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The Relative Efficiency of Auditory (Social) Reinforcement vs. Food Reinforcement with the Squirrel Monkey (Saimiri Sciureus) in an Operant Situation

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THE RELATIVE EFFICIENCY OF AUDITORY (SOCIAL) REINFORCEMENT VS. FOOD REINFORCEMENT WITH THE SQUIRREL MONKEY (SAIMIRI SCIUREUS) IN AN OPERANT SITUATION

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CHAPTER I

THE PROBLEM

Traditionally, in operant conditioning situations, the reinforcement used to shape and maintain a desired response is a food preferred by the species being conditioned. More recently, however, a number of investigations have exploited, for reinforcement, sensory modalities other than those related to satiation of such organic drives as hunger and thirst. Harlow (1950) and Harlow and McClearn (1954) found that non-human primates will learn to discriminate with the reinforcer being the presentation of a situation permitting exploratory behavior. Extending this discovery, Butler (1953) and Butler and Harlow (1954;1957) have shown that monkeys learned a color discrimination by pushing against a door to reveal the sounds and sight of the laboratory.

Kimble (1961) has presented an argument interpreting the reinforcement in these studies as secondary reinforcement deriving its reinforcing properties from previous association with a primary reinforcer. For example, the sounds of a monkey colony may be related to primary reinforcement such as food, sex, and perhaps the general social need of the species (Butler, 1957).

Kish (1966), on the other hand, has interpreted these results in terms of a general sensory reinforcement theory divorced from such organic drive states as hunger and thirst and apparently not dependent upon a secondary reinforcement. As Kish (1966, p. 128) defines secondary reinforcement in the laboratory, it is "a transient phenomenon, the secondary reinforcer rapidly losing its effectiveness when primary reinforcement is no longer forthcoming." Earlier, Butler (1957) demonstrated that response frequency to levers increased rather than decreased during an experiment, thus precluding any simple explanation based on secondary reinforcement. In a study by Butler and Harlow (1954) on visual exploration and studies by Harlow (1950) and Harlow and McClearn (1954) on manipulation, results have shown that behavior reinforced by sensory means can be maintained.

Kish (1966) states the sensory reinforcement hypothesis without limitation upon the sensory modalities in which stimulation would be found to be reinforcing. In relation to this hypothesis, investigations have been conducted in various modalities. (1) Exploratory visual behavior. Girdner (1953) found that response-contingent illumination increased the rate of emission of the lever-contact response. (2) Motion, or kinesthetic feedback. Kish and Barnes (1961) demonstrated that duration of contact with a lever markedly increased when the lever was made movable,

suggesting that the kinesthetic consequences of pressing the bar were reinforcing. (3) Gustation. Sheffield, Roby and Campbell (1954) concluded that gustation as a reinforcing modality involves increments of stimulation coincident with, or arising from performance of the consummatory response. Their results are interpreted according to the sensory reinforcement hypothesis to indicate that gustatory stimulation, per se, may be reinforcing. (4) Olfaction. Berlyne (1955) found that rats spent a considerable amount of time sniffing a novel stimulus object presented in a testing situation. (5) Tactual stimulation. Wenzel (1959) investigated tactual stimulation as a reinforcer when he trained kittens to contact a lever in an operant conditioning chamber by reinforcing each contact with petting. Harlow (1960), using "surrogate" mothers, investigated the tactual preference shown by young monkeys and found that a soft, cloth surrogate was preferred to one made of wire. The cloth surrogate was tactually stimulating and reinforcing while the wire one was not. (6) Audition. Barnes and Kish (1957) and Harrison and Tracy (1967) initiated research to test the effects of response-contingent auditory stimulation. Their results indicate that intense white noise may act as a negative reinforcer, suggesting the termination of intense auditory stimulation has reinforcing value.

These results seem to validate the "sensory reinforcement" hypothesis, i.e., operant behavior probability can be increased and maintained by stimuli unrelated to the usual organic need states (Barnes, Kish & Wood, 1959). According to English and English (1958), the phrase "usual organic need states" refers to the internal needs of the organism which are physiological in nature.

Butler (1958) initiated research in the area of auditory reinforcement with primates as a result of his concern with the incentive value of selected visual and auditory sensory rewards. The results using visual reward were inconclusive, but those involving auditory reward showed that responsiveness to auditory incentives varies with the type of auditory stimuli. He found that sounds normal to the social background of the animal were reinforcing, although not significantly so. The reinforcing efficiency of the auditory stimuli was shown in the following order: (1) monkey feeding sounds, (2) single monkey sounds, (3) white noise, (4) monkey sounds of rage and (5) dog sounds.

In 1957, Butler completed a study devoted solely to the reinforcing properties of audition. In this study, rhesus monkeys learned to discriminate when the only reinforcer was 15 seconds of sounds emitted by the colony. Butler's work demonstrated positively the reinforcing

effects of social-auditory stimulation for rhesus monkeys taken from a colony where normal vocal interaction occurred.

In the majority of the investigations relating to sensory reinforcement, food, water and/or sensory deprived rather than satiated subjects have been used. Wendt, Lindsley, Adey and Fox (1963) completed a study in which the variable studied was exposure to visual stimulation. Monkeys with very different histories of exposure to visual stimulation and the same pre-experimental visual deprivation were compared with respect to their rates of self-maintained visual stimulation. The conclusions were that an animal's previous visual experience is an important determinant of his later "need" for visual stimulation, and that the effects of short term experimental deprivation cannot be isolated from the total sensory history of the animal.

Theory and research in the study of motivation assume that an animal will learn those responses that produce food and cease making those responses that do not produce food, if it is in a state of deprivation (Hull, 1943). According to such a theory, under deprived conditions, food would be a uniformly reinforcing substance serving to increase the probability of responses associated with it. Thus, short term experimental food deprivation has a different effect upon responding than does sensory deprivation. This differential effect invalidates the use of

deprivation as an experimental technique in a comparative study involving both food and a sensory modality.

Research using non-deprivation and sensory or food reinforcement has received little attention to the present time. It is possible that, at least in the laboratory, sensory reinforcement under non-deprived conditions may be a much more economical and efficient reinforcer than food reinforcement under deprived conditions, which is traditionally used.

The use of non-deprived animals in a comparative sensory and food experiment has been investigated by Sackett, Keith-Lee and Treat (1963). They found evidence that the laboratory rat, when non-deprived sensorily or with food, will not choose the response alternative leading to food. Instead, he tends to choose a response alternative leading to a sensorially stimulating situation. On the basis of these results it is hypothesized in the present study that social-auditory reinforcement will maintain behavior more efficiently than food under laboratory conditions. This hypothesis is independent of the primary or secondary nature of the reinforcement.

To test this hypothesis, squirrel monkeys (Saimiri sciureus) will be placed in an operant situation in a non-deprived sensory and food state. The hypothesis predicts

that the monkeys will show a preference in terms of rate of response and resistance to extinction for social (auditory) as opposed to food (banana pellet) reinforcement.

CHAPTER II

METHOD

Subjects

The Ss were four male squirrel monkeys (A,B,C,D), taken from a colony of twelve, and experimentally naive at the start of the experiment. Animals A, c and D appeared to be adults while animal B appeared to be an adolescent. Prior to experimentation, the Ss were housed in a large, communal living cage with food and water available. They had been in a laboratory situation six weeks prior to pre-training. The four test animals were placed in four 18" x 18" x 31" individual holding cages in the colony room during experimentation, with food and water available on a regular, non-deprived feeding schedule.

Reinforcers

Food reinforcement consisted of 190 mg. Noyes peanut, sucrose and banana pellets. Auditory reward consisted of hearing recorded monkey colony sounds. The initial recording of colony sounds was made at Woodland Park Zoo in Seattle, Washington. This was done to insure that the interaction between the S and the tape would not depend upon the animal and his social position in the experimental colony. The vocalizations were taken from the most active

vocal periods of the day, pre- and post-feeding and early afternoon, when there seems to be much vocal interaction, both in the Woodland Park colony and the experimental colony. In an attempt to keep the sounds as uniform as possible and to insure that during any 5 second period on the tape there was vocalization, the initial recordings were edited. The edited tape was 45 minutes in length so that the sounds the animal received were different for each reinforcement.

Apparatus

The apparatus, an operant conditioning chamber (Foringer #1104 squirrel monkey chamber), provided a means for delivering sound or pellet reward to the Ss following a response. The chamber contained a single lever and food cup. The use of auditory reward necessitated auditory isolation of the tested monkey during testing, except during reinforcement. To remove the monkeys from the sounds of the laboratory during testing, the animals were tested in a small, separate room which has plaster walls and ceiling and a wood floor. Furthermore, the room was not lighted during testing and there were no windows, with the exception of a 1' x 2' one-way vision screen which was placed in the door for the purpose of observation.

Located in the middle of the room was a sound deadened booth, 38" x 24" x 24". The Foringer test chamber was

placed inside this booth. The interior of the chamber was illuminated by a 5 watt lamp located 3" above the plexiglass chamber.

A tape recorder (Revere T 3000) was used to deliver the sound through a Foringer #1135B speaker in the testing chamber. Responses to the lever operated a relay, thus closing a circuit and operating a timer which controlled the duration of sound reward. Connected to the timer was an impulse counter, which recorded the number of sound reinforcements and recorded them on a cumulative recorder. The number of responses was also recorded on a counter and cumulative recorder. Under conditions of banana pellet reinforcement, an impulse counter and cumulative recorder recorded the number of reinforcements and responses in a similar way.

Procedures

The procedure followed in this study consisted of rewarding lever pressing responses by five seconds of sound emitted by the monkey colony under condition (a) and with banana pellets under condition (f).

All the Ss were pre-trained on continuous reinforcement (crf), using experimenter controlled successive approximation techniques with sucrose pellets as reinforcement. Ss B and C were run on crf and changed to a variable

ratio (VR) schedule with a low ratio, but never reached a performance level where they could be changed to VR5 without extinction occurring. There was no consistency of behavior defined in terms of their response from test period to test period (Fig. 1). Ss A and D under non-deprived conditions would not continue responding on a ratio any greater than 8 to 1, so they were placed on VR5 (instead of VR6 as originally planned) after pre-training sessions 12 and 8, respectively (Fig. 2). During pre-training, the monkeys were fed one Purina Monkey Chow biscuit one hour prior to training, and during testing, they were given two at 7:30 A.M. each morning and two immediately after the morning test period was completed. They were given fresh food (grapes, bananas, carrots, apples, lettuce, oranges and meat) and three biscuits after the afternoon test periods. The moning test period started at 9:00 A.M. and terminated at 11:30 A.M., and the afternoon period started at 1:00 P.M. and terminated at 3:30 P.M.

The Ss were given six blocks of test sessions with each block containing four thirty-minute tests. Each animal was run twice each day, once during each of two 2½-hour testing periods. The order of testing during the 2½-hour testing periods was determined by the use of a Latin square 4 x 4 to insure random assignment.

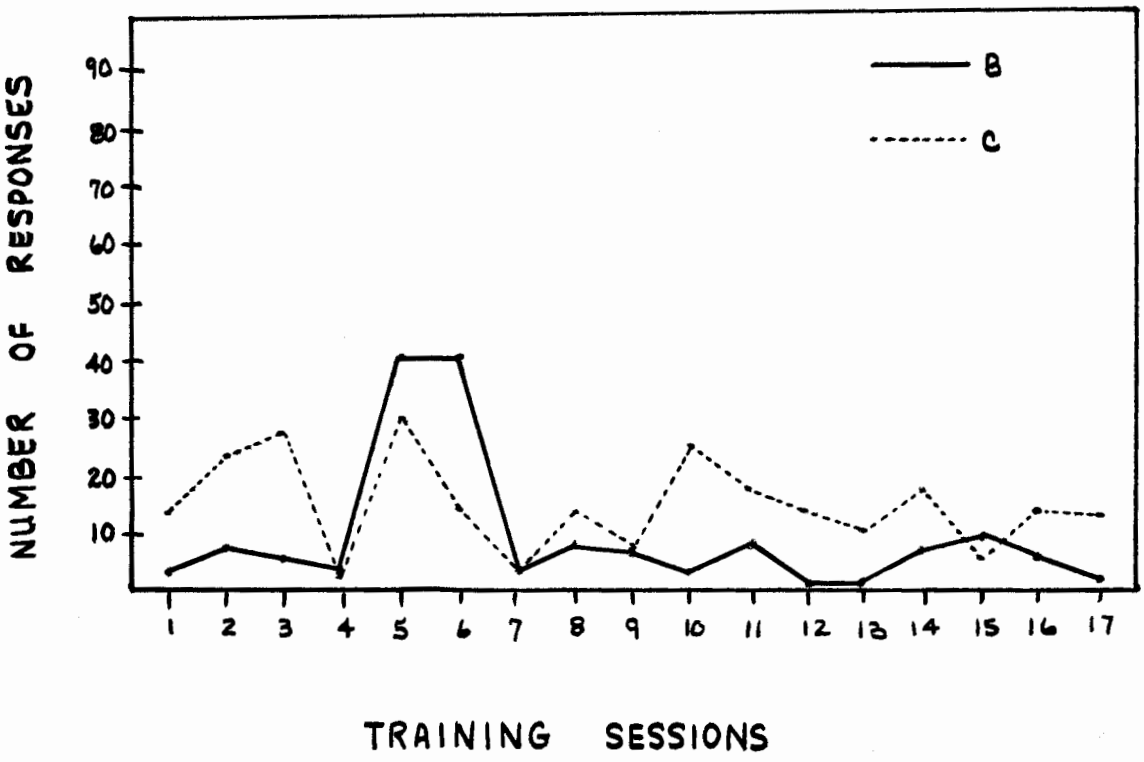

Fig. 1. Pretraining response record for animals B and C under sucrose pellet reinforcement.

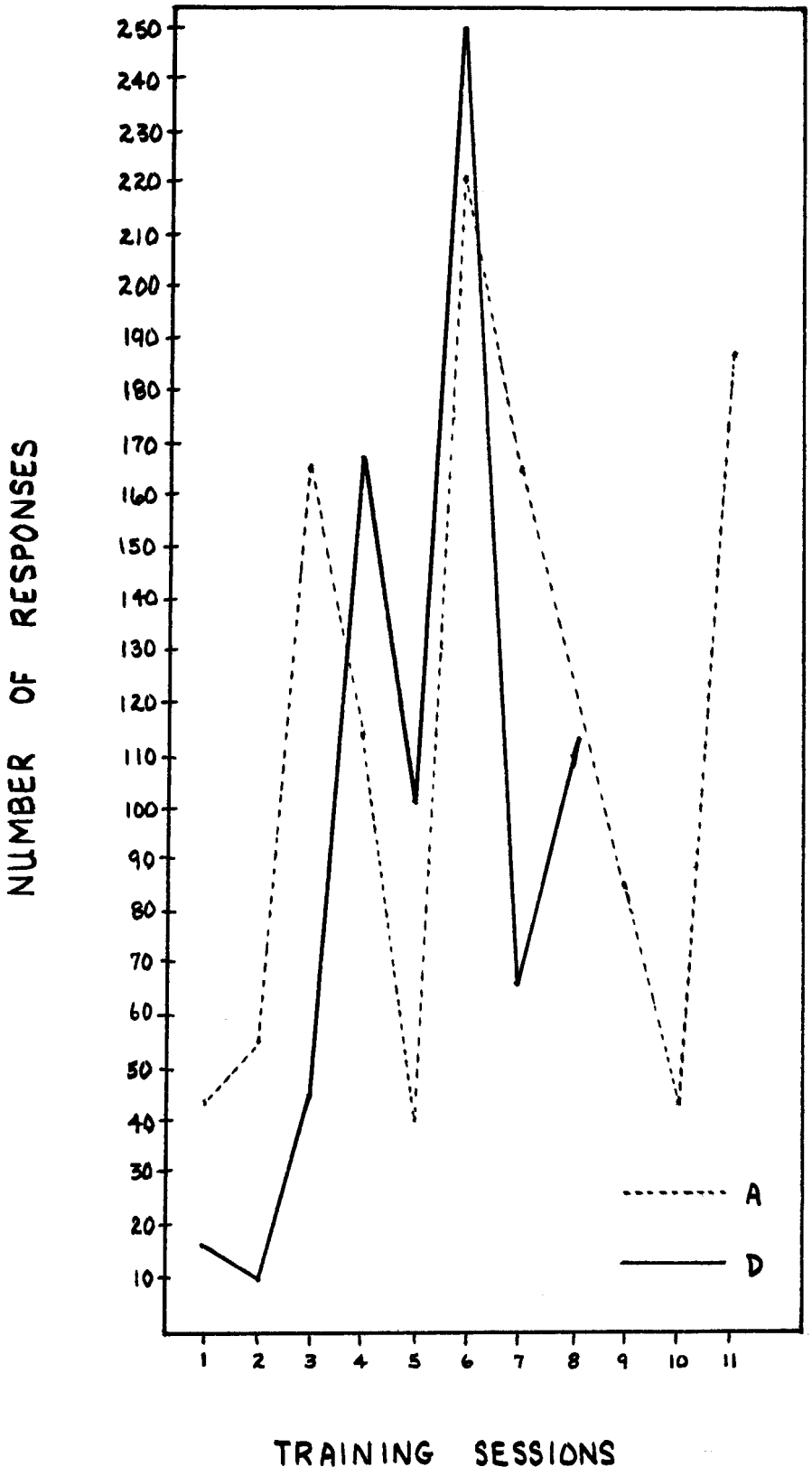

Fig. 2. Pretraining response record for animals A and D under sucrose pellet reinforcement.

The design is shown in Fig. 3, with rows representing S, columns representing blocks of six test sessions, and (a) and (f) representing the two incentive conditions. Extinction sessions were run after S completed the three blocks of four test sessions under one of the conditions.

History

After the experiment, the experimental animals were marked with ear notches and returned to the colony cage.

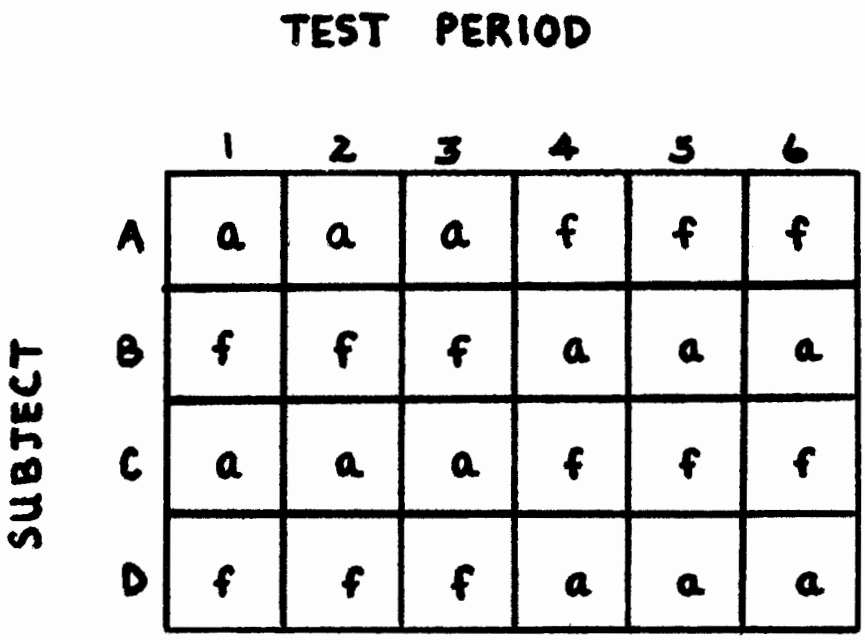

Fig. 3. The experimental design with rows representing S, columns representing blocks of six test sessions and letters a and f representing auditory and food reinforcement, respectively.

CHAPTER III

RESULTS

Applying an F test for the main effects of the treatments, the results are F = 12.419 which is significant with P $<$ .001 and df = 1/44 for banana pellet preference (Table 1). In relation to the null hypothesis that the treatment effects are equal and the experimental hypothesis that a significant preference will be shown for social (auditory) as opposed to food (banana pellet) reinforcement, this means that both must be rejected. Significant preference was shown by animals A and D for banana pellets over monkey vocalizations under experimental conditions. The mean number of responses for the twelve test sessions under (a) was 18.3 for A and 6.5 for D. Under (f) the mean number of responses was 64 for A and 44 for D (Figures 4 and 5).

Animal A made 16 responses in the first three minutes of the first extinction session and 3 responses in the first three minutes of the second session, under (f). Under (a), there was one response during the first three minutes of the first session and none during the second session. Animal D made 29 responses during the first three minutes of the first session and 1 during the first three minutes of the second session under condition (f). Under

Table 1

Analysis of Variance Summary:

Auditory over Food Reinforcement

Source of variation	df	Sum of squares	Mean square
Columns (treatments)	1	20,584	20,584
Rows (subjects)	1	3,103	3,103
Cells	(3)	23,971	
Row x Columns	1	284	
Within	44	72,927	1,657.43
Total	47	96,898	2,061.67

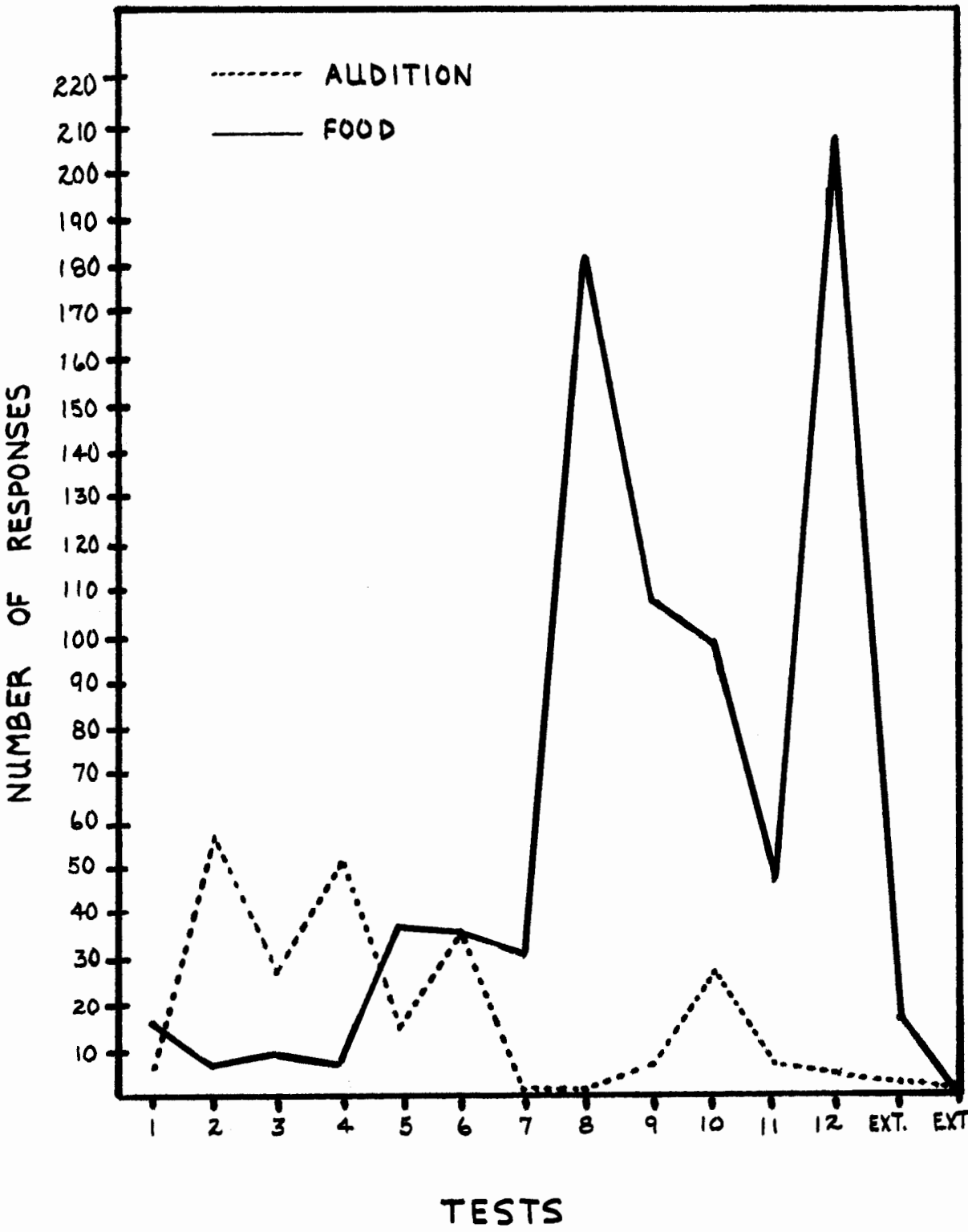

Fig. 4. Response record for animal A during testing sessions under conditions a and f.

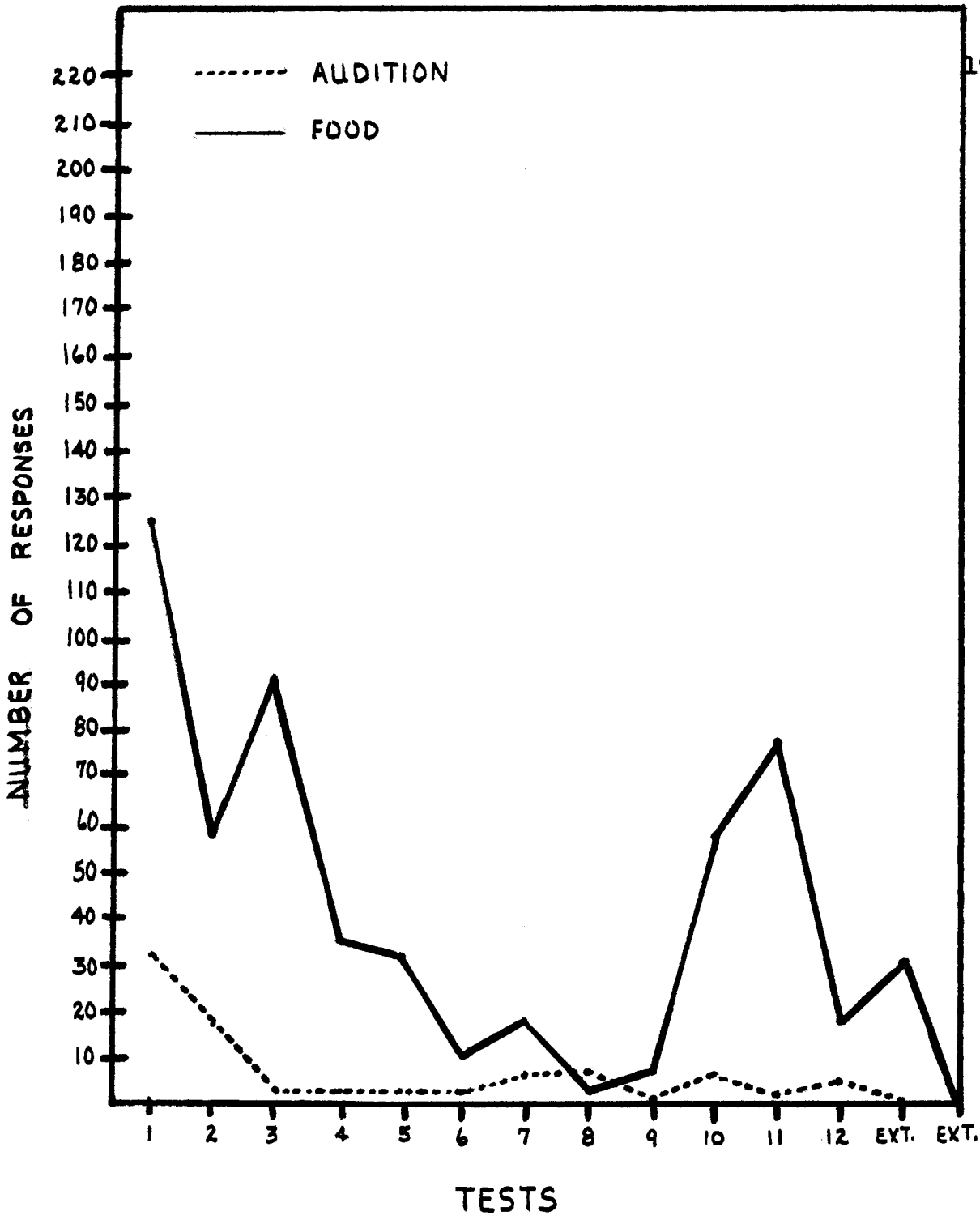

Fig. 5. Response record for animal D during testing sessions under conditions a and f.

(a), in both sessions one and two, D made no responses (Figures 4 and 5).

There was a preference shown for banana pellets in terms of resistance to extinction. It should be noted that when behavior was established under audition (Fig. 6--session 6; Fig. 7--session 1), it was more dispersed throughout the experimental session than under food.

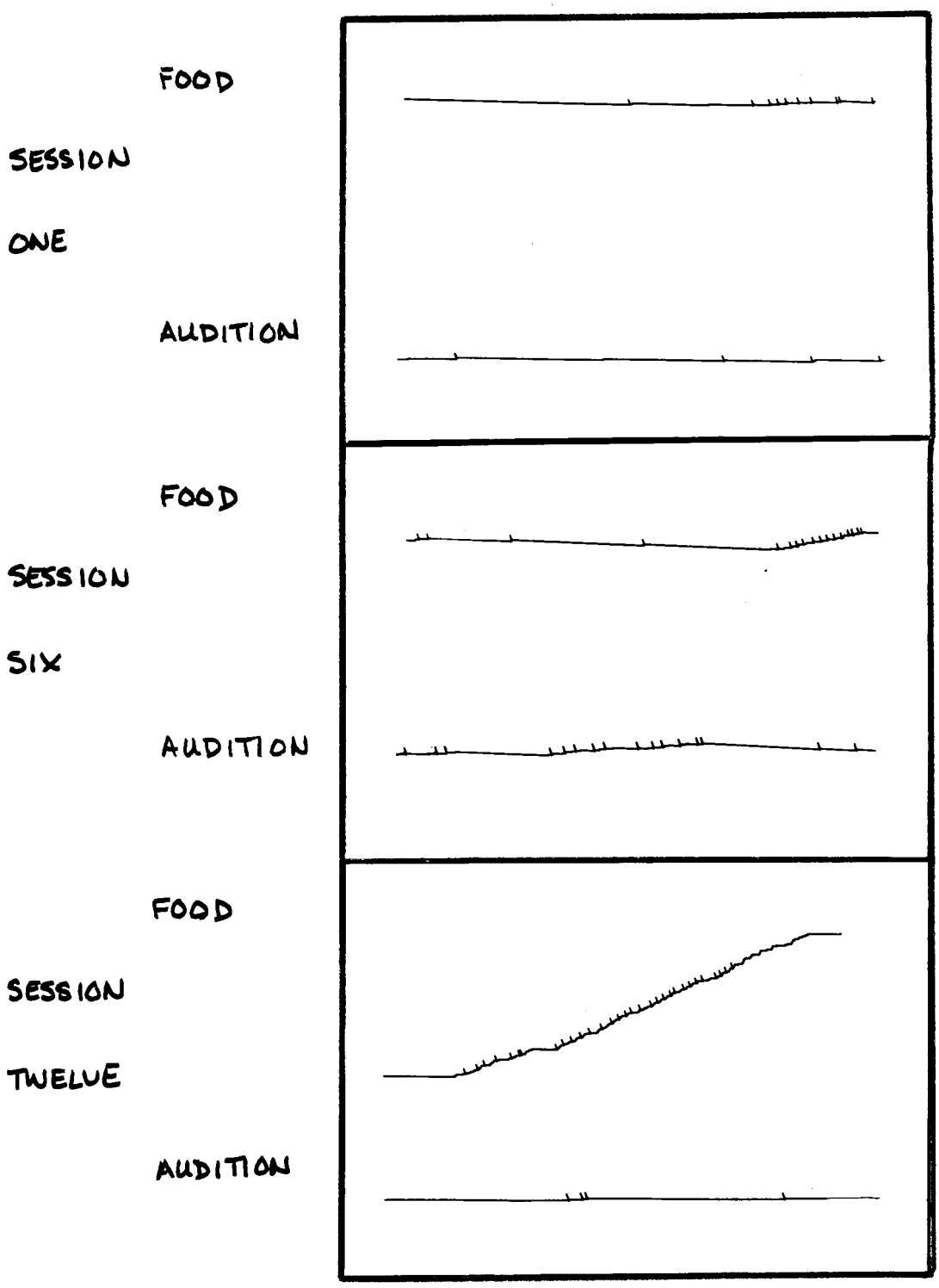

Fig. 6. Cumulative response (bar pressing) record for animal A during testing sessions 1, 6 and 12 under audition and banana pellet reinforcement.

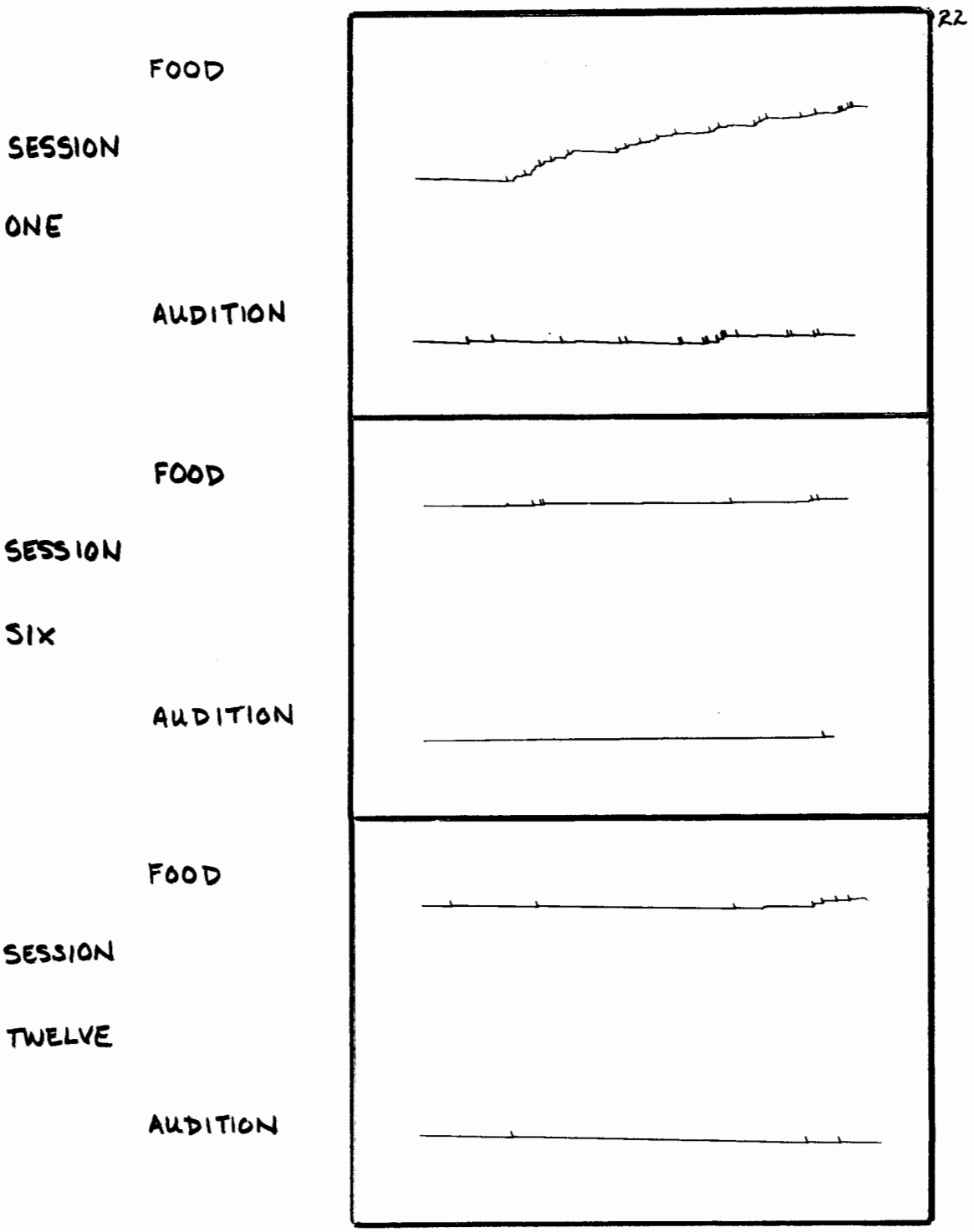

Fig. 7. Cumulative response (bar pressing) record for animal D during testing sessions 1, 6 and 12 under audition and banana pellet reinforcement.

CHAPTER IV

DISCUSSION

The results do not add support to the sensory reinforcement theory, nor do they necessarily detract from that theory. Butler (1958) found that sounds normally in the social background of the animal were reinforcing, although not significantly so. He demonstrated, however, as had prior research, that non-human primates would learn with the only reinforcer being exposure to auditory stimulation. All research in the area of auditory reinforcement has been under deprived sensory conditions, so there are limitations placed upon interpreting the data and making conclusions in terms of theory. The present study has not demonstrated that squirrel monkeys will maintain consistent behavior with the reward being exposure to auditory stimulation under these experimental conditions. The data show a need for further study of audition as a reinforcer for this species and of a comparison of the efficiency of auditory and food reinforcers.

In discussing the experimental conditions which may have had an effect upon the outcome, it should be mentioned that pre-training, using pellets as reinforcement, had a confounding effect upon the results of the study because responding under conditions of auditory reinforcement

required responding to a different modality of reinforcing stimulus. The design called for animal D to go from pre-training conditions of sucrose pellet reinforcement to testing condition (f) (banana pellets) (Fig. 5). The first test session under (f), the animal responded 125 times. Under (a), D responded 32 times. The new reinforcing condition (a) brought about a greatly reduced rate of response as evidenced in Fig. 2. Animal A went from pre-training under sucrose pellets to (a) (audition). In the last pre-training session, the animal responded 187 times (Fig. 2), and in the first test session, 4 times (Fig. 4).

It would be preferable to pre-train using a mixed auditory-food reinforcement, or using a reinforcement other than those used during testing, e.g., liquid or another modality.

Butler (1957) used 20-minute test sessions and (1958) 30-minute test sessions. Under satiated conditions, the shorter test period might be more effective as it was observed that early in the test session the animals were active and later in the session they rested (Figures 6 and 7: A-(f)-1; A-(f)-6; D-(f)-6; D-(f)-12). Ss B and C were not run under experimental conditions because their response rate was low and inconsistent. It is hypothesized that if shorter test periods had been used, a higher response rate per running time during pre-training would have been achieved,

thus making it possible to run them under the experimental conditions.

For the initial taping and playback of the sounds during testing, a Revere T 3000 tape recorder was used. The Foringer chamber contains a Foringer #1135B speaker for playback in the chamber. Butler (1958) used a Magnacord P-T-7-P tape recorder for reproducing sound. Animals A and D (Figures 4,5,6 and 7) each responded at a rate which indicates that the behavior was established using audition as a reinforcer. After session 7 and session 3, respectively, the rate of responding dropped greatly. It is postulated by the experimenter that a better quality recorder and playback speaker might have maintained the behavioral level more consistently throughout the experimental sessions. The fidelity of the reproduction may have a direct relationship to the ability of the audition to maintain behavior.

Butler (1957) used as auditory reward, hearing sounds emitted by the monkey colony which was housed in another room. To present monkey sounds to the animal being tested, a microphone connected to an amplifier was placed in front of the colony. The 15 seconds of colony sounds the animal heard after a response varied in volume, pitch and connotation, defined in terms of the associated physical activity. The sound of a colony varies with the time of day, visual

stimulation, and interaction of the colony members, so there could be no way to control the auditory feedback received as reinforcement. Butler (1958) found that various vocalizations had a traceable differentiating effect upon their reinforcing value. In the present study, the vocalizations were recorded prior to the experimentation and the tape edited so that vocalizations were continuous and uniform. Further control of the type of sound used for reinforcement could be gained by identifying efficient reinforcing sound through research. There should be an analysis made of the activity associated with each sound, of the aggressive-passive qualities of the sound, of the number of animals producing the sound, and of the effect of any extraneous sounds recorded with the vocalizations.

The control of extraneous variables in an auditory study is must difficult and vital to the outcome of the experimentation. The visual isolation of the Ss during testing was difficult because a closed chamber requires ventilation, and in an auditory study, the fan noise would interfere with the vocalizations during reinforcement. Auditory isolation during testing was also difficult because of the closed chamber problem. Even with a sound-deadened chamber there was occasionally interaction between the colony and the S, although they were in separate rooms. There were noises from people, weather, traffic and other

animals in the building. A pigeon colony moved onto the same floor created a noise problem as reflected in sessions 7 and 8 (Figures 4 and 5). On that same day there was a substitute experimenter, which might have had some effect upon the S's performances. The noise problem may cast a doubt on any conclusions to be drawn from the data. It confounded the results to the extent that generalizations cannot be made from them.

This study has suggested several new areas of research that might profitably be undertaken with the squirrel monkey. The use of satiated subjects has not been substantiated as a valid research procedure with the squirrel monkey and this research provides neither supportive nor refutative indications. The use of animals which have been experimentally deprived does not bring about reliable testing in auditory studies. Wendt, Lindsley, Adey and Fox (1963) concluded that previous sensory experience is an important determinant of the need for sensory stimulation under short-term experimental deprivation, and previous sensory exposure in many experimental situations is something that cannot be controlled. The fact that experimental deprivation cannot be isolated from the total sensory history of the animal makes experimental satiation a worthwhile technique to investigate for studies involving a comparison of a sensory modality and another reinforcing agent.

After the animals were pre-trained on crf, they were placed on a VR schedule which graduated from 1/1 to 8/1, and they were then placed on the experimental schedule, VR5.5. There is no indication in the literature of an efficient mean for the VR schedule using this species. It was found during pre-training that under conditions of non-deprivation the Ss would extinguish if the ratio exceeded 8/1, and the experimental schedule had to be altered from VR16 to VR5.5. The literature contains little on schedules of reinforcement, either ratio or interval, and their efficiency when dealing with auditory reward. Segal (1966) provides information about the VI schedule using food pellets, but this seems to be the only literature available for food reward using this species. This indicates an area of research which needs to be investigated and made available in the literature.

It was observed that under experiment (non-deprived) conditions, the size and type of pellets used has a differential effect upon response rate. In the literature, Reynolds (1964) used a 97 mg. peanut pellet; Green, Moore and Sargent (1966) used a 75 mg. banana pellet; and Segal (1966) used a 45 mg. rat chow peanut pellet and a 45 mg. sucrose pellet. This experimenter used a pellet size of 190 mg. and found a very sporadic rate of response. It might be advisable to use a pellet size of 45 mg. under these experimental conditions.

During pre-training, both peanut and sucrose pellets were used, and banana pellets were used during experimentation. There was a distinct preference shown for sucrose under conditions of satiation. This is reflected in Fig. 4, where animal D went from pre-training on sucrose pellets to experimental conditions under banana pellets. During the last three pre-training sessions, the mean number of responses was 144.7, but for the first three test sessions the mean number of responses was 90. A detailed study of these factors would have some value if this research direction is to continue.

It has been noted that behavior during auditory reinforcement is more spread throughout the experimental session than it is under food reinforcement (Fig. 6--session 6). There is a question as to whether 5 seconds of auditory reinforcement is equivalent to one pellet and whether one response under (a) is equivalent to one response under (f). It is possible that a small number of auditory reinforcements satiate an animal, while even under non-deprived conditions a large number of food reinforcements will not satiate an animal. Detailed analysis of a large collection of data is required before a statement can be made as to the validity of considering two different modalities on one scale of measure.

If what has been hypothesized in relation to social-auditory reinforcement can be shown to be valid, the techniques used would be valuable in experimental work where behavior is studied and maintained over time. The use of non-deprivation would eliminate the confounding effect that deprivation has upon results of drug studies and studies of other variables. Satiation would no longer limit the length of experimental sessions. Social audition would provide an efficient positive reinforcer for the maintenance of behavior.

In conclusion, the consideration of auditory social reinforcement needs to receive extended attention and the results will be of benefit not only to experimental psychology, but to the investigation of primate communication systems and social organization. The experimenter hopes that the present study will make evident new areas of inquiry and will emphasize the importance of this line of research.

CHAPTER V

SUMMARY

Four auditory and food non-deprived squirrel monkeys were run in an operant situation to determine the relative reinforcing efficiency of social-auditory reward and food reward. Two of the subjects completed the testing sessions and showed a significant preference for food reward in terms of rate of response and resistance to extinction. It was felt that the environmental conditions surrounding the experiment were such that a statement in relation to the sensory reinforcement theory would not be valid.

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