A Model for Behavioral Research with Mice in Biosatellites

MAJOR FREDERICK H. ROHLES, JR., USAF (MSC) and
CAPTAIN MARVIN E. GRUNZKE, USAF

THE ADVANTAGES of including psychological measures with standard physiological determinations on infra-human organisms participating in orbital flight have been well established.[3] By supplementing one another, the two measures present a complete appraisal of the organism.

While this postulate is true, regardless of the phylogenetic level of the organism participating in the flight, the extent to which behavioral measures can be made on mice is usually considered to be extremely limited. In fact, the knowledge of physiology of the mouse is considerably in advance of the understanding of its behavior. Yet, with the increased use of the mouse in flights beyond our atmosphere coupled with the need for measuring both the physiological and psychological effects of these flights, it became paramount that behavioral processes of this organism be studied. Thus, the purpose of this study was to develop a model for the type of behavioral research that could be done with mice in biosatellites.

PROCEDURE

The subject in this study was a male C-57 BL mouse (Roscoe B. Jackson Laboratories strain), 160 days old, weighing 25 grams at the beginning of the experiment.

A standard operant conditioning chamber was used. The force required to operate the lever, and the height of the lever and food chute were the same as described by Anliker and Mayer.[1] Programming and recording were handled with automatic operant conditioning equipment.

Before the actual training was started, food deprivation procedures were employed until the subject was at 80 per cent of its normal body weight. When the subject reached this weight, magazine training was begun. This consisted of placing the subject in the operant chamber for 30 minutes for five consecutive days and aperiodically feeding it commercial rat food pellets (.047 gram) by means of an automatic pellet dispenser.* The subject was 14 hours hungry during this training. During these periods the interior of the chamber was illuminated with a 6-watt lamp, and an electronic clicker was sounded which presented background clicks at the rate of 180 clicks per minute. During this five-day period, the lever was removed from the chamber. Water was allowed *ad libitum* throughout the course of the experiment.

On the sixth day, the lever was incorporated into the chamber and the subject was rewarded with one food pellet for every lever press. When the subject began to respond to this schedule the ratio of lever presses to rewards was increased gradually until, after approximately four weeks with 30-minute training sessions daily, the subject exhibited consistent and reliable behavior on an FR100 reinforcement schedule (fixed ratio of 100 lever presses for one pellet of food).[2]

Subsequent to the training on the ratio schedule, discrimination training was initiated. Here the animal was trained to differentiate between work periods (time during which responses were rewarded) and rest periods (time when no responses were rewarded). To accomplish this the subject was placed in the darkened chamber for 10 minutes; during this time none of the lever

From the Aeromedical Field Laboratory, Holloman Air Force Base, New Mexico.

*This pellet is the product of P. J. Noyes and Co., Lancaster, N. H., and is designed for use in a pellet dispenser manufactured by Davis Scientific Instruments, 12137 Cantura Street, Studio City, California.

presses was rewarded. Following this period, the light and clicker were activated for 20 minutes and served as cues for the work period, or time during which performance on the FR100 reinforcement schedule was rewarded. When the work period was over, the lamp and clicker were turned off and the subject remained in the chamber for 10 more minutes; none of the responses was rewarded during this period. The subject was returned to its home cage after each of these sessions.

After approximately seven days, responses during the 10-minute periods before and after the work periods were reduced to such a degree so as to give evidence that the subject was discriminating between the work and rest periods. The duration of the rest periods was then increased gradually so that after approximately five weeks, the length of the rest period was 5 hours and 40 minutes.

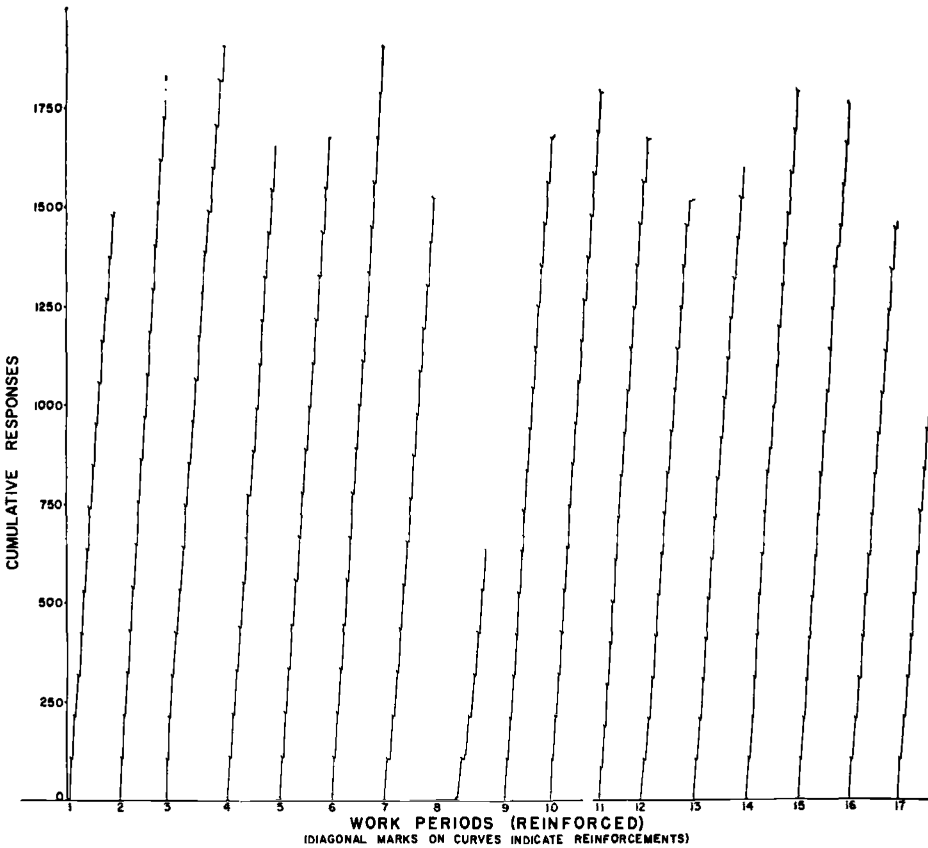

Fig. 1. Cumulative response curves for seventeen 20-minute work periods during the four-day reinforcement session.

With the subject responding well on this 6-hour cycle, the next step was to simulate the isolation aspects of the satellite environment. To do this, the operant chamber was placed in a portable ice chest which, in turn, was placed in a portable testing room of double-walled soft fiber board construction. This room was located in a small laboratory room that was lined with acoustical tile. All programming and recording equipment was located outside the laboratory room. The subject was placed in the chamber and remained in this isolated environment throughout the experiment. The work-rest intervals were the same as described above: a repeating 6-hour cycle consisting of a 20-minute work period in which the lamp and clicker were activated and responses were rewarded on a FR100 reinforcement schedule, and a rest period of five hours and 40 minutes in which both the lamp and clicker were turned off and none of the responses was rewarded.

The subject remained on this 6-hour cycle for seventeen work periods or 96 hours and 20 minutes. Following this period the electrical power that controlled the feeder in the operant chamber was turned off at the programming unit and the subject remained in the chamber for an additional 96 hours in order to measure performance under non-reward or extinction conditions. This procedure eliminated all secondary reinforcement orginating from the operation of the feeder solenoid. During the extinction sessions the 6-hour repeating cycle remained in effect; the light and clicker were employed the same as they were during the reinforced periods. The only difference was that none of the responses during this 96-hour period was rewarded.

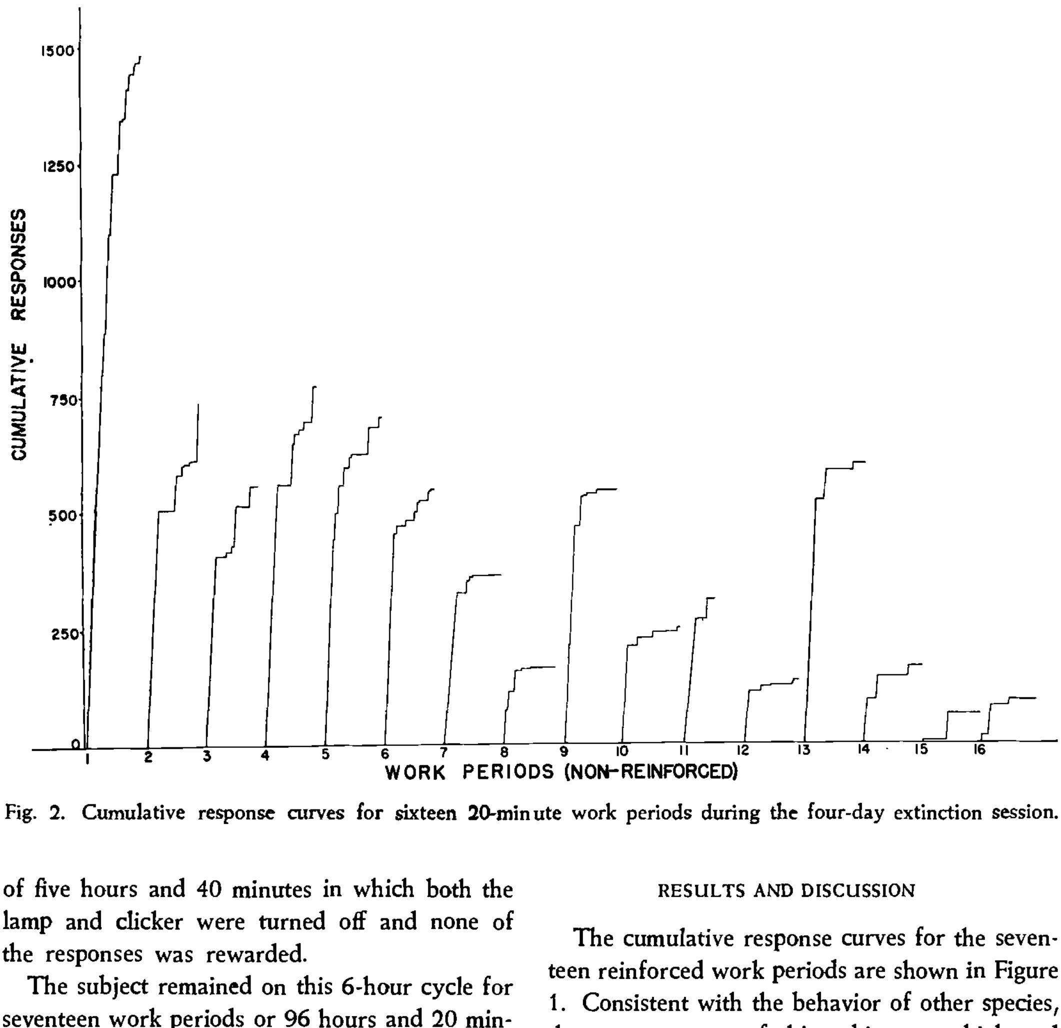

Fig. 2. Cumulative response curves for sixteen 20-minute work periods during the four-day extinction session.

RESULTS AND DISCUSSION

The cumulative response curves for the seventeen reinforced work periods are shown in Figure 1. Consistent with the behavior of other species, the response rate of this subject was high and reliable from work period to work period. In only one work period did the performance show any noticeable decrement.

The cumulative response curves for the sixteen non-reinforced work periods are shown in Figure 2. As expected, the highest response frequency and most sustained response rate occurred during the first non-reinforced work period. Those following showed a marked decrement. However, it is notable that after three days without food (period 13) the subject still showed a high response frequency.

Response frequencies for the entire eight-day period are shown in Figure 3. It should be pointed out that the majority of the responses during the 5-hour, 40-minute rest periods were made immediately following the 20-minute work period. In addition, the response frequencies during the reinforcement sessions tend to show rhythmical tendencies which could be attributed to the diurnal cycle.

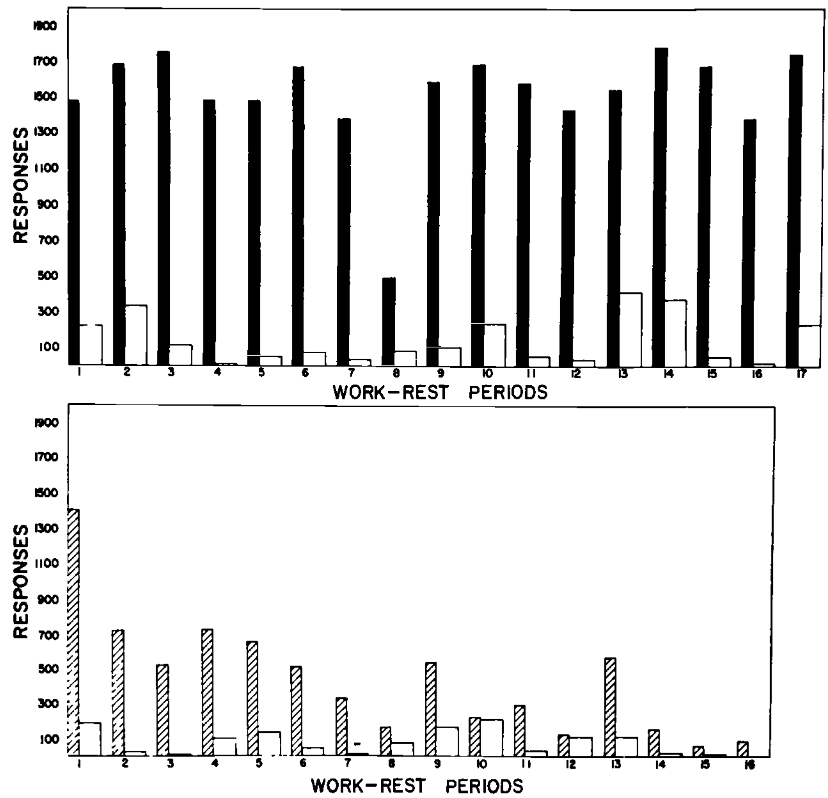

Fig. 3. Response frequency by period for the eight-day session. (Solid bars indicate responses during the 20-minute work periods when food was rewarded on FR100 schedule; crosshatched bars indicate responses during the 20-minute work periods when no reward was given; white bars indicate responses during the 5-hour, 40-minute rest periods.)

Although other investigators have trained mice to perform on ratio reinforcement schedules, several problems were encountered in insuring the sustained performance described in this paper. During the magazine training it was found that a 14-hour food deprivation period was more satisfactory than 18 hours or the customary 22 hours used with rats. Also the response-to-reward ratio was increased very gradually and only when the animal was responding on FR20 were large increments of the ratio introduced. As indicated above, training to discriminate between the work and rest periods was also done very gradually. The 6-hour cycle, which was arbitrarily selected, proved to be satisfactory as was the 20-minute work period.

Future plans call for using several subjects on reduced and staggered work-rest cycles; this would increase the reliability of the results and insure near-continuous recording of information.

The C-57 BL strain was selected for three reasons: first, animals of this strain showed no detrimental effects during high-altitude balloon flights; second, their fur, which is black, turns white when exposed to cosmic radiation; and third, they are not susceptible to audiogenic seizures. The latter becomes of paramount importance since during launch the satellite occupant will be subjected to extremely high noise levels. In our laboratory several groups of these mice have been exposed to 140 db of wideband noise for periods as long as 2 minutes and showed no evidence of sound-precipitated convulsions.

It is believed that there are implications for both space work and other fields in this experiment. It was shown that it is possible to obtain consistent and reliable behavior from a mouse for a period up to 96 hours; there is no reason to doubt that with continued reinforcement this period could be extended. It also demonstrates that complete response extinction is slow under this procedure and that meaningful behavioral information can be obtained in the absence of reward. Concerning other disciplines, a 3- or 4-hour cycle could be used for assessing the behavioral effect of drugs and exposure to unusual environmental conditions such as prolonged acceleration or vibration could also be measured with this design.

SUMMARY

As a model for obtaining behavioral measures with animals in outer space, sustained operant behavior was observed in a mouse that performed on a FR100 reinforcement schedule for 20 minutes out of 6 hours for 96 hours. The performance continued for an additional 96 hours in the absence of reward. It was concluded that this type of performance can be obtained from a mouse for prolonged periods of time and that the behavior is highly reliable and consistent from work period to work period.

REFERENCES

1. Anliker, James, and Mayer, Jean: An operant conditioning technique for studying feeding-fasting patterns in normal and obese mice. *J. Appl. Physiol.*, 8:667-670, (May) 1956.

2. Ferster, C. B. and Skinner, B. F.: Schedules of Reinforcement. New York: Appleton-Century-Crofts, 1957.

3. Rohles, F. H., Belleville, R. E. and Grunzke, M. E.: The measurement of higher intellectual functioning in the chimpanzee and its relevance to the study of behavior in space environments. *Aerospace Med.*, 32:121-125, 1961.

Glaucoma Detection

If the high incidence of blindness from glaucoma is to be reduced, testing with a tonometer of intraocular pressure must become part of the routine physical examination by all physicians, not just by ophthalmologists.

The prevalence of this serious condition, according to Dr. W. L. Mould, is shown by the finding that about two per cent of people over 40 have glaucoma; approximately one-sixth of blindness is caused by this dysfunction.

The measurement of intraocular pressure is an easily acquired technique and requires only a tonometer and a corneal anesthetic. Although some patients develop no visual disturbances with pressure levels of 25 mm. Hg, 22 mm. Hg is usually considered the upper limit of normal pressure. If pressure readings of 22 mm. Hg or more are found, the patient should be referred to an ophthalmologist for treatment.