Commentary

Environmental Neuroethics for Global Neuroscience

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Introduction

On November 14, 2023, I was honored to give the David Kopf Lecture at the annual Society for Neuroscience meeting. It was the second time for me to do so. The first time, in 2006, I spoke about the ethical management of incidental findings in neuroimaging research. Now, nearly two decades later, I brought the enduring pragmatism of neuroethics to human-made and natural changes to the environment, and considered the landscape of both benefits and harms on brain and well-being. Moreover, I emphasized how understandings of brain and mental health from diverse cultures can contribute to learning, knowledge, and actions in neuroscience.

My reflections at the meeting and here are from the positionality of a person with a European background, and as continuous learner of Indigenous methods and perspectives on brain and mind. I also draw upon my now nearly 25 year experience in neuroethics to link three lines of inquiry — neuroscience, environment, and ethics and culture — together in a five-component framework adapted from Cabrera et al. (2016). The framework is inherently porous and necessarily flexible to evolve with an ever-changing landscape. The examples I have chosen to illustrate each component are based on the neuroscience-environment-ethics space to which my team at Neuroethics Canada has directly contributed. There are many variations on the themes, and other important and relevant areas that merit the attention of the neuroscience community that are beyond the scope of this writing.

Relationality: environment as a relational and psychosocial process

The relationships and social constructions that humans make of the environment, and how we interact with it is the first component of the framework. In a very practical sense for neuroscience, the movement in brain-based architecture — neuro-architecture — is a direct example of relationality, and has led to profound and ethically enabling improvements in peoples' lives across the lifespan. Drawing on studies of the neurobiology and emotional content associated with spatial mapping (e.g., Bower et al., 2019), brain-based design embraces the needs of individuals who think differently or who live with neurologic and cognitive challenges (Albright, 2022; Huang and Illes, 2022). Brain-based architecture has improved opportunities for young people with neurodevelopmental disorders to relate to and navigate their environments and integrated trauma-informed design for people with post-traumatic stress disorder to provide them with safety as well as a sense of empowerment in relation to the environments in which they reside and survive. It has assisted people with aging and associated memory disorders to find comfort and personal security in otherwise complex spaces. In this regard, relationality speaks not only to how people use their built environment but actually value it for the very attributes it offers for brain and mental wellness. Here, benefits prevail. In the next component of the framework, health and brain science, the equation has benefits and risks as well.

Health and brain science

Healthy behaviors, physical activity, and enriched environments are all known to support brain and mental health. Adverse environments, such as extreme changes in climate naturally have the opposite effect, as do contaminants introduced by humans into water and soil. Studies from around the world (e.g., Japan, the Amazon Basin, and Canada among others) have revealed potential negative effects from exposures to environmental chemicals, such as the organic form of mercury (methyl mercury) in water and food sources. Adverse neurodevelopmental impacts on cognition have been reported for children, and Minamata disease with signs and symptoms that span ataxia to psychosis have been reported for adults. While results on the effects of methyl mercury in water are still variable and debated, selenium found in soil might be neuroprotective to exposure (Nakamura et al., 2014).

In contrast, findings about exposures to pesticides introduced into the soil and that seep into water sources are less controversial (Cabrera, 2017). Glyphosates found in everyday garden weed killers have been shown to increase anxiety in animal models. Other studies have documented neuroinflammation and further neurologic harms, including to the blood–brain barrier.

The impact of mining and fracking on the environment and health has also garnered significant attention with regard to both mental health and neurologic conditions. Fracking involves the insertion of high-pressure water and sand with chemical additives, such as hydrochloric acid, to create fractures in the earth and enhance the flow of fuel trapped in shale deposits. While many benefits, including economic

Received Sep. 22, 2023; accepted Sep. 25, 2023.

The author declares no competing financial interests.

This Neuro and Beyond commentary is based on the David Kopf Lecture, Society for Neuroscience, November 2023. Neuroethics Canada is situated on the unceded territory of the Coast Salish Peoples. Current and past research and neuroethics initiatives are supported by Canadian Institutes of Health Research, Institute of Neuroscience, Mental Health and Addiction, the U.S. National Institute of Health Mental Health and National Institute of Neurological Disorders and Stroke, Fonds de Recherche de Québec for support of the International Brain Initiative, the Canada Research Chairs Program, the Michael Smith Foundation for Health Research, the Vancouver Foundation, the Dana Foundation, and the North Family Foundation. I thank the David Kopf Family for supporting the neuroethics lecture at SfN each year; the outstanding researchers, trainees, collaborators, and advisors with whom I have the privilege to work in Vancouver; members of the Tahltan First Nation for tireless engagement with my team; and the University of British Columbia (UBC) Center for Alzheimer Disease and Related Disorders (since 2009).

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https://doi.org/10.1523/JNEUROSCI.1801-23.2023

growth and opportunity from such industrial innovation may accrue to communities at nearby sites, advisory panels in both the United States in 2011 and Canada in 2014 declared fracking a threat to human rights, and the lack of monitoring of changes to health and traditional ways of life a critical issue. As I will explore next, these issues were picked up in both public and academic discourse, the third component of the environmental neuroethics framework.

Public and academic discourse

News media were quick to draw attention to concerns about mining articulated by committee reports and government briefings, especially as destructive earthquakes linked to fracking simultaneously shook the world in Canada, the United States, Europe, and elsewhere abroad.

My team and I were interested to see whether the attention occurring in the public sphere was mirroring in the academic sector. We systematically searched major databases for peer-reviewed and gray literature articles using terms from mining, brain, and mental health, as well as variations on the terms culture and ethics. We examined the frequency of major themes arising in the literature, and used rigorous qualitative methods to characterize them (Grier and Illes, *Neuroethics*, under review).

We found 190 articles over the time period of 2009-2022 that met inclusion criteria. Ten regions of the world were represented; most were from North America. The division between research reports and reviews was split evenly. Fewer than 10% of all papers mentioned brain and mental health in any depth. The rest made reference to the CNS superficially as part of a list, for example, or briefly in a few words only. Nearly none discussed impacts on the brain and mental health in any depth, opening the door to a significant opportunity for the neuroscience community to contribute.

A majority of papers in the second half of the dataset beginning in 2016 ($n = 84$) had some form of ethics content, consistent with the inclusion criteria for analysis. We were not surprised to find that a majority of them (65%) invoked discussions of physical safety, as safety is a first principle for nearly any advancement in industry, science, or medicine. Other ethics themes, such as trust, vulnerability, and disempowerment, appeared sporadically. We did, however, find substantial references to environmental justice, codified by the U.S. EPA as the fair treatment of all people with respect to environmental regulations and policies, and its counterpart environmental injustice or environmental racism, in 38% of the dataset.

The concept that the most socioeconomically disadvantaged people are the most vulnerable to hazardous environmental exposures was noted well before this study. Even 30 years ago, one could easily consider that environmental racism was a factor in the 1984 Bhopal industrial disaster in India — considered to be one of the world's worst. Around half a million socioeconomically disadvantaged people were exposed to the highly toxic methyl isocyanate gas after a chemical leak in their neighborhood. Thousands died and thousands more were injured and left with disabilities and illnesses, many of which were neurologic. In the 1990s, the classic bioethics case of the Kennedy Krieger study described the neurologic disabilities and impaired trajectories of children, mostly African American, who were exposed to lead in low-income housing compared with a comparable cohort for whom lead exposure had been mitigated. Historical and contemporary examples of injustices to marginalized populations related to the neuroscience-environment-ethics landscape are unending.

Traditional ecological knowledge

The next component of the environmental neuroethics discussion focuses on traditional ecological knowledge — the spiritual and intangible experience of relationships, health, and the environment. I illustrate this component of the framework by drawing on a many-year research collaboration between UBC and the Tahltan First Nation whose lands are located in northern British Columbia along the western flank of Canada. This highly collaborative work focused on the causes and understandings of early onset familial Alzheimer Disease (EOFAD).

With Elders from the Nation, community members, and representatives from the Health Authority, we explored how the neurogenetic explanation of EOFAD — the effect of the dominant presenilin-1 gene — can coexist in harmony and complement to traditional beliefs.

To approach this work in a culturally appropriate way, we co-created research questions. We moved from the poorly formulated, paternalistic urban approach of *"Why aren't they [Tahltans] coming to us [UBC], for testing?"* to one that resonated with the community, "*How does a Nation achieve wellness in EOFAD*?" The latter reflected the values of the Nation, the medicine wheel, and relationships with the environment.

We worked together to situate the research in the context of the people, their homes, their place of being, their ways of doing, and their personal and economic interests. We had to contend with tricky questions about how to balance privacy, where the desire of the community was to model good work for other Indigenous communities affected by neurologic diseases, but the possible risk of increased stigma to the community in doing so (Stevenson et al., 2013). We grappled with the complexities of consent involving far more than just any single individual as is customary for conventional Western research ethics.

Over 7 years, we co-designed the study, raised funds to support it, and then collected and analyzed 25 h of narrative data to yield a deep understanding of the intersection of traditional knowledge, brain, and the environment. Results embraced the notion of two-eyed seeing (Marshall et al., 2015), where biomedicine and tradition offered shared explanations for EOFAD. In tension with economic securities afforded to the Nation through the growth of industry in the region, results also unexpectedly revealed perceptions about the adverse impact of mining: *"[...] they've been doing a lot of mining... [...] and I heard that's affecting them, like making them rotten inside."* We heard: *"I am part of my environment and if my environment suffers, I suffer,"* a reflection that captures traditional ecological about wellness and the environment, as well as notions of relationality and brain and health.

Activism and advocacy

There is no neuroethics without action; it is philosophy otherwise. We used findings from a range of studies in the sphere of environmental neuroethics for voicing our concerns and informing the public in an Op Ed, and to respond to a call for new areas of focus in neuroscience from the then U.S. President Obama's Commission on the Study of Bioethical Issues (Illes et al., 2014). Naturally, many others have made their voices heard over time: women of color protesting the development of pipelines on native lands in Michigan; Bishop Desmond Tutu writing on climate change and environmental apartheid. A special issue in Cell Press' *Trends in Neuroscience* focused on the environment in 2022. Recent workshops at the National Academies of Science, Engineering and Medicine, the Kavli Foundation, and the International Neuroethics Society have placed brain and

mental health together with environmental change in center focus.

In conclusion, through principles of relationality, brain and mental health, public and academic discourse, culture, and advocacy and activism, environmental neuroethics covers both the benefits of human changes *to* the built environment as in the case of neuroarchitecture, and to changes *of* the natural environment in terms of both economic benefit and brain health risks from climate and industrial impacts. Ethically guided, geopolitically-free neuroscience is the future in advancing gains and mitigating the worldwide environmental challenges in play. Strategies can fall under the nomenclature of environmental neuroethics or some other. It matters less what we call it, as long as we pursue it.

Returning to the fundamental practical tenets of neuroethics, anticipation and responsiveness remain central themes at the intersection of neuroscience, environment, and ethics and culture. Continued balance in the equation of benefit and risk will ensure that neuroscience in this space remains scientifically practical and free from political sway. Cultural competence in research and care will ensure respect for all people on a global scale, especially those who are vulnerable and historically have been disregarded. Justice stands as a core principle uniting all to take the environmental neuroethics journey to the next level.

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