

A Neuroethics Framework for the Australian Brain Initiative

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Neuroethics is central to the Australian Brain Initiative's aim to sustain a thriving and responsible neurotechnology industry. Diverse and inclusive community and stakeholder engagement and a trans-disciplinary approach to neuroethics will be key to the success of the Australian Brain Initiative.

Australia has a strong history of neuroscience discovery and neurotechnology translation, which led to the launch of medical device companies including in hearing (Cochlear), vision (Bionic Eye), pain (Saluda Medical), epilepsy management (IBM Research Australia), cognitive assessment (Cogstate), and brain-computer interfaces (EMOTIV). The Australian Brain Alliance (ABA) aims to further catalyze technological and scientific advances to sustain a thriving neurotechnology environment in Australia and engage global collaboration across industry and science. Major investment in an Australian Brain Initiative is needed to coordinate and build capacity in basic neuroscience and provide discovery pipelines that will translate discovery into tangible therapeutic applications. The ABA brings together diverse strengths in Australian brain science across cellular and molecular neuroscience; neurophysiology; clinical, cognitive, and behavioral neuroscience; psychology; computational neuroscience; and neuroengineering to work with industry partners and end-users. The goals are to develop more accurate methods of brain recording and stimulation, wearable devices that capitalize on recent advances in artificial intelligence (AI) and machine learning, and new methods for cognitive assessment and behavioral adaptation to better prevent, predict, and treat mental and neurological disorders and maximize learning across the lifespan.

The Australian government has provided significant investment in infrastructure through the National Collaborative Research Infrastructure Strategy, which supports the National Imaging Facility, and the Australian National Fabrication

Facility, which manufactures devices for neuromorphic and brain computer interfaces, and significant investments in personalized medicine through the Australian Genomics Health Alliance. There have also been major investments in priority areas such as dementia, mental health, and brain cancer. But to be truly transformative, a coordinated effort aimed at maximizing Australia's efforts across these major platforms is necessary.

Along with bringing innovation and opportunities, disruptive developments that cleave the boundaries between neuroscience, technology, and machine learning also raise new questions regarding privacy, autonomy, and agency that question traditional divisions between humans and machines. The ABA recognizes that a careful consideration of the ethical, social, and legal issues that engages with all elements of Australian society is necessary to realize the vision of an Australian Brain Initiative. To meet this challenge, the ABA formed the Neuroethics and Responsible Research and Innovation Committee (NRRIC). The NRRIC is responsible for the development of a neuroethics scholarship in Australia and for overseeing work to examine the neuroethical issues emerging from neuroscience. The Committee will advise the ABA, funders, policy makers, and relevant government departments by meeting with government officials and publishing briefing documents and consensus statements on key neuroethical issues. The NRRIC will also provide guidance to Australian Brain Initiative project leaders and a portal to enable members of the public and other organizations to raise neuroethical concerns. The NRRIC will work with the [Australian](#)

[Neuroethics Network \(ANN\)](#), an interdisciplinary collection of ethicists, philosophers, legal and humanities scholars, public health professionals, clinicians, and social scientists to facilitate neuroethics scholarship in Australia and provide a platform for collaboration.

In 2017, the NRRIC was charged with the development of national priorities for ensuring an environment of responsible research and innovation across all areas of brain research. The committee recognized that neuroinnovation creates a number of ethical tensions that need to be balanced to realize the promise of neuroscience: these tensions capture the five neuroethical questions for neuroscientists (NeQNs) identified at the 2017 Global Neuroethics Summit ([Rommelfanger et al., 2018](#)). Here, we address these questions and outline a neuroethical framework being developed for the Australian Brain Initiative.

Responsible Innovation through Community Engagement

Successful neuroinnovation requires early and ongoing engagement between researchers, end-users (i.e., patients, families, carers, clinicians, and the public), developers and industry, engineers, peer-support representatives, health regulators, government funders, ethicists, and policymakers to ensure that technologies meet the needs of those that they are intended to benefit, with minimal adverse outcomes ([Institute of Medicine, 2001](#)). While neurotechnologies promise to alleviate neurobiological and neuropsychiatric diseases, they can also cause unanticipated and potentially significant side effects. They may affect an individual's thoughts and perceptions, agency,

sense of self, and personality, as described in NeQN 4: How could brain interventions impact or reduce autonomy? For example, deep brain stimulation (DBS), an invasive neurosurgical intervention used to treat movement disorders in more than 150,000 individuals globally, can cause serious compulsive behaviors (e.g., shopping, hypersexuality, and gambling), impulsivity, mania, and aggression (Fasano and Lozano, 2015). Many experience marital difficulties or significant psychosocial adjustment issues post-surgery despite improved motor symptoms (Schüpbach and Agid, 2008). As DBS is increasingly trialed in a growing number of psychiatric disorders, research on how to minimize these side effects is essential if society is to embrace this technology and ethically advance this form of treatment.

The ABA is also examining the potential non-therapeutic use of novel neurotechnologies to enhance cognition (NeQN 5: In which contexts might a neuroscientific technology/innovation be used or deployed?). Non-invasive brain stimulation devices, wearables, portable brain recording devices, and cognitive training software are being promoted as ways to improve student performance, sustain productivity in an aging workforce, and compete in professional environments, and in military applications. Given that evidence on the safety and efficacy of these cognitive enhancement tools is in its infancy, appropriate regulation and safeguards are needed to prevent potential harm. For example, misuse of commercially available transcranial direct current stimulation devices (Farrell et al., 2018) is an issue for users who are unaware of or ignore risks associated with overuse. The current regulatory framework in Australia for non-therapeutic uses of new neurotechnologies is inadequate (Farrell et al., 2018). The ABA proposes to facilitate collaborations between scientists, clinicians, developers, and legal scholars to address this regulatory void.

Competing therapeutic and social or criminal justice goals can also affect the way in which technologies are provided in the real world. Stigma, fear, and discrimination associated with mental and neurological disorders can affect whether treatment is sought or how it is delivered. Coercion (e.g., court orders

and pressure from employers and families) can limit or influence people's treatment choices. Researchers must anticipate likely adverse events by examining historical antecedents and engaging with end-users and clinical and health service providers to understand the effect of the social context on how new technologies are used and provide user guidelines. It is critical that scientists and developers continue to evaluate the effectiveness and safety of new technologies as they are taken up by society.

The goal of the ABA is clear: to develop national guidelines for responsible neuroinnovation to assist neuroscientists, engineers, and developers to translate research into effective and ethical products. The ABA will create targeted working groups for emerging neurotechnologies in Australia, which will include relevant stakeholders to develop ethical frameworks that will enable the efficient, but also responsible, research, development, and translation of technology into the health, science, education, and defense sectors. The ABA will also host multidisciplinary consensus workshops to bring together researchers, practitioners, regulators (e.g., the Australian Therapeutic Goods Administration), industry, end-users and patient advocates, and policy makers from across the country to develop these guidelines. One of the aims will be to work with developers and engineers to identify ethically aligned design solutions that mitigate potential ethical threats at the design stage, that meet the needs of the community, and that also enhance the capacity for implementing recommendations through public uptake and policy.

Balancing Big Data and Privacy

Australia currently lacks a clear regulatory framework for ensuring that individuals are informed about how their data are captured, stored, analyzed, and shared, particularly data collected by ubiquitous digital wearable devices and smartphones. As a society, we need to carefully consider how to protect the privacy of individual data while allowing people to benefit from advances in brain research, large-scale data linkage, and big neural data, including data captured from brain-machine interfaces and available in electronic health records. To address

NeQN 2: What are the ethical standards of...data collection...? the Australian Brain Initiative will develop data methods and protocols that maximize sharing between researchers, and with industry, of reliable and reproducible datasets while protecting the privacy and well-being of all members of society. History shows that failure to do so can undermine public trust and support for large data-driven initiatives. A proactive approach is integral to the Australian Brain Initiative.

An international shift toward making big data widely available through open access platforms significantly speeds up the translation of neuroscience research into new treatments, technologies, and policies. At the same time, it is important to address how personal information is shared with third parties, and what regulations are necessary to protect people's privacy. The use of AI and machine learning to analyze data that reflect historical inequities can yield algorithms that discriminate against some populations. This needs to be considered when interpreting results and drawing conclusions from these kinds of data.

In collaboration with organizations such as the Australian Genomics Health Alliance, the ABA proposes to establish national human ethics protocols for data sharing and collaboration. These will cover coordinated tissue banks providing brain material for gene expression, epigenomic, and proteomic studies. The ABA proposes that the national brain banks be encompassed as part of the National Collaborative Research Infrastructure Strategy and the acquisition of both postmortem and brain tumor tissue from well-phenotyped research participants, preferably with longitudinal clinical data. This aim also dovetails with the Australian Government's investments in mental health and dementia research, particularly targeted research initiatives supporting Indigenous health, both of which would benefit from a coordinated national brain and tissue banking facility.

Neuroscience, the Law, and Criminal Justice

Neuroscience and psychology are helping us to better understand the causes and correlates of criminal behavior. This work holds the promise of psychological

interventions and neurotechnologies to modify or prevent criminal behavior. These have implications for people's rights, safety, and welfare. Improved treatments and brain interventions could improve the reliability of memories, assist criminal offenders to reform, or make it safer to release offenders. Neuroscience explanations may have double-edged legal implications. Evidence that might diminish guilt (e.g., brain scans suggesting compromised self-control) can have adverse consequences at sentencing if a defendant's impaired brain circuitry is deemed to require indefinite imprisonment.

These issues require urgent examination. Neuroscientific evidence and technologies are already being applied in Australian legal cases. Analysis of the [Australian Neurolaw Database](#) shows that legislators, judges, lawyers, and juries inconsistently use evidence from neuroscience research ([Alimardani and Chin, 2019](#)). As a significant proportion of individuals in custodial settings have neurological or psychiatric disorders, new models for their detention and care in prison are urgently required. A recent study in Western Australia found that 36% of juvenile offenders in one institution had fetal alcohol spectrum disorder, while 89% had a serious neurodevelopmental impairment; over 74% of children in these facilities are Indigenous ([Bower et al., 2018](#)).

The ABA is working with the legal profession and policy makers to tackle these challenging issues by providing continuing professional education. Support for research on the impact of neuroscience on the law, and the development of judicial, expert witness, and jury training is essential to avoid inconsistent use of neuroscience evidence in forensic settings.

Diversity and Inclusion

Australia is home to the longest continuous culture in the world. However, Aboriginal and Torres Strait Islander peoples have significantly poorer health outcomes and a life expectancy approximately 10 years less than non-Indigenous Australians ([Holland et al., 2013](#)). Rates of mental illness, neurodevelopmental disorders, and substance abuse are higher among Indigenous Australians. Improving

access to quality treatments and prevention programs is critical. However, attempts to improve the health and well-being of Indigenous Australians must also address the impact of colonization, and subsequent failed social policies, on Indigenous people and the dispossession of and disconnection from land, culture, and community. It is critical that research that seeks to improve the mental health and well-being of Indigenous Australians engages Indigenous peoples as partners. Genuine collaborative and equal partnerships are essential to ensure that research is prioritized, carried out, disseminated, and translated in ways that make Indigenous Australians the primary beneficiaries ([Dudgeon et al., 2010](#)).

The ABA will also ensure that there is diverse representation, including gender, disability, ethnicity, sexuality, and age, as both partners and collaborators in research as well as participants in neuroscience research. Efforts to protect vulnerable populations, such as children with neurodevelopmental disorders, from being exploited or harmed through research is paramount and important research conducted with these individuals that may benefit them must be carefully managed.

Science Communication, Health Promotion, and the Impact of Neuroscience on Stigma, Health, and Selfhood

Neuroscientists have a professional obligation to communicate the results of their research to the public, and the ABA can provide expert information to the public. Broad, proactive communication about the aims, procedures, and outcomes from neuroscience research, as well as responsible communication of neurobiological research findings, is necessary to avoid creating unrealistic expectations about the benefits and imminent availability of new technologies to prevent, diagnose, or treat disorders of the brain. Poorly substantiated claims can undermine public support for neuroscience. This is particularly true for experimental or invasive treatments for debilitating disorders in which patients are desperate for a cure.

Equally important is the understanding that the positive benefits of research may be realized through the use of model systems whose potential moral status

raises challenging issues, including the use of animals, especially non-human primates, neural organoids, and computer systems running AI and deep learning algorithms. The ABA plans to carefully promote public debate and understanding in addressing NeQN 3: What is the moral significance of neural systems...in research laboratories?

Neuroscience research may expose society prejudice relating to people with mental and neurological disorders, or those whose behavior is viewed as deviant or dangerous. Attitudes may be modified if the neurobiological changes in the brain that underpin mental and neurological disorders are better understood, and if effectively communicated, could be used to reduce stigma and discrimination. Greater public acceptance of neurobiological explanations may have reduced stigma around some mental disorders (e.g., depression), but this acceptance can also increase perceptions that patients are abnormal and dangerous, thereby increasing stigma and discrimination ([Lebowitz and Ahn, 2014](#)). The message that mental illness is hard-wired into one's brain might also undermine a person's belief in their ability to overcome their illness or their motivation to try. This tension is recommended for further exploration with NeQN 1a: What are the possible unintended consequences of neuroscience research on social and self-stigma? The ABA recognizes that the communication of the impact of neuroscience research needs to be empirically informed by social science research and by those potentially impacted. At present, often optimistic assumptions about the positive effect of scientific discoveries on society or populations (for example, those suffering from a specific disease) are overblown in media releases.

Responsible media reporting of neuroscience research is critical, and it has become more challenging given the loss of science expertise in traditional media. The ABA will work with organizations like the Australian Science Media Centre to ensure experts comment on new research findings and place these findings within a broader context. The NRRIC includes a leading neuroscience journalist to ensure the ABA communicates effectively and responsibly with the public. Diverse Lived Experience

Expert Reference Groups, Participatory Networks, and an Indigenous Advisory Panel, featuring patient representatives and members of the public, should be formed to assist with the development and application of advances in the key neuroscience research priorities of the Australian Brain Initiative. The ABA will also hold public debates about ethical, social, and legal issues raised by neuroscience research.

Balancing Public and Personal Health Approaches to Brain and Mental Health

The social and physical environment can affect brain health. Social disadvantage, loneliness, stress, violence, crime, and social conflict are all associated with higher risks of anxiety and depression. Malnutrition, overcrowding, and poor sanitation can cause poor physical health, cognitive deficits, and mental and neurological disorders. Many of these risk factors are over-represented in socially and economically disadvantaged groups, who accordingly bear a disproportionate share of the burden of mental and neurological disorders. A consideration of the ways in which brain health might be addressed by the public health system could increase overall health and well-being of Australians, reiterating the importance of NeQN 5b: Does this research raise different and unique equity concerns and, if so, have equitable access and benefit of stakeholders been considered?

Achieving optimal brain and mental health will require research that examines ways of reducing inequalities in healthy brain development through public health policy interventions. This will involve balancing the use of emerging neurotechnological advances so that they do not replace exercise and social activity, which are proven to enhance cognition and slow age-related cognitive decline.

The NRRIC and all working groups will adopt a multidisciplinary approach, including public health researchers and related professionals, to ensure that societal benefits of improved brain health are optimized. Engagement with politicians and policy makers about the social and policy impact of neuroscience is a priority. In 2017, the ABA held a national meeting at our nation's capital and a 3-day roadshow at Parliament House in 2018,

"Brains on the Hill," at which we met individually with over half of our elected representatives or their delegates about the potential impact of large national brain research initiatives on Australian society.

Growing Neuroethics in Australia

Training and the growth of neuroethics expertise are essential to realize the ABA vision. The ABA will develop a neuroethics syllabus for undergraduate and postgraduate courses in collaboration with international networks and national professional bodies. An intensive neuroethics workshop could be held in conjunction with the annual Australasian Neuroscience Society meeting. Similarly, the ABA proposes to host an annual intensive neuroscience course for ethicists, legal scholars, social scientists, policy makers, and clinicians. Another effective way to develop the field would be to provide short internships for ethicists, social scientists, and humanities scholars to spend time in neuroscience laboratories, clinical teams, and industry working on specific issues in neuroscience and technology relevant to the Australian Brain Initiative. These schemes could provide early- and mid-career researchers with unique professional development opportunities and increase the exchange between neuroscience and the humanities. It would also seed the incorporation of ethical and social science perspectives within neuroscience projects. These interdisciplinary exchanges will be key to the success of the Australian Brain Initiative.

SUPPLEMENTAL INFORMATION

Supplemental Information includes a complete author list with affiliations and can be found with this article online at <https://doi.org/10.1016/j.neuron.2019.01.004>.

CONSORTIA

The Australian Brain Initiative's Neuroethics and Responsible Research and Innovation Committee has been responsible for developing the vision for neuroethics within the proposed Australian Brain Initiative, in conjunction with the Australian Brain Alliance's Executive and Steering Committees and Early- and Mid-Career Brain Science Network Committee and members of the Australian Academy of Science Policy Division. The Neuroethics and Responsible Research and Innovation Committee consists of Jeanette Kennett (Co-Chair), Adrian Carter (Co-Chair), James A. Bourne, Wayne Hall, Neil Levy, Jason B. Mattingley, Andrew J. Lawrence, Cynthia Forlini, Lynne Malcolm, and

Nicole Vincent. The Australian Brain Alliance Executive Committee consists of Linda J. Richards (co-chair), Gary Egan (co-chair), Michael Breakspear, James A. Bourne, Kim Cornish, Glenda Halliday, Jason B. Mattingley, Laura Poole-Warren, Sharath Sriram, Tina Soulis, Bernadette Fitzgibbon, and Isabell Kiral-Kornek. The Australian Brain Alliance Steering Committee consists of David R. Badcock, Bernard Balleine, John M. Bakkers, Michael Berk, James A. Bourne, Andrew Bradley, Michael Breakspear, Alan Brichta, Adrian Carter, Olivia Carter, Anne Castles, Judith Clements, Jennifer Cornish, Kim Cornish, Greig de Zubicaray, Gary F. Egan, Peter G. Enticott, Alex Fornito, Lyn Griffiths, Judith Gullifer, Anthony J. Hannan, Stefan Harrer, Alan Harvey, Ian B. Hickie, Liz Jazwinska, Matthew Kiernan, Trevor Kilpatrick, Isabell Kiral-Kornek, Rick Leventer, Julio Licinio, Nigel Lovell, Geoff Mackellar, Jason B. Mattingley, Sarah E. Medland, Patricia T. Michie, Jess Nithianantharajah, John Parker, Jonathan M. Payne, Laura Poole-Warren, Linda J. Richards, Susan Rossell, Pankaj Sah, Zoltan Sarnyai, Peter R. Schofield, David H.K. Shum, Tim Silk, Mark Slee, Sharath Sriram, Greg J. Stuart, Jonathan Tapson, André van Schaik, Bryce Vissel, and Allison Waters. The Australian Brain Alliance Early-Mid-Career Brain Science Network Committee consists of Deborah Aphorip, Adrian Carter, Sarah Cohen-Woods, Simon J. Conn, Bernadette Fitzgibbon (Chair), Isabell Kiral-Kornek (Deputy Chair), Mayuresh Korgaonkar, Alice Mason, Jess Nithianantharajah, Mostafa Rahimi Azghadi, Olga Shimon, Ashleigh Smith, and Matthew B. Thompson. Members of the Australian Academy of Science Policy Division who contribute to the Australian Brain Initiative are Khaled Chakli (Executive Director, Australian Brain Alliance) and Chris Hatherly (Director, Science Policy and Projects). The ABA acknowledges the AAS National Committee for Brain and Mind for initiating this effort and, through its application to the Theo Murphy (Australia) Initiative, helping to create the ABA Early-Mid-Career Brain Science Network.

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AUTHOR CONTRIBUTIONS

Adrian Carter, Neil Levy, Jeanette Kennett, Nicole A. Vincent, Cynthia Forlini, James A. Bourne, Khaled Chakli, and Linda Richards drafted the manuscript, and members of the Australian Brain Alliance (across various committees listed above) and the Australian Academy of Science contributed to its finalization.

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