A PARALLEL PROCESSING HYPOTHESIS FOR SHORT-TERM AND LONG-TERM MEMORY IN APLYSIA

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The primary focus of this program of research is a mechanistic analysis of the relationship between short-term and long-term information processing in central neural circuits of the marine mollusks Aplysia. During the last year we have completed several projects in this program; these projects fall into two broad classes which focus on facilitatory and, more recently, inhibitory information processing. We have identified several forms of behaviorally relevant cellular and circuit modifications which involve both facilitatory and inhibitory information processing. Our goal for the current year is to analyze each of these processes mechanistically, and determine their interaction in both short-term and long-term storage of information in identified neural networks.

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The primary focus of this program of research is a mechanistic analysis of the relationship between short-term and long-term information processing in central neural circuits of the marine mollusc *Aplysia*. During the last year we have completed several projects in this program; these projects fall into two broad classes which focus on facilitatory and, more recently, inhibitory information processing. I will summarize each class of findings in turn.

**Facilitatory Processing**

*Aplysia* shows both short-term and long-term memory for several forms of facilitatory learning, such as sensitization and classical conditioning. It is commonly thought that memories for most kinds of learning must be stored in short-term form before they are transferred or transformed into a long-term form. However, we have recently shown at identified excitatory synapses that are known to contribute into both short-term and long-term memory in *Aplysia* that the long-term process can be expressed in the complete absence of the short-term process (Emptage and Carew, 1993). We have also shown that the expression of the long-term process occurs throughout the neuron, even at synapses that have not been exposed to the modulatory transmitter (serotonin) which induces the long-term process (Emptage and Carew, 1993). Finally, we have recently found that the short-term process, also induced by serotonin, reaches its peak immediately (within 5 minutes) and decays away within 3 hours, whereas at the same synapse, the long-term process does not begin to be expressed for at least 6 hours, reflecting the time required for gene activation (translation and transcription) and for transport of gene products from the cell body to the synaptic terminal (Parker, Emptage and Carew, in preparation). We are currently determining the critical intracellular signals that initiate the short-term and long-term processes.
Inhibitory Processing

In parallel to the above studies, we have also examined inhibitory information processing in an identified interneuronal network mediating a behavioral reflex in *Aplysia*. We have discovered a form of short-term inhibitory processing that uses activity-dependent potentiation of recurrent inhibition as a mechanism of dynamic gain control in this reflex (Fischer and Carew, 1993) and have generated a computational model that captures important features of network processing (Blazis, Fischer and Carew, 1993). We have also identified a naturally occurring stimulus (the reflex release of ink from neighboring *Aplysia*) that triggers the short-term inhibitory process. Finally, quite recently we have found that the inhibitory modulation described above can be suppressed by a long-term process that is triggered by the same stimulus (tail shock) that produces long-term facilitation described in the previous section. This stimulus alters a specific form of inhibitory synaptic plasticity, apparently for several days or even longer (Fischer and Carew 1993, in preparation; and Blazis, Fischer and Carew, 1994). We are currently examining the cellular and molecular mechanisms of both the short-term and long-term forms of circuit modification.

In conclusion, we have identified several forms of behaviorally relevant cellular and circuit modifications which involve both facilitatory and inhibitory information processing. Our goal for the current year is to analyze each of these processes mechanistically, and determine their interaction in both short-term and long-term storage of information in identified neural networks.
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A. Publications in Reviewed Journals


A. Publications in Reviewed Journals (Cont.)


B. Book Chapters/Reviews Published


C. Graduate Students

Kent Fitzgerald, Ph.D. (Psychology/expected 1994)
Laura Stark, Ph.D. (Neuroscience, expected 1995)
Gretchen Parker, Ph.D. (Psychology, expected 1996)
Steven Fisher, Ph.D. (Psychology, expected 1996)

D. Post-Doctorates

Thomas Fischer, Ph.D., Psychology, US
Diana Blazis, Ph.D., Psychology, US
Julianna Maleshagen, Ph.D., Biology, GER
E. Awards

Elected Section Editor: Behavioral Neuroscience
Journal of Neuroscience.
This technical report has been reviewed and is approved for public release JAN AFR 190-12 – distribution in unlimited.

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