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MATHEMATICAL ANALYSIS AND DESCRIPTION OF CONTINUOUS HUMAN BEHAVIOR

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13. ABSTRACT

To record and analyze sequential (i.e. continuous) motor behavior in the human during performance of a task, a method is being devised whereby the relations of body units during spontaneous activity are measured using the angular displacement of each unit with respect to a reference body unit as a function of time. For any given sequence of behavior, the angular displacements are being reduced to linear differential equations. In addition, the sequences of behavior are being related to important physiological substrates such as brain function, cardiac output, muscle tension, respiration rate and volume, body temperature and the like.

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Computer analysis of movement						
Sequential analysis of performance						
Brain mechanisms in motor behavior						

General

This report covers work on this contract from 1 November 1970 through 31 October 1971.

1. Personnel

The following persons have been employed on this contract in the positions indicated.

A. Professional:

Dr. Lawrence R. Pinneo, Principal Investigator and Manager, Neurophysiology Program
Mrs. Patricia Johnson, Biologist
Mr. Edward Davis, Biologist

B. Technical and Administrative:

Mrs. Margaret Lerom, Secretary

C. Consultations:

Dr. Daniel Robinson, Associate Professor of Psychology, Amherst College, Amherst, Massachusetts, for two days (April 1 and 2, 1971), on filming and recording techniques of human behavior.

2. Major Trips and Presentations

A. December 1-3, 1970. L. R. Pinneo to the University of Southern California, Los Angeles, to consult with Dr. Gary Galbraith on computer techniques.

B. February 21-24, 1971. L. R. Pinneo to Amherst College and University of Massachusetts, Amherst, Massachusetts, to consult with Drs. Daniel Robinson, Michael Arbib, and Stanley Plagenhoef on filming techniques, computer soft-ware, and measurements of human movement.

C. March 21-24, 1971. L. R. Pinneo to University of Southern California, Los Angeles, to consult with Dr. Gary Galbraith on computer techniques, and to the San Diego Zoo to consult with Dr. Robert Cooper on chimpanzee enclosures for photography.

D. April 21-24, 1971. L. R. Pinneo to San Francisco to attend symposium and present paper on chimpanzee behavior (this project) at Western Psychological Association Convention.

E. October 16-22, 1971. L. R. Pinneo to Hollins College, Richmond, Virginia, to attend Conference on Psychophysiology of Behavior, and to Yerkes Primate Research Center, Emory University, Atlanta, Georgia, to inspect chimp compounds.

3. Publications

No publications from work on this contract during this period.

Summary of Scientific Results

The purpose of this project is to develop a precise method of expressing the behavior of humans with respect to themselves and their environment, and to relate this behavior to underlying physiological processes. The aim is to provide a technique for the analysis and description of body and limb movements of the freely moving person in real-time during performance of a specific task, and to relate the continuous behavior to important physiological substrates such as brain function, cardiac output, muscle tension, respiration rate and volume, body temperature and the like.

Observations of both humans and animals are important. Animals are required for three reasons: first, hours of observations of a wide variety of movements may be made at a relatively low cost compared with the cost of using humans; second, physiological measures may be taken initially from animals with much greater ease than from humans; and third, certain controlled movements and physiological changes may be elicited from animals by direct stimulation of the brain (using techniques developed previously in this laboratory) that would be difficult or impossible under controlled conditions with humans, but which could occur spontaneously in humans on a random basis. All animal recordings are made from primates (primarily rhesus monkeys and chimpanzees) whose behavior and physiological activity closely resemble those of humans. When each appropriate measure has been worked out with the animals, observations will be made on humans.

The specific tasks carried out during this period were:

1. Determination of Measures of Real-Time Behavior

To record continuous motor behavior, a method is being devised whereby the relations of body units during spontaneous activity are measured using the angular displacement of each unit with respect to a reference body unit as a function of time. For any given sequence of behavior, the angular displacements will be reduced to linear differential equations.

During a literature survey, it was found that Dr. Stanley Plagenhoef of the Department of Physical Education, University of Massachusetts, was carrying out similar research on analysis of movements occurring during physical exercise and sports. A visit was made to Dr. Plagenhoef's laboratory to discuss his techniques and observe his filming methods. Of great importance was the fact that he had worked out several possible systems and was currently analyzing one system on a computer. Though some of his measurements were not applicable to our situation, nevertheless many of his techniques may be useful. His procedures, mathematics,

and computer programs are now being analyzed for possible use in modified form in this project.

During the visit to Amherst, possible computer strategies for pattern recognition of body movements were discussed with Dr. Michael Arbib, Chairman of the Department of Computer Sciences. In addition, Dr. Daniel Robinson of Amherst College suggested new methods we had not yet tried on filming three-dimensional behavior for a two-dimensional analysis.

2. Observations of Chimpanzee Behavior

To obtain measurable real-time behavior, the movements of three juvenile chimpanzees, freely moving in a large compound, were observed and recorded on a closed circuit television and video recorder. Twenty hours of observations were made, each hour consisting of three 20-minute segments of continuous behavior. Each video record is now being rerun to divide the behavior into subsets that would be relatively easy to analyze. Stick figures of representative movements are now being drawn on overlays of stills from the video monitor; angles of limbs with respect to the body are measured with a protractor. Allowance will be made for foreshortening according to suggestions made during consultation at SRI with Dr. Robinson of Amherst College.

During filming and later analysis of the chimps' behavior, it was discovered that much greater film coverage could be obtained if a temporary three-way enclosure could be constructed as part of their compound. Accordingly, permission was obtained to make this modification, amounting to about $3000, with contract funds. To obtain advice on construction of this enclosure, a visit was made to the San Diego Zoo and the Yerkes Primate Research Center, Emory University, both of whom have fairly large chimpanzee colonies. This enclosure has been installed and is functioning satisfactorily.

3. Computer Soft-Ware Development

Two computer soft-ware problems are currently being worked on. The first is to reduce the angular displacement of body and limbs to linear differential equations, which can then be used by our Linc-8 computer to redraw the stick figures on a cathode-ray oscilloscope in real or modified time for analysis of specific sequences. We are now attempting to convert Dr. Plagenhoef's computer programs for use on our computer, and to reduce his equations to a form more suitable to our needs.

The second problem is to devise soft-ware that will analyze forms from the video recorder output in terms of stick figures, and then to specify the angular displacements of the stick figures for later reduction to equation form. Dr. Gary Galbraith of the University of Southern California was consulted about this pattern-recognition problem, since he has already devised statistical methods for computer analysis of

simultaneously occurring electrical signals in pattern-recognition problems similar to ours. From these discussions, it appears that a larger computer may have to be utilized for initial analysis, or hardware that will allow the Linc-8 to perform these tasks will have to be designed and constructed.

4. Brain Function in Motor Behavior

Our initial effort to relate brain function to continuous motor behavior involves reproducing the movements observed in the compound studies by direct electrical stimulation of the brain. Techniques already developed in this laboratory for programmed stimulation of motor sites in the brain stem of rhesus monkeys, using the Linc-8 computer, are employed. Toward this end, we are preparing a brain-stimulation Atlas for production of sequential motor acts to use as a guide.

Plans for Future

Since this project will terminate October 31, 1972, plans for the remaining year are being limited to (a) completion of the analysis of motor movements in the three chimpanzees during specific sequences of behavior; (b) preparation of a report on the analysis of motor behavior of the chimps; and (c) completion of the brain atlas of the rhesus monkey, depicting those brain sites involved in the motor sequences of behaviors, similar to those analyzed for the chimps.