

Humboldt/Princeton Strategic Partnership

Teaching and Research Collaboration Grant Application Form 2013

Title: **Uncovering principles of neural computation in the *Drosophila* auditory system**

Grant Category: One-year open grant (total support: 20,000 \$ = approx. 15,000 Euros)

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Project Summary:

We propose a novel interdisciplinary project between the research groups of Drs. Susanne Schreiber and Mala Murthy. Both aim to understand how the brain processes and encodes sensory information. Dr. Schreiber's group uses mathematical modeling to study principles of neural computation, and has recently focused on auditory coding and its temperature dependence in grasshoppers. Dr. Murthy's group studies the neural basis for acoustic communication in fruit flies (*Drosophila*), using a mix of behavioral, electrophysiological, molecular/genetic, and computational approaches. We propose to bridge our expertise to examine the processing of natural sounds in *Drosophila*, an organism that uses dynamic acoustic signals to communicate during its mating ritual. Studying how fly brains process their courtship songs will elucidate how neurons, more generally, extract salient information from noisy, dynamic stimuli in order to drive robust behavioral responses.

The specific questions we seek to address include: 1) How are neural codes optimized to process species-specific songs? The Murthy lab was the first to record from neurons of the *Drosophila* auditory pathway, and discovered that these neurons encode information with analog/graded codes, as opposed to using action potentials. Graded transmission, observed even in mammals, has certain advantages for encoding fast time-varying signals; however, its role in sensory processing has not been characterized in depth. We will address where graded transmission is used in the *Drosophila* auditory pathway and how/if this method of transmission is optimal for representing songs. 2) How does the temperature dependence of neurons that produce and process song impact song recognition? Flies are temperature sensitive, as is neural transmission. As such, male song parameters speed up at high temperatures and slow down at low temperatures. It is unresolved how the female nervous system adjusts her song processing to match the changing dynamics of male song. The question of temperature-robust neural computation is important to address because human brains are also subject to temperature variation (e.g., during vigorous exercise or fever/hypothermia), and the effects on sensory processing remain largely uncharacterized. For both aims, we will combine *in vivo* electrophysiology and mathematical modeling to resolve these outstanding issues.

Statement:

Benefits for Internationalization at Both Universities:

1) Acquisition of future external funding in a specific German-American program: The first aim of our proposal is to prepare a high-quality application for submission to the Collaborative

Research in Computational Neuroscience (CRCNS) grant program. This funding program is run jointly by the National Science Foundation/National Institutes of Health (NSF/NIH) and the German Federal Ministry of Education and Research (BMBF, here named "Foerderlinie Deutschland - USA Zusammenarbeit in Computational Neuroscience").

This funding line seeks to foster "Innovative Approaches to Science and Engineering Research on Brain Function" in a collaborative effort that brings together scientists with complementary experience and training, and deep understanding of multiple scholarly fields. According to the funding agencies, (1) proposals should include collaborations among computational and/or modeling experts, theorists, and experimental neuroscientists, (2) collaboration should involve a dynamic and possibly protracted period of development and refinement of models, theories, and/or analytical techniques, and intense interactions among scientists and engineers from different disciplines, and (3) the development and testing of new models or theories should provide a framework for the design of experiments and the generation of new hypotheses that can help reveal mechanisms and processes underlying normal or diseased states of the nervous system. We feel that we are ideally suited for this funding mechanism, as we combine expertise in theory and experiment and are focused on a set of interesting neurobiological questions. The typical way in which theorists and experimentalists have interacted in the past is for experimentalists to first complete their study, and for theorists to then take the results and generate models based on them. One problem with this arrangement is that it does not take full advantage of the collaboration – theorists should influence and shape the experiments, while experimentalists should validate models. We therefore are seeking initial funds from the Princeton-Humboldt grant to facilitate true collaborative interactions between the groups of Dr. Murthy and Dr. Schreiber. These interactions should lead to completely new ideas for the CRCNS grant proposal.

New calls for the NSF-BMBF CRNCS funding line are expected towards the end of this and next year. Total award sizes for US-German Research Projects (funded in parallel by US and German agencies) can be up to \$250,000 US dollars per year (corresponding to approximately 180.000 Euros per year) in direct costs, including the combined costs of all components of the collaborative project, inside and outside of the United States. The durations of these projects is three years. For further details see <http://www.nsf.gov/pubs/2011/nsf11505/nsf11505.htm> and <http://www.bmbf.de/foerderungen/19774.php>.

2) Contribution to internationalized training opportunities for PhD students at our universities: A second aim of our proposal in the partnership program is to contribute to the implementation of innovative educational and training opportunities between our universities. We hence propose to exchange a PhD student from each lab to spend a period of one to two months in the partner lab in order to acquaint him/herself with a complementary (modeling or experimental) technique. Students will benefit from this teaching experience. Moreover, the intensive interaction will help Dr. Murthy and Dr. Schreiber to shape the design of the grant proposal for the CRNCS program. The student exchange will also serve as a test bed to explore opportunities for a larger-scale exchange between the prestigious PhD programs in neuroscience at Princeton University and in computational neuroscience at the Bernstein Center in Berlin, in the years to come. Dr. Murthy and Dr. Schreiber are PIs in the respective programs and will use the partnership program to explore the exciting perspective of a formalized exchange between the programs. Further, international research experiences for students and early-career researchers are highly encouraged in all projects involving international collaborations for the CRCNS application. It would hence be beneficial for the application to demonstrate that we have already started to explore broadened training opportunities.

Additional Information:

The proposed collaboration is entirely new – Profs. Murthy and Schreiber have not collaborated together before, and this proposal also represents a new partnership between neuroscience at Humboldt University and Princeton University. The funding also effectively targets the mobility of students and PIs at both universities, as we have a plan for the professors and two PhD students (one at Humboldt and one at Princeton) to make visits to Germany or the US to further the collaboration. The proposal also has the longer-term goals of securing outside funding through the CRCNS program, and also creating interactions for neuroscience between the two universities. As each institution has a strong and burgeoning neuroscience program, this represents a unique opportunity. Of course, Prof. Murthy and Schreiber have additional funds to support research in each lab – we are only asking for funds for mobility/discussion between the two groups.

Summary:

Overall, funding of the proposed project in the Princeton University - Humboldt-University partnership program will (1) foster collaborative, interdisciplinary research in the neurosciences, (2) help to prepare an excellent proposal for the NSF/NIH-BMBF CRNCS solicitation, which seems to be tailored for Dr. Murthy's and Dr. Schreiber's expertise, (3) improve the educational experience of PhD students in both labs, (4) serve as a seed for a longer-term formalized exchange between the two PhD programs of Princeton University and Humboldt-University.