CAN 2014 satellite workshop: outcomes

During 2012 Canadian Association for Neuroscience (CAN) meeting, the International Neuroinformatics Coordinating Facility (INCF) and NeuroDevNet organized a satellite meeting where we identified the lack of experimental-theory/modeling interactions, and in general a lack of support for neuroinformatics and computational biology in Canada, with serious implications for progress in Canadian health research. We concluded that this gap was unaddressed due to a lack of organization of neuroinformatics and computational neuroscience in Canada and decided to take action. As a first step, in 2012 we created the Canadian Association for Neuroinformatics and Computational Neuroscience (CNCN) to convey our vision and to enhance our visibility and impact. Our goal is to promote theory-experiment collaborations leading to more efficient knowledge advancement and transfer. In 2014 we held a second workshop as a CAN satellite, for which this document is the report.

Over 60 years ago Hodgkin and Huxley predicted the existence of ion channels based on modeling work of axonal spike propagation, for which they received the Nobel Prize in 1963. Since then, whenever computational modelling or neuroinformatics have been involved, Neuroscience has made tremendous advances. One of the most important contributions of neurocomputation is to provide quantitative experimental predictions that optimize experimental design which is of particular importance when dealing with animal research or clinical patients. Computational Neuroscience is also instrumental for our mechanistic understanding of brain (dys-) function. In addition, computational neuroscience and neuroinformatics provide crucial research tools for deciphering Big Data and the complexity of clinical symptoms after brain damage. There is a huge emphasis on neurocomputing in the world and major international projects (like the Human Brain Project) have very noble long-term goals of understanding whole-brain function. However, despite a tremendous amount of neurocomputational and neuroinformatics expertise, Canada is not part of such efforts and - without action - might be left behind, due to a lack of organization. This is why we created CNCN: the diversity of Canada's neurocomputational and neuroinformatics expertise could be readily exploited in a unique way to improve human health through a multi-pronged effort integrating different approaches across scales. Today, Canada is at the top in the world in terms of health research (measured by citation impact); we will ensure Canada's leading position through boosting collaborations between experimentalists and neurocomputation / neuroinformatics. This will have a huge benefit for health research requiring comparatively little investment.

Goals of the 2014 workshop & program

We had three distinct goals: (1) showcase the significance of CNCN-experimental collaborations with Dr. Eve Marder (Brandeis University; a world renowned computational neuroscientist and former president or the Society for Neuroscience) as a keynote speaker, (2) enable new breakthroughs on major health questions by initiating novel collaborations during chaired break-out sessions matching CNCN expertise with experimentalists (during dinner), and (3) prepare a joint vision on how CNCN will optimally benefit health research in Canada. As a tangible outcome, we also planned to deliver a detailed roadmap to CIHR with specific suggestions, their expected impact and how funding agencies (e.g. CIHR, NSERC, CIFAR, MITACS) can foster development of computational neuroscience research in Canada.

The workshop had 60 participants (about ¼ invited and ¾ selected from an open application process), including 16 graduate students, 9 postdocs and 35 PIs. About half of the attendance defined themselves as experimental, the other half being more computationally oriented. This nice balance allowed us to identify both needs of the CNCN community as well as expectations of the experimental community from CNCN. We are happy to report that we had an extremely successful workshop from which emerged a series of specific needs of the neuroscience research community, including experimentalists and computationalists. We also enjoyed the presence of two CIHR representatives; however, unfortunately no other funding agency was represented, despite being invited.

Program:

5pm – 5:15pm – Welcome by Paul Pavlidis & Gunnar Blohm

Showcases of CNCN-experimental collaborations

5-15pm – 5:45pm: Modeling the lateral interactions in the superior colliculus and beyond (Thomas Trappenberg, Dalhousie; Doug Munoz, Queen's)

5:45pm – 6:15pm: Nonlinear processing in early vestibular processing pathways, rethinking the neural code (Kathy Cullen, McGill; Maurice Chacron, McGill)

6:15pm – 6:45pm: Changes in the dynamics of network oscillations in hippocampus as markers of neurodegeneration in Alzheimer disease mice models (Frances Skinner, U Toronto, TWRI/UHN; Sylvain Williams, McGill)

6:45pm – 7:15pm: Genomics and neuropsychiatric disorders (Gustavo Turecki, McGill; Paul Pavlidis, UBC)

7:15pm – 8:30pm: 6 chaired round table discussions & dinner

8:30pm – 9:30pm: keynote lecture (Dr. Eve Marder)

9:30pm – midnight: open discussion on vision of CNCN

Outcomes

Preamble

It is well recognized that computational modelling and neuroinformatics are crucial for efficient and responsible research advancements. Computational neuroscience and neuroinformatics are rapidly growing fields that can provide formal theories and frameworks to analyze and explain empirical findings using computational models and can bridge the gap between neural properties, computational objectives and behaviour. Indeed, one of the most important contributions of neurocomputation is to provide quantitative experimental predictions that optimize experimental design which is of particular importance to optimize animal research or working with clinical patients. Computational neuroscience and neuroinformatics are also instrumental for our mechanistic understanding of brain (dys-) function. Not only do computational models identify hidden assumptions and missing knowledge, but more importantly, models can make targeted and testable predictions. This theory-driven approach streamlines all aspects of clinical and basic research resulting in more efficient and accelerated discovery. In addition, computational and neuroinformatics approaches provide new research tools for deciphering the complexity of clinical symptoms after brain damage. CNCN is dedicated to promote these approaches for neuroscience research in the hope of benefitting Canadian health research.

The need and timeliness for computationally advanced, multidisciplinary health research in Canada as a "critical and high-potential research field" has been acknowledged by Dr. Remi Quirion (former Director of the Institute for Neuroscience, Mental Health & Addiction at CIHR) in his Strategic Research Plan and has been targeted for funding in strategic initiatives: "The INMHA, in collaboration with its partners, wishes to foster development in this domain by supporting innovative transdisciplinary teams composed, preferably, of computer specialists, engineers, neuroscientists and clinicians". CNCN will achieve this by helping to bring neurocomputational and experimental researchers together.

The promotion of neurocomputation by CNCN will not only help neuroscience research but will also positively impact Canadian industry. Indeed, neuroinformatics and computational neuroscience provide a lingua franca that connect new technologies embraced by industry (machine learning, AI, big data, etc) with research. Thus the skills and knowledge acquired and generated by neurocomputation is highly transferable to industry in a huge variety of fields (e.g. any database-related product or simulation tool). Thus promoting education in neurocomputation through HQP involvement in research products will also largely benefit Canadian industry.

General outcomes

From the round table discussions and final open discussion a series of suggestions, comments and needs were expressed. Specifically, experimentalists expressed their wish to obtain more help with structuring their experiments and data in a broad sense, ideally even before they collect it. This would require specific models to make quantitative predictions that can be addressed. Once recorded, mathematicians are needed to provide important insights into the trends/patterns in data, but they need the wants/needs of experimentalists communicated to them better. A difficulty to achieve this can stem from a lack of efficient communication between experimentalists and theoreticians, e.g. terminology is often discipline-specific etc. Experimentalists feel that mathematicians need to impart intuitions in a more understandable way.

It is one of the goals of CNCN to overcome these difficulties and cater to the needs of both computationalists and experimentalists. Indeed, there is a range of ongoing work in computational neuroscience and neuroinformatics that largely overlaps with experimental work but is conducted independently. Thus, consideration of how to combine these different approaches needs some thought and discussion. CNCN will help in finding overlapping research and bringing disciplines together to achieve neuroscience research advances with efficient multi-disciplinary teams.

Specific outcome 1: CNCN strategy / vision & service to the community

As data sets become larger, more complex, and more comprehensive, there is an increasing need for capacity and expertise in neuroinformatics and computational neuroscience. Integration of data across studies and modalities (neuroimaging, genomics, clinical, and others) is increasingly difficult but crucial for our understanding of brain function and dysfunction. The development of models can help transform the realm of neuroscience data into mechanistic explanations. This includes models to understand neurological diseases, models that accelerate the development of treatments, and theories that result in new rehabilitation strategies ultimately improving the quality of life. Thus, neuroinformatics and computational neuroscience are highly relevant to health research and worthy of explicit funding support. Indeed, there is already a lot of it going on in Canada and is thus a strength that can be built upon. CNCN been working to build a research community to identify & improve opportunities, training, collaborations.

One main identified goal of CNCN is to bring researchers together in new collaborative efforts to understand brain function and dysfunction. We will achieve this through a series of means that we will gradually put in place: (1) we will open our mailing list for collaboration inquiries to all subscribed members to simplify the matching process in finding potential collaborative partners; (2) we have already started creating a publicly accessible database of CNCN members that contains research interests and expertise to help identifying meaningful collaborators; and (3) we will improve our visibility to reach out to more Canadian researchers so that our network will become more effective in promoting collaborative research.

CNCN will further improve the visibility and impact of neuroinformatics and computational neuroscience in Canada through a series of additional actions. This includes providing more training opportunities (advertise summer schools, courses, conferences), teaching material (online courses and tutorials), and research resources (toolboxes, programs, shared code, etc.). The latter will constitute a platform for knowledge exchange that should facilitate collaborative research as well as open source developments, both fostering new and existing collaborative research. We also plan to partner up with other networks to promote visibility, such as for example NeuroDevNet. Indeed CNCN is already highly cross-connected with NeuroDevNet on the ground but this has not yet been made official.

Our future vision is to create a Centre of Excellence in Neuroinformatics and Computational Neuroscience as a nation-wide resource and coordination facility. Such a centre will effectively coordinate large research groups focussing on specific brain diseases (e.g. through facilitating group grant applications to CIFAR, Brain Canada or CIHR), administer central resources (both in terms of hardware, software and knowledge transmission) and create a critical mass organism for fund raising and international research efforts. In addition, such a centre would offer and administer a nation-wide computational neuroscience platform (e.g. housed on Computing Canada infrastructure) to make neuroinformatical approaches and computational modelling more readily accessible to researchers. This centre could also play a pivotal role in linking neuroinformatics and computational neuroscience resources with CAN members and the annual CAN meeting.

Specific outcome 2: yearly CNCN workshop requested

The 2014 CNCN satellite workshop at CAN was extremely well received. So well so that participants unanimously requested an annual CNCN workshop. While the exact format and venue of this would need to be determined, such a workshop would have multiple goals:

- To identify strategic research directions in Canada for which CNCN can make a significant contribution, e.g. neurorehabilitation

- To promote CNCN expertise through lab poster sessions
- To facilitate research collaborations through break-out discussion groups
- To decide upon future directions for CNCN
- To offer specific introductory methods lectures that display the power of certain neurocomputational techniques

Specific outcome 3: recommendations to funding agencies – training / collaboration programs

Both students and PIs at the CNCN workshop suggested that relatively little funding to support training and collaboration costs could go a long way. Obviously, student funding in CNCN-related activities is crucial to advance neuroscience research. But such funding would also promote more collaborative work. For example, one could imagine a collaborative training program (co-funded by CIHR and NSERC?) in which students would obtain quantitative training and apply the newly acquired expertise to health research. Practically, collaborative research is carried out by the students involved; thus another possibility would be to promote longer-term training programs that are longer than a summer school but shorter than a full degree, such as 6-12-month lab visits of students for collaborative research endeavours. Such research exchanges would not only promote CNCN-experimental collaborative research but would also enhance the students' training.

One specific suggestion would be to instate a fund that supports travel for collaboration development. Given the large land mass of Canada this would be most welcome and could go a long way to encouraging and building collaborations. There are less modellers/theoreticians compared to experimental labs and so providing monies for people (PIs, HQPs) to spend time in each other's labs would be extremely beneficial. For example, discussions might start at a CAN workshop, and then subsequent visits could develop the collaboration. However, there are currently no funding sources available to encourage and initiate such collaborative efforts.

Specific outcome 4: recommendations to funding agencies – research funding

Everywhere in the world, governments invest hugely in neuroscience research through big group funding. While we do not suggest that Canada should follow the models of other countries, we do think that making neurocomputation a central part of big funding initiatives will have a huge impact in discovery in neuroscience research and will further boost this highly proliferating field. As such, we urge the government and funding agencies to not only inject new money into neuroscience research (such as the US has done for the BRAIN project) but to specifically direct those (and existing) monies towards research endeavours including a neurocomputational component. Again, the presence of explicit neurocomputation in research projects would ensure the Canadians get the most bang for their buck in terms of tangible returns for health benefits.

In addition, it is not yet recognized enough that neuroinformatics and computational neuroscience are not just add-on activities to experimental research projects but should be regarded as important and fundable activities on their own. This was not only apparent in the lack of interest from Canadian funding agencies in this CNCN workshop; the 2014 international Organization for Computational Neuroscience (OCNS) annual meeting in Quebec City was not attended by any Canadian Agency, while

NIH, NSF etc. were present. Funding theoretical approaches for their own sake does of course not mean that neurocomputation works independently of experimental data; quite the contrary. But neurocomputation is an important field for our understanding of brain function and dysfunction that can (and should) also be carried out without necessarily having a direct interaction with or subordinate role to specific experimental projects. Specifically, neurocomputation builds overarching models and theories that most of the time go far beyond specific experimental paradigms. But to do so, neurocomputationalists need operating funds for HQP salaries, computing infrastructure and (sometimes) CPU time rentals on computing clusters. Thus funding of neurocomputation on its own is crucial for Canadian health research.

It will also be important for NSERC and CIHR (and maybe other funding organisms) to come together and develop a joint strategic plan. A first step towards this goal has already been realised with the CIHR/NSERC Collaborative Health Research Projects. Such collaborations should only be the beginning and such funding initiatives should be extended and made the norm rather than the exception.

Collaborative (neurocomputation and experimentation) research should also be reinstated internationally. CIHR used to be part of CRCNS initiative, but this has unfortunately been abandoned despite this collaborative research network being expanded internationally (USA, France, Germany, and Israel). CNCN believes that Canada is missing a huge opportunity to benefit from significant international funding requiring only a comparatively small contribution from Canada. In addition to all the above-mentioned benefits for experimental-computational collaborations, those initiatives also have the potential to bring new knowledge and technology to Canada. The impact on such technology transfer for Canadian research and industry would be enormous. We would therefore like to suggest that program officers from NSERC/CIHR meet with their NSF/NIH counterparts to get a new discussion started.

Finally, CNCN recognizes that building collaborations between experimentalists and theoreticians takes time. Thus the question is how such interactions can be accelerated. We believe that it is particularly hard for young PIs that just start out to devote resources (i.e. time and costly HQP) to collaborative projects while they have to build their own lab and show independent productivity to obtain tenure. Thus, providing operating (stimulus) money to new faculty and independent researchers during the first years would allow them to more quickly gain critical mass and be able to engage in collaborative projects.

Gunnar Blohm & Paul Pavlidis, CNCN co-Directors

(Reviewed and approved by the CNCN steering committee)