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From: Sidney Lehky [mailto:sidney@salk.edu]
Sent: Tuesday, December 30, 2003 2:22 AM
To: De Ruyter, Robert R.
Subject: Biocomplexity Faculty Position Application

Dear Dr. de Ruyter:

Attached are materials in support of an application for the faculty position in Biocomplexity recently advertised. My area of research is visual perception, including monkey neurophysiology, human psychophysics, and neural modeling.

Sincerely,
Sidney Lehky

Computational Neuroscience Lab
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Sidney R. Lehky

Research Statement

My areas of research are systems biology and biophysics, specifically cognitive and computational neuroscience oriented towards understanding problems of visual perception. This research has had three components. The first is neurophysiological recordings from the cortex of awake behaving monkeys, the second is psychophysical studies of visual processing in human subjects, and the third is modeling of visual information processing, including the use of neural networks.

Most recently, I have been doing some modeling of data related to information theoretic efficient coding in nonlinear units in striate visual cortex. Also, related to visual memory processing, I have identified neural correlates of visual memory in monkey perirhinal cortex, in which neural activity specifically appears in perirhinal cortex (but not in the immediately adjacent visual neocortex) when monkeys must remember photographs presented to them, but which does not appear when monkeys just view the photographs passively without remembering them.

In the future I would be interested in studying higher level visual phenomena such as object recognition (which involves both perception and memory). This would involve collecting data on far extrastriate visual neurons (such as "face neurons", for example) and trying to model their receptive field properties. At present, neurons at this level are characterized by randomly presenting dozens of photographs of real world objects until by chance finding something they respond to, and we need to develop a more systematic approach to characterizing them and a theoretical understanding why they have developed the particular selectivities that they have. Also, the role of massive feedback projections from higher level visual neurons to lower level neurons (which are sometimes greater than the feedforward) is entirely unknown, but presumably affecting their dynamics in some manner based on top-down expectations.

Human brain imaging (fMRI) can be useful with these problems by presenting a more global perspective on neural activity. For example, informal observations indicate that object recognition is disrupted under isoluminant color conditions, and brain imaging could identify what brain areas are being affected so that a more detailed examination can be undertaken using electrodes.

Concerning the types of models I would like to see in the long term, detailed biophysical modeling of individual neurons is probably too low a level for the issues I'm interested in. Information theoretic and other signal processing approaches have proven useful towards providing explanations of neural organization at the periphery of sensory systems, but my feeling is that they will be somewhat less useful at more central levels where cognitive issues become of greater concern. By cognitive I mean issues related to meaning or semantics that the signal has for the organism operating as an integrated sensorimotor system trying to survive in the environment. My recent thinking is that to develop our intuitions concerning high level visual processing we need to go with models of embodied cognition such as artificial life agents or robots, in which the parameters of a dynamical system (neural network) are evolved/learned through interactions with a reasonably complex environment. The biggest challenge is breaking out from producing an endless series of toy models in which small bits of a larger system are considered in isolation, and at present none of our theoretical methods really scale up very well to large inhomogeneous systems.

With regard to teaching, I'm inclined to emphasize the experimental literature, motivating it with presentation of theoretical ideas and models as appropriate. I'm thinking of a general "brain and cognition" course at the undergraduate level and then perhaps a more specialized course on issues in vision at a higher level. As a graduate student at the U. of Chicago, I developed undergraduate neuroscience laboratory exercises (recording from cockroach mechanoreceptors, and a comparative neuroanatomy exercise), and perhaps that is also something that could be developed at Indiana University, along with computer lab exercises dealing with more theoretical issues.

MACAQUE INFEROTEMPORAL VISUAL RESPONSES DURING MEMORY-INTENSIVE AND PASSIVE VIEWING TASKS S.R. Lehky and K. Tanaka, Lab. for Cognitive Brain Mapping, RIKEN Brain Science Institute, Wako, Japan

Responses of units in TEav (medial bank of AMTS) and the adjacent perirhinal cortex (lateral bank of rhinal sulcus) were compared under two tasks. In the memory-intensive task, the monkey responded to any repetition within a short series (2-5) of object visual stimuli. It was therefore required to keep all stimuli simultaneously in working memory until the response was made. In the passive viewing task, the monkey viewed the same stimuli but was not required to keep them in memory. To discourage the monkey from covertly performing the object-recognition memory task during passive viewing, a distractor task was used in which the monkey responded to a repetition in the color of a small dot briefly displayed during the 900 ms blank periods between object presentations. The colored dot was randomly located to discourage the monkey from maintaining a narrow focus of spatial attention. Each unit was initially tested with 110 stimuli while doing the object-recognition memory task. From that set, ten were selected for further study, whose responses spanned the range from best to worst. Using those ten stimuli, the two tasks were then performed in interleaved blocks. No task-related changes in visual stimulus selectivity were found in either perirhinal or TEav cortices. However, there was a task effect for response magnitude. Responses to the best stimulus decreased in perirhinal by an average of 23% for passive viewing relative to the memory task, but decreased only 5% in area TEav. This last observation reinforces recent lesion studies suggesting that TE is oriented towards purely perceptual processing, while an important function of perirhinal cortex is the incorporation of visual inputs into the formation of memories.