Brain Stimulation 16 (2023) 977–979

Contents lists available at ScienceDirect

Brain Stimulation

journal homepage: www.journals.elsevier.com/brain-stimulation

Defining distinction between real vs hypothetical problems in the ethics of neurotechnology

A defensible argument can be made that current and emerging neurotechnologies are being developed with benevolent intent. However, benevolent intent and beneficent applications in practice can - and often do as applications of use become more widespread and diverse – incur neuroethical problems. In developing solutions to these ethical problems of neurotechnology, we believe that it is critical to distinguish between two kinds of problems.

The first are problems that relate to a specific, existing technology and empirically established capabilities. In this case, identifying a technology that in its present form produces documented outcomes that, without extrapolation to greater effects, raises genuine and immediate ethical concerns. We propose calling such problems *real*.

The second kind of problem we propose calling *hypothetical*; in the sense that either 1) there is an existing technology that might be used for some purpose, but there is no empirical evidence that it is effective (or even employed) for that purpose; 2) where such uses, in practice, require development of yet unachieved technology (no matter how incremental or ambitious the improvement may seem). That such problems are *hypothetical* does not imply that associated ethical concerns are unimportant or illegitimate, only that ethical discourse or debate is being raised in the absence of real-world evidence that the explicated problem is relevant given current technological capabilities and/or would even work in practice. These concerns are therefore extrapolative: they are about technologies that may one day exist, or (if/when they) exist may be used for the purpose discussed. Indeed, tools have been proposed to address *hypothetical* problems/scenarios [1,2].

The caution with *hypothetical* problems is that absent imposition of real-world constraints discussions can lead to unconstrained speculation and become uncoupled from feasibility. At worst they assume a science fictional tone, and become quixotic, if not frankly performative. By dissociating from real technology and evidence, *hypothetical* problems can presuppose any kind of technology with any kind of application, and can then foster 'toy issues' to raise abstract ethical issues.

Hypothetical problems make for interesting thought experiments and fun discussions (e.g., super intelligent cyborgs and dystopian states), and support catchy stories in the media. And, we have noted the conditional value of science fictional themes and enterprises in prompting public narratives [3]. But *hypothetical* problems can have a real-world cost, in possibly interrupting or halting neurotechnology development – which they may have only cursory (and by definition hypothetical) relationship to.

In some cases, distinction between *real* and *hypothetical* neuroethical problems can be tenuous. This is especially so when researchers are inclined to amplify the theoretical impact and manifest influence of their findings. For example, the demonstration that a type of neuromodulation can increase performance on a specific laboratory experimental task linked to "creativity" could without direct evidence (and ergo presumptively, if not erroneously) suggest that current technology can enhance general creativity in the real world, on real tasks (for further discussion, see Refs. [4–6]). If that generalization is even tentatively accepted, it may therefore appear that associated neuroethical problems are *real,* and address an actual issue. There are other examples of such *hypothetical* problems based on extrapolating laboratory findings to generalized use, such as enhancing memory and learning, changing mood, and superlatively augmenting cognitive performance.

This grey zone is not merely academic. Rather, recent calls for "no new neuroscience and technology without neuroethical engagement" are laudably being iteratively heeded. But given this requires dedication of fiscal support (personnel, and resources [7,8] and the opportunity-cost in inhibiting research programs, we posit the implementation of neuroethical review must be cognizant of the demarcation between *real* and *hypothetical* problems (viz.- "no neuroethics without real-world insight on the readiness and applications of neurotechnology"). For the case of reviewing (for funding) new research programs – where one expects new technology or use-cases – the neuroethics are *hypothetical* but become *real* should the proposal succeed. Nevertheless, the scope of new technology and use-cases is constrained (from fantastic speculation) by its technical review. For the case of laws or guidelines which need to anticipate new developments, acceptance of all *hypothetical* problems would simply shut down all research programs (neurotechnology or otherwise). While we have no simple prescription for balancing these considerations, failure to distinguish between *real* and *hypothetical* problems makes neuroethics impractical.

We proposed a demarcation to distinguish *hypothetical* from *real* problems-which rather than being an end it itself, can guide further neuroethical considerations. Namely, is there empirical evidence the technology in its exact current form is applied and effective in the exact use-case (beyond human trials)? If the answer to this query is 'no', then any neuroethical discourse should first acknowledge this. Rather than use the ambiguity between speculative or laboratory-based and real-world use as a departure point for speculations about problems that may not be *real*, it is instead more useful to precisely consider the issue of 'why not?'. Such a thought exercise motivates a detailed and nuanced understanding of both experimental findings and technology, to delineate gaps limited adoption, and so *real* vs. *hypothetical* problems.

Further concerns in *hypothetical* and *real* problem demarcation can arise if individuals, after reading some paper, direct technology toward some goal that differs from the original intent. As well, imagine a secret neurotechnology deployment by a state. There may be a technology so

https://doi.org/10.1016/j.brs.2023.05.016
Received 12 May 2023; Received in revised form 15 May 2023; Accepted 21 May 2023
Available online 9 June 2023

complex to use in its current embodiment (such as an implanted brain computer interface that requires a team of engineers for maintenance) that it can only be operated in a laboratory environment – yet it provides real benefit to very limited number of subjects. It can be argued that any *hypothetical* problem, for example, neurotechnology use that is currently confined to laboratories, could "one day" become practical – indeed that is the goal of *applied* research. This argument is rational; however, in the absence of an existing technology within established use-cases (beyond experimental laboratory settings), neuroethical issues remain *hypothetical,* per our criterion for demarcation. When neuroethical issues require extrapolation from what is currently feasible in real-world applications, then these should be recognized as *hypothetical* problems. Moreover, in accordance with the tenor of hypothesis formulation, such *hypothetical* problems posit trajectories and valences that could arise, as based upon both current, and some specifically identified future capability and/or constraint of science, technology, social ecology, etc. In other words, while we do not impugn posing and addressing *hypothetical* problems, it is essential to precisely identify them as such, so as to maintain a reality principle throughout any resulting discourses.

It remains to be seen if and to what extent in neurotechnology such *hypothetical* problems are inductively justifiable, if we consider that actual *solutions* to problems cannot precede the identification a real problem (i.e., a corollary of the so-called Collingridge dilemma or more generally a Popperian constraint that philosophy should address problems).

To wit, we opine that any discussion of neurotechnology ethics must be cognizant of, and explicit about what technology can and cannot achieve in its *present* form (inclusive of the technology (hardware/software) itself, the knowledge of how to use it, and the limits of empirical evidence for outcomes intended, desired, and/or unanticipated and deleterious. This requires discursive distinction between subjective hopes and apprehensions about what the technology may achieve, and the humbler objective reality of actual technologic abilities and limitations.

Discussion that is grounded in actuality also requires clear delineations of the technology addressed. For example, discourses about "brain computer interfaces" or "neuromodulation devices" in general should be clarified, since these nomenclatures represent a broad palette of approaches with major differences in capabilities and use. For example, spanning invasive implants to wearables. By identifying the unique aspects of a technology, *real* problems can be pragmatically defined for prudent address. Simply put, treating DBS, TMS, ECT, and tDCS as a singular entity (eg. - "neuromodulation") is erroneously generalizing. Any meaningful discourse about these technologies -and their varied real-world uses in practice – must be informed by, and based upon the factual particularities, and specifics that these approaches entail, obtain, and incur.

To this point, discussing ethical issues of neurotechnology without reference to a specific technology is analogous to discussing the potential (benefit and risks) of "drugs" without considering that the term "drugs" does not refer to a monolithic entity. It becomes clear how any discussion (or attempt at rational argument) of this sort can quickly become muddled when the capabilities and concerns related to a particular entity are conflated with others – or rather no distinction between diverse drugs or technologies is made at all. This is not to say that analysis can't cluster and/or compare distinct (but somehow convergent) technologies, but any neuroethical concerns beyond what is currently achieving with any one technology are axiomatically *hypothetical.* For a similar reason, while it can be rational to combine findings from distinct studies to suggest a problem is in fact *real* (for example a technology is available for home use and separately has been shown to produce an effect in a lab) such combinations should be done with utmost diligence (for example if the effect in the lab is on a controlled and limited task of questionable relevance to home use).

Finally, we caution against slippery slope fallacies that can easily follow from *hypothetical* problems, especially if they are confused with those that are *real*. For instance, stating that a particular neuromodulatory technology "x" can be rationally posited to induce to some type of "long lasting" changes in brain function "y" (e.g., via neuroplasticity), and then demanding caution (or even restraint) because of under-specified and/or ampliative concerns about resulting perdurable and undesirable alterations in brain structure and function "z"", is representative of committing fallacies of composition (i.e.- "x" results in "y", and some "y" is associated with some "z", does not show "x" results in "z") and hasty generalization (wherein a generalization is inferred from limited, inadequate, or inappropriate information).

Such concerns can also be exaggerated in reference to any susceptible population without reference to empirical evidence supporting enhanced risk. Susceptible population by definition require special consideration, but this applies to *both* safety and not unjustifiably restricting access to interventions (including in trials). Without appropriately referencing evidence, and appealing only to platitudes (e.g., developing brains are developing), *hypothetical* problems can succumb to the fallacy of "appeal to the gallery" to evoke reaction in/among a particular group. Moreover, these "cautions" often ignore that experimental research proceeds under strict ethical oversight of institutional review boards, human subject committees, and data safety monitoring boards; therefore. It is a mistake – and disingenuous - to imply, without specifics, that efforts dedicated to measuring or modulating the brain are inherently cavalier.

Our consternation about spurious neuroethical concerns regarding *hypothetical* problems also reflect an additional (informal) fallacy; namely*, argumentum ad ignorantium* (literally, an argument from or to ignorance, i.e.- an absence of available, valid knowledge) in that their assertions have not yet been disproven, or even impossible to falsify. Such arguments not only fail to provide empirical evidence for identified risk (e.g., injury deficits) but also fail to identify specific and plausible *mechanisms* of risk by devolving to speculations about "putative effects". This often happens on issues of dose and subject selection. For example, given a technology tested for set period, one should not imply use beyond this set period is necessarily hazardous without a mechanistic rational. Such a rational may be a specific mechanism that is empirically established to activate only after exceeded the set. Instead to say the risk of any hazard X increases generically with time, is not a good explanation since it can be applied to anything. Indeed, all approved therapies are based on a specific tested dose(s) and fixed period of monitoring, at least the latter must be exceeded in any practical use. And indeed, empirical methods are in place for monitoring of long-term real-world evidence. Thus, hypothetical concerns about yet untested populations, doses, or time-periods should be addressed through established risk mitigation processes (e.g., IRB/Helsinki review, data collection) rather than preemptively aborting research programs designed to precisely address these issues, using only *argumentum ad ignorantium*.

It is correct to say that evidence for safety is never "for the technology" but rather always "for the technology in the given use case including dosing and sub-selection". It is incorrect to suggest that simply absence of evidence outside these parameters is evidence for risk. This is again a bad explanation since it can be applied to anything (i.e., a *hypothetical* problem applied to anything new). It is rational to consider use of a technology across extensive and diverse use-cases, as cautiously supporting use analogous cases. From the context of this essay, we note extensive ethical frameworks exist for human trial as exhaustibly formulized through process such a IRB/Helsinki review – where assessment of risk (and benefit) always considers technology and used-case. Similarly, exhaustive efforts developing technical/safety standards for specific neurotechnologies such as TMS [9]and tES [10] are ongoing, and ethical considerations should - at a minimum - recognize such efforts.

The critical tone of this essay is not intended to discourage philosophical discourse focusing upon neurotechnology; and we believe that both real and *hypothetical* neuroethical concerns warrant attention. But we also believe that it is vital to explicitly distinguish between *real* and *hypothetical* problems. Discussions of creating elites with super-powered brains, and dystopian societies of neuro-enhanced haves and have-nots make for fanciful fiction [11], but are divorced from the genuine capabilities and proximate goals of science. Discussion of *hypothetical* problems in neurotechnology are often warranted (e.g., anticipating near-future patterns and implications of medical misuse, and national security concerns as based upon recent prior/current issues, questions, and problems of similar sort. Still, clear demarcation from *real* problems supports: (1) consideration of which neuroethical issues are timely (i.e.-most probable); (2) apt focus upon those issues should be addressed; (3) what issues and problems warrant an immediate solution; and (4) dedicated efforts to developing such solutions. Apropos this latter point, given limited resources at hand, committing time, effort and funds to proposing solutions for *hypothetical* problems can be regarded as chasing straw man ideas, wasteful, and inconsistent with sustaining goods in those ways best viable for public benefit. And, if the benevolent aims of neurotechnology are to be realized, then principial focus upon *real* problems and their solutions, together with complementary consideration of *hypothetical* problems and the speculations they generate afford best steps for prudent ethical progress along the path ahead.

CRediT authorship contribution statement

Marom Bikson: Conceptualization, Writing – review & editing. **James Giordano:** Conceptualization, Writing – review & editing.

Declaration of competing interest

The City University of New York holds patents on brain stimulation with MB as inventor. MB has equity in Soterix Medical Inc. MB consults, received grants, assigned inventions, and/or served on the SAB of SafeToddles, Boston Scientific, GlaxoSmithKline, Biovisics, Mecta, Lumenis, Halo Neuroscience, Google-X, i-Lumen, Humm, Allergan (Abbvie), Apple, Ybrain, Ceragem, Remz. MB is supported by grants from Harold Shames and the National Institutes of Health: NIH-NIDA UG3DA048502, NIH-NIGMS T34 GM137858, NIH-NINDS R01 NS112996, NIH-NINDS R01 NS101362, and NIH-G-RISE T32GM136499. JG is supported by federal funds from Award UL1TR001409 from the National Center for Advancing Translational Sciences (NCATS), National Institutes of Healthh, through the Clinical and Translational Science Awards Program (CTSA), a trademark of the Department of Health and Human Services, part of the Roadmap Initiative, “Re-Engineering the Clinical Research Enterprise”; National Sciences Foundation Award 2113811 - Amendment ID 001; Henry Jackson Foundation for Military Medicine; Asklepios Biosciences; and Leadership Initiatives.

References

[1] Neuroethics at 15: the current and future environment for neuroethics. AJOB Neuroscience 2019;10:104–10. https://doi.org/10.1080/21507740.2019.1632958.
[2] Schoemaker PJH. Scenario planning: a tool for strategic thinking [n.d].
[3] Wurzman R, Yaden D, Giordano J. Neuroscience fiction as eidolá: social reflection and neuroethical obligations in depictions of neuroscience in film. Camb Q Healthc Ethics 2017;26:292–312. https://doi.org/10.1017/S0963180116000578.
[4] Shook JR, Giordano J. Neuroethics beyond normal: performance enablement and self-transformative technologies. Camb Q Healthc Ethics 2016;25:121–40. https://doi.org/10.1017/S0963180115000377.
[5] Weinberger AB, Cortes RA, Green AE, Giordano J. Neuroethical and social implications of using transcranial electrical stimulation to augment creative cognition. Creativ Res J 2018;30:249–55. https://doi.org/10.1080/10400419.2018.1488199.
[6] Racine E, Martin Rubio T, Chandler J, Forlini C, Lucke J. The value and pitfalls of speculation about science and technology in bioethics: the case of cognitive enhancement. Med Health Care and Philos 2014;17:325–37. https://doi.org/10.1007/s11019-013-9539-4.
[7] Shook JR, Giordano J. Toward a new neuroethics in a multipolar and multicultural world. Global-e 2020;13.
[8] Giordano J, Shook JR. Neuroethics: what it is, does, and should do [n.d].
[9] Rossi S, Antal A, Bestmann S, Bikson M, Brewer C, Brockmöller J, et al. Safety and recommendations for TMS use in healthy subjects and patient populations, with updates on training, ethical and regulatory issues: expert Guidelines. Clin Neurophysiol 2021;132:269–306. https://doi.org/10.1016/j.clinph.2020.10.003.
[10] Antal A, Alekseichuk I, Bikson M, Brockmöller J, Brunoni AR, Chen R, et al. Low intensity transcranial electric stimulation: safety, ethical, legal regulatory and application guidelines. Clin Neurophysiol 2017;128:1774–809. https://doi.org/10.1016/j.clinph.2017.06.001.
[11] Wilson DH. Amped. Doubleday; 2012.

Marom Bikson*
Department of Biomedical Engineering, The City College of New York, USA

James Giordano
Dept of Neurology and Neuroethics Studies Program, Pellegrino Center for Clinical Bioethics, Georgetown University Medical Center, USA

* Corresponding author.
E-mail address: bikson@ccny.cuny.edu (M. Bikson).
Handling Editor: Dr. M. George