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A Preparatory Neuroethical Approach to Assessing Developments in Neurotechnology

James Giordano, PhD, MPhil

Incising the Brain, Mind, and Self

The intricate—and still not fully understood—relationship of the structures and functions of the brain to the properties of consciousness, cognition, emotion, and behavior that define what it is to be a human person represents an important philosophical and pragmatic construct of neurosurgery. Of course, any surgical intervention involves possibilities of changing the physical structure of the body to alter some subjective or objective qualities that are regarded to represent "the self" (one need only consider cosmetic surgery, perhaps the most obvious example). And, like all forms of surgery, neurosurgery possesses certain inherent risks (e.g., infection, hemorrhage), which are of concern when balancing benefits, burdens, and harms. Increasingly, neurosurgical intervention is being regarded as a valid, viable, and valuable option for the treatment of a number of neurological disorders and psychiatric conditions [1-4].

Yet, there is something about incising the brain and the relationship of brain-to-mind-to-self that conjures concerns of a more profound sort. There is disquiet about using neurosurgery to change thoughts and emotions, if not what is considered by many to be the "essence" of the "self" [5]. Perhaps it is that consciousness is wholly subjective and internal, and thus there is something almost sanctified—and inviolable—about that space where consciousness, thought, feeling, and the ability to experience and exercise the qualities that define the "me-ness of me" are generated, or at least focused. For over 100 years, neurosurgery has crossed that threshold of inviolability with ever-improving finesse. In this essay, I first discuss the concerns raised by these interventions and then introduce a comprehensive framework for identifying and addressing ethical issues in neurosurgery.

Altering Behavior and Thought with Neurosurgical Techniques and Technologies

Attempts at cutting the brain to alter the mind and self are not new, and history reveals similar concerns about the prior use of techniques, such as leucotomy and lobotomy, that were "state-of-the-science" at the time [6]. Retrospection now enables us to view such techniques as relatively crude. With this in mind, I look to the current palette of neurotechnologically enabled neurosurgical interventions with enthusiasm—and apprehension. The newest methods evoke imaginings that border on the science-fictional, and fictionalized accounts and the fears they evoke should

not be taken lightly: they tend to reveal important dimensions of public perception and emotion [7].

Arguably, the use of novel neurosurgical techniques and technologies to alter behavior (e.g., impulse control disorders), cognition and emotion (e.g., depressive disorders, posttraumatic stress disorder), and memories (e.g., restoring function following brain insult, mitigating memories of traumatic events) could all be regarded positively as therapeutic. There are near-term possibilities of utilizing neurosurgery-dependent neurotechnologic approaches to treat personality disorders, reduce criminal behavior, and augment specific dimensions of cognitive performance [8, 9]. Yet, these very same approaches could be employed as means to ends that are more controversial: e.g., to enforce social norms or "public safety" [10]. To what extent can—and should—these interventions be used to alter human thought, intellect, mood, personality, belief, and actions? And how do we know whether to categorize these interventions as treatments of "abnormalities" (particularly if said norms are neuroscientifically defined), enhancements (and how far can and should brain functions and human performance be enhanced?), or "enablements" (e.g., to promote qualities deemed desirable in certain public servants and professionals such as peace officers, fire fighters, soldiers, or even physicians) [11-14]? What will this portend for the practice—and ethics—of neurosurgery?

Much of this remains something of a brave new world, as many of the mechanisms and effects of these novel techniques remain unknown precisely because they are, in fact, new. Thus, ongoing research is important to establish and clarify the possible benefits, burdens, risks, and harms. Since many of the more controversial aspects of these approaches are related to control of human cognition, emotion, and behavior, animal research alone will not suffice [15]. At this stage—and in the near future—much of clinical neurosurgery that employs advanced technology will likely be regarded as a research endeavor. Given that any such intervention is exploring uncharted interactions between a novel neurotechnology and its effect upon the brain, the possibility arises of neurosurgery having unanticipated outcomes and unintended consequences as well as its being used to enforce social norms.

Toward a Preparatory Neuroethical Framework: A Twelve-Step Approach

In many ways, ethical issues in neurosurgery overlap with those of surgery and medicine in general. Surgical intervention must always regard relative risks, harms, gains, and losses; well-informed patients must completely and genuinely consent to the treatment(s) offered; and equitable allocation and distribution of services, resources, and goods must be considered [16]. However, these ethical issues are amplified in neurosurgery given the unknowns of the brain-mind relationship, the novelty of neurologic techniques and technologies, and uncertainties arising from their intersection [17]. As a result, actual benefits and harms can be misperceived or misrepresented, available science and technology can be over- and underused, and the extent of care can be inadequate to provide and sustain meaningful good to patients and society at-large—all of which can impact the current and near-future practice of neurosurgery. Such issues are the domain of the field of neuroethics.

We have called for a preparatory neuroethical posture [18], which (a) realistically appraises the actual capabilities and limitations of the tools and techniques at hand; (b) works to define the domains and dimensions that new techniques and technologies will influence; (c) employs qualitative and quantitative modeling to plot benefits, burdens, and risks as accurately as possible; and (d) addresses what can and should be done to mitigate risks and harms while maximizing benefits [19].

A first step in this process is to characterize and parse neuroethical issues into six essential questions:

1. *What* types of techniques and technologies are available for current use, and what are their defined benefits and known and potential burdens and risks?
2. *Why* are specific techniques and technologies being considered or advocated for use, and why and how can technical capabilities affect identified substrates of neurological and psychiatric disorders and conditions that require treatment?
3. *Who* will receive these neurosurgically administered interventions (i.e., which disorders and conditions are to be targeted, which specific patients will be candidates for such interventions)?
4. *When* will neurosurgically administered interventions such as deep brain stimulation (DBS) be considered within a therapeutic algorithm or protocol? Will (and how will) factors such as age and comorbidities be considered in making such decisions?
5. *Where* will these techniques be practiced (e.g., large medical center "hubs," private practice clinics, specified research-based trials)?
6. *Which* funding mechanisms will be employed to subsidize equitable provision of resources and services necessary for both the intervention and any subsequent care that may be required?

These questions (the "six Ws") can be seen as serial and interrelated, yielding a detailed description and definition of the ethical problems in neurosurgery that are—and will soon be—generated by new developments in neuroscience and neurotechnology.

From this point, the six W questions listed above should be framed and informed by considering the "six Cs" (expanding upon initial work by William Casebeer [20]):

1. *Capacities* and limitations of the neurotechnology and neurosurgical intervention in question [16],
2. *Consequences* that will be incurred by patients, patients' families, and society as a result of the intervention in the short, intermediate, and long-term,
3. *Character* of the patient (e.g., patterns of cognition, emotion, and behavior) that could be affected by the intervention,
4. *Continuity of clinical care* for any and all adverse or undesirable effects and manifestations of the intervention (including multidisciplinary approaches, or repeated neurosurgery to alter or reverse the initial treatment) [15],
5. *Consent* based upon the provision of the greatest extent of information possible [20],

6. *Contexts* of culture and circumstances that may affect the aforementioned variables [21].

These lists of considerations for addressing, analyzing, and answering neuroethics questions can be used together with a general approach to ethical reasoning (as shown in table 1) to formulate a decision and actions.

Table 1. Using the six Ws and six Cs in a typical ethical reasoning process

Step	
1	Gather and assess all relevant facts (i.e., the six Ws).
2	Identify the circumstances of the case (i.e., what, who, when, where).
3	Identify the agents involved and their respective roles.
4	Identify the nature of the ethical issue, question, or problem (i.e., the six Ws) and if/how these relate to capacities, consequences, character, or contexts (4 of the Cs).
5	Plot possible actions toward resolving the issue or problem and offer a grounding rationale for each (considering the six Ws).
6	Identify potential trajectories, outcomes, and effects of each possible action (considering the six Cs).
7	Discern what should be done and why (to maximize beneficial consequences in particular contexts).

This approach acknowledges that (a) the most contemporary science and technology represent a "frontier" of possibilities, (b) conditions at the frontier are always somewhat uncertain, and (c) given such uncertainties, things can—and often will—go wrong [11, 16]. Indeed, pressing the boundaries of innovation can sometimes be risky. But risk need not stifle the quest for novel tools and methods. Rather, it's better and far more valuable to pragmatically assess trajectories of effect and recognize, prevent, or mitigate potential problems before they escalate in order to reap the benefits that new techniques and tools may afford [22].

Conclusion

Rapid developments in neuroscience and neurotechnology position neurosurgery to be increasingly employed to treat an expanding range of neurological and psychiatric conditions—and generate a host of ethical concerns about the ways such techniques might be used and misused. Neuroethics provides a set of practices for realistically defining horizons of possibility and pursuing the deliberations necessary to move ahead with prudence [11, 17, 21, 23]. But the field cannot continue to advance without representation in medical education and training at a variety of levels and through a diversity of resources, inclusive of medical curricula, resident training, grand rounds, and case presentations [24]. Such education will ultimately be vital to informing and developing neuroethically sound guidelines and policies to direct the provision and use of clinical resources, goods, and services and to providing public education about the trajectories and implications of employing neuroscientific techniques and neurotechnology in neurology, psychiatry, and neurosurgery.

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James Giordano, PhD, MPhil, is chief of the Neuroethics Studies Program of the Edmund D. Pellegrino Center for Clinical Bioethics and a professor of neurology at Georgetown University Medical Center, Washington, DC. His research focuses on the neurobiology of neuropsychiatric spectrum disorders and the neuroethical issues engendered by the use of neurotechnology in neurologic, psychiatric, and neurosurgical research and practice.

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