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Meeting report

Neuroethics hackathons bridge theory to practice

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Ethical practice is a vital component in neuroscience innovation, and that practice must reflect the interests of society. However, truly ethical and responsible innovation may require moving beyond current theory toward more creative and imaginative approaches. Here, we present neuroethics hackathons as a case study in bridging theory to practice.

Anyone involved in the neuroscience and neurotechnology space must be equipped to proactively address ethical issues and integrate ethical and social considerations throughout the research and innovation life cycle. The proliferation of global governance activities shows the need for ethical science innovation. Ethical practice is an integral element of a science that aims to be impactful and ethically viable. However, achieving socially responsible innovation in the face of radically complex challenges may require more creative approaches, thus the need for ethics innovation. Such innovative approaches can facilitate a more societally positive transition from laboratory to market.

Aware of the need to coordinate creative activities to embed ethics into scientific practice, the Institute of Neuroethics Think and Do Tank hosted its inaugural neuroethics hackathon on June 25, 2024 at the Federation for European Neuroscience Societies (FENS) Forum 2024. Bringing diverse creative thinkers together to propose solutions to complex ethical and social issues, neuroethics hackathons can serve as significant tools for capacity building. In this instance, we collaborated with an international community of early-career scientists specializing in neuroscience and AI who are the future developers of next-generation neurotechnologies.

Neuroscience innovation need neuroethics innovation

The rapid pace of neuroscience research and the significant investments in this field have resulted in the development of sophisticated tools, technologies, patents, and the creation of companies with increased capacities to gain deeper insights into the brain.[1] At the same time, these advances have surfaced multiple ethical and social considerations.

Neuroethics is the systematic reflection and analysis of both individual and societal issues raised by neuroscience and emerging neurotechnology. Awareness of those issues has risen to the highest levels of governments worldwide.[2] Since 2017, the International Brain Initiative (IBI)—a consortium founded on the 7 large-scale, national-level brain research projects—has prioritized neuroethics as a critical element to help the global enterprise to effectively leverage joint efforts, ensuring that public investment maximizes societal benefit.[3] As part of the IBI's neuroethics working group, in 2018, we collaboratively designed a list of Neuroethics Questions for Neuroscientists (NEQNs) intended to help neuroscientists identify and attend to neuroethical issues in their work.[2] Because neuroscientists today must be globally oriented and possess the tools to address ethical issues related to their research, we emphasized the need for addressing these issues through a culturally aware lens.

In 2019, the Organization for Economic Cooperation and Development (OECD) introduced the first international recommendation on responsible innovation in neurotechnology, which was adopted as a legal instrument by its 38 member countries.[4] Since then, the recommendation has entered its implementation phase. In April 2024, OECD published its Neurotechnology Toolkit, intended to help policymakers navigate the increasingly promising yet ethically complex terrain of neurotechnology. In the last 5 years, we have seen growing awareness and activities related to neuroethics, which has led to further proliferation of neuroethics guidance proposals[5] with most recent activities in the UN Office of the High Commissioner of Human Rights (OHCHR) and UNESCO. Moreover, new laws have been passed in both Chile[6] and the US to establish specifying protections for data collected from neurotechnologies.

Neurotechnology illustrates a converging technology, its progress driven by advances in AI, computational sciences, data science, and other fields. As these fields evolve together, there is a growing need for ethical guidance and legislation that also converges. Importantly, as international efforts consider the creation and implementation of neuroethics guidance and regulatory tools, involving a breadth of communities and including typically underrepresented voices is critical. This includes engaging with next-generation innovators, active neuroscience and neurotech researchers, diverse user communities, and the private sector, which plays a significant role in translating much of the technology developed in universities into practical applications. As these technologies will be deployed globally, cultural considerations should be integrated as well.

A way to bridge neuroscience guidance to action

We intend for neuroethics hackathons to be a venue for raising ethics awareness and facilitating diverse groups to co-create socio-technical solutions. We also expect that these activities

will be adapted and customized to a variety of contexts and communities. Our neuroethics hackathons are tailored to specific audiences and include the following key features:

(1) accessible and evocative scenarios—future-looking scenarios and technologies that participants used as springboards for discourse and exploring solutions. These tools enabled creative thinking while asking participants to consider the near and intermediate term realities based on the current state of the art in neuroscience and AI. We used accessible, customized public engagement materials integrating the state of the art in neurotechnology, ethics, and governance to design the hackathon.
(2) spotlight on professional tools for ethics—our hackathon was designed to promote awareness of available tools for scientists to tackle ethics challenges and to build the capacities needed to put these into practice. In this case, we adapted the NEQNs[2] and the recently published OECD Neurotechnology Toolkit.

At the FENS Forum, we focused on the requested theme, NeuroAI, tailoring the task to early-career scientists. We assumed participants had some interest in neuroethics but limited background in neuro- or AI ethics.

A key part of our customization process involves not only tailoring content to the audience and context but also careful consideration of what we hope participants will gain from the experience. Based on participant input, we worked to achieve several goals:

(1) leverage diverse perspectives in collectively identifying and exploring ethical issues raised by neuroinnovations;
(2) provide an engaging opportunity to access and use the professional tools designed for scientists to reflect on and address ethical issues in neuroscience and neurotechnology; and
(3) provide a training experience that also serves as a networking opportunity to dialogue with peers as well as leaders in science, ethics, governance, and public engagement.

METHODS

About the participants

Team composition: our hackathon included 27 participants divided into teams of 4–7 people. The variation in group size is related to attrition in groups. Of significance is that 6 individuals arrived well into the hacking process. These individuals were unable to participate as the process required that individuals participate from the beginning of the hackathon and be able to stay through the end.

The teams were pre-selected to maximize diversity in dimensions of discipline and areas of study, geography, career stage, and reported gender. In order to participate, individuals had to submit an application that included demographic information, research areas, affiliation, career stage, and self-reported gender.

Motivations: applicants to the Hackathon submitted short paragraphs explaining why they wanted to participate. Their motivation included themes such as the following:

(1) having ethical concerns and questions within their own work and finding a community to discuss ethical implications of their work;
(2) having some exposure to ethics and being intrigued to learn more;
(3) interests in exploring how their expertise and unique knowledge might connect with society beyond their laboratory and the hope to be more involved in diplomacy, policy, or in exploring more clinical applications of their work;
(4) curiosity and enthusiasm about the unique format and a chance to meet others; and
(5) overall ensuring that science results in positive outcomes for society.

Pre-hackathon prep

To maximize our time and better prepare participants, we held a pre-hackathon webinar. This meeting presented the event's format, schedule, and judging criteria while offering an opportunity for pre-assigned teams to introduce themselves and plan their preparations for the hackathon. On our end, through reviewing the applicants' submitted personal statements, we assembled teams with a focus on maximizing diversity in skills and nationalities. This invited opportunities to openly explore questions and collectively solve problems with reflexivity while incorporating multiple worldviews.

HACKATHON

The hackathon was a 4-h event consisting of 2 h of actual hacking followed by presentations, judging, and the awards ceremony.

The hacking for the FENS Forum was broken into four blocks. Participants

(1) utilized technology cards based on future and developing technologies,
(2) explored ethical provocation questions,
(3) devised strategies to implement existing tools in ethics and governance, and
(4) shared a presentation, which was followed by judging and awards.

The activities were structured around two series of cards that framed the considerations of the challenge. This was the first time the participants had seen the cards. Each team selected one of three cards featuring future technologies that blended together both existing and plausible neurotechnology products. The groups took on the identity of an AI-enabled neurotech company tasked with offering testimony in a government hearing to convince policymakers that they were creating an ethically viable product.

The teams were asked to upgrade the technology with specific considerations in mind. First, they needed to articulate the value of their technology. Because the participants were scientists working at the intersection of neuroscience and AI, we asked them to leverage their expertise by explaining the technical capabilities and limitations of the technology describing how the use of AI could enhance its potential.

Technology cards were based on the pedagogical design of past public engagement activities from the National Informal STEM Education (NISE) Network. Museum educators in this network have been using similar future-oriented resources to help their learners explore how values shape the research that society chooses to pursue and the way technologies are developed and adopted. For example, prior evaluation showed this anticipatory narrative was particularly effective in supporting collaboration and reflection when learners were required to make a decision based on the available information.[7]

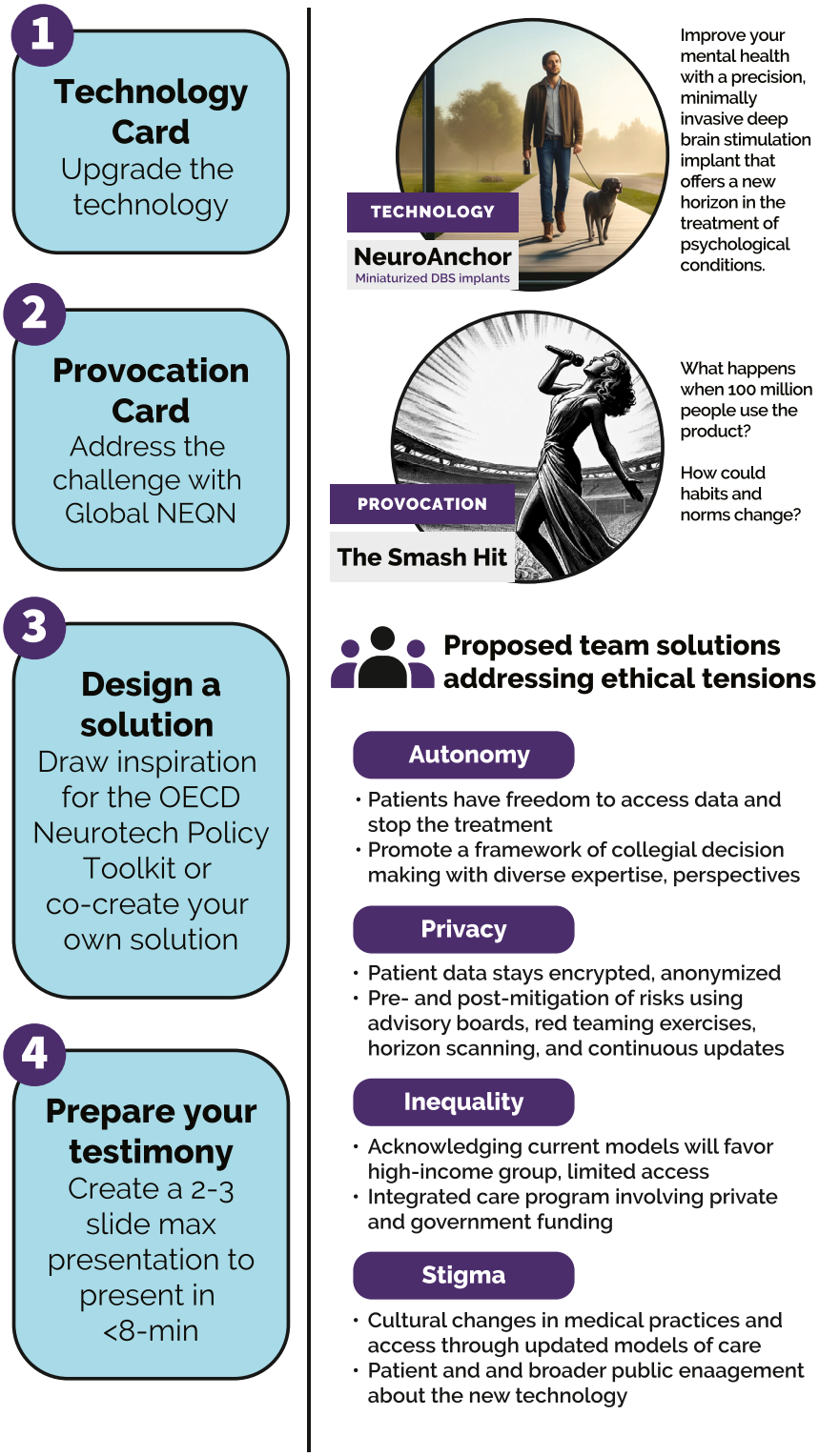

Figure 1. Hackathon structure

The neuroethics hackathon guided teams through four stages: upgrading technology, addressing ethical challenges, designing solutions, and preparing presentations. Using a scenario of a new, minimally invasive deep-brain stimulation device with potential mass adoption, teams responded as developers with testimony for a government hearing. Proposed solutions by teams given this specific combination of technology and provocation cards included measures for patient control, data security, equitable access, and cultural sensitivity. This structured approach promoted real-world, practical, ethical considerations in neurotechnology innovation directly tied to the themes and suggested practices from the NEQNs and OECD toolkit.

In the second block of time, the teams received a provocation card, which offered a set of challenge questions (Figure 1). The goal of these cards was to foster ethical awareness and reflection. The groups were prompted to use the NEQNs to articulate and explore the ethical dimensions that they identified.

In the third block, participants began designing their "solutions" using the OECD Neurotechnology Toolkit as a guiding framework. The toolkit utilizes an anticipatory governance approach to strategies that can be used to guide the trajectory of emerging technologies. The toolkit was designed to help innovators, the public, and policymakers use a values-based approach to think ahead, anticipate, and act on potential policy needs. It also underscores the importance of building stronger governance strategies to responsibly innovate in effective and efficient ways.

While we offered participants a subset of strategies from the toolkit, they also had access to its interactive online PDF version, which allowed them to explore additional strategies as needed.

Of note is that the scenarios, provocations, NeQNs, and the OECD Toolkit were meant to inspire curiosity and creativity. The groups were not expected, for example, to directly answer each provocation question or each NeQN in their presentations and solutions.

In the final block of the hackathon, participants were invited to prepare and rehearse their presentations. IoNx provided a slide template to create a verbal presentation to be completed in under 8 min. Throughout the hackathon, teams were visited by onsite mentors who offered support and encouraged deeper exploration of the ethical tensions, governance, and engagement strategies as well as the technological capacities of the teams' projects.

The event concluded with live presentations to the other participants and the panel of judges. During these presentations,

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Box 1. Neuroethics engagement attributes

Humility: initiating and pursuing neuroethics engagement requires humility, both epistemically and morally.
Openness: openness in neuroethics engagement creates a context for transparent sharing of perspectives as well as curiosity that can facilitate generative and authentic exchange of ideas.
Reflexivity: reflexivity allows a self-exploration of biases and presents an opportunity to shed light on respective ideological commitments and assumptions while recognizing where they converge and diverge.
Intellectual agility: neuroethics engagement requires real-time intellectual agility that allows agents to (1) adapt to new goals or constraints of the engagement experience; (2) respond to different perspectives; and (3) cultivate willingness to iterate, learn, and reimagine one's stance and values.
Creativity: fostering creativity in participants through moral imagination (a blend of creativity and ethical thinking) is a type of creative cultivation that can enhance empathy and perspective taking and even facilitate quick ethical decision-making when needed.
Cultural curiosity: proactive exploration of culture understood broadly, e.g., in the disciplinary and geographical sense not only of one's own culture and others. Key considerations for neuroethics include conceptions of the relationship between brain and mind with cognitive experience, memory, identity, autonomy, and agency. These conceptions can also impact personal and societal perspectives on value conflicts that might arise with emerging neurotechnology.
Adapted from Das et al.[8]

participants took on the role of company representatives explaining the ethical issues that they had identified and would address as they attempted to create an ethically viable neurotechnology. The panel of judges acted as a mock policy jury.

Judges assessed the teams' work using three main criteria: awareness of ethical issues, capacity for dialogue and co-developed solutions, and the logic and organization of their presentations. After deliberations, the judges' chair shared reflections on the team's performances, offering critiques and insights, and announced the overall hackathon winner. Each of the remaining groups received a superlative award that highlighted a unique strength demonstrated during their process and presentation.

SUMMARY AND FUTURE DIRECTIONS

What we learned

While we envision that neuroethics hackathons could be adapted and customized to a variety of contexts and communities, there are a few key elements that we have found lead to a more impactful hackathon.

Key elements (Box 1) for a neuroethics hackathon include

(1) creating and facilitating a safe space that empowers participants to openly share opinions and expertise,
(2) deliberate organization of groups that offers opportunities for dialogue and problem-solving with individuals with a wide variety of perspectives and worldviews to contribute, and
(3) a process that enables co-creation toward a shared solution to a complex challenge.

Customized elements that were uniquely developed in this case include

(1) awareness raising to build career foundations for the use of key neuroethics tools and fundamental knowledge,
(2) opportunities to step into unfamiliar roles (e.g., an entrepreneur and ethicist) to enable multiple perspective taking, and
(3) a context that promoted the relevance of ethical theory by applying ethical issues inherent to timely research at the intersection of neuroscience and AI.

As with public engagement, customization of hackathon materials and themes is a critical component for aligning with the participating scientists' interests and concerns. In this particular context, most attendees were academic, early-career professionals in sciences (the neurosciences, engineering, computational sciences, data sciences, and biomedical sciences). In a typical university setting, scientists have limited opportunities to work beyond their disciplinary and laboratory siloes. The participants benefited from this dedicated time together to ideate and problem-solve wherein they could use their expertise and dialogue with people doing different work from different geographic regions and culture. In the informal survey responses (that were collected for internal FENS purposes), as well as in conversations with participants, it was clear that participants appreciated the opportunity to have an occasion to work with a diverse set of disciplines and worldviews.

We intentionally worked at every stage to cultivate a safe space for open dialogue on thorny tensions, encouraging conversations that could not easily be fostered in the lab in a collaborative and productive way. Some lab cultures promote the notion that ethics is somehow a separate endeavor from science and that serious scientists might be distracted by humanistic inquiry. In this case, participants were given a clear shared goal (i.e., creating and defending an ethically viable neuroAI technology) in which they collectively identified and articulated how they would enact their collectively articulated values. By participating in this multidisciplinary event, these scientists were given the tools to embed ethical reflection and integrate what they have learned into the next generation of technologies they develop.

Our team did not view the neuroethics hackathon as a unidirectional training exercise where experts give knowledge to recipients. We approached this as an interactive dialogue wherein all participants could learn from one another. We saw it as a neuroethics engagement activity and as such approached it by taking into account some key attributes: humility, openness, reflexivity, intellectual agility, creativity, cultural curiosity.[8] These

attributes shaped the design of the pre-meeting workshop, the cards to facilitate conversations, and the process of hacking together in diverse teams. We aimed to have these attributes reflected in the experience of the participants and give them the opportunity to practice those attributes during the hackathon. In doing so, we hoped to empower participants in this shared-learning space.

FUTURE DIRECTIONS

Based on feedback from the event as well as from our community conversations, we see several opportunities ahead for additional tailored neuroethics hackathons. As these neuroethics hackathons are customized to the contexts and concerns of the participants, we see several key groups and topics that would be ripe for creative collaborative problem solving with this methodology.

First, neuroethics hackathons could offer novel experiences for training and capacity building in trainees and professional neuroscience communities. Participants appear very motivated to participate in these hackathons to address pressing ethical issues in their university laboratories, where they often feel at the "limits of the law" and need assistance for creative problem solving in the gray areas introduced by emerging technologies and discoveries. Neuroethics hackathons can allow participants to engage in an ethics-by-design approach where neuroscience and neurotechnology development are not just viewed as solving engineering problems but instead as creating socio-technical solutions[9]—in other words, creating technology that embeds social, ethical, and good governance principles.

Second, there is an urgent need to engage a broader group of problem solvers in the context of generating and implementing governance tools. In our workshop, participants utilized elements of the OECD's Neurotechnology Toolkit, which derived from the first international standard in ethical neurotechnology innovation from 2019. Launched only months before the hackathon event, the toolkit will continue to evolve and iterate as it is used. While many of the existing recommendations and guidance are generated through top-down mechanisms, they will be enacted and implemented in the research and development setting through bottom-up efforts.

Third, hackathons may also serve as an accessible entry point for public participants, lived experience experts, and other representatives from civil society to work side by side with scientists. We can see future hackathons addressing issues related to the pending UN Human Rights Council report on human rights and neurotechnology as well as the UNESCO's recommendation on ethical neurotechnology to be released this fall 2024.

We expect neuroethics hackathons to offer a powerful tool for capacity building in neuroethics as well as a bridge for real-world bridging of theory in ethical inquiry. In this way, we can foster a more robust culture of best practices that is as dynamic as neuroscience and neuroengineering, promoting trusted neuroscience that benefits all communities.

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DECLARATION OF INTERESTS

The corresponding author, K.S.R., is an advisory board member of *Neuron*.

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