Opportunities for US-Israeli
Collaborations in Computational Neuroscience

Report of a Binational Workshop*

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Introduction

Both Israel and the United States have played and continue to play leading roles in the rapidly developing field of computational neuroscience, and both countries have strong interests in fostering collaboration in emerging research areas. A workshop was convened by the US-Israel Binational Science Foundation and the US National Science Foundation to discuss opportunities to encourage and support interdisciplinary collaborations among scientists from the US and Israel, centered around computational neuroscience. Seven leading experts from Israel and six from the US (Appendix 2) met in Jerusalem on November 14, 2012, to evaluate and characterize such research opportunities, and to generate suggestions and ideas about how best to proceed. The participants were asked to characterize the potential scientific opportunities that could be expected from collaborations between the US and Israel in computational neuroscience, and to discuss associated opportunities for training, applications, and other broader impacts, as well as practical considerations for maximizing success.

Computational Neuroscience in the United States and Israel

The computational research communities in the United States and Israel have both contributed significantly to the foundations of and advances in applying mathematical analysis and computational approaches to the study of neural circuits and behavior. This shared intellectual commitment has led to productive collaborations between US and Israeli researchers, and strong ties between a number of institutions in Israel and the US. These scientific collaborations are built on over 30 years of visits and joint publications and the results have been extremely influential.

United States-Israel collaborations in computational neuroscience are far too numerous to fully annotate, so we provide a few representative examples that serve to illustrate the extent, range, and the quality of the work:

Idan Segev (Hebrew University) and Christof Koch (Caltech) – classic work on the computations done by single neurons and the biophysics that supports these computations (e.g., references 1-3).

Misha Tsodyks (Weizmann Institute) and Terry Sejnowkski (Salk Institute) – fundamental results on spatial coding in the hippocampus (e.g., references 4, 5).

Ehud Ahissar (Weizmann Institute) and David Kleinfeld (University of California at San Diego) – development of ideas in active sensing (e.g., reference 6) and subsequent experiments on coupled orofacial behaviors (e.g., reference 7)

David Golomb (Ben-Gurion University) and Bard Ermentrout (University of Pittsburgh) – mathematical foundations of oscillations and slow signal propagation in neural circuits (e.g., references 8, 9).

Omri Barak (Technion) and David Sussillo (Stanford) – recent work on uncovering the mechanisms by which neural networks perform their computations (e.g., reference 10).

Haim Sompolinsky (Hebrew University) and Surya Ganguli (Stanford) – applying ideas from compressed sensing to neuroscience (e.g., reference 11).

Misha Tsodyks (Weizmann Institute) and Haim Sompolinsky (Hebrew University) and Larry Abbott (Columbia) – research on network dynamics and its relation to recorded neural activity (e.g., references 12, 13)

Tali Tishby (Hebrew University) and Bill Bialek (Princeton University) – development of basic ideas about predictive information and the information bottleneck principle (e.g., reference 14).

Nathan Intrator (Tel Aviv) and Leon Cooper (Brown) – a well-known set of papers on synaptic plasticity and learning (e.g., references 15, 16).

Bob Shapley (New York University) and Haim Sompolinsky (Hebrew University) did important work together on the contrast invariance of orientation tuning in primary visual cortex (e.g., references 17, 18).

In addition to these and many other collaborations between individuals, there are a number of institutional collaborations. The new campus of Cornell and the Technion in New York City, and a long collaboration between Caltech and Hebrew University are examples.

Both the United States and Israel have exceptionally strong nationwide programs in computational neuroscience with numerous graduate programs, departments and institutes that emphasize computational aspects. The strength of the computational neuroscience programs in both countries and the history of strong and fruitful collaborations suggest that broadening these interactions through the proposed NSF-BSF program will be highly advantageous to all parties and to the field of neuroscience in general. Indeed, these interactions should be broadened and expanded to support new experimental technologies and medical applications as well.

For example, the Hebrew University has been a major player in stimulation of the sub-thalamic nucleus as a treatment for Parkinson's disease (deep brain stimulation). US researchers are using both optogenetic techniques and theoretical approaches to understand and enhance DBS treatments. Clearly technological development will be a major focus of collaborative research between the two countries. To mention one noticeable example, Intel has recently invested $20M in a collaborative research institute at the Technion and Hebrew University with a declared goal of developing Brain-Inspired computer architectures as a central component of the future Intel computers. This center is closely associated with the computational neuroscience centers of both Institutes. Another related area is the emerging field of autonomous systems and robotics. Here again ideas and methodologies emerging from theoretical cognitive science, such as models of sensing-acting systems, are playing a major role in the design and development of autonomous robots. DARPA is currently supporting two teams in Israel, as well as their strong support in the US, for theoretical work related to the mathematics of sensing, execution, and exploration (MSEE) and of autonomous vehicles. An additional interdisciplinary research area mentioned at the workshop cross-lingual information retrieval and machine translation. There are currently several groups in Israel (e.g., Ari Rapoport and Ronen Feldman at HUJI) who are currently world leaders in these areas and are working with computational neuroscience and machine learning centers in Israel and the US. A new $25M NSF-funded Center for Brains, Minds and Machines involves investigators from MIT, Harvard, Rutgers University, Hebrew University, and the Weizmann Institute.

The Need for Collaboration

Computational neuroscience cannot and does not exist in isolation. Collaborations with experimentalists are essential to the field and, as experiments get more complex and data files more massive, collaborations of experimental groups with theorists are crucial if the lessons, ideas and insights contained in the data are to be extracted. Many experimental groups are looking for theorists to help analyze their data and model their results, but collaborators with the appropriate expertise may not be nearby and forming the desired connections may require some facilitation. US experimentalists will, undoubtedly, want to gain access to the exceptional computational neuroscientists in Israel and, conversely, Israeli experimental groups offer unique approaches and data sets that will enrich computational neuroscience in the US. Of course, there are also many opportunities for collaborations between different theorists and theory groups.

Researcher and Student Exchange

There is already a regular exchange of researchers and students between the US and Israel. For example, an extremely valuable aspect of the collaboration involving Columbia, Hebrew University, and University College London has been the exchange of postdoctoral researchers and graduate students. Continuing these exchanges and interactions, and expanding them to include more research centers and researchers should be a top priority.

The typical trajectory of an Israeli researcher involves a considerable amount of research experience outside the country, often in the US. Virtually all Israeli researchers do

postdoctoral research outside Israel and many work frequently in other countries throughout their careers. This means that the foundations for collaboration are in place, but these are not well balanced. US researchers, especially early in their careers are less likely to visit scientists in Israel. It would be helpful if these valuable exchanges could be made more two-way. This should start already at the graduate school level with trips to Israel by US graduate students as part of research collaborations. And it should extend to all career stages, with collaborative visits in both directions by PIs as well. From the Israeli point of view, US research experience assures a steady supply of outstanding and well-trained researchers to maintain the high-level of neuroscience research in Israel during a time when increasing numbers of currently active researchers will reach the mandatory retirement age. From the US viewpoint, interactions with Israeli graduate students, who are some of the strongest in the world, and with more experienced researchers with different viewpoints (in particular the strong tradition of applying approaches from mathematics, physics and computer science) will strengthen research and, we predict, lead to important new insights.

As an example, Hebrew University has what is widely regarded as one of the top graduate training programs in computational neuroscience in the world, the Interdisciplinary Center for Neural Computation (ICNC). It would be a wonderful opportunity for computational neuroscience students studying in the US to spend some time at the ICNC, as well as at other Israeli universities, perhaps even having both US and Israeli thesis advisors. In the Israel-to-US direction, this arrangement is already working well. To cite an example, three students from Hebrew University have participated in exchanges with Columbia University. This example is admittedly Columbia/Hebrew University centric because we are writing about the examples with which we are extremely familiar, but it provides an indication of what can be done.

Practical Considerations for Implementation

We see no substantial impediments but one issue to which attention will have to be given is the difference in cost-of-living and salary levels between the two countries. Israeli researchers and students traveling to and then living in the US will have to be provided with extra support beyond their home salaries.

We are not aware of human subject or animal welfare issues that would arise, but this might be further investigated. Visas and travel arrangements could be handled by the host institution and, while aggravating, these have been handled successfully in previous exchanges. Again from our previous experience, the contrasts in culture between the two countries is one of the major pluses of such exchanges.

Conclusions

The general idea of collaborations between US and Israeli researchers was met with great enthusiasm by the group that met in Israel to discuss these issues. The following ideas were discussed and supported:

1) We agreed that RO1-type grants of the CRCNS type would be one effective and useful funding mechanism.

2) The idea of combined NSF and BSF proposals was discussed, with the suggestion that both sides could benefit from more substantial research budgets.

3) For theory/experimental collaborations to work well, it is essential for the right groups to find each other and start working together. A good suggestion arising from our discussion was to have a web-based listing of potential collaborators, both experimental and theoretical, to facilitate this process.

4) Another key element of theoretic/experimental research is access to data. We propose supporting servers and arrangements for assuring that data are fully annotated and shared in a format that allows all collaborating researchers, in particular theorists, to access, analyze and/or model the data.

5) Travel grants are needed at all levels, that is, for PIs, postdocs and students. For PIs, the idea of funding of sabbaticals was enthusiastically supported.

6) The group felt that the program should include opportunities for co-advising of graduate students and postdoctoral researchers, either with two computational advisors or with one computational and one experimental advisor.

Appendix 1: Answers to Specified Questions

At the meeting, we were asked to address the following questions. Here are our answers, in brief, with more detail given in the main text.

What are the potential scientific opportunities that could be expected from collaborations between the US and Israel?

Significant advances in pure theory, in data analysis, and in data modeling.

Are the potential benefits narrow or are there some highlights across the CRCNS spectrum?

We envision that the work will range from the cellular to the cognitive level, as outstanding researchers working over this wide range are ready to participate in both countries.

Are there other complementarities in expertise or styles of doing science that an international partnership can leverage?

Yes. Israel is exceptionally strong in theoretical neuroscience and, while also strong in experimental work, lacks the broad range of topics and techniques that exists in the US.

Do you foresee any potential completely new opportunities?

Absolutely, we see a major point of pursuing this enterprise as promoting new collaborations and research topics. We have tried to provide suggestions for structuring the program to assure that this happens.

Is there sufficient depth to support a stable, long-term international partnership?

For sure, although Israel is a small country, it is a world-wide leader in neuroscience research.

Appendix 2. Workshop Participants

The workshop, on November 14, 2012, was attended by the following participants and observers, on site at Hebrew University in Jerusalem, and via audio or video conference from NSF and NIH in Washington:

Co-chairs:
Larry Abbott, William Bloor Professor of Theoretical Neuroscience, Columbia University
Naftali Tishby, Professor of Engineering and Computer Science and Director, Interdisciplinary Center for Neural Computation, Hebrew University

Participants:
Yali Amit, Professor of Statistics and Computer Science, University of Chicago
Omri Barak, Assistant Professor of Neuroscience, Technion
Opher Donchin, Assistant Professor of Neuroscience, Ben Gurion University
Nathan Intrator, Professor of Computer Science, Tel Aviv University
Nancy Kanwisher, Professor, Department of Brain and Cognitive Sciences, Massachusetts Institute of Technology
David Kleinfeld, Professor of Physics and Neurobiology, University of California at San Diego
Ron Meir, Professor of Electrical Engineering, Technion
Gal Richter-Levin, Director, Haifa Forum for Brain and Behavior and Institute for the Study of Affective Neuroscience, Haifa University
Dov Sagi, George Zlotowski Professor of Brain Research, Weizmann Institute
Robert Shapley, Natalie Clews Spencer Professor of the Neural Sciences, New York University
Karel Svoboda, Group Leader, HHMI Janelia Farm Research Campus

Observers:
Stacey Chambers, Program Analyst, National Institute of Neurological Disorders and Stroke
Dennis Glanzman, Chief, Theoretical and Computational Neuroscience Research Program, National Institute of Mental Health
James Gnadt, Program Director, National Institute of Neurological Disorders and Stroke
Heni Haring, Assistant Executive Director, US-Israel Binational Science Foundation
Mary Ann Horn, Program Director, Division of Mathematical Sciences, National Science Foundation
Yuan Liu, Chief, Office of International Activities, National Institute of Neurological Disorders and Stroke
Yair Rotstein, Executive Director, US-Israel Binational Science Foundation
Julia Skapik, Fellow, Division of Information and Intelligent Systems, National Science Foundation
Kenneth Whang, Program Director, Division of Information and Intelligent Systems, National Science Foundation

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