WHERE WILL WE BE IN 2025?

Terrence Sejnowski
Computational Neurobiology Laboratory, Salk Institute for Biological Studies, La Jolla, USA

On April 3, 2013, President Obama announced the BRAIN Initiative, whose goal is to develop innovative neurotechnologies. The working group that advised the Director of the NIH for the BRAIN Initiative prepared a detailed plan and goals. The final report, which was accepted by NIH on June 5, 2015 (BRAIN 2025: http://www.braininitiative.nih.gov/2025/index.htm), a few days after the symposium, identified 7 major goals:

#1. Discovering diversity: Identify and provide experimental access to the different brain cell types to determine their roles in health and disease.
#2. Maps at multiple scales: Generate circuit diagrams that vary in resolution from synapses to the whole brain.
#3. The brain in action: Produce a dynamic picture of the functioning brain by developing and applying improved methods for large-scale monitoring of neural activity.
#4. Demonstrating causality: Link brain activity to behavior with precise interventional tools that change neural circuit dynamics.
#5. Identifying fundamental principles: Produce conceptual foundations for understanding the biological basis of mental processes through development of new theoretical and data analysis tools.
#6. Advancing human neuroscience: Develop innovative technologies to understand the human brain and treat its disorders; create and support integrated human brain research networks.
#7. From BRAIN Initiative to the brain: Integrate new technological and conceptual approaches produced in Goals #1-6 to discover how dynamic patterns of neural activity are transformed into cognition, emotion, perception, and action in health and disease.

The NIH BRAIN Initiative and complementary programs at NSF and DARPA are underway and are accelerating the pace of innovation in cognitive neuroscience. The overall goal is to scale up current techniques so that by 2025 it will be possible to have a connectomic wiring diagrams for all areas of the mouse brain, to be able to record simultaneously from a million neurons, and to develop sophisticated behavioral paradigms that engage multiple brain systems under more natural conditions. These advances will generate enormous datasets that will require new experimental designs, the development of new algorithms for analyzing the data, new ways to model the data and new theories for interpreting the results. Some of these datasets will be made available to the community, just as the availability of large genomic data sets, crystallographic data and astronomical data from the Hubble Space Telescope have enhanced their usefulness.

All of these goals will depend on scaling up the resolution, speed and comprehensiveness of behavioral, anatomical, physiological, and genetic techniques by factors of thousands. We are already on an exponential rise in the number of neurons that can be simultaneously recorded, with datasets that include calcium measurements from a thousand neurons in the hippocampus with 10 ms resolution and 80,000 neurons in the zebrafish with 1 sec resolution. Machine learning, which provides a set of powerful algorithms for analyzing data in high-dimensional spaces, has made it possible to automatically track behavior with high spatial and temporal resolution. But big data is not

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enough by itself to make progress: We will need new insights and theories that explain the data in ways that we cannot yet predict.