Title: NASA Grant No. NsG 189-61.

"Behavioral Research and Experimental Analysis of Complex Behavioral Repertoires Under Full Environmental Control".

Responsible Investigators:

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SEMI-ANNUAL STATUS REPORT

NASA GRANT NO. NsG 189-61

October 1, 1961 - March 31, 1962

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Background and Research Objectives

In view of the critical behavioral factors encountered in the present and continuing exploration of space, current grant funds are being used for the development of a behavioral research program aimed first at extending the basic experimental analysis of behavior, and, secondly, at amplifying the many technological advances which hold particular relevance for the proper functioning of man and primates in outer space.

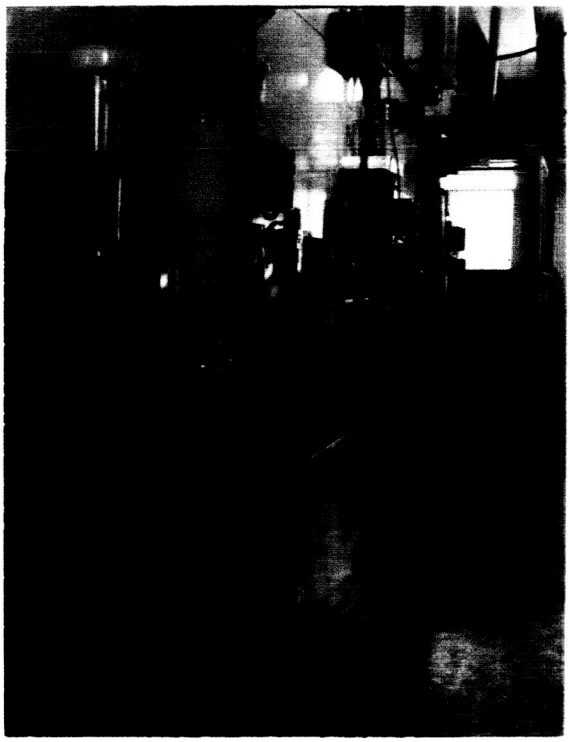
More specifically, the initial phases of this program are concerned with problems 1) in the establishment and maintenance of complex repertoires under conditions of full environmental control, 2) in the refinement of behavioral techniques for the assessment of sensory and motor processes; 3) in problems surrounding the maintenance of sustained performance under conditions of long term isolation and confinement, and finally, 4) in the preliminary extension of such experimental analysis to man.

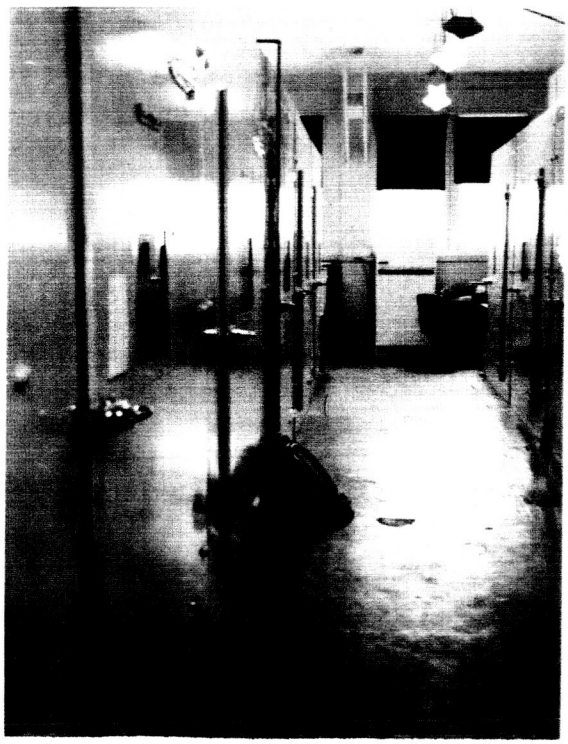
Establishment of the Space Research Laboratory

Facilities

During the initial six months of the present grant, a unique research facility has been designed, constructed, staffed, and placed in operation. This usually prolonged task has been accomplished rapidly by the design and procurement of large walk-in refrigeration units which serve as experimental chambers for chimp, man, and other organisms in the research program. In addition to the experimental chambers, an instrumentation shop and animal maintenance facilities have been established. Typically the research program calls for a chimp or other organism to be housed continuously in an appropriate chamber where various experimental programs are established automatically by means of special electrical or electronic programming equipment. The shop facilities and personnel have been used in both the modification of the chambers for experimental use, and in the construction of the associated programming equipment.

The largest part of the initial funds (see expenditure breakdown below) have been spent in the development of these typical experimental units. Approximately 10 units are now in operation or nearing completion. Research activities are housed within approximately 8,000 square feet of space in the Space Research Laboratory of the University of Maryland. In addition to the research units, administrative, clerical, and training facilities are also available within the same building. Several photographs of the research chambers and associated equipment are presented on the following page.





Personnel

The personnel of the Space Research Laboratory has been selected specifically for the program of research to be conducted and consists principally of key investigators and support personnel. Members of the professional staff are listed below.

Responsible Investigators:	Joseph V. Brady, Ph.D. Jack D. Findley, Ph.D.
Research Associates:	Stanley S. Pliskoff, Ph.D. Norman W. Weissman, M.A. Roger Frey, M. A. Wendell H. Niemann, D.V.M. (Veterinarian) Marshall G. Powell, E. E. (Instrumentation)

In addition to the key personnel approximately 25 other individuals are currently employed as part of the research teams, instrumentation shop, and in the clerical and data analysis activities. One important aspect of the Laboratory activities related to personnel has been the training of approximately five University graduate students and approximately six undergraduates. These students are making a substantial contribution to the research program and to its continued growth. Consultants to the Laboratory have been: Dr. Charles Ferster, Indiana University; Dr. Hershel Liebowitz, IBM; Dr. Murray Sidman, Harvard University; and Dr. William Marcus, M.D.

Expenditures

An approximate breakdown of expended funds during the first six months of operation is presented below. In respect to the original budget, the figures for personnel are low due to the necessary phasing in of personnel. Similarly, expenditures for travel are low due to the restrictive demands of establishing an on-going laboratory. Expenditures for consumable supplies, however, have been considerably greater than originally anticipated. Within this category of consumable supplies are included food, bedding, and the usual laboratory supplies, but as well are included

component parts such as relays, wire and other electronic and mechanical materials needed for the continuing construction of prototype apparatus. Expenditures within this category are now anticipated to remain considerably above the estimates contained in the original budget request. One final item needing explanation is the expenditures for animal subjects. Original funds requested for subjects were deleted in view of the anticipated receipt of chimpanzees from NASA sources. Due to delays in that arrangement it has been necessary to procure chimps directly. A more specific breakdown of all expenditures is available from the University accounting office.

Summary of Research Progress

The research activities of the Space Laboratory are organized within the framework of several general problem areas. The overall character of this research is "basic research". However, the specific nature of the some thirty experiments that are underway are slanted toward problems intimately related to behavioral problems likely to be encountered in future space exploration - be it with animals or man. The support for such an argument of relevance lies not only in the past accomplishments with chimps and other animals in space, but more fundamentally, with the similarity of the restricted environment within which either organisms in outer space or experimental subjects within our laboratory must live and perform satisfactorily. On the basis of this fortuitous similarity of requirements, the transition from basic research activities to applications with future space flight behavioral problems may be considerably more rapid than ordinarily expected.

For reasons of brevity, the thirty experiments currently underway are not described in detail, rather an attempt has been made to outline the general problem areas of investigation giving in several instances examples of specific experiments.

Problem Area (I) Basic Research on the Integration of Complex Behavioral Repertoires as they Relate to Space Flight Problems.

In this problem area research is directed at fundamental processes governing the organization of complexes of behavior. Thus the emphasis is not simply analysis of variables controlling performance on specific tasks, but more an investigation of how to interrelate and combine many different performances in the most efficient and optimal manner. One example of a study in this area is an experiment with baboons. They are required to complete 5 separate work tasks in a serial sequence before earning a reward. Since the work requirements in each task are independently manipulatable, the analysis now underway is expected not only to yield basic information about work distribution, but as well to further our understanding of the characteristics of serial sequences of behavior. Such experiments combined with other work in progress are already leading to general formulations with applicability to the rational

organization or planning of man's activities under controlled environment.

Problem Area (2) Development of Better Procedures for Maintaining Large and Continuously Effective Behavioral Outputs.

Since problems in the organization of behavior presuppose that individual task performance can be maintained and well controlled, the ongoing experiments in this problem area are directed at the exploration of basic techniques for sustaining good performance over long periods of time and under even adverse conditions. An example of this type of problem is found in an experiment in which a chimp monitors a visual display on a 24 hour basis making reset responses when appropriate. By means of these responses the display is kept in effect and food becomes available at various times. The long periods of monitoring behavior are maintained in part by the food needs of the chimp, but as well by the avoidance of an additional work task which results from improper performance. Results to date suggest that the chimp has adopted a sleeping pattern of short "naps" properly spaced to keep the display in effect continuously for several days.

Another procedure under investigation is one in which a chimp emits an avoidance response to ward off an electric shock. The chimp has the option, however, at any time of making another response the consequences of which sometimes results in an electric shock, and sometimes in a "time-out" period during which the avoidance condition is removed. By arranging the parameters of the avoidance condition such that substantial vigilance is required, and by proper arrangement of the probabilities governing the occurrence of shock versus "time out", it is thereby possible to produce a conflict between the alternative behaviors. Since continued selection of the avoidance behavior will result in progressive fatigue and sleep deprivation, an oscillating relation is thereby established between those variables and the selection of the alternative to the avoidance condition. The refinement of the techniques in this area not only promise valuable tools for maintaining large and continuous outputs of behavior, but they as well serve as sensitive baselines for the assessment of numerous subtle variables controlling long term performance.

Problem Area (3) Development of Repertoire Components Relevant to Space Flight Problems Involving Timing, Counting, Information Processing, and Decision Making.

Another fundamental problem in the behavior of Man, be it on the ground or in outer space is in the establishment and maintenance of very complex tasks which demand fine discriminations and which draw greatly upon higher mental processes. Thus it is not sufficient that we know how to efficiently organize many different behaviors, nor is it sufficient that we know how to maintain behaviors which in themselves are mundane or laborious for long periods of time, but as well we must increase our ability to deal with the behaviors associated with higher mental processes. Our laboratory work with chimps and higher primates affords a unique opportunity to approach these problems on a basic level. For example, in one current experiment two chimps are successfully performing a complicated task combining timing and counting performances which few humans could master without comparable training. Results to date suggest the timing performance to be more easily disrupted than the counting performance when variables such as amount of work and duration of both tasks are varied. In another experiment a baboon is being taught concepts of numerosity and will eventually be taught simple mathematical operations. The importance of this type of work is that, unlike with humans, the development of such complex behaviors may be examined and studied in detail at each step without the complication of past history and experience.

Problem Area (4) Refinement of Techniques for Controlling and Assessing Changes in Sensory and Motor Functioning.

In this area of research, experiments are directed at refinement of basic techniques which will allow fine grain assessment of changes in sensory and motor functioning perhaps induced by radiation, prolonged weightlessness, etc., and in improving the performance factors which suggest themselves as means for counterbalancing deliterious effects. Specific animal experiments are being conducted with variables such as extremes in temperatures, concurrent punishment, and other stress conditions. Other experiments are being initiated with humans measuring visual

thresholds, and changes in autokinetic phenomenon as a function of isolation, suggestion, and stress. Other basic experiments in this area are concerned with the discriminative capacity of organisms for stimulus conditions generally unexplored. For example, one experiment currently underway is designed to test for the discriminative capacity of birds to detect magnetic lines of force. Such experiments as the latter are now feasible as a result of the continued refinement and sensitivity of the behavioral techniques employed.

Problem Area (5) Design of Long Term Behavioral Environments for Overcoming Problems of Reliability, Isolation, and Confinement.

Research activities outlined in the previous problem areas all hold relevance for the design and testing of special environments in which the greater part of an organism's activities are all brought under experimental control. The nature of such an environment is termed a "behavioral environment" in that it is the total patterning and structure of the individual activities that most critically determine the resulting stability or non-stability of the organism-environmental system.

To be more explicit, previous research in our laboratory has included experiments in which primates lived for periods exceeding 2 years within a fully controlled and automatically programmed behavioral environment. Building upon biological necessities obtained via the experimental program, large complexes of behavioral tasks were established and analyzed. Currently, our research activities in this area are aimed on the one hand at extensions of such work to designing and testing various "behavioral environments" for man. Already under construction is a relatively simple chamber to test a carefully designed program for the support of one man for an indefinite period. Other work in this problem area is directed at an attack upon the more difficult problem of the proper design of a behavioral program for two or more organisms. In one case a special environment has been developed in which two dogs are housed continuously. The nature of this environment is characterized by several enclosures, one way electrically-locked doors, and by the subtle experimental requirements established between the behavior of each dog and the obtaining of biological and social rewards. One special feature of the situation is that the control of the

social behavior is indirectly maintained by its consequence for the behavioral program of each dog. This is possible in the present situation in that a separate behavioral and physical environment is maintained for each individual dog when not in the social environment. Since continuous experimental control is maintained over both the social and non-social behaviors, the technique is viewed as a powerful tool for the analysis and programming of multi-organism interactions in a circumscribed environment.

It is already abundantly clear that the long term stability of an organism, be it monkey, dog, chimp, or man, does not depend solely upon the characteristics which the organism may possess upon entrance into a new and circumscribed environment. Much more important is the nature of that environment and the demands it places upon the organism. Given the general restrictions and anticipated demands of living in outer space, man's success there becomes, in part, a technical problem of programming and designing the proper interactions. The basic research laboratory where such organism-environment relations may be clearly manipulated affords real promise for such a needed technology.

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