Building ethics into next-generation BCI: A model for embedded ethics in neurotechnology industry

Juhi Farooqui[1]*, Landan M. Mintch[2], Jon Nelson[2], Jacob T. Robinson[2,3], Anna Wexler[1]

[1]*University of Pennsylvania, Philadelphia, PA, USA;* [2]*Motif Neurotech, Inc., Houston, TX, USA;*
[3]*Rice University, Houston, TX, USA*
*E-mail: jhf@upenn.edu

Introduction: Over the last decade, brain-computer interfaces (BCIs) and neurotechnology have become an impactful industry, innovating for various applications and enjoying optimistic market projections.[1] In this context, deep ethics integration is more important than ever. Embedded ethics, popularized via frameworks like responsible research and innovation (RRI),[2] has been applied in some academic neurotechnology research labs.[3] However, despite industry members' interest in ethics,[4,5] this model is largely absent from neurotechnology industry.[6] Prior work in our lab identified some potential reasons for this. For instance, traditional embedding emphasizes idea generation through embedded observation, which can be impractical in industry. Moreover, the distinction between embedding and consulting can become blurred in the industry context. Here we present a partial embedding approach that addresses these challenges to support research that both draws from and contributes to neurotechnology industry.

Materials, Methods and Results: We implemented our model in partnership with Motif Neurotech, a company developing novel therapeutic neurotechnology to measure and regulate mental and cognitive states. Our process (Fig. 1) begins with pre-embedding discussions between neuroethicists and company leadership to identify valuable research directions. Background research based on this early brainstorming informs both the project proposal and the identification of relevant teams for embedding. In this project, we established relationships with product, science, clinical, and lived experience teams that ranged from participation in team meetings to one-on-one meetings with team members to develop research questions, methods, applications of potential findings, and more. Through this process, we co-developed a research project examining how factors such as neurotechnology device characteristics, implantation procedures, and therapeutic regime impact patients' risk perceptions and willingness to undergo a neurotechnology intervention. As study activities are completed in the spring, we will collaborate with Motif team members to incorporate findings into future decision-making related to device development and commercialization activities. Critically, the project is designed to generate insights into patient perspectives that will inform not only the specific partner company, but also priorities for future implanted BCI and neurotechnology research across the field.
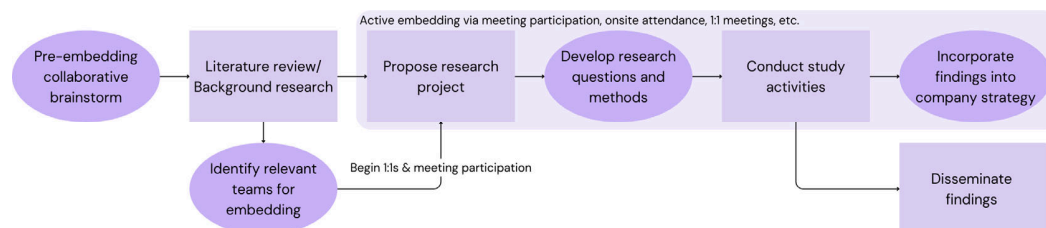

Figure 1: Process for conducting embedded ethics research with neurotechnology industry partners. Ovals represent steps taken in active collaboration with team members at the partner company.

Discussion and Significance: This project presents a new model for ethics engagement in the neurotechnology industry. Beyond collaboration or consulting, the embedded model fosters deeper integration of the ethicist with the company and prioritizes research with broad implications for the field while remaining grounded with practical industry needs. Moreover, the embedded model can generate ethics recommendations that are mindful of the constraints and realities of neurotechnology companies.

References:
1. Titchmarsh, K. L. *et al.* Brain Computer Interface Primer: The Next Big MedTech Opportunity? (2024).
2. Pansera, M., Owen, R., Meacham, D. & Kuh, V. Embedding responsible innovation within synthetic biology research and innovation: insights from a UK multi-disciplinary research centre. *J. Responsible Innov.* **7**, 384–409 (2020).
3. Goering, S. & Klein, E. Embedding Ethics in Neural Engineering: An Integrated Transdisciplinary Collaboration. 17–34 (2020).
4. MacDuffie, K. E., Ransom, S. & Klein, E. Neuroethics Inside and Out: A Comparative Survey of Neural Device Industry Representatives and the General Public on Ethical Issues and Principles in Neurotechnology. *Ajob Neurosci* 1–11 (2021)
5. Maiques, A. To Be or Not To Be Involved in Neuroethics: An Entrepreneurial Perspective. *AJOB Neurosci.* **10**, 202–204 (2019).
6. Pfotenhauer, S. M. *et al.* Mobilizing the private sector for responsible innovation in neurotechnology. *Nat Biotechnol* **39**, 661–664 (2021).