Opportunities for US-Japan Collaboration in Computational Neuroscience

Report of an NSF-NICT Workshop
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Introduction

Computational Neuroscience provides a mathematical description of brain and behavior, across multiple spatio-temporal scales and at different levels of analysis (atomic, molecular, genetic, cellular, systems, cognitive and algorithmic), across species and development. By encompassing domains such as biology, neuroscience, psychology, computer science, physics, chemistry, engineering, and mathematics, computational neuroscience benefits from a reciprocal exchange between theory and data, proposing models to frame hypotheses that can then be tested experimentally. Multiple interdisciplinary approaches working synergistically brings enthusiasm and excitements among scientists and engineers to promote collaborations. Further, the field has the potential to provide significant, influential advances in biology, medicine, and computing, and as such, constitutes an interdisciplinary grand challenge for contemporary science and engineering.

Computational Neuroscience thrives on integrating expertise across multiples disciplines. Breakthroughs in Computational Neuroscience are often driven by tight collaborations between researchers in different disciplines, in particular by collaboration between scientists from experimental and theoretical backgrounds.

Within this context, the National Institute of Information and Communications Technology (NICT, Japan) and the National Science Foundation (NSF, USA) studied the possibility of launching a joint funding opportunity in Computational Neuroscience. This would be in conjunction with the Collaborative Research in Computational Neuroscience (CRCNS) program,

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Any opinions, findings, and conclusions or recommendations expressed in this report are those of the workshop participants and do not necessarily reflect the views of the National Institute of Information and Communications Technology (NICT, Japan), the National Science Foundation (NSF, USA), or the National Institutes of Health (NIH, USA).

which currently involves NSF, the National Institutes of Health (NIH, USA), and partner agencies in France, Germany, and Israel. The goal would be to support collaborative projects involving labs in Japan and the US. In addition to collaborative research, these projects could include data or infrastructure sharing.

The workshop explored areas for potential collaborative research, and how the impact and success of a joint activity can be maximized.

Venue:
Conference Room, CiNet Bldg.
1-4, Yamadaoka, Suita City, Osaka, 565-0871 Japan

Sponsors:
National Institute of Communications Technology (NICT)
National Science Foundation (NSF)

Intellectual merit of a partnership between US and Japan

The scientists from both countries agree that successful US-Japan partnerships are likely to generate high intellectual merit.

(a) Exciting science

Based on feedback following the meeting, the participants were excited about research they heard and discussed. There was a shared feeling that they enjoyed the talks of other participants from both countries, many of which were in areas beyond their immediate expertise. For example, it was particularly exciting to hear talks on the same or similar topic, one using experimental approaches to understand the neuronal representation and the other using computational approach to achieve in silico classification. Finding a point where multiple different approaches can meet and potentially work synergistically brings enthusiasm and excitement to conduct collaborations whose scope is wide and interdisciplinary.

Because of the diverse approaches and disciplines of the participants, most presentations were new to the participants. Some US scientists did not know the strength of Japanese science in areas such as neurophysiology. It was valuable to have such an occasion to interact with a neighboring community.

Participants were impressed by the fact that many participants value international collaborations with researchers from the other country. Attractive research motivated the participants to learn more about what is being done on the other side. In addition, participants enjoyed learning about the culture of science in the other country and thinking about how they might interact with scientists from the other country in the future. As a consequence, participants were motivated to learn how to start collaborations, how to build trust and how to discuss collaborations among the US and Japanese scientists.

(b) Potential intellectual partnerships

Both US and Japanese scientists expressed interest in setting up collaborations. Examples include the following:

1. A Japanese primate neurophysiologist expressed interest in US computational neuroscience because theoretical framework is beneficial not only to reveal neural mechanisms underlying the

temporal aspect of information representation, but also to advance technologies in computer vision and artificial intelligence.

2. A US researcher using electrocorticography (ECoG) in humans looked forward to potential feedback and interest from Japanese scientists regarding the use of deep neural nets for feature extraction.

3. A US scientist saw potential areas for collaboration with areas such as cognitive neuroscience, neural and motor-control systems, auditory coding and language processing fields.

4. A US computational scientist saw great opportunity for training opportunities and collaborative resources in the area of computational modeling.

5. A US scientist pointed out that the question of how objects are encoded in the visual system will benefit enormously by US-Japan collaborations. It is a massively difficult problem, much more data needs to be collected, and all of the data should be used to validate, improve, and modify a set of candidate models. No one lab can successfully achieve the goal of discovering the bases of form encoding in the brain.

(c) Specific technical and methodological expertise

In the context of computational neuroscience, both countries have strength in many areas. It is critically important for the researchers to find partners with complementary expertise and have a common goal. To facilitate finding right collaborative partnerships, a mechanism to learn more about the research interests and needs of scientists on the other side would be desirable.

For some fields, such as in non-human primate sensory encoding, finding partners in Japan (for US scientists, and vice versa) maybe easier because there are few labs focused on this question and Japan has been historically strong in primate neurophysiology. This is one example where a US-Japan collaborative venture would be beneficial because, historically, many labs focused on form encoding in the primate have been in Japan.

While the US maybe a bit stronger in computer science and deep learning methods, scientists in both countries are engaged in both experimental and computational methods, which was also evident from the presentations.

Japan clearly has a strong technology sector, particularly in the consumer electronics arena, and strong research in related areas such as robotics, artificial intelligence, virtual reality, and speech recognition. The US is seen as stronger in software and algorithms, while Japan is considered stronger in hardware. Japan also has strength in neuroinformatics, well known for its exceptional neuroscience research community.

(d) Supporting transformative and innovative research

Both US and Japanese scientists value transformative and innovative research. Workshop participants felt that a collaborative funding mechanism could provide a way to support innovative and challenging approaches.

The perception of grants in Japan is that grants are a reward for what was done in the previous cycle. As a consequence, scientists may not attempt challenging projects because of fear of not publishing and thereby losing future funding. Having a history of collaborations makes for safer science but does not necessarily build new, possibly very innovative collaborations.

There was discussion of whether one might feel pressure to work on problems that are very applied and with impact on disease or technology. It seems to depend on the funding agency both in the US and Japan. NSF, NIH, and NICT, though driven by different missions, have a common interest in basic research on computational neuroscience.

In both countries scientists have to write a section on why their work is innovative. Grant proposals in Japan are shorter (the science part is only 4 pages) than US equivalent (the science part is 10-15 pages). For Japanese scientists, allowing additional pages for justification may encourage young scientists to propose higher-risk projects.

Broader impacts of a partnership between the US and Japan

In general, opportunities that enable experimentalists and theoreticians in the US and Japan to come together are highly valued. Collaborative teams, with understanding of the systems in both countries, could use a joint program to develop far-reaching, high-impact projects.

(a) Educational and training experiences

The graduate school systems are different. In Japan there are some schools with a time limit but because the graduate students do not get paid, they cannot work for too long. In addition, Japanese students usually have to pay tuition. (2-year Masters and 3-year PhD programs are typical.) US students are typically compensated, and may be less constrained, at least by time, from pursuing research experiences in Japan. For the benefit of students in both countries, stipend and travel could be requested for PhD students involved in collaborative projects.

Japanese culture might lead students to feel that they cannot question their advisor's results or statements in some cases.

To maximize student and postdoctoral international experiences, it would be desirable for US-Japan projects to support longer-term exchanges of trainees (for example, for a semester or half-year in each country). This would foster a more developed collaborative approach and would be a unique opportunity for trainees. Postdoctoral training abroad would further enable team members to interact. Postdocs would gain valuable knowledge. For instance, postdocs in Japan carrying out computational work in US would benefit by interacting with experimentalists.

(b) Challenges arising from international research collaboration

International collaboration between US and Japan will be a very powerful tool to advance science, and members participating in collaboration will get scientific benefit. To maximize the potential benefit and to advance research effectively, US and Japanese scientists need to organize collaborative teams in a way that each member agrees with the aim and understands direction of the project and associated tasks. Sharing not only outputs such as data and results of analysis, but also the process of each task would be also important. Preparing the infrastructure for the collaboration is also essential.

The computational neuroscience modeling field seems to be divided and there is still relatively little interaction between statistical and biophysical modeling. Those in the statistical modeling community aim to derive abstractions from high-dimensional data regarding the functions of neural processes involved, often with little regards to neural mechanisms and anatomy. Scientists in the biophysical modeling community focus more on detailed mechanisms and correct anatomy. Interactions amongst these two communities could potentially lead to more realistic models with higher predictive power.

In order to bridge this gap, collaborative research funding mechanisms are needed that give scientists the resources to work together across scientific disciplines and across national boundaries. A partnership between the US and Japan through the CRCNS program would be well suited to serve this role.

(c) Roles that industry plays in each country

In both the US and Japan, industry collaborations are valuable but knowledge transfer is often one directional. The proprietary nature and need to turn out a product in industry often supersedes the need to inform and push forward basic science.

Certain areas of neuroscience research are clearly better suited to collaboration with industry, especially those related to medical applications or with direct consumer applications. BCI/BMI, prosthetics technologies including cochlear & retinal implants, and artificial intelligence all stand out. There was a sense that US scientists in medical or applied science fields tend to be more willing to collaborate with others including industry.

Practical considerations for making a collaborative research program involving the US and Japan work smoothly and effectively

(a) Mechanisms of data and resource sharing

Data and resource sharing is getting more and more critical, and is already very critical in some fields. Therefore, sharing plans should be carefully reviewed to ensure data reproducibility. In particular areas such as models, they should be submitted to databases, and developers should be encouraged to write their code to enhance readability and shareability.

Current data and resource sharing can often be narrowly focused. Datasets from different labs are often too disparate to allow for comparison across neural structures and animal species. Efforts should be undertaken to come up with strategies to standardize data sets as much as possible. For instance, it would be valuable to have standardized data sets of neural activity in sensory systems across the processing hierarchy, and even across species. Having a common experimental paradigm would facilitate comparisons across anatomical structures and identification of underlying mechanisms and transformations. Comparisons across species with standardized paradigms would facilitate identification of common mechanisms or species-specific differences.

Data standardization

There were discussions of issues in sharing and standardizing data. It is important that experts in each field define key questions and appropriate paradigms to inform the development of standardized data sets. Experts representing the full data lifecycle could collaborate internationally to help establish guidelines and data sharing programs to facilitate such efforts.

One issue is that scientists may plan to get publications so may delay sharing data. Another issue is that it is difficult to share data and one might worry about people being critical of the data. It would be good to know about resources for data sharing across institutions in both countries. There was some discussion of journals providing ways to cite sharing of data. Also, the transition from proprietary data analysis software to open source software is helping with preparing data for sharing. As scientists have better software pipelines, it becomes easier to share data. There was some discussion of use of sharing sites such as github, opensource, ModelDB, etc.

(b) Differences between data types in data/resource sharing

One should think carefully in advance how to share data/resource when applying for a joint project, as it can be very difficult to implement in reality. Even within the lab, raw data is stored in different formats and thus the database has to be designed so that storage and search can be done systematically. After the experimental data production and data analysis period, allocating time and funding for constructing a system for data sharing could encourage long-term collaborations and benefit the community.

Many scientists from both sides shared the same or similar concerns and conflicts in proceeding with collaborations between experimentalists and theorists. For example, experimentalists tend to set up their own experimental conditions to maximize particular data outputs whereas theorists want all the experimentalists to standardize their experimental conditions.

One major issue, apart from the importance of data, is how easy it is to use such data. Machine learning codes are now more straightforward to share and use. On the other hand, neuroscience data are often harder to manipulate and time-consuming to make sense of. To promote neuroscience data sharing, it is critical, apart from data importance, to make the data easily usable. However, if experimental methods are not established for a given project, trials and errors are inevitable. As discussed during the workshop, we need to analyze parameters not only related to nerve activities but also others such as subjects' behaviors. Though we need to analyze the data through many steps of processing starting from raw data, sharing raw data in the collaborative group can be beneficial. As such, it is necessary for the group to discuss how to distribute raw data, analysis programs and analysis results in a form that all the participants can understand.

Metadata is critical for data sharing. Specifically, one could provide all the raw data files, and even analysis code, from an experiment one is currently performing, but the data files themselves may not indicate what drugs were applied, age and sex of animal, brain region, etc. Without this other information the data is not very useful. Thus, a major obstacle to data sharing is collating the metadata with the data in a useful form. This brings back the issue of data types – some data collection software or experiment types may embed more (or less) of the metadata in it (such as time of stimulation and current injection for intracellular recordings, behavior information with in vivo recording data). However, standardization might be extremely difficult, especially since new questions often require new experimental paradigms to test.

(c) Differences between human vs animal research in data/resource sharing

One of the main differences between human and animal data has to do with privacy, thus human data must not allow identification of the person. Non-human primate ethics demands are also very high.

(d) Culture supporting data/resource sharing

Each lab in both countries appears to have its own level of enthusiasm in supporting collaboration and data/resource sharing. There is a strong culture for model and software sharing, but an apparent weaker culture for experimental data sharing.

For an uploading person, current ways of sharing (such as arXiv, GitHub, ModelDB, and Journal attachments/supplemental data) are sufficient. On the other hand, for a data user, the current support for making various data easily available is not sufficient.

(e) Intellectual Property

Workshop participants shared a variety of personal experiences related to intellectual property in the course of multi-institutional and international collaborations. One described a complex contracting process that took several months. Within the US, government agencies leave IP rights and responsibilities up to the universities, most of whom have similar practices. Across countries, there may be different rules that need to be clarified. A forum for discussing how to manage IP for international projects could be beneficial for both countries. In Japan, contract rules are very strict and must be very detailed and include what happens with IP. The US grant process is less rigid, leaving these issues to the awardee institutions.

How to make US-Japan collaborations attractive to talented scientists and engineers

Researchers discussed ways to encourage interdisciplinary research, allow flexibility in approaches, and ensure longer-term support.

(a) Mechanisms to encourage interdisciplinary research

Encouraging interdisciplinary international collaborations should rely on common research interests of both sides. Scientists are interested to learn more about the research interests of colleagues on the other side, and to develop questions that would push boundaries in both domains.

(b) How to allow flexibility of approaches

In order to support future-oriented, higher-risk areas, the workshop participants felt it would be important for a collaborative program to provide opportunities for new researchers, and to be open to high-risk ideas. Highly innovative proposals could come from already well-formed collaborations that are seeking to push new boundaries, or from investigators starting new collaborations.

(c) How to provide graduate students, postdoctoral and faculty with the opportunity to study abroad

Support for research and travel of graduate students to the foreign partner's lab would improve student exchange (travel) international experience. This could be an important part of a joint proposal or, if mechanisms are available, as supplemental funding (to be applied for later and attached to the original grant).

(d) How to develop long term funding mechanisms, support for innovation, infrastructure and projects

Three years is a very short term for newly established collaborations, especially for interdisciplinary collaborations. Longer-term awards and the flexibility to give no-cost extensions would both be highly desirable.

Trainees involved in joint projects might also continue their collaborative work in the foreign partner lab by applying for other forms of support for international research experiences.

Conclusions and Recommendations

Opportunities for international collaboration between the US and Japan will be a very powerful tool to advance science, likely to generate high intellectual merit and broader impacts for both countries.

Some of the recommendations are:

1. Develop a mechanism for scientists to learn more about the research interests of colleagues on the other side to help establish productive collaboration teams.
2. Support international experiences for students and postdocs via collaborative projects and other mechanisms.
3. Promote flexible interactions not only between theorists and experimentalists but also amongst statistical and biophysical modeling communities.
4. Facilitate discussion of Intellectual Property (IP) issues in both countries.
5. Support efforts to develop and share standardized data sets and other resources.

Appendices

1-Participants

US Participants
Kim Blackwell, Professor, George Mason University
Sharon Crook, Associate Professor, Arizona State University
Rodica Curtu, Associate Professor, University of Iowa
Monty Escabi, Associate Professor, University of Connecticut
Ranu Jung, Professor, Florida International University
Ko Nishino, Professor, Drexel University
Anitha Pasupathy, Associate Professor, University of Washington
Nao Uchida, Professor, Harvard University
Daniel Yamins, Assistant Professor, Stanford University

Japanese Participants
Naokazu Goda, Assistant Professor, National Institute for Physiological Science
Tomoyasu Horikawa, Senior Researcher, Advanced Telecommunications Research Institute International
Hokto Kazama, Team Leader, RIKEN Brain Science Institute
Takamichi Nakamoto, Professor, Tokyo Institute of Technology
Shinji Nishimoto, Senior Researcher, NICT
Yasuko Sugase-Miyamoto, Research Staff, National Institute of Advanced Industrial Science and Technology
Hirokazu Takahashi, Lecturer, Tokyo University
Taro Toyoizumi, Team Leader, RIKEN Brain Science Institute
Yukako Yamane, Lecturer Osaka University
Takanori Uka, Professor, University of Yamanashi

Chairpersons
Izumi Ohzawa, Professor, Osaka University
Hiroaki Matsunami, Professor, Duke University

2-Government Observers

Toshio Yanagida, Director, CiNet
Fumihiko Tomita, Vice President, NICT
Takahisa Taguchi, Vice Center Director, CiNet
Nozomu Nisinaga, NICT
Kenneth Whang, Program Director, NSF
Laura Skipper-Kallal, AAAS Fellow, NSF

3-Workshop Schedule

January 17, 2017

9:00- 9:30	Opening **Toshio Yanagida**, Director, CiNet; **Fumihiko Tomita**, Vice President, NICT; **Kenneth Whang**, Program Director, NSF
9:30-10:05	Talk 1 [J] **Hokto Kazama** (RIKEN) 風間 北斗 Olfactory computations in a three-layered circuit
10:05-10:40	Talk 2 [U] **Kim "Avrama" Blackwell** (George Mason University) Calcium control of synaptic plasticity in striatal spiny projection neurons
10:40-10:50	----- Coffee break -----

10:50-11:25	Talk 3 [J] **Takamichi Nakamoto** (Tokyo Institute of Technology) 中本 高道 Human Olfactory Interface
11:25-12:00	Talk 4 [U] **Ranu Jung** (Florida International University) CENAVEX: Computation-enabled adaptive ventilatory control system
12:00-13:00	----- Lunch -----
13:00-13:35	Talk 5 [J] **Taro Toyoizumi** (RIKEN) 豊泉 太郎 Cortical hierarchy revealed by embedding brain-wide dynamics
13:35-14:10	Talk 6 [U] **Monty A. Escabí** (University of Connecticut) Neural codes and models for sound recognition in the presence of acoustic uncertainty
14:10-14:30	----- Coffee break -----
14:30-15:05	Talk 7 [J] **Hirokazu Takahashi** (Tokyo University) 高橋 宏知 Intelligence emerging from neural system
15:05-15:40	Talk 8 [U] **Rodica Curtu** (University of Iowa) Decoding Human Auditory Perceptual Switches: An Intracranial Electrophysiology Study
15:40-16:00	----- Coffee break -----
16:00-16:35	Talk 9 [J] **Takanori Uka** (University of Yamanashi) 宇賀 貴紀 Neural basis and computation for flexible perceptual decision making
16:35-17:10	Talk 10 [U] **Naoshige Uchida** (Harvard University) 内田 直滋 Toward new theories of dopamine
17:10-18:10	Discussion on collaborative research
18:20-20:00	----- Welcome Reception -----

January 18, 2017

9:00- 9:35	Talk 11 [J] **Tomoyasu Horikawa** (ATR) 堀川 友慈 Shared hierarchical neural representations between perception, imagery, and, dreaming
9:35-10:10	Talk 12 [U] **Daniel Yamins** (Stanford University) Using Artificial-Intelligence-Driven Deep Neural Networks to Uncover Principles of Brain Representation and Organization
10:10-10:45	Talk 13 [J] **Shinji Nishimoto** (CiNet, NICT) 西本 伸志 Modeling and decoding of brain activity during natural vision
10:45-11:00	----- Coffee break -----
11:00-11:35	Talk 14 [U] **Sharon Crook** (Arizona State University) Reproducibility and Rigor in Computational Neuroscience: Testing the Data Driven Model
11:35-12:10	Talk 15 [J] **Naokazu Goda** (NIPS) 郷田 直一 Representation of visual and non-visual material properties of objects in the visual cortex
12:10-13:10	----- Lunch -----
13:10-13:45	Talk 16 [U] **Ko Nishino** (Drexel University) 西野 恒 Computational Material Perception
13:45-14:20	Talk 17 [J] **Yukako Yamane** (Osaka University) 山根 ゆか子 Active Vision --- international collaboration project
14:20-14:40	----- Coffee break -----
14:40-15:15	Talk 18 [U] **Anitha Pasupathy** (University of Washington) Uncovering object representations in visual cortex
15:15-15:50	Talk 19 [J] **Yasuko Sugase-Miyamoto** (AIST) 菅生 **(**宮本**)** 康子 Neuronal mechanisms underlying the face inversion effect in macaque area TE
15:50-16:10	----- Coffee break -----
16:10-17:10	Discussion on collaborative research
17:10	Closing