Massachusetts Institute of Technology

Department of Brain and Cognitive Sciences
Cambridge, Massachusetts 02139

December 5th, 2003

Biocomplexity Faculty Search Committee
c/o Prof. Rob de Ruyter van Steveninck
Biocomplexity Institute
Indiana University
Swain Hall West 117
Bloomington, IN 47405-7105

Dear Search Committee Chair,

I am writing in reference to the advertisement for a tenure-track assistant professor position in biocomplexity. I am currently employed as a post-doctoral fellow in the laboratory of Dr. Mriganka Sur in the Department of Brain & Cognitive Sciences at the Massachusetts Institute of Technology. The focus of my research is systems neuroscience, and in particular I am interested in cross-modal plasticity between the visual and auditory pathways. I apply neuroimaging, physiological and behavioral techniques to the study of plasticity in these sensory systems. I have enclosed my curriculum vitae, a statement of my research and teaching interests, two reprints and one pre-print. Thank you for your consideration and please let me know if there is any additional information that would assist you in assessing my application.

Sincerely,

Jessica Reeves Newton, Ph.D.

**Research Interests**

My research focuses on plasticity, the ability of the brain to adapt to changes in its environment, and in particular cross-modal plasticity. This line of research explores the physiological and behavioral changes that occur when a sensory system is deprived of its normal inputs. Such experiments can provide valuable insight into the relative contribution of input activity to sensory system development and plasticity as well as advance our general understanding of synaptic plasticity and the recovery of function after central nervous system damage.

During my graduate studies at Northeastern University, I explored adult cross-modal plasticity using electrophysiological and anatomical techniques to examine plasticity in rabbit visual cortex after monocular enucleation. Chronic extracellular in vivo recordings were made in visual, somatosensory, and the intervening association cortex in order to investigate cortical responses to tactile stimulation before and after eye removal. I demonstrated an increase in tactile responsive neurons in visual cortex after monocular enucleation. Retrograde fiber-tracing analysis showed that intracortical connections from the association cortex might underlie these novel responses. These results provide a physiological basis for the enhanced sense of touch in the blind, and imply that visual cortex can process any sensory information it receives, with this input being somewhat malleable throughout life.

I have also conducted human visual psychophysics experiments as an undergraduate studying age-related macular degeneration, and as a graduate student exploring peripheral color vision. My doctoral work focused on peripheral compared to foveal human color vision, and investigated the characteristics of peripheral color mechanisms that underlie detection and discrimination. These experiments characterized peripheral color mechanisms, examined their cone inputs and explored differences in sensitivity between red and green mechanisms in the periphery. This provided the best characterization of peripheral color mechanisms to date as well as evidence that peripheral red and green mechanisms have the same cone weights as in the fovea.

Following the completion of my Ph.D. in 2001, I began post-doctoral work with Dr. Mriganka Sur at MIT, and in September 2001 I was awarded a competitive individual post-doctoral National Research Service Award from the NIH. At MIT I study developmental cross-modal plasticity and learning using behavioral, physiological and neuroimaging techniques.

Specifically, I am examining the relative contribution of sensory inputs to the acquisition of fear conditioning behavior in mice with a "rewired" auditory system, which is induced to receive visual information. Input activity plays an important but ambiguous role within the visual system, however, the use of a "rewiring" procedure separates the role of input activity from the underlying structure of the visual system by inducing retinal axons to innervate a novel target, the auditory system. Visual axons can be induced to grow into auditory structures in hamsters, ferrets and mice through bilateral destruction of the inferior colliculus the day after birth. This conveys visual information through existing connections to primary auditory cortex (A1) and other related structures, providing a very different spatial and temporal pattern of activity to the auditory pathway.

Traditionally fear conditioning experiments pair an auditory cue (conditioned stimulus, CS) and a mild foot shock (unconditioned stimulus, US), and after as few as one tone-shock pairing learning occurs, with subsequent CS presentations in a novel context eliciting a conditioned fear response, such as freezing. In contrast a visual cue is less effective, requiring many more light-shock pairings to elicit freezing to the light presented alone. The aim of this project is to understand the role of sensory inputs versus the underlying pathway in this learning process, by examining whether visual inputs directed to the auditory thalamus instruct the behavioral function of the subsequent projections and structures responsible for conditioned fear responses. Thus, if the underlying pathway plays a vital role in eliciting conditioned fear responses, then any appropriate sensory stimulation of the auditory pathway should elicit the same rapid fear conditioning observed with an auditory cue. Alternately, if the activation generated by the normal auditory input is key in eliciting conditioned fear responses, then the normal slow rate of visually cued conditioned fear should be observed for both sham lesion and rewired mice. I demonstrated that visual cued conditioned fear responses are accelerated in rewired compared to sham lesion mice. This is accompanied by an increase in the expression of the immediate early gene c-fos, an indirect measure of neural activity, in the lateral amygdala of rewired mice. This suggests that retinal projections directed to the auditory thalamus accelerate visual cued fear conditioning and that this novel type of sensory input is capable of mediating behavior.

I am also conducting cross-modal plasticity experiments exploring the fundamental, but unresolved, issue of whether the serial visual processing streams observed in visual cortex arise because of intrinsic (genetic) specification of cortical areas or because of activity-dependent development of connections based on the statistics of visual input. I am using in vivo optical imaging of intrinsic signals and extracellular physiological recordings to examine the representation of direction of motion preference information in ferret visual cortex, as well as whether or not there is an elaboration of motion information in the rewired ferret auditory pathway. I am also conducting optical imaging experiments examining cortical feature maps in mouse visual and rewired auditory cortex.

In setting up my own laboratory, I plan to pursue research that will build upon this work. I will continue to use optical imaging, behavioral and physiological techniques to examine cross-modal plasticity and the influence of input activity on the development, function and organization of sensory pathways. I also intend to extend my work to include experiments using neuroimaging to examine plasticity and cross-modal plasticity in human subjects. In doing so I hope to reveal general rules that govern the specificity and plasticity of sensory pathways and networks. I feel that with a solid background in neuroscience, I am now at an ideal stage in my career to take on the challenge of setting up my own enthusiastic and industrious laboratory.

**Teaching Interests**

My primary objective in teaching students is to use experimental and theoretical approaches to introduce students to the concepts of psychology and neuroscience. I enjoy teaching, and have served as both a primary instructor and a teaching assistant. As a teaching assistant I lead discussion sections in introduction to psychology as well as psychobiology and sensation and perception laboratory courses. I acted as the instructor for a behavioral statistics course that served as an introduction to statistics and covered such topics as frequency distributions, measures of central tendency, z-scores and correlation. I found this experience very rewarding and received positive reviews from the students. I would be interested in and could readily contribute to the teaching of these courses as well as courses in experimental psychology and neuroscience. At the graduate level, I could teach courses in neuroscience and learning as well as provide training for students in neuroscience, using experimental approaches to examine cross-modal plasticity.