BRAIN NeuroAI Workshop Meeting Summary

Bridging Brains and AI: The NIH BRAIN Initiative NeuroAI Workshop

NeuroAI research lies at the intersection of neuroscience and artificial intelligence (AI). The BRAIN Initiative's recent workshop explored how NeuroAI models, neuromorphic computing, and virtual brains can be used to close the loop between brain data and real-world impact. Workshop participants identified exciting opportunities and approaches that could jump-start a transformative future for neuroscience and brain health.

The NIH BRAIN Initiative recently convened leading experts from neuroscience, artificial intelligence, and related fields to explore opportunities enabled by the convergence of brain science and AI. As neuroscience, neurotechnology, neuromorphic engineering (systems inspired by brain structure and function), and AI have made impressive advances over the last decade, the BRAIN NeuroAI Workshop, held on November 12 and 13, 2024, examined how these domains might converge to drive progress in understanding the brain and developing safer, more secure, and efficient computing technologies for health.

Over two days, 193 in-person participants and 1,749 virtual attendees from 48 countries gathered to discuss critical questions across four thematic sessions. The opening keynotes and the first scientific session established a vision for NeuroAI as a framework where neuroscience and AI drive reciprocal advances with mutual benefits. Speakers highlighted how natural intelligence emerges from complex systems shaped by evolution, development, and learning — sharply contrasting with current AI technology based on static models requiring massive datasets. Discussions emphasized the importance of looking beyond neurons to include elements like astrocytes and considering the crucial role of feedback loops in natural intelligence.

The afternoon session on the first day examined how large-scale brain data and computational tools might enable advances in NeuroAI frameworks and theories. Participants explored structural differences between biological and artificial systems, moving beyond simple performance metrics to understand fundamental computational principles. A key theme emerged around the need for "dynamic connectomes" that capture how network properties change over time accounting for the complexity of brain structure and function. The session highlighted differences between hypothesis-driven and data-driven approaches. Digital twins emerged as a promising platform for exploring how artificial systems align with biological ones, though participants noted that digital twins could serve as hypothesis-generating tools rather than as complete theories of brain function. Panelists discussed the need for robust mathematical frameworks that can be applied to neurological disorders by developing integrated NeuroAI models that link neural mechanisms to behavior.

On the second day of the workshop, the morning session focused on creating new theories through neuromorphic computing and embodied intelligence. Speakers highlighted a fundamental challenge in AI: while the human brain accomplishes complex tasks like speech, thought, emotion, and real-time sensory processing using only the power of a light bulb, current AI systems require massive energy resources to perform a far more limited set of tasks, primarily language and image processing. The session revealed how neuromorphic devices mimic brain function to achieve biological levels of efficiency while enabling sophisticated computational capabilities. Several presenters argued that incorporating elements of the brain structure and function could guide the development of energy-efficient hardware and software models, underscoring the transformative potential of brain-inspired approaches.

The afternoon session on the second day explored practical applications and translation of NeuroAI technologies. Discussions ranged from energy-efficient neuromorphic hardware for biomedical devices or brain computer interfaces to using insect nervous systems as templates for autonomous decision-making. Speakers emphasized the need for collaboration and standardized platforms for clinical applications. Speakers discussed how NeuroAI could transform health applications for novel devices that match natural brain dynamics, enabling more precise and adaptive therapeutic interventions. Successful translation of these technologies will require balancing innovation with safety and accessibility to ensure meaningful incorporation of clinician and patient perspectives.

The day also included representatives from the Department of Energy, the Department of Defense, the National Science Foundation, the Simons Foundation, and the OpenGPU Foundation, each outlining the current landscape of opportunities for research into NeuroAI approaches. The panel described shared goals, community needs, and applications for NeuroAI that potentially engage complementary missions of funding agencies and investors across multiple domains, including health and safety, cybersecurity, energy efficiency, continual learning for operation in extreme or unknown conditions, and neurotechnologies that adapt to user needs over the lifespan.

The Early Career Scholar poster session featured research from 18 rising stars. Aditya Nair from Caltech won first place in the poster competition for work using machine learning to discover neural mechanisms of aggression. Runners-up Xinhe Zhang (Harvard) and Harrison Espino (UC Irvine) were recognized for their research on decoding intrinsic brain dynamics and adaptive neural networks for robotics, respectively.

Looking ahead, the workshop identified several critical considerations for the field. First, NeuroAI must bridge multiple scales. Second, standardization of data and metrics will be crucial for leveraging large-scale brain data to understand sensorimotor interactions. Third, proactive ethical frameworks must develop in parallel with technical advances to mitigate potential risks and implications for human privacy, agency, and identity.

Importantly, workshop discussions highlighted how interdisciplinary collaboration across agencies and research communities will be vital for sharing resources, training the next generation of NeuroAI researchers, and translating basic insights into broader applications. The NIH BRAIN Initiative is positioned to foster an ecosystem that embraces technological innovation while remaining grounded in large-scale data and real-world impact.

Watch the BRAIN NeuroAI Workshop on NIH VideoCast:

- VideoCast Day 1 (Tuesday, Nov. 12) — BRAIN Welcome & Opening Keynotes, Session 1, Funders Panel, Session 2, and Day 1 Wrap-up Discussion
- VideoCast Day 2 (Wednesday, Nov. 13) — Early-Career Scholar Poster Blitz, Session 3, Session 4, Day 2 Wrap-up Discussion, Workshop Synthesis, Poster Awards, and Director's Closing Remarks.