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March 11, 1993

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Beatrice Morales
Grants Officer
ASC:241-1
National Aeronautics and Space Administration
Ames Research Center
Moffet Field, CA 94035

RE: NASA-Ames Agreement No. NCC 2-495

Dear Ms. Morales:

Enclosed is the original and five copies of the Final Technical Report for the above referenced Agreement. The Final Disclosure of Inventions Report has been mailed under separate cover to the University Affairs Office. The Federal Cash Transaction Report will be submitted to the Financial Management Division as soon as our Director of Finance and Accounting, Mr. Greg Forsythe, receives Form 272.

If you need further information, please contact me at (412) 647-8048.

Thank you.

Sincerely,

Dennis W. Dalton

Dennis W. Dalton
Director of Grants Administration

Neural Processing of Gravity Information

Final Technical Report, covering the period
November 1, 1987 through June 30, 1992

NCC 2-495

Robert H. Schor

The Eye & Ear Institute
203 Lothrop Street
Pittsburgh, PA 15213

The goal of this project was to use the linear acceleration capabilities of the NASA Vestibular Research Facility at Ames Research Center to directly examine encoding of linear accelerations in the vestibular system of the cat. Most previous studies, including my own, have utilized tilt stimuli, which at very low frequencies (e.g. "static tilt") can be considered a reasonably pure linear acceleration (e.g. "down"); however, higher frequencies of tilt, necessary for understanding the dynamic processing of linear acceleration information, necessarily involves rotations which can stimulate the semicircular canals. The VRF, particularly the Long Linear Sled, has promise to provide controlled pure linear accelerations at a variety of stimulus frequencies, with no confounding angular motion.

This Cooperative Agreement provided three years of support (which were extended to additional years without further expenditure of funds). Several parallel developments were carried out by myself and the VRF staff during this period. They include the following:

1) Design and construction of an animal restraint system suitable for single unit recording studies in the cat. This unit is designed to mount on either linear sled, preferably on a manual positioner which would allow the realignment of the unit about a vertical (yaw) axis, so as to allow multiple orientations (with respect to the animal) of the single horizontal drive axis of the table. The system incorporates a modified stereotaxic frame, allowing for stable and reproducible head orientations of experimental animals. The unit also incorporates a one-degree-of-freedom roll rotation axis, allowing the (fixed earth-horizontal) drive axis to be moved out of the animal's horizontal plane.

2) Creation of software for driving the Short Linear Sled and simultaneously collecting multiple analog data channels (typically accelerometer tracings) and neural spike occurances. This software was a custom modification of a package I had developed for my other studies, allowing me to take advantage of substantial analysis and display software which had already been developed and tested.

3) Integration of the software into the PDP-11 computer system at the VRF. I accomplished this satisfactorily, temporarily installing necessary system software on disks dedicated to my use. Some modifications of my software was required to take into account some different lab interface hardware present on the VRF computer.

4) Construction of miscellaneous support equipment necessary for these experiments. We developed the following capabilities at the Short Sled site: (a) on-line monitoring of animal blood pressure, with audible alarms to alert us if the pressure deviated from physiological norms; (b) on-line measurement of animal temperature; (c) low-noise recording amplifiers suitable for measuring single neuron extracellular potentials; (d) identifying and eliminating extraneous noise sources in the table and drive system; (e) developing a method for passing small currents through the recording electrode for purposes of cleaning the electrode or providing a dye spot at the electrode tip.

5) Developing an approved Animal Care and Use protocol for these studies.

6) Interaction with the Animal Care Facility staff at ARC to have them observe and understand the type of surgery and animal preparation called for in these studies. Acute cat studies appear not to be a common occurance at Ames.

7) Demonstrating the feasibility of performing single unit recordings on the Short Linear Sled by performing three pilot experiments.

8) Interaction with other investigators using the VRF Short Linear Sled. In particular, I have provided significant consultation to a single unit study performed by Chris Somps and David Tomko, "Vestibular Afferent Responses to Linear Oscillations in Alert Squirrel Monkeys".

9) I participated in the symposium Sensing and Controlling Motion, sponsored by NASA and the New York Academy of Sciences. I presented (and co-authored) a paper on "The Algebra of Neural Response Vectors" at this symposium, and co-authored a second presented paper.

To successfully accomplish the goals I originally outlined in the 1987 grant application, I required the ability to provide a variety of frequencies of stimulation while recording from a single neuron. These capabilities were planned for the Long Linear Sled; to date, a suitable drive system for this apparatus has not been constructed.

Published bibliography:

Schor RH, Angelaki DE. The algebra of neural response vectors. In: Sensing and Controlling Motion, Cohen, Tomko and Guedry (Eds), Ann NY Acad Sci 656: 190-204, 1992.

Wilson VJ, Bolton PS, Goto T, Schor RH, Yamagata Y, Yates BJ. Spatial transformation in the vertical vestibulocollic reflex. In: Sensing and Controlling Motion, Cohen, Tomko and Guedry (Eds), Ann NY Acad Sci 656: 500-506, 1992.