.m.	Q&A Session	Laura Cabrera, PhD
1:55 – 2:30 p.m.	Key Issues in Neuroethics	Martha Farah, PhD
2:30 – 2:40 p.m.	Q&A Session	Martha Farah, PhD
2:40 – 3:20 p.m.	Neuroethics Case Study Discussion	Martha Farah & Laura Cabrera
3:20 – 3:35 p.m.	Group Report Out	
3:35 – 3:45 p.m.	BREAK	
3:45 – 4:20 p.m.	Public Engagement: What It Is and Why It Matters	Emily Cloyd, MPS • American Association for the Advancement of Science (AAAS)
4:20 – 4:45 p.m.	Public Engagement Case Study Discussion	Emily Cloyd, MPS
4:45 – 5 p.m.	Group Report Out	
5 – 5:30 p.m.	Overall Q & A Session & Closing Remarks	Laura Cabrera, Martha Farah, & Emily Cloyd

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Neuroethics: What It Is and Its Role in Public Engagement

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Introduction

Recent advances in neurosciences raise important ethical questions as to who should have access to certain brain diagnosis techniques and brain treatments, whether and when we should use them, and if so, under what circumstances. These advances also raise broader societal concerns about the uses of neuroscientific knowledge, such as to advance marketing or weapons development. Related philosophical questions might address how neuroscientific innovations shape our understanding of ourselves as moral beings. It is precisely because of the profound meaning that neuroscience has for individuals and society that neuroscientists need to proactively address the implications of their work. This state of affairs illuminates the need to formally educate neuroscientists in neuroethics. Moreover, it calls for some measure of public engagement to create awareness of the implications their work might have for society, to engage the public, to promote discussion of novel developments, and to receive necessary feedback (Morein-Zamir and Sahakian, 2009).

Neuroethics Defined

The term “neuroethics” was first introduced in the early 1970s to describe overlooked bioethical questions encountered in clinical and basic neuroscience (Pontius, 1973). While certain issues raised by neuroethics are similar to those of other biomedical sciences, other ethical issues are unique to neuroscience. There are familiar bioethical justice concerns surrounding access to promising new therapies as well as safety concerns; however, as more enhanced tools are developed to both understand and manipulate the brain, the range of neuroethics issues widens. Neuroethics addresses particular sensitivities related to intentional manipulation of the brain and CNS. It is in this anatomical locus that many ethical issues surface, such as the privacy of thoughts, the enhancement of cognitive and affective abilities, and whether and how new understandings of mental life might radically change long held perceptions of personhood and agency.

In 2002, following a series of meetings in the United States (Marcus, 2002) and Canada (Canadian Institutes of Health Research, 2002), neuroethics emerged as a specific area of interdisciplinary research and social practice. At the 2002 U.S. meeting “Neuroethics: Mapping the Field,” organized by the Dana Foundation, neuroethics was defined as “the study of ethical, legal and social implications that arise when scientific findings about the brain and behavior are carried into medical practice, legal interpretations, and health and social policy”

(Marcus, 2002). William Safire, a participant at that meeting, described neuroethics as the examination of what is good and bad about the “manipulation of the human brain” (Safire, 2002). A more holistic definition was suggested a few years later by Michael Gazzaniga, a neuroscientist, who described neuroethics as “how we want to deal with the social issues of disease, normality, mortality, lifestyle, and the philosophy of living informed by our understanding of underlying brain mechanism” (Gazzaniga, 2005). These definitions highlight the importance of acknowledging the impact that neuroscientific discoveries and novel neurotechnologies can have for individuals and society.

Neuroethics “seeks to give neuroscience what bioethics and the ethical, legal and social implication (ELSI) program provided for the human genome project” (Lomber and Illes, 2009). That is to say, it offers a platform where various stakeholders—including scientists, social scientists, clinicians, patients, and the lay public—are able to interact and discuss the future of neuroscience and neurotechnologies. That is why neuroethics is in some ways an inadequate name for the disciplinary field, since much of the interest in neuroethics extends beyond ethical concerns to incorporate legal and societal implications as well. Yet for more than 15 years, it has turned out to be a practical name, enabling cross-disciplinary dialogue among neuroscience and ethics, philosophy, law, sociology, anthropology, economics, political science, and other fields.

Three Perspectives on Neuroethics

Depending on the questions posed, one can adopt various perspectives when approaching neuroethics. Three common ones are a knowledge perspective, a technology-driven perspective, and a health care perspective (Racine, 2010). First, from a knowledge-driven perspective, neuroethics can be divided into two main classifications (Roskies, 2002). The “ethics of neuroscience” deals with those principles and considerations that deservedly should be raised in the course of designing and executing neuroscientific studies. This includes, for instance, what neuroscientists should or should not do as well as an evaluation of the ethical and social impacts that study results might have on existing social and legal structures. The “neuroscience of ethics” covers notions of free will, self-control, personal identity, and intention, which are investigated from the perspective of brain function. This reflective way of thinking takes a theoretical approach to examining how the neuroscience worldview affects how one thinks about oneself and others.

A second perspective takes neuroethics to be defined by the technologies it examines rather than any particular philosophical approach. Within such a technology-driven perspective, neuroethics encompasses both “research and clinical applications of neurotechnology as well as social and policy issues attendant to their use...the field’s distinctiveness derives from novel questions posed by applying advanced technology to the brain” (Wolpe, 2004).

Third, there is a health care–driven perspective that sees neuroethics as a field focused “on the ethics of neuroscience research and the ethical issues that emerge in the translation of neuroscience research to the clinical and public domain” (Racine and Illes, 2008). This applied perspective then enables the integration of ethical concerns found in those medical specialties dealing with the brain and CNS.

A Brief History of Ethics in Neuroscience

Having a grasp of the history of ethics in neuroscience can help us better understand the present and future of neuroethics. In fact, many of the issues with which

neuroethics concerns itself have been the focus of centuries of philosophical thought. Discussions found in early literature are precursors to current debates about responsibility, self-control, and the neurobiological underpinnings of moral decision-making. It was not until the late 19th century, with the work of scientists like Santiago Ramón y Cajal (2002), that a deeper understanding of the role of the brain and its functions were identified. Later, in the 20th century, research experiments in human subjects posed concerns that today would be considered within the scope of neuroethics, such as ethical questions associated with the application of neuroscience findings and the conduct of neuroscience research. From that time forward, attention to neuroethical topics has increased steadily (Fig. 1).

For example, in the late 19th and early 20th centuries, controversial debates surrounded the use of electroconvulsive therapies and psychosurgery to treat mental conditions and control problematic behavior (Valenstein, 1986). These debates have reemerged with the recent development of psychiatric neurosurgery innovations, such as deep-brain stimulation and focused ultrasound.

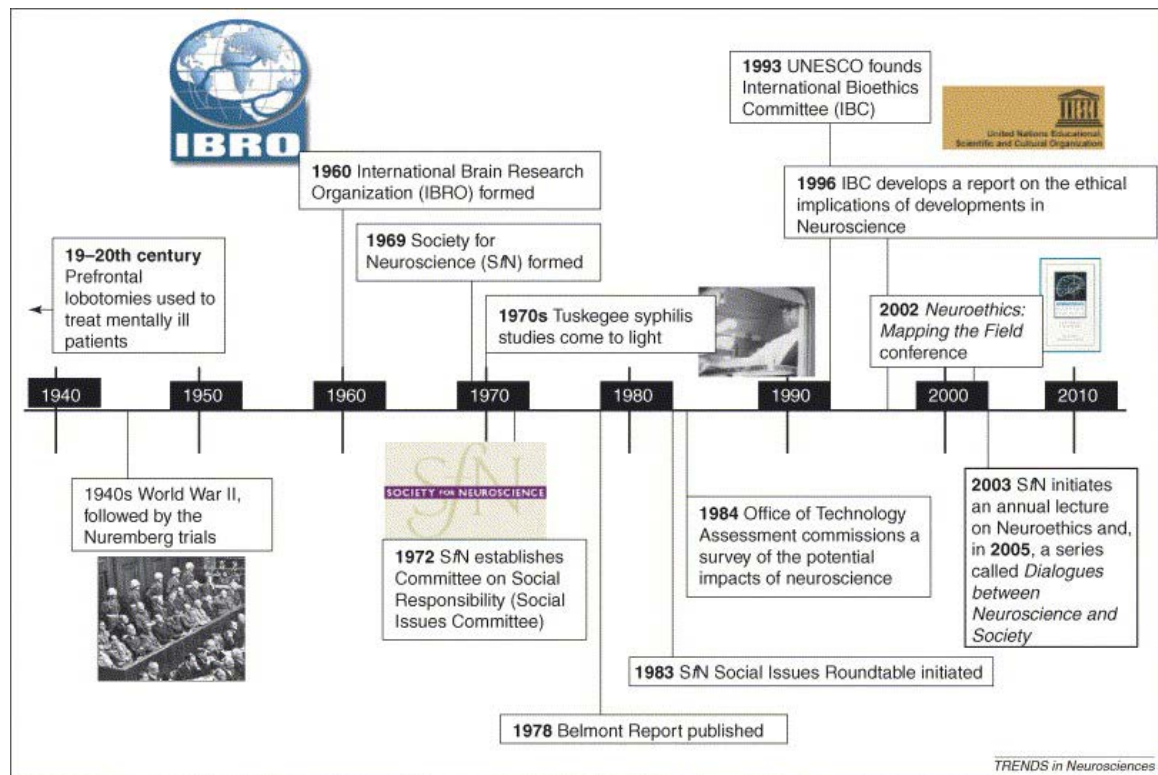


Figure 1. Timeline of milestones in neuroethics and human research. Reprinted with permission from Illes and Bird (2006), Fig. 1. Copyright 2006, Elsevier.

Human experimentation that took place during the Second World War involving research without consent and torture resulted in the drafting of the Nuremberg Code, a set of research ethics principles guiding human experimentation. Among its many tenets, the code highlights the need for voluntary consent of human subjects; recognizes that the degree of involved risk must be proportional to the humanitarian importance of the problem; and mandates that scientists must cease an experiment when it is recognized that injury, disability, or death might occur as a result of the experiment.

The International Brain Research Organization was formed in 1960 (IBRO, <http://www.ibro.org>) as a result of expanded research on the brain and behavior in a wide range of disciplines. Other regional societies followed, including the Society for Neuroscience (SfN) in 1969, now the largest professional society of neuroscientists in the United States.

Around that time, questions arose about how to conduct medical experiments involving human subjects in the most ethically acceptable manner. In hindsight, we may easily judge past studies to be unethical, but it was not always clear whether that was indeed the case at the time they were conducted. Examples include Stanley Milgram's obedience experiment in 1969, which was based on the conflict between compliance with authority and personal conscience, and the 1971 Stanford Prison Experiment, which was a simulation of the psychology of imprisonment (<http://www.prisonexp.org/>). The Tuskegee Syphilis Study is another well-known ethical transgression that took place over a 40-year period (1932 to 1972) and involved 400 African American men. Ethical concerns include the facts that study participants were not informed that they had syphilis. Moreover, when penicillin became widely available in the course of the study, the men were denied access to that effective syphilis treatment. As a result of the Tuskegee study and other human subject research violations, the Belmont Report was commissioned (Department of Health, Education, and Welfare, 1978). Highlights of the report include discussion of the boundaries between research and practice as well as the identification of respect for persons, beneficence, and justice as foundational ethical principles underlying the conduct of human subject research.

The Belmont Commission's report, published in 1978, prompted enhanced attention to ethical conduct both in biomedical research and in medical practice. As for neuroscience, in 1983 SfN held the first of what was to become an annual Social Issues Roundtable

series. At the inaugural roundtable, participants examined controversies such as research on the use of fetal tissue to treat neurological diseases, possible sex differences in the brain and related application of that research, therapeutic and nontherapeutic use of cognitive enhancers, food additive neurotoxicity, and the role of neuroscience research in the development of health and public policies (Illes and Bird, 2006). The SfN has a sustained interest in the implications of neuroscience, launching an annual special lecture on neuroethics in 2003 and a series called "Dialogues between Neuroscience and Society" in 2005. Today SfN embraces as a core part of its mission informing legislators and other policy makers about the implications of research for public policy, societal benefit, and continued scientific progress.

Other landmarks in the history of ethics in neuroscience include the U.S. Office of Technology Assessment report that addressed the potential societal impacts of neuroscience research in areas such as the criminal justice system, the workplace, and education (Office of Technology Assessment, 1984). Additionally, an independent report was published by the International Bioethics Committee of UNESCO on the ethical implications of developments in neuroscience (Vincent, 1995). However, much of the momentum for modern neuroethics came from the 2002 conference "Neuroethics: Mapping the Field." This conference brought together a wide range of scholars including neuroscientists, philosophers, bioethicists, lawyers, and others and gave the new field substantial publicity. More recently, in 2006 the International Neuroethics Society (INS) was formed (<http://www.neuroethicssociety.org>) to promote sustained interaction, learning, and critical discussion needed to strengthen the field and attract new members. The society's mission is to "encourage and inspire research and dialogue on the responsible use of advances in brain science." The INS hosts its annual meeting as a satellite event of the SfN's annual meeting. From the late 2000s, the field of neuroethics has grown, supported by foundational books (Illes, 2006; Levy, 2007; Farah, 2010; Racine 2010; Illes and Sahakian, 2011); journals (*Neuroethics* and *AJOB Neuroscience*); and various conferences, workshops, seminars, and courses.

Finally, the latest addition to the history of ethics in neuroscience is the formation of neuroethics groups linked to the two major international brain initiatives: the USA BRAIN Initiative (<https://www.braininitiative.nih.gov>) and the European Human Brain Project (<https://www.humanbrainproject.eu/en/>). In the case of the BRAIN Initiative, the newly established division of neuroethics recognizes important

ethical questions raised by the associated development of new research tools and technologies. This is indeed an exciting time for the field of neuroethics.

Pillars of Neuroethics

Neuroethics today encompasses those theoretical, empirical, practical, and policy issues that lie at the intersection of neuroscience and ethics, law, and society. These issues can be grouped into five major areas (Table 1).

Why Neuroethics Is Important

A key debate has been whether neuroethics is a separate field of inquiry at the intersection of bioethics and neuroscience or, alternatively, whether it is a subfield of bioethics addressing characteristic questions and employing specific concepts and tools (Schick, 2005; Wildfond and Ravitsky, 2005). Regardless of which of these two views you subscribe to, it can be argued that the brain holds special status as the core of our selfhood, personal capacities, and autonomy. Like genetics, neuroscience deals with the biological essence of persons, including their minds and behaviors. The nervous system, however, is considered to be one causal step closer to behavior than genes or features of the

environment. In fact, it encompasses the totality of those influences (Farah, 2012). For that compelling existential reason, manipulating brain function is fundamentally different from manipulating other organs or systems. That is precisely why such manipulation raises distinct ethical issues. With a deeper and more complex understanding of how the brain functions, we inevitably will need to examine long held views about personhood, the self, agency, responsibility, and consciousness. Brain science has led to clinical innovations that have both therapeutic and nontherapeutic dimensions. Equally, brain science has shaped related education and the law. Such consequences profoundly influence society in complex ways. Lately there have been increases in interdisciplinary and translational research, commercialization of brain sciences, and the importance of public understanding and engagement with neuroscience topics. These many points underscore the prime role of neuroethics (Illes and Bird, 2006; Morein-Zamir and Sahakian, 2009).

Neuroethical issues are of concern not only to neuroethicists and philosophers. All members of society have a stake in them, and as such, continuous dialogue is needed in a forum where neuroethics might be addressed (Roskies, 2002).

Area	Topics Discussed
Brain science and the self	Challenges to moral responsibility, decision-making, agency, and free will that result from neuroscience and neurotechnological developments.
Brain science and social policy	Challenges to privacy, legal consequences of behavior, and unequal access to neuroscience-based innovations and health care. Ways that neuroscientific evidence can be incorporated into policy debate should be closely monitored to ensure they are not used as vehicles for espousing particular values, ideologies, or social divisions (O'Connor et al., 2012).
Brain science and clinical practice	Ethical issues and challenges in human subjects research, clinical trials, novel therapeutics, new diagnostic procedures, and biomarkers for disorders of the CNS. These include issues of informed consent, competency, as well as safety and risk.
Brain science, public engagement, and public discourse	Brain science conversations among stakeholders, including scientists, lawyer, neuroethicists, philosophers, and the general public. In this process, brain scientists interact with, influence, and are influenced by society (O'Connor et al., 2012) with the goal of addressing difficult ethical and social debates raised by neuroscience, promoting education and awareness, providing opportunities to exert influence, and diversifying perspectives.
Brain science across cultures	Challenges connected to the role of culture in different perspectives and ways of knowing related to brain and mind; interactions between traditional knowledge and neuroscience evidence.

Adapted from Marcus (2002), Illes and Bird (2006), and Lomber and Illes (2006).

These five areas provide a useful framework to think about the implications of neuroscience for individuals and societies around the globe.

Neuroethics is not about deterring neuroscience advances. Rather, it is about promoting meaningful and responsible research for the benefit of individuals and society, anticipating and addressing ethical challenges to the most effective translation of research, and promoting reasoned, informed discourse among stakeholders. In these ways, neuroscientists might be able to best determine which innovations and applications are safe and appropriate.

Acknowledgments

Figures and tables for this chapter were excerpted with permission from Illes, Judy, and Stephanie J. Bird. "Neuroethics: a modern context for ethics in neuroscience." *Trends in neurosciences* 29.9: 511-517, Copyright 2006, Elsevier; Lomber, Sofia, and Judy Illes. "The international dimensions of neuroethics." *Developing world bioethics* 9.2: 57-64, Copyright 2009, Wiley.; and Marcus SJ "Neuroethics: mapping the field." *Cerebrum: The Dana Foundation*, Copyright 2002.

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Neuroethics: Critical Issues for Neuroscientists

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Introduction

As Laura Cabrera recounts in her chapter introducing neuroethics, neuroscientists and others have long taken note of the potential ethical impacts of neuroscience, and even the name “neuroethics” dates back to the 1970s. In contrast, the emergence of a distinct field called neuroethics is a relatively recent phenomenon, marked by the conferences, journals, and societies mentioned there (e.g., the 2002 U.S. meeting “Neuroethics: Mapping the Field”). These activities began in the first decade of the 21st century and have grown in size and scope since then, in part because of advances that enable neuroscience to affect human life—for better and for worse—in many new ways. In this Short Course, we will introduce you to the field of neuroethics and its relation to public engagement with science and will review current issues that occupy the field. This chapter focuses on a selection of those issues.

Neuroscience can now be brought to bear in many different spheres of human life, beyond its traditional applications to neurological and psychiatric medicine. Any endeavor that depends on being able to understand, assess, predict, control, or improve human behavior is, in principle, a potential application area for neuroscience. Consider how many different sectors of society this encompasses: education, business, politics, law, entertainment, and warfare, to name a few. The goal of this chapter is to identify critical issues—arising now or in the near term—that have ethical, legal, or societal implications.

Most of this chapter will address the implications that emerge from neuroscience-based technologies concerning how the fruits of neuroscience can and should be applied. These include ethical, legal, and social challenges raised both by newfound abilities to image the brain and thereby obtain information about mental states and personal traits, and by our growing ability to intervene in individuals’ brain function to alter these states and traits. I will also touch on neuroethical issues that emerge from the impact of neuroscience on our understanding of ourselves and others, quite apart from any uses to which we might put neuroscience.

Neuroethics of Brain Imaging

Developments in brain imaging have engendered a large body of literature in neuroethics. Some of this literature is concerned with matters for which we can find helpful precedents in clinical bioethics. For example, with magnetic resonance imaging (MRI) of healthy normal subjects now a widespread research

method, we face the question of what to do when anatomical abnormalities or signs of disease are revealed in the course of scanning. Do researchers have a duty to search scans for such abnormalities? Should subjects be allowed to opt out of being informed of such findings in advance of the scan? A letter from an anonymous neuroscientist illustrates the difficult ethical territory to be navigated with incidental findings in research scans of the brain (Anonymous, 2005). Researchers are working toward a consensus for dealing with incidental findings from research scans (Illes et al., 2006).

In other cases, brain imaging raises new issues whose ethical, legal, and social aspects stem directly from the special relationship between brain and mind. The ability of brain imaging to deliver information about our psyches—who we are and what we might be thinking or feeling while in the scanner—opens up a range of ethical challenges. The idea of, essentially, mind reading via brain scan has many potential uses, some of which could be good for individuals and society. Predicting future dangerousness in criminal offenders would help us protect citizens from threat while letting us give low-risk offenders more freedom. Distinguishing truthful from deceptive testimony could promote justice. Matching young learners with educational programs that meet their needs based on their neurocognitive strengths and weaknesses could boost student achievement. All these applications are being developed, but none has yet achieved success in the “real world.” This is the result of many factors, but two of the most important concern what is called “ecological validity” and the “group-to-individuals” problem.

Ecological validity

Ecological validity refers to the degree of realism captured by a research study. Consider all the ways in which imaging procedures that are feasible in research differ in important ways from the real use to which such a method might be put. Is the defendant or witness telling the truth? The psychology of testimony in a real-world case will differ in numerous ways from the psychology of a typical research volunteer performing a task in a scanner. As my colleagues and I discussed in a recent review, the lies of a defendant will differ from those of the typical college student research subject in many ways, including the familiarity and the degree of emotion associated with the lie (Farah et al., 2014). This is a huge barrier to establishing the validity of an imaging-based system for detecting deception. Although commercial functional MRI (fMRI) lie detection is on offer, it has yet to be admitted as evidence in

court. In the 2010 case of *United States v. Semrau*, an fMRI method for detecting deception (developed by Cephus) was the subject of a hearing to determine whether it met the criteria for admissibility. It was ruled inadmissible primarily on the basis of its unknown ecological validity. Consider the damage to innocent people that could result if such a system were used without proper validation. It is chilling to realize that an EEG-based method for detecting deception has been used for several years in Indian courts (Aggarwal, 2009). In situations such as these, the need for neuroscientists to guide the use of novel neuroscience technologies by society is apparent.

The group-to-individuals problem

An additional barrier to the translation of imaging to uses in law, education, medicine, and other fields arises from the fact that most neuroimaging research knowledge is based on inferences from groups of subjects. In contrast, most of what we want to know when applying neuroimaging is about individuals. This has been called the group-to-individuals (G2I) problem, which afflicts most research studies we might want to adapt for real-world use. It is not an impossible problem to solve, but depending on how much individuals vary from one another, it may require much larger-scale studies than are now typically performed. Similar kinds of statistical problems afflict efforts to predict someone's future behavior or health status based on a set of data already in hand. Here too, this is not an insurmountable problem, but it requires some methodological heavy lifting to avoid overestimating the predictive power of neuroimages for outcomes, such as criminal reoffending or educational achievement, as well explained by Gabrieli and colleagues (2015).

Concerns about privacy and public misunderstanding

Concerns about the ethics of brain imaging fall into two general categories, which can roughly be described as the “damned if you do” and “damned if you don’t” categories. To the extent that brain imaging can actually deliver useful information about a person's mental states or traits, the issue of privacy becomes important. To the extent that it cannot, but people believe that it can, the issue of public misunderstanding becomes important.

Mental privacy

In relation to mental privacy, a number of writers have commented on the potential threat to privacy posed by functional neuroimaging (Richmond et al., 2012). On the face of things, brain imaging poses a novel challenge to privacy in that it can (in principle)

deliver information about thoughts, attitudes, beliefs, and traits even when someone offers no behavioral responses. More concretely, and perhaps more significantly, imaging-based psychological investigations lend themselves to stealth uses in ways that more conventional paper-and-pencil or other low-tech methods do not. Both structural and functional brain images can be obtained with consent for one purpose but later analyzed for other purposes. Further, in many studies, the stimuli and instructions do not reveal the nature of the psychological information being sought. For example, past studies have shown that unconscious racial attitudes and impulsive aggression are both correlated with brain activity evoked by simply viewing pictures of faces (Phelps et al., 2000; Coccaro et al., 2007). Hence, in principle (and qualified by G2I limitations), it should be possible to obtain information about racial attitudes or aggressive tendencies without subjects' knowledge or consent by misleading them into thinking the study concerns mere face perception.

Public misconceptions

At present, however, the problem of public misunderstanding of neuroimaging is a more immediate challenge than the problem of mental privacy. Some studies suggest that laypersons attribute greater objectivity and certainty to brain images than to other types of information about the human mind (McCabe and Castel, 2008). Even if this is not a distinctive feature of neuroimaging (Farah and Hook, 2013), the perceived authority of science more generally lends credibility to brain-based technologies.

Although the risks of prematurely adopting imaging-based methods are substantial, overly restrictive policies can also be counterproductive. It seems unlikely that neuroimaging applications will be uniformly regulated across countries. Thus, efforts to discourage imaging-based approaches to problems with potentially significant economic or security relevance has an element of unilateral disarmament. Neither the unrealistic science fiction scenarios of mind reading nor the irresponsible hawking of unvalidated methods are reasons to discourage the development and validation of neuroimaging approaches to lie detection, employment or security screening, or business and education.

Neuroethics of Brain Enhancement

As used in the neuroethics literature, “brain enhancement” refers to interventions that make normal, healthy brains better, in contrast with treatments for unhealthy or dysfunctional brains.

People have been chemically enhancing their brains for millennia, far longer than they have been treating brain disorders. Coffee, tea, coca leaves, and alcohol are among the familiar substances used to alter brain chemistry for improved cognition or mood. Yet with the advent of biological psychiatry, drugs developed for the purpose of treating neuropsychiatric disease can now be used by healthy people for enhancement, greatly increasing the variety and potency of methods for chemically adjusting our brain states. In addition, nonpharmacological means of altering brain function (e.g., by electrically stimulating specific brain regions to achieve desired psychological effects) have now made the same transition from clinical to lifestyle use. These developments raise a host of new questions concerning personal improvement in the age of psychopharmaceuticals and neurotechnology.

Enhancement use of stimulants

Stimulants such as amphetamine and methylphenidate (sold under trade names such as Adderall and Ritalin, respectively) are widely used for nonmedical reasons in the United States, and student surveys suggest that stimulant use for cognitive enhancement is commonplace on college campuses (Smith and Farah, 2011). Students with prescriptions sell surplus pills to other students, who use them to help study and finish papers and projects; similar use by college faculty and other professionals has been documented, but prevalence is unknown (Maher, 2008; Schwartz, 2015). More recently, the wakefulness-promoting drug modafinil is also being used for cognitive enhancement (Farah, 2015).

These practices have been interpreted as paradigm cases of cognitive enhancement, generally aimed at improving executive function (EF): the ability to marshal cognitive resources for flexible multitasking or focusing, as needed. Because these drugs are widely used to treat attention deficit hyperactivity disorder, in which EF is impaired, they are assumed to enhance EF in healthy individuals as well. However, the current evidence suggests a more complex state of affairs. The published literature includes substantially different estimates of the effectiveness of prescription stimulants as cognitive enhancers. A recent meta-analysis suggests that the effect is most likely real but small for EF tests stressing inhibitory control, and probably nonexistent for EF tests stressing working memory (Ilieva et al., 2015).

Why, then, do these drugs continue to be used for enhancement? One possibility is that there are important individual differences in people's response to them, with some people benefiting. In addition,

stimulants have other effects for which they may be used. In a report entitled "Just How Cognitive Is 'Cognitive Enhancement'?" sociologist Scott Vrecko interviewed students who used Adderall and found that they emphasized motivational and mood effects as reasons for using the drugs for schoolwork (Vrecko, 2013). There is, of course, a close relationship between cognitive performance, on the one hand, and motivation, on the other. Even if one's laboratory-measured EF is not appreciably increased, one is likely to get more done, of better quality, if one is feeling cheerful and "into" the tasks at hand. Unfortunately, the mood- and motivation-boosting abilities of stimulants are related to their well-known dependence potential, and that potential is a significant safety concern. How likely is cognitive enhancement use of stimulants to lead to dependence? The prevalence of drug dependence among enhancement users is not currently known.

Transcranial electric stimulation

The newest trend in cognitive enhancement is the use of transcranial electric stimulation (tES) (Dubljević et al., 2014). In the most widely used form of tES, transcranial direct current stimulation (tDCS), a weak current flows between an anode and a cathode placed on the head, altering the resting potential of neurons in the current's path. The simplicity and low cost of tDCS devices have enabled wide use of the technology for research and, increasingly, for home use. No epidemiological data exist on the use of these devices, but the internet abounds with discussion and advice on how to build and use tDCS systems. An initial survey with a convenience sample recruited from internet sites indicates that cognitive enhancement is the most common reason for personal use of tDCS (Jwa, 2015).

The true cognitive benefit of tDCS in normal healthy users is also unknown. As with research on pharmaceutical enhancement, the published literature includes a mix of findings. One attempt to synthesize the literature with meta-analysis concluded that tDCS has no effect whatsoever on a wide range of cognitive abilities (Horvath et al., 2015), while more recent analysis suggests that effects on working memory are small to nonexistent except when used as an adjunct to training (Mancuso et al., 2016). Newer tES protocols involving alternating current stimulation, random noise stimulation, or pulsed stimulation have different physiological effects and hence potentially different psychological effects, although the empirical literature is still developing. At present, there is little scientific evidence for or against the effectiveness of these specific systems,

nor is there evidence concerning physiological and psychological effects of regular use over months or years in humans or animals. In sum, it remains difficult to say what benefits these practices offer in the lab, let alone in the classroom or workplace, and their attendant risks are even harder to gauge.

Implications and risks

The most obvious ethical issue pertaining to brain enhancement is safety. As already noted, there is a dearth of information about the health risks of long-term use of the drugs and devices mentioned here by healthy people. In addition to this very pragmatic concern, there are other ways in which brain enhancement can affect our lives, for better or worse. Some concern fairness and freedom. Is it fair if some individuals boost their performance in academic or occupational contexts by enhancing their brains? Would this be akin to doping in sports? Or would it be no better or worse, in terms of fairness, than inequalities we already live with, such as good schools available to some people but not to others? Will the people who must compete with enhanced individuals be completely free to continue living with unenhanced brains, or will there be implicit pressure to start enhancing themselves? Might the pressure one day become explicit, with employers requiring enhancement by employees?

In contrast to these risks, brain enhancement has the potential to improve our lives. Pilots on long-haul flights or doctors on night call could benefit by being more alert and focused, and this would, of course, benefit other people who depend on their performance for their own safety. Imagining a world in which we have truly effective brain enhancement, it seems clear that there would be substantial upsides as well as the risks mentioned earlier. If people became smarter, more energetic, and more cheerful, then they could more effectively solve the problems of their own lives and society more successfully.

Toward a Neuroscience Worldview

Neuroscience does not merely give us new tools, such as imaging modalities, drugs, and devices, to be used to the benefit or detriment of humanity. It also gives us a new way of thinking about humanity. The idea that human behavior can be understood in terms of physical mechanisms runs counter to deeply ingrained intuitions. Whereas we naturally think in terms of physical causality to understand the behavior of most objects and systems in the world (e.g., why a bicycle is easier to pedal uphill in low gear, why a plant grows in the sun or withers in the shade, why a printer jams), when it comes to human behavior, we

tend to think about people's intentions and reasons. There is evidence that even infants understand human behavior in terms of intentions and reasons rather than physical causes (Meltzoff, 1995).

Neuroscience provides an alternative perspective from which human behavior can also be understood as the result of physical causes. The idea that all our behavior, moral and immoral, is physically caused by brain processes throws a monkey wrench into our intuitive reasoning about moral responsibility. We think of ourselves as moral agents, normally acting intentionally with free will. Thus, I am morally responsible for knocking down the old lady if I pushed her on purpose to get her out of my way, but not if I stumbled or was myself pushed and thereby pushed her because of the physics of my body and its interactions with other objects on the scene. Of course, many people believe in the abstract that human behavior is physically determined. However, we tend to put aside such abstractions when making moral judgments. We do not say, "But he had no choice—the laws of physics made him do it!" As the neuroscience of personality, decision-making, and impulse control begins to offer a more detailed and specific account of the physical processes leading to irresponsible or criminal behavior, the deterministic viewpoint will probably gain a stronger hold on our intuitions. This has already happened to an extent with the disease model of drug abuse (Leshner, 1997), in which addiction is now viewed as more of a medical problem than a failure of personal responsibility.

Most religions endorse a two-part view of the person: body and mind or soul. This accords well with most people's intuitions, according to which there is some essence of a person that is more than just the one- or two-hundred pounds of matter we can see and touch. Yet as neuroscience advances, all aspects of a person are increasingly understood to be the functioning of a material system. In this way, neuroscience may pose a more fundamental challenge to many religions than evolutionary biology.

In sum, neuroscience is calling into question our age-old understanding of the human person. Much as the natural sciences became the dominant way of understanding the world around us in the 18th century, so neuroscience may be responsible for changing our understanding of ourselves in the 21st. Such a transformation could reduce us to machines in each other's eyes—mere clockwork devoid of moral agency and moral value. Alternatively, it could help bring about a more understanding and humane

society, as people's behavior is seen as part of the larger picture of causal forces surrounding them and acting through them.

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Case Studies

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Case Study 1: Neuroenhancement Vignette

Eric rarely if ever has challenges being able to maintain sustained attention. He reads an article about attention deficit hyperactivity disorder (ADHD), a condition that affects people's ability to maintain sustained attention. The same article also mentions [a new pill/a new brain headset for transcranial direct current stimulation (tDCS)] that can help people with or without ADHD to improve sustained attention. The [pill/headset] has been thoroughly tested, shown to be effective as a therapy for ADHD, and has minimal side effects that most people don't mind. From previous medical tests he knows that, given his lack of challenges with sustaining attention, he does not fulfill the medical criteria for ADHD. However, Eric concludes that the [pill/headset] could help him to be even better able to remain attentive and decides to try it.

Questions for discussion

1. How acceptable do you think it is that people like Eric might use [a pill/headset] with that purpose?
 - 1a. Explain your main reasons for your answer.
2. If you were in the same situation as Eric, how likely is it that you would use [a pill/headset] for that purpose?
 - 2a. Explain your main reasons for your answer.
3. What are some of the distinctive problems associated with evaluating and regulating the safety of brain enhancers compared with evaluating and regulating the safety of therapies?
4. To what extent do your concerns, or concerns from the academic literature, apply to the use of substances like coffee, which are used to enhance mood and cognition?
5. Are there morally relevant differences among different modalities (e.g., pill vs headset) of brain enhancers?

Within the academic discussion of neuroenhancement, common reasons for disagreement have been issues of safety, access to the intervention (justice issues), authenticity, and changes to the person.

Case Study 2: Incidental Findings in Neuroimaging Vignette

Mike is a Neuroscience PhD student conducting research on working memory. He has been a mentor to the incoming PhD student class. Two weeks into the program, Sarah enthusiastically enrolls in Mike's study that involves functional magnetic resonance imaging (fMRI). On one of Sarah's scans, Mike notices an anomaly in her prefrontal cortex. There is no institutional protocol in place about the disclosure of such findings.

Questions for discussion

1. What should Mike do? Do you think he should tell Sarah about this anomaly? If so, why?

In this situation, the overall occurrence of anomalies in adults and children is between 18% and 20%. Of these, only 2–8% are clinically significant findings that require follow-up. If Mike discloses the incidental finding, he might be preventing a potentially significant disorder of the CNS while enhancing trust and reciprocity with his research subjects. On the other hand, if Mike decides not to disclose the finding, he might be preventing anxiety-provoking feelings in Sarah, in case it is just a false-positive. There are also the costs and morbidity of follow-up tests to consider, so preventing Sarah from undergoing unnecessary tests might be beneficial.

2. Are there any pros and cons that you can identify for disclosing or not disclosing Sarah's incidental findings?

Case Study 3: Use of Neuroimaging in Disorders of Consciousness

Functional MRI has been used to identify residual cognitive function and conscious awareness in patients assumed to be in a vegetative state whose retained cognitive abilities have evaded detection using standard clinical methods. In a study by Monti and colleagues (2010), researchers instructed 54 patients with disorders of consciousness to imagine playing tennis when they wanted to answer a yes-or-no question "yes," and walking around their house or navigating the streets of a familiar city when they wanted to respond "no." Five of these patients, of whom four were considered vegetative,

were able to modulate their brain activity. In one so-called vegetative patient, the investigators were able to open a narrow-band communication channel through which the subject could respond yes or no by willful brain activity modulation.

Questions for discussion

1. What are some clinical, practical, and ethical considerations that need to be taken into consideration regarding the use of neuroimaging in disorders of consciousness?
2. Do you think, given the current state of imaging technologies, that these forms of “communication” with patients with disorders of consciousness should be used to determine end-of-life decisions?

Reference

Monti MM, Vanhaudenhuyse A, Coleman MR, Boly M, Pickard JD, Tshibanda L, Owen AM, Laureys S (2010) Willful modulation of brain activity in disorders of consciousness. *N Engl J Med* 362:579–589.

Case Study 4: Use of Neuroimaging for Predicting Autism

Andreas and Karen just had a baby, and although little Aleen seems fine, the pediatrician has recommended an fMRI test to predict whether Aleen might or not develop autism (Callaway, 2017).

Questions for discussion

1. Do you think Andreas and Karen should have Aleen undergo the imaging procedure?
2. What benefits would Andreas and Karen gain by having Aleen tested? What might be potential harms of having Aleen tested?
3. Can you think of other reasons that call for caution regarding the widespread use of such a technology for the prediction of autism?

Reference

Callaway E (2017) Brain scans spot early signs of autism in high-risk babies. *Nature News Explainer*. Available at <http://www.nature.com/news/brain-scans-spot-early-signs-of-autism-in-high-risk-babies-1.21484>.

Case Study 5: Using Imaging in Court Cases to Determine the Truthfulness of Pain Claims

The use of neuroimaging techniques like fMRI and positron emission tomography (PET) to identify brain regions that enable us to experience physical pain is one of those contested areas that has raised concerns from the academic community about the use and misuse of neuroscientific results. Because pain is one of the medical complaints that are easiest to feign, detection of pain could be particularly valuable in the courtroom when there is no definitive medical evidence to prove or disprove claims about the existence and extent of pain symptoms.

While Tom was driving to a client appointment, he was hit by an out-of-control car. Tom was seriously injured and required hospitalization. Tom ended up having a back injury, and even though surgery was successful and he was able to walk, he suffered from excruciating pain. Tom’s insurance did not want to cover the “pain and suffering” that he was still experiencing. Tom hired a lawyer to submit a compensation claim.

The court decided to use fMRI to determine whether Tom’s pain complaints were truthful. The defendants (in this case, the insurance company) do not want fMRI to be used because they do not feel that the tests are reliable. Tom’s lawyers, however, want to use fMRI because they believe it will prove their client is not feigning his pain.

[One group takes the defendants’ (insurance company’s) side, and the other group takes the plaintiff’s (Tom’s) side.]

Questions for discussion

1. Make a list of reasons why fMRI should or should not be allowed in this case.
2. Were there any ethical considerations you thought relevant when considering the decision to use fMRI for settling a pain compensation claim?

Case Study 6: Forgetting About Fear

The alluring possibility of deleting memories has been the topic of movies such as *Men in Black*, *Total Recall*, and *Eternal Sunshine of the Spotless Mind*, yet in real life, the chances of ever achieving such fine-tuned memory erasure is not a realistic bet. But suppose if, by taking a pill, we could forget about fear and those things that cause us to be anxious. A *New York Times* article addressed exactly that possibility with recent coverage of a drug to “cure” fear—by dampening memory (Friedman, 2016). Discussion around the normative implications of memory modification is an especially hot topic within neuroethics. Some are disturbed by attempts to directly tamper with memory because they view it as threatening to our identities and the authenticity of our experiences. In contrast, others see it as a genuine attempt to relieve suffering.

Questions for discussion

1. What do you think? Should people use or refrain from using such pills if they prove safe and effective?
2. Explain your reasons.

Reference

Friedman RA (2016) A drug to cure fear. *The New York Times Sunday Review*, Jan. 22. Available at <https://www.nytimes.com/2016/01/24/opinion/sunday/a-drug-to-cure-fear.html?smid=pl-share>.

Public Engagement with Science: What Is It and Why Is It Needed?

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What Is Public Engagement with Science?

The centrality of science to modern life bestows an obligation on the scientific community to develop different and closer links with the general population. That convergence will help evolve the compact between science and society so that it will better reflect society's current needs and values. We need to move beyond what too often has been seen as a paternalistic stance. We need to engage the public in a more open and honest bidirectional dialogue about science and technology and their products, including not only their benefits but also their limits, perils, and pitfalls. We need to respect the public's perspective and concerns even when we do not fully share them, and we need to develop a partnership that can respond to them (Leshner, 2003).

The above quote is from an editorial by Alan Leshner, the former chief executive officer of the American Association for the Advancement of Science (AAAS). He describes the challenge that many scientists face when seeking to join civic dialogue on issues that lie at the intersection of science and society. Indeed, there is no shortage of such issues, as many of the challenges we face as a society—from climate change to public health to genetic engineering—have science and technology at their core. The science–society relationship is complex—sometimes constructive and sometimes tension-filled. Yet in order to move forward on these issues and make decisions as a society, we must find ways to foster dialogue among scientists and other members of society.

Public engagement with science (PES) can provide a constructive platform to combine public views with scientific expertise in a variety of contexts. PES describes intentional, meaningful interactions that provide opportunities for mutual learning between scientists and members of the public. These actions, in turn, lead to acquisition of knowledge and to increased familiarity with a breadth of perspectives and worldviews (Braha, 2015).

In many cases, scientists have sought to resolve tensions between science and society by trying to increase the public's understanding of scientific discoveries and theories. Adherence to the so-called deficit model, which attributes skepticism about science to a lack of understanding, has caused scientists to focus on providing more information in hopes of breaking down opposition to science (Dudo and Besley, 2016). However, many members of the public already understand basic scientific facts and concepts, yet they may disagree or be uncomfortable with the presumed implications and thus resist exploring and acting on particular issues (Leshner, 2007).

The PES approach often uses and builds on efforts to further public understanding while moving toward more comprehensive and interactive opportunities for dialogue and exchange. Through engagement, scientists and the public participate in discussions about the benefits and risks of the science and technology impacting their daily lives. In doing so, questions and concerns can be better understood and addressed. Further, involving a wide range of interested stakeholders can connect seemingly unrelated viewpoints, with potentially far-reaching effects. Scientists can expand the reach of their work and make it more relevant to society.

Key Approaches to Public Engagement with Science

In recent years, the AAAS has sought to provide a common framework, language, and research-based foundation for the many professionals involved in PES. Included in this work is a characterization of major approaches to PES (Nisbet and Markowitz, 2015) and the development of a typology that further describes options for engagement and potential metrics for success (Storcksdieck et al., 2016). The approaches to PES are not mutually exclusive; instead, each presents opportunities, strengths, and constraints. These engagements may take place in person or virtually, in real time or asynchronously. It is important to remember that there is no “silver bullet” for achieving a long-term vision of science and society in dialogue. What is needed instead are complementary activities with well-defined goals related to communication and engagement. The five major approaches to PES identified in the AAAS's work are reviewed next.

Everyday engagement

Informal interactions in daily life between scientists and the public are likely the most frequently experienced but least studied type of engagements. Often these opportunities arise spontaneously, when talking with a taxi cab driver, someone at the library, or around the dinner table at family holiday gatherings. Nevertheless, they are an opportunity to share how a scientist's work intersects with society and to learn from others about how they use science.

Public dialogue

Engagements that fall under this category are process-based, focused on cultivating conversation, but not necessarily intended to lead to a decision about a particular issue. Public dialogue approaches recognize that informal discussions with the public result in learning for both members of the public and scientists. Science cafés, storytelling events, and

festivals bring together scientists and the public to explore scientific topics from a variety of perspectives and provide opportunities for scientists to build their engagement and communication skills. Many of the activities conducted as a part of the annual Brain Awareness Week (organized by the Dana Alliance for Brain Initiatives and the Society for Neuroscience) fall into the category of public dialogue.

Policy deliberation

Public input into science-related policy making is an important facet of PES and is typically oriented toward achieving actions or outputs from the interactions. Dialogue often focuses on a contentious science-related issue and provides time for participants to share their knowledge, needs, concerns, and questions. Examples include the 2007 British Columbia Biobank Deliberation and the 2009 British Columbia Biolibrary Deliberation, which invited members of the public to deliberate about the ethical and social implications of biobanking and to formulate recommendations for policy makers (Burgess et al. 2008; Participedia 2017).

Knowledge coproduction

Researchers and nonacademic partners jointly designing or carrying out a research project are engaging in knowledge coproduction. Depending on the points at which the research process collaboration takes place, participants may cooperatively define research questions that correspond to their collective needs and interests, collect data, or analyze results. Examples include citizen science programs, such as those under the National Phenology Network or Zooniverse, and the American Geophysical Union's Thriving Earth Exchange, which brings together Earth and space scientists and community leaders to address local challenges related to natural hazards, natural resources, and climate change.

University-led cooperative engagement

Cooperative engagement initiatives are typically led by universities and deploy university-based networks, resources, and infrastructure such as cooperative extension and NOAA Sea Grant programs, or faculty and outreach staff affiliated with specific university departments, colleges, and schools. University-led cooperative engagement emphasizes building trust and

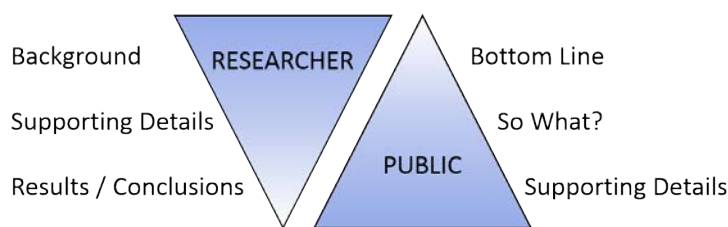


Figure 1. Scientists and the public have different communication styles. While scientists often start by placing research in a historical context, the public looks for the key points at the start. Reprinted with permission from the AAAS Center for Public Engagement with Science.

social learning in collaboration with key stakeholder groups such as farmers, coastal landowners, minority groups, and industry members. Researchers consult with these groups about their concerns, needs, and specialized knowledge and recruit opinion leaders and early adopters of best practices among these groups to influence their peers.

Communicating Science

As highlighted in Figure 1, typical scientific publications and communications, such as journal articles and conference presentations, begin with a lengthy introduction that situates the research within the larger scientific context. They continue with descriptions of methods and results, and it is usually only toward the end of the paper or talk that the scientist dives into a discussion of what the results might mean for advancing the field or for society. Public-facing communication products, such as newspaper articles, flip this approach on its head, leading with the most exciting information (generally the results or the implications of the results for society), followed quickly by the “So what?” and then the supporting details as appropriate.

Scientists who are proactive about developing messages that speak directly to an audience's interests, or even embedding a discussion of science in places where less motivated audiences might discover them accidentally, are generally more successful in engaging with that audience. In this way, they increase the odds of achieving the goals for a specific PES activity. The AAAS has developed a framework for PES to assist scientists with improving their science communication skills and building successful PES activities (Fig. 2). The framework can be applied across the various PES approaches described above and can help scientists organize their plans for engagement.

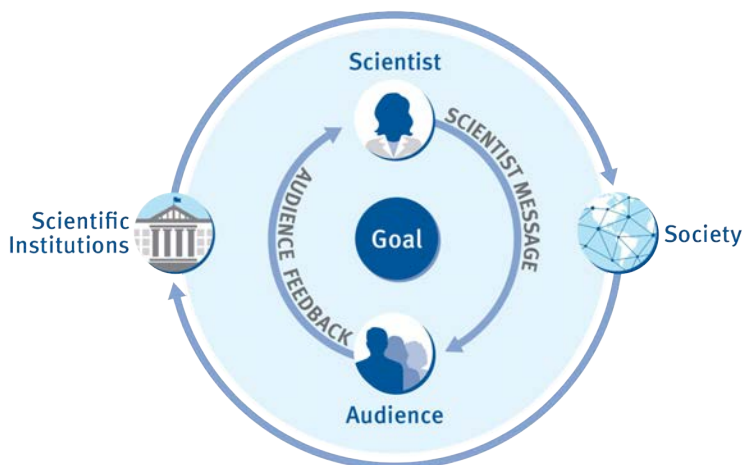


Figure 2. Framework for public engagement with science. Reprinted with permission from the AAAS Center for Public Engagement with Science.

Goal

The first step for scientists thinking about PES is to consider why they want to communicate about their work and engage with the public—that is, what is their goal? The scientist’s goal is at the center of this framework for a reason: It helps to determine the target audience, the messages the scientist will use to engage that audience, and the approaches he or she might select for engagement. Having a specific goal will also help scientists evaluate their success.

In developing their goals, scientists might start by considering what inspires them in their work and how that work might be connected to issues in society. Goals come in many forms, from short term to long term and from individual to big picture, and scientists may have multiple goals that build on each other. The AAAS theory of change provides several examples of short-term to long-term goals for engaging with the public that scientists may find useful as they plan their own science communication and PES (AAAS, 2016).

Big-picture goals are generally things that advance science as a field and improve interactions between science and society—and often take longer to achieve. Examples of big-picture goals include building trust between the public and scientists, promoting evidence-informed public decision-making on science-related issues, building a resilient science and technology workforce, or increasing support for PES at academic institutions.

Individual goals focus more on what the scientist hopes to achieve with his or her own work and are often focused on more concrete projects. These goals include starting conversations around a particular issue, identifying new research questions, or building a social media presence. Even goals related to getting funding for a particular research project can be PES goals—as long as they include elements that promote interactive dialogue and mutual learning.

It is important to be realistic in setting goals. PES is not a quick fix for advancing the science–society relationship. It is an ongoing activity, and it is important to identify smaller goals that build on each other. As scientists do more PES, they may

need to adjust their goals to be larger (or narrower) in scope.

Audience

Once scientists have a goal (or set of goals) in mind, the next step is to identify the audience(s) they would like to engage. At first, it may be tempting to select a broad audience (e.g., “the public”), but selecting such a wide range of people makes it difficult to consider that audience’s needs, values, and interests. Being as specific as possible about the intended audience will help scientists select PES activities and craft messages that are better able to achieve the stated goals.

Even when scientists select a narrower audience (e.g., policy makers), it is necessary to think about who within that audience they are most likely to be conversing with. Within the example of policy makers, will the scientist be talking with local, state, or nationally elected officials, or with their staff members? Or perhaps he or she will be engaging the constituents of the elected official.

As scientists think about their audience, they should ask themselves questions, such as which research topics might interest the audience, what commonalities they have with the audience, and what questions the audience might ask. It is important to learn as much as possible about the audience—for example, their demographics, culture,

geographic location, level of understanding, and experience with the topic. Identifying the audience's interests, values, and concerns is essential, as these are often the basis for connecting with them.

There are many ways in which scientists can learn about their audience in advance of engaging them—from studies that characterize public attitudes about science (National Science Board, 2016) to online resources such as web pages and social media accounts, to colleagues who have experience working with that particular group. Scientists who are participating in an event organized by someone else can talk with the organizers to learn more about expected attendees. Of course, nothing beats on-the-ground research: having in-depth conversations with a few members of the intended audience as part of the planning process, showing up early to chat with attendees, or beginning the activity with a few questions that elicit additional information, such as “How many people here have heard of attention deficit hyperactivity disorder?” or “What do you think of when you hear the words ‘cognitive enhancement’?”

Message

Clear and succinct messages serve as a scaffold that can help scientists plan what they would like to say when conversing with the public (or anyone else) about their research. Preparing these messages in advance allows scientists to be concise, remember their key points, and craft messages that will resonate with a particular audience. Clear messages also help the audience pay attention, focus on the discussion at hand, and think seriously about how the points relate to them. In turn, the audience will be better able to formulate questions, dig more deeply into the content, and connect the messages with their own interests. Clear messages also help the audience later repeat them more easily to friends and colleagues.

To develop these messages, scientists might start by thinking about the question, “Why should my audience care about this research?” Reflecting on how audiences might connect with a particular topic will help scientists think about the big picture their research fits into as well as specific messages that inform listeners at an appropriate level of detail. As scientists think more about specific messages, they can convey information that conforms to a “3M” structure: miniature, memorable, and meaningful.

Miniature

First, messages should be miniature. To create miniature messages, scientists should identify a few key points they wish to share during the engagement.

Limiting the number of key points to approximately three will help both the scientist and the audience remember and engage with these points. The key points might be research questions or focus areas, research results, potential applications of the research in society, or other reasons the work is important. The key points need not be elaborate—a few words or phrases a scientist might jot down on a notecard kept in a pocket will suffice. For example, a researcher studying the effects of socioeconomic status (SES) on neurocognitive ability might list key points as (1) neurocognitive ability and SES; (2) executive function and declarative memory disparities; and (3) achievement gap (Farah, n.d.). By themselves, these key points do not provide all the information the scientist may wish to convey, but they are a sufficient outline for the scientist, who may then develop each point more fully with a given audience.

Memorable

Second, messages should be memorable. Messages that are memorable allow both the scientist and the audience to remember the messages so that they can explore and digest them further. To make messages memorable, use verbal cues such as alliteration or rhymes, analogies, stories, or even pop culture references (as long as such references are appropriate for the audience and make sense). Returning to our example, the researcher focusing on SES and neurocognitive ability might reformulate the three shorthand messages to focus on socioeconomic (1) status, (2) stress, and (3) stunting (Landau, 2013).

Meaningful

Third, messages should be meaningful both to the scientist, who can convey the messages with passionate enthusiasm, and to the audience. When developing longer messages from key points, creating meaningful messages requires considering what will matter to the audience and building a connection with that audience based on their values, interests, and concerns. Scientists can also make their messages more meaningful by infusing emotion and experience into the discussion—explaining the adventure or mystery of embarking on a research project or the thrill of discovery. Meaningful messages also use language that is accessible to the audience. This means that scientists must examine their messages for jargon—defined here as the technical terms that scientists or others use as shorthand and for precision in research on a particular topic. These terms are often off-putting to audiences who do not have deep knowledge of a particular field and who may be reluctant to ask for definitions.

Returning to Farah's research web page, the discussion of why her work is important provides a good example of creating a meaningful message: "People of low socioeconomic status face enormous economic and social barriers to improving their lives. It is a tragic irony that they so often face this challenge with diminished capabilities as a result of the hardships experienced early in life. The ultimate goal of this research program is to understand and help break the cycle of poverty using insights from neuroscience" (Farah, n.d.).

Audience feedback and evaluation

The final element of the PES framework is audience feedback and evaluation. Individual scientists who are attuned to audience feedback throughout a PES activity can make quick course corrections to improve the dialogue (e.g., noticing that someone looks confused or disengaged and using it as an opportunity to pause and invite the audience member to ask a question or to revisit a concept). It is essential to remember that PES is meant to be a conversation, so it is important to allow the audience to help steer the interaction.

Longer-term evaluation is also important. Scientists can use their initial goals to define what they would consider a successful outcome and then identify metrics that will help them evaluate success. For example, a scientist sets a goal of sparking conversations around whether ADHD medications should be available to people who have not been diagnosed with the disorder. She does so by visiting a science museum several times to engage visitors to an exhibit about brain chemistry in such conversations, so she might select metrics related to (1) the number of people who conversed for more than five minutes, (2) the types of questions visitors asked, and (3) the content of Tweets about the exhibit that mentioned ADHD medications. It is also important to note that what is considered successful can vary from one individual to another and one project to another. For example, a scientist who has not previously done PES and is not well known at the museum may consider 10 conversations over the course of five visits to be successful, whereas another scientist who has served as a guest scientist at the museum's exhibits for several years and is recognized by regular visitors may be disappointed by fewer than 10 conversations over the span of a single day.

Discussion Materials

Select one of the previous case studies or use your own research as a basis for discussing the following questions:

1. Why is public engagement needed in this case? What is the central issue or point of contention?
2. What is the goal for engaging the public?
3. What mechanism would you use to engage the public? Why would you choose that approach?
4. Who is the audience? What do you know about them? How could you learn more about them?
5. What core messages could you use in your engagement efforts?
6. How could you get feedback from the audience and evaluate the activity? What would you consider a success?

Additional Resources

The AAAS Center for Public Engagement with Science and Technology Communication Toolkit is a free online resource that includes web-based seminars, video, how-to tips for media interviews and public presentations, public outreach opportunities, and more: <http://www.aaas.org/page/communicating-engage>.

The AAAS Center for Public Engagement with Science and Technology works with social science researchers to conduct and synthesize research on best practices for science communication and public engagement. A collection of papers resulting from these collaborations is available at <https://www.aaas.org/pes/other-resources#Articles/Reports>.

The AAAS Public Engagement with Science Group on Trellis brings together scientists, researchers, and public engagement practitioners to share their experiences and expertise, build new collaborations, be inspired, and improve skills related to PES: <http://www.trelliscience.com/publicengagement>.

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