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13. ABSTRACT (Maximum 200 words)

Our primary objective is to carry out a cellular and computational analysis of operant conditioning of the head waving response in *Aplysia*. During the last twelve month period, progress has been made in four areas: (1) We have now identified the critical muscle groups and motor neurons responsible for generating the operant response (head waving); (2) We have now identified the interganglionic connections in the CNS that are necessary for coordinating headwaving movements in *Aplysia*; (3) We have found that the endogenous firing rate of headwaving motor neurons can be operantly conditioned in a preparation consisting only of the isolated CNS attached to the oral veil (reinforcement pathway); and (4) We have developed techniques for a network model of information processing in the CNS of *Aplysia*.

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ANNUAL TECHNICAL REPORT
Thomas J. Carew
AFOSR-89-0362

A. OBJECTIVES

The overall research project has three primary objectives:

1. **The first objective is to carry out a detailed circuit analysis of the neural networks underlying operant conditioning in Aplysia.**

To perform a complete circuit analysis of operant conditioning we are specifying: a) the <u>operant response circuitry;</u> b) <u>feedback circuitry;</u> and c) <u>reinforcement circuitry</u> involved in the learning.

2. **The second objective is to analyze the expression of operant conditioning in identified neural circuits.**

Three experimental strategies are being used: a) We are examining <u>neural correlates</u> of the conditioning in previously trained animals; b) we are producing the operant conditioning *in vitro* while recording from relevant circuit elements; and c) we are examining <u>neural analogues</u> of the conditioning by direct activation of relevant circuitry.

3. **The third objective is to generate a quantitative computational model of operant conditioning.**

An essential feature of the computational model we plan to generate is that it will use empirically derived biophysical parameters, synaptic weights and circuit properties in its construction. The modelling analysis will be carried out at three levels: a) individual circuit elements; b) restricted neural networks; and c) simulations of adaptive changes within elements and networks.

B. STATUS OF THE RESEARCH EFFORT

In the second year of this award we have made significant progress towards achieving the first two research objectives described above. We are currently beginning our modeling efforts, which is the third objective. In the second year of this award, important progress has been made in four areas, which I will discuss below.

1. We have identified the critical muscle groups responsible for generating the operant response (head waving).

These studies now allow us to identify the unique contribution of individual motor neurons to the operant response. This information is critical for developing a quantitative model of operant conditioning (objective #3).

2. We have identified the interganglionic connections in the CNS that are necessary for coordinating head waving movements in <u>Aplysia</u>.

These studies now pave the way for a detailed examination of the cellular mechanisms that are utilized to generate and coordinate the response that we operantly condition in *Aplysia*.

3. We have found that the endogenous firing rate of neurons can be operantly conditioned in a reduced preparation, consisting only of the CNS connected to the oral veil.

These studies now allow us to unequivocally study the actions of the reinforcement pathway (the oral veil and its afferent nerves C1-C3) within the neural circuit for headwaving.

4. We have developed techniques for developing a network model of information processing in the CNS of <u>Aplysia</u>.

Using the network simulator GENESIS, we have begun to compute a biologically realistic network model of a simple reflex circuit which mediates the siphon withdrawal reflex. The algorithms and network rules used in this network model can now be incorporated into our modelling efforts in the neural circuit for operant conditioning of headwaving in *Aplysia*.

C. Publications

1. Baxter, D.A., Buonomano D.V., Raymond, J.L., Cook, D.G., Kuenzi, F.M., Carew, T.J and Byrne, J.H. (1991) Empirically derived adaptive elements and networks simulate associative learning; In *Quantitative Analysis of Behavior Volume XII: Neural Network Models of Conditioning and Action*. Hillsdale: Lawrence Erlbaum & Assoc (in press).

2. Cook, D.G., Stopfer, M. and Carew, T.J. (1991) Identification of the neural pathway mediating reinforcement in operant conditioning of head-waving in *Aplysia*. *Behavioral and Neural Biology*. <u>55</u>:313-337

3. Kuenzi, F.M. and Carew, T.J. (1991) Identification of the neural pathway mediating phototactic modulation of head-waving in *Aplysia*. *Behavioral and Neural Biology*. <u>55</u>: 338-355.

D. PERSONNEL

1. Frederick Kuenzi, graduate student (Ph.D. expected Fall, 1991).
2. Kent Fitzgerald, graduate student (third year)
3. Diana Blazis, Ph.D., post doctoral fellow.

E. INTERACTIONS

Papers at scientific meetings

1. Kuenzi, F.M., and Carew, T.J., 1990. Interganglionic connections necessary for coordinating head waving movements in *Aplysia californica*. *American Society of Zoologists Abstract*, <u>30,</u> *49A*.
2. Blazis, D.E., Berkowitz, D.A., Kairiss, E.W. and Carew, T.J. (1991). A network model of inhibitory information processing in the siphon withdrawal reflex of *Aplysia*. *Soc. Neurosci. Abstract*. (in press).

Invited colloquia and plenary presentations

1. Royal Society, London (Winter 1990)
2. University of Southern California Medical School (Spring 1990)
3. Florida State University (Winter 1991)
4. University of California, Davis (Spring 1991)
5. Gordon Research Conference (Summer 1991)
6. Invited lecturer in Workshop on Learning and Memory, Berlin (Fall 1991)

F. DISCOVERIES, INVENTIONS, PATENTS

not applicable