

New Brunswick Strategic Planning Proposal

Proposal Title: **Computation, Cognition and the Brain**

Proposal Initiator:

David S. Vicario

Dimitri Metaxas

Charles R. (Randy) Gallistel

Primary Contact Name and Phone Number:

David S. Vicario (848) 445-8883 (917-575-7702)

Primary Contact Email Address:

vicario@rci.rutgers.edu

Primary Strategic Priority/Foundational Element/Integrating Theme Addressed (Select one)

Envision Tomorrow's University

Build Faculty Excellence

Transform the Student Experience

Enhance Our Public Prominence

Strong Core of Sciences and Humanities

Inclusive, Diverse, and Cohesive Culture

Effective and Efficient Infrastructure and Staff

Financial Resources Sufficient to Fund Our Aspirations

Robust Shared Governance, Academic Freedom, and Effective Communication

Cultures, Diversity, and Inequality—Local and Global

Improving the Health and Wellness of Individuals and Populations

Creating a Sustainable World through Innovation, Engineering, and Technology

Educating Involved Citizens and Effective Leaders for a Dynamic World

Creative Expression and the Human Experience

Measuring Progress and Defining Success

Proposal Abstract (brief summary of the proposal – 250-word limit):

Computational neuroscience seeks to understand how the brain combines sensory input together with prior experience and ongoing goals to choose and shape adaptive behaviors. Recent advances in modern neurobiology and computer science, both conceptual and technical, now enable new approaches to this fundamental problem. An emergent insight is that sensory perception does not just reflect static measurements of physical quantities, but interprets new input in combination with dynamic representations of the statistical properties of prior experience to enable behavioral decisions. Neural processing is inherently cognitive, computational and contextual; neurobiological data (obtained by electrophysiology and imaging) are best analyzed with tools from information theory. Such computational approaches are critical, both to provide analytic tools for large data sets (from imaging, optical and high-density electrophysiological recordings) and to build algorithmic models that embody the principles of neural information processing. The most fertile research opportunities now lie at the intersection of biological, psychological and computational approaches. This proposal aspires to fulfill this interdisciplinary vision by building faculty excellence. The first step is to hold a conference that brings national experts already engaged in collaborative research with this synthetic approach to New Brunswick as models for our own development, followed by internal assessment of our strengths, weaknesses and potential collaborations. Finally, a strategic initiative for growing a unique interdisciplinary environment at Rutgers New Brunswick will be presented, including proposals for research infrastructure and recruitment of new faculty leadership. The goal is improving our understanding of the neural basis of cognition using new computational methods.

Full Proposal Description (5-page limit)

[Insert here the full proposal, which should describe in detail a) what is being proposed, b) how the initiative aligns with the University Strategic Plan, c) any additional themes, priorities, and elements addressed, d) who will be involved, e) desired outcomes, and f) anticipated resources to support this initiative.]

a) what is being proposed

We propose to host a multi-day conference that brings together nationally recognized figures who work at the interface between neurobiology and computation. This will expose faculty to the kinds of collaboration that exist and provide models for what can be developed at Rutgers New Brunswick. Furthermore, this conference will enable the identification of targets for faculty recruitment that would provide synergism and “glue” to our research community. The results of this exposure will be used to generate a formal strategic proposal to strengthen computational and cognitive neuroscience, including new faculty and core infrastructure.

Computational Cognitive Neuroscience

Traditionally, Computational Neuroscience is concerned with the dynamic processes, computations, and representations that underlie brain function, structure and development. The data studied in Computational Neuroscience can arise from a very wide set of

experiments, result from multiple scales of representation, including molecular, neural, circuit/network, and whole brain connectivity (e.g. "connectome"), and utilize a wide array of methods including single cell recording, EEG, MEG and MRI. The binding element across computational neuroscience is the emphasis on explicitly formulated models. These models can take the shape of mathematical formulas or computer simulations. Computational Neuroscience often draws from fields including probability theory, control theory, dynamical systems, statistical learning theory, and large scale ("big data") computational algorithms. This area is particularly ripe for interaction as computer models are increasingly driven by data obtained from other areas of excellence, including sensory processing, learning, plasticity and memory.

Furthermore, recent developments in video capture, have enabled the synchronized capture of video and MEG or EEG signals which has opened the way to the improved understanding of brain representations and cognitive processes through new computational methods capable of analyzing these complex signals. This motivates our proposal since we aim to focus on improving our understanding of the cognitive representations in the brain and open new avenues of collaborative research in this exciting domain.

b) how the initiative aligns with the University Strategic Plan

Our initiative will help to build stronger collaborations between departments and units on campus, including the medical school. By providing our faculty with a forum for interaction and the necessary resources to apply for larger and more prestigious awards, we will grow our research output and infrastructure, ultimately enhancing our national and international reputation. This proposal contributes to the strengthening the core of basic sciences, improving health and wellness in the community, and helping us to secure the financial resources required to fund these aspirations. It will also contribute to future collaborative research between SAS and the medical school for the improved understanding of cognitive and motor impairments due to mental disorders and Parkinson's disease.

c) any additional themes, priorities, and elements addressed

The modest financial resources requested in this proposal will be used to identify opportunities for collaboration that cut across units at New Brunswick (Psychology, Computer Science, RUCCS). They will also be used for a Computational Neuroscience Conference in the Fall of 2014, in which we will invite senior faculty from other universities that will help us discuss the future of Computational Neuroscience. This Conference will improve our future plans in this areas and will result in further collaborations with those senior faculty which will in turn leverage the existing strengths in computational neuroscience at Rutgers, New Brunswick. This will significantly enhance the environment, creativity and productivity of New Brunswick faculty. Additionally it will help us decide the limitations of our current collaborative research and make plans for future faculty hiring in areas we currently lack.

d) who will be involved

Strengths in Computational Neuroscience

Jacob Feldman, RuCCS, Psychology Department, SAS

Charles Randy Gallistel, RuCCS, Psychology Department, SAS

Stephen José Hanson, RUBIC, Psychology-NK, RuCCs
Eileen Kowler, Distinguished Professor, Psychology & RUCCS, SAS
John McGann, Assoc. Professor, Psychology, SAS
Melchi Michel, Asst. Professor, Psychology, SAS
Dimitris Metaxas, Computer Science, CBIM, SAS
Vladimir Pavlovich, Computer Science, CBIM, SAS
Manish Singh, RuCCS, Psychology Department, SAS
Elizabeth B Torres, RuCCS, CBIM, Psychology Department, SAS
David S. Vicario, Professor, Psychology, SAS
Ahmed Elgammal, Computer Science, CBIM, SAS
Tina Eliassi-Rad, Computer Science, CBIM, SAS
Kazimir Kulikowski, Computer Science, SAS
Kostas Bekris, Computer Science, DBIM, SAS
Kasia Bieszczad, Asst. Professor, Psychology, SAS (arriving 2015)

e) desired outcomes

1. Creation of a shared vision of computational neuroscience at Rutgers NB.
2. Evaluating effective collaborative models at other universities.
3. Design and implementation of a model that leverages strengths at Rutgers NB.
4. Preparation of proposals for collaborative research that win external support.
5. Attracting new faculty to complement existing strengths and provide new leadership.
6. Engaging university support for modern research infrastructure.
7. Building national recognition of our unique approach to this area of research.

f) anticipated resources to support this initiative

The research climate and the ever more complex open research questions increasingly favor multidisciplinary groups that combine skills to solve larger questions. This is true both on the ground, due to increasing technical specialization, and in the eyes of funding agencies, who recognize that elucidating complex structure-function relationships may often be better done by teams rather than individual investigators working in silos. This is especially true of neuroscience, where the brain can be studied at so many interacting levels, from molecules to cell-cell interactions and circuits, and from circuits to cognitive representations, behavioral profiles and social variables. These types of collaborations, however, can only be successful with the support of seed grants that will provide funds needed to generate the preliminary data necessary to win competitive external grant opportunities. We therefore request funds for a conference during the first year (\$25K) and 2 seed grants / year (\$25K maximum award, \$50K/year) for two years to be given for computational cognitive neuroscience projects among Computer Science, RUCCS and Psychology faculty. These projects must be collaborative and are expected to show proof-of-concept for work that can attract external funding

Total Request:

2014 \$75,000.
2015 \$50,000.