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AN ATTEMPT TO FIND AUDITORY COMMUNICATION IN THE SQUIRREL MONKEY VIA COOPERATIVE CONDITIONING

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AN ATTEMPT TO FIND AUDITORY COMMUNICATION IN THE SQUIRREL MONKEY VIA COOPERATIVE CONDITIONING

Michael T. Bardo
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Perhaps in no other area of psychology has the tendency towards anthropomorphic interpretation been greater than in the area of primate social behavior. Today, some African and Asian cultures continue to view the monkey as a sacred beast (Southwick, 1963). The literature on primate behavior before about 1930 is both anecdotal and scientifically unvalued. It was not until the 1930's that primate societies came under the eye of a number of objective psychologists working in the field. Carpenter's (1934) diligent work with Panamanian howling monkeys remains today as a milestone in primate social studies. Explicit in his rejection of anthropomorphic "data", Carpenter was instrumental in outlining a methodology which objectified field observations.

A new standard of primate research was extended and delineated by a number of other psychologists during this period of the 1930's. Nissen (1931), working with chimpanzees and Zuckerman (1932), working with free-ranging South African baboons, are cases in point. These authors supposed that the objective study of primates would have vast implications for the understanding of the development of social behavior in man. Despite a lull during the second

World War, research on the social behavior of many different primate species has been quite extensive.

Carpenter (1942), in a comparative review of 13 different non-human primates, differentiated between the terms social integration and social coordination. Integration refers to dominance and territorial behaviors which are directed towards and elicited by a specific member of the species. Coordination, on the other hand, refers to those social behaviors which elicit a stereotyped response from all the members of a particular social group. Social coordination encompasses such behaviors as species recognition and stereotyped, species-specific body gestures and vocalizations which commute a "message".

Altmann (1966) has defined social communication as the process by which the "probability distribution of behaviors occuring in one organism is changed by the behavior of another organism." This concept is generally delineated as an intra-species phenomenon, dependent partly upon innate attributes. So-called "communication" between members of different species has a much more pronounced learning component involved. Free-ranging baboons, for example, respond by fleeing to the alarm calls of zebra, water buffalo and other ungulates inhabiting the same area (Washburne and Devore, 1961). Such behavior is not found in baboons which are raised in captivity, and in a rigid context this is not social communication.

In social communication there is a transmitter agent and a receiver agent, separated from one another by a transcoder. This process can be depicted as follows: Transmitter ⟶ channel ⟶ transcoder ⟶ channel ⟶ receiver. This represents a biological version of traditional information-theory (Sebeok, 1965). It is not typical, however, that a communicative signal is limited to one channel or sensory modality. Mammals, especially primates, make use of multi-sensory channels to communicate a "message". In general, primates have a highly evolved visual system which is incorporated in social communication. Auditory and tactile channels also play a significant role in this process, while olfaction has only a minor role. According to Altmann (1966), "from a comparative and evolutionary standpoint, it would be interesting to know, for each species of primate, the relative contributions of each channel of communication." The communication system of any individual species is of course directly limited by the evolved sensory equipment, integrative nervous system and behavioral repertoire.

It has been suggested by Kaufmann (1966) that evolution has worked to select those members of a species that respond properly to social signals. Dominance, for example, is largely a matter of social signaling which is not physically exhaustive. It has been shown that some of the most aggressive members of a social group are low in the status hierarchy (Bernstein, 1970). Kaufmann uses the term "biological waste" to describe that aggression which would have been better circumvented by appropriate social signals. Those species members which exhibit excessive "biological waste" are less likely to progenerate. The selected members are most efficacious in using the various social signals to avoid conflict from within the social group and to insure survival from predators. An alarm signal initiated by one member of a colony of primates requires an immediate and appropriate response from all other members. This is quite true for the squirrel monkey, whose social behavior will be described, emphasizing auditory social signals.

Saimiri Society

Saimiri, for reasons of low cost and relatively easy maintenance, have become popular primate subjects in both psychological and medical research. It has been pointed out, however, that investigation is lacking regarding their taxonomy and zoogeography (Cooper, 1968). Cooper has found Saimiri to inhabit the llanos areas (i.e., grassland and river bank forests) occuring around the river drainages of South and Central America. The habitat of Saimiri is not uniform, however, differing both botanically and zoologically. Not only do Saimiri have local variations in color patterns, but it is reasonable to assume that there are local variations in behavior patterns as well (Hill, 1965).

Thorington (1968) has observed Saimiri for 500 hours in a Columbian forest and reported on their social behavior. The Saimiri troop which Thorington observed consisted of three adult males, five adult females and ten juveniles. This troop was actually small in size relative to the others in the surrounding area, but this expedited the matter of field observation.

Thorington found Saimiri to be most active during the early morning and late afternoon, at which times they were engaged in foraging the forest for food. During these foraging bouts, Thorington noted a marked increase in vocalizations. While foraging for fruits and insects, Saimiri would break off into small groups. Individuals often became visually separated from other group members. According to Thorington, the vocal patterns appeared to maintain troop organization and localization during these foraging bouts. It was further noted that vocalizations diminished whenever the troop was in close visual contact (e.g., when congregated together in a high tree just prior to dusk). Any predator, such as the toucan bird, would always elicit immediate and intense vocalizations. These findings on the vocal behavior of Saimiri in a natural habitat have subsequently been corroborated by Baldwin (1971).

Saimiri are one of the most vocal of all the primates. In contrast to many of the other primates, however, *Saimiri* do not visually investigate or manipulate objects often. DuMond (1968) has noted that they show "very little sustained interest in objects that cannot be eaten or are not threatening." In addition, *Saimiri* are one of the few primate species which do not engage in grooming, a social behavior which requires a high degree of visual concentration and hand coordination. The perceptual-behavioral system of *Saimiri* must be taken into consideration in the laboratory. Noble and Thomas (1970), for example, found that *Saimiri* required extensive training to enable them to develop a sufficient visual scanning technique for solving an oddity problem using the Wisconsin General Test Apparatus.

Winter (1968), reviewing *Saimiri* social behavior in a phylogenetic perspective, has concluded that *Saimiri* vocalizations are generally directed to more than one species member, while visual signals are directed to a specific member. Contrasted to Old World primates, *Saimiri* exhibit more variable vocal patterns, although facial gestures are much less important. A notable exception to this generalization is the talapoin monkey, an Old World species whose extensive vocal repertoire has been compared to *Saimiri* (Wolfheim and Rowell, 1972).

Even under laboratory conditions, Saimiri behavior is characterized by rich and lively vocalization (Winter and Ploog, 1967). The auditory patterns apparently serve some social function since an isolated Saimiri will almost immediately cease vocalizing (Winter, Ploog and Latta, 1966). Winter, et al. have attempted to analyze the "meaning" of specific Saimiri vocalizations that have been classified via sound spectrography. Four methods were employed to decipher the "information content" of each vocalization: (1) a defined visual stimulus was presented and the stereotyped vocalization which was elicited was recorded; (2) a audio-taped vocalization was presented and subsequent behavior was recorded; (3) the monkey's motivational state was manipulated (e.g., the animal was food deprived) and subsequent vocal changes were recorded; and (4) vocal behavior was correlated to such factors as age, sex, dominance status, etc.

Winter et al. distinguished 26 different call types in captured Saimiri by means of this spectrographic analysis. The authors chunked the 26 vocalizations into five main groups: (1) peeps; (2) twits; (3) has; (4) arrs; and (5) shrieks.

(1) An isolation peep was emitted whenever a member of the group lost visual contact. Hearing this peep, members of the group would answer with the same vocalization, thus allowing the "lost" member to locate the group acoustically.

Exploring Saimiri emitted peeps regularly, as did juvenile members at play. There was also an alarm peep of such short duration and high frequency that an unprepared observer could have missed noticing it. A potential predator would have a difficult time trying to localize the source of such an alarm vocalization.

(2) Twits, unlike peeps, had a change in their frequency pattern of more than one octave. This was the characteristic vocal pattern emitted during feeding and was elicited by stimuli associated with food. Apparently, twits served to maintain a minimum individual distance between members of the social group. Twits were rarely in evidence when the group was huddling in tactile contact, but were common as a "welcoming announcement" to a member that had been separated from the group.

(3) The group of ha calls had the lowest tonal frequency of any Saimiri vocalization. They were common when new objects or animals were introduced to the group. Dangerous stimuli also tended to elicit this call, which served to warn other members to flee to a higher place. Ha calls had a certain amount of aggressive capacity as well, since they often preceded actual physical assault.

(4) Unlike the first three groups of calls, arr calls possessed no tonal structure, but had a noiselike character. They appeared to have a significant role in inter-group

social relations. Arrs did occur alone, but were more commonly associated with dominance behaviors such as head grasping, food stealing and genital display. Huddling at dusk was often disrupted by arr calls and aggressive behavior. Arrs were usually directed to a specific member of the social group.

(5) The last group of calls outlined by Winter _et al_. was the _shriek_. Shrieks were distinguished from arrs by their longer duration and accentuated loudness. Shrieks reflected the highest degree of excitement in Saimiri. One shriek was found to excite the entire group. They were emitted by an injured animal or by intense fighting, which was often connected with severe biting. Shriek calls and vigorous biting were readily elicited by picking up a feral _Saimiri_ with gloved hands.

When compared to Old World primates such as macaques and baboons, _Saimiri_ behavior appears to be much more influenced by physiological factors contingent on seasonal changes. The vocal patterns of _Saimiri_ have been found to fluctuate with the reproductive season (DuMond, 1968), and some authors have used the term "vocal reflex" to describe _Saimiri_ vocal behavior (Talmage-Riggs, Winter, Ploog and Mayer, 1972). Talmage-Riggs _et al_. deafened four _Saimiri_ which were previously paired with a social partner. The deafened monkeys continued to vocalize appropriately despite the absence of any auditory feedback. Although there was no quality difference in these vocalizations, they tended to be louder than normal. The undeafened monkey of the pair, however, significantly reduced its output of vocalizations. This was probably because the deafened monkey did not respond properly to their emission, instead relying solely on visual social signals. There appeared to be no disruption of normal social behavior in either deafened-undeafened pair and Talmage-Riggs *et al*. concluded that vocalization in *Saimiri* is probably much more important to members unadapted to each other.

A number of other investigators have proceeded to describe and analyze the various social signals of *Saimiri* (Ploog, 1966; Maurus and Pruscha, 1973; Maurus, Hartmann and Kuhlmorgen, 1974). Hopf, Hartmann-Wiesner, Kuhlmorgen and Mayer (1974) have accumulated and defined over 100 separate behavioral "units" in *Saimiri* social communication. (The reader is referred to the extensive bibliography of Hopf, *et al*. for further literature dealing with *Saimiri* social signals.) It is the purpose of this paper to proceed in outlining a laboratory method which allows for the further analysis of *Saimiri* vocalizations used in social communication.

Cooperative Conditioning

As has already been mentioned, field studies have provided a wealth of information about primate social behavior. Unobtrusive field observation is a research method which has merit. At some point, however, experimental manipulation and laboratory control are imperative. Von Frisch (1923), for example, possibly would have been unable to decipher the "language" of the honey bee without engaging in a certain amount of experimental manipulation and hypothesis testing. Ideally, field and laboratory studies should complement one another. Rowell (1967), in discussing primate research, has argued that there is not as sharp a dichotomy between field and laboratory studies as might be anticipated.

There have been a number of notable psychologists who have developed methodologies for investigating primate social behavior in the laboratory (for a review of this literature refer to Miller, 1970). Robert E. Miller, working at the University of Pittsburgh, has been a prominent researcher in the area of primate behavior and has developed the "cooperative conditioning" paradigm. Concentrating specifically on the visual cues which rhesus monkeys (*Macaca mulatta*) employ in social communication, Miller and his colleagues have made significant contributions which could not have been made by field observations alone. Since the present experiment stems from Miller's research, the literature in this area will be adequately reviewed.

In a series of studies (Miller, Murphy and Mirsky, 1955; Murphy, Miller and Mirsky, 1955; Murphy and Miller, 1956), it was found that rhesus monkeys could be conditioned to avoid the sight of a second monkey and that this interanimal conditioning had a significant effect on the monkeys' social dominance status. Within 200 trials, all the Ss had learned to press a bar to avoid shock and remove a second monkey from view. With appropriate training, the avoidance response was not found to generalize to other monkeys. Clearly, these monkeys could visually discriminate between members of their own species.

When a monkey was conditioned to avoid the sight of another monkey, it was found that the social behavior indicative of dominance was altered in both animals (Murphy and Miller, 1956). When a dominant monkey was conditioned to avoid the sight of a submissive monkey, upon later testing it was found that their status ranks were reversed. The formerly dominant monkey, when exposed to the formerly submissive monkey, "cowered in the corner of the testing apparatus and gave the fear grimace display." In this new arrangement of status roles, the formerly submissive monkey became more "confident" in food competition and showed more aggression towards the other monkey. After a period of time, the conditioning of avoidance behavior extinguished and the monkeys reverted to their original dominance rank.

Such data lends cogent support to the hypothesis that social dominance among primates is largely dependent upon the submissive animal's fear expressions (Miller, 1970). It is assumed that fear responses by other monkeys is indicative of a dominant status. The dominant animal perceives these fear expressions. If two monkeys encounter each other and neither expresses fear (as in an initial encounter), aggressive fighting is likely. Upon meeting each other vis-a-vis in subsequent encounters, one monkey will express fear and therefore assume the submissive role. This fear is expressed through facial gestures, body posture and vocalizations. Receiving such social expressions, the dominant monkey needs not reassert its dominance and aggression is circumvented. Without such social signals, primate groups would be in constant aggressive turmoil.

In an attempt to learn more about the way in which rhesus monkeys perceive and interpret the social expressions of other members, Mirsky, Miller and Murphy (1958) performed the following experiment. Monkeys were conditioned to avoid the sight of another monkey (stimulus monkey) and then this avoidance behavior was extinguished. When no avoidance responses were elicited to the sight of the stimulus monkey for three consecutive sessions, both animals were returned to their home cages. No testing was done for three weeks. After this period, the monkeys were placed back into the testing situation and run on four more days of extinction trials. On the succeeding two days, the monkeys were placed into the testing situation as before. The first five seconds of each trial showed the stimulus monkey as normal, but then a shock was administered. The shock was presented only to the stimulus monkey through the grid floor. It was found that even though the viewing monkeys were not shocked, these animals immediately reinstated the bar press response which removed the stimulus monkey from view and terminated the shock in the stimulus compartment. Mirsky *et al*. concluded that the viewing monkey perceived and interpreted the cues afforded by the stimulus monkey being shocked as an aversive event. It is also noteworthy that when rabbits were shocked and exposed as the stimulus animal, no avoidance responding by the monkeys was found. This points out the species-specificity of social expressions in the rhesus monkey.

One major limitation of the method used in the studies thus far cited is that exposure to stimulus expressions are episodic, presented in discreet trials. Social behavior, however, is a dynamic and continuous process. With this consideration in mind, Miller, Banks and Ogawa (1962) developed a laboratory technique known as *cooperative conditioning*. With this method, monkeys are first trained to perform an instrumental response to a conditioned stimulus (CS). The appropriate response can lead to either a reward or avoidance of a shock. After reaching criterion levels of performance, two monkeys are then paired in the testing chamber. One monkey is supplied with the CS only and is known as the _stimulus monkey_. The other monkey is supplied with the response bar only and is known as the _responder monkey_. Since both animals receive parallel reinforcement, it becomes the task of the stimulus monkey to provide the cues to the responder monkey for appropriate bar-pressing. By precise experimental techniques, the social signals expressed by the stimulus monkey can be defined via one sensory modality.

Miller _et al_. (1962) restrained and tested three post-adolescent male rhesus monkeys in a cooperative conditioning paradigm. After each monkey was individually trained to bar-press to a visual CS in order to avoid a shock, test trials were begun. Trials consisted of placing two monkeys in the testing chamber and wiring up the shock electrodes in parallel to both of them. The stimulus monkey was supplied with the CS only; the responder monkey with the response bar only. A wooden screen separated the two animals visually and prevented the responder monkey from seeing the CS. The CS for shock was presented on a variable interval two-minute schedule.

For the pair of monkeys to avoid shock successfully, two social components were needed: (1) the stimulus monkey needed to send an appropriate social signal to the responder monkey during CS onset; and (2) the responder monkey needed to recognize the social signal as a cue to respond. The results from Miller _et al_. showed that the responder monkey learned very quickly to attend to facial gestures or vocal cues, depending upon which were available from the stimulus monkey. In data analysis, these authors used a calculation which estimated the number of chance avoidances and compared this measure to the number of actual avoidances. The _p_ values from session nine to 32 were all significant ($p < .01$) except on two occasions.

In order to limit the social signals used by the pair of monkeys to just one sensory modality, Miller, Banks and Ogawa (1963) incorporated television equipment into their cooperative conditioning procedure. Six male rhesus monkeys were tested in groups of three, each group representing an independent replication of the experiment. All of the animals were first trained to avoid shock by pressing a bar when an auditory CS was presented. Two monkeys were then randomly paired for testing in cooperative avoidance conditioning. The stimulus monkey was placed in an isolation room equipped with a speaker for the presentation of the CS and a television camera. The camera was mounted eight feet in front of the monkey's face. In another isolation room, the responder monkey was supplied with a 21-inch television monitor and a response bar. The television camera was adjusted so that only the face and head of the stimulus monkey were telecasted to the responder monkey. Shock electrodes were wired in parallel so that both animals received simultaneous shock if the bar was not pressed within six seconds of CS onset. A session consisted of 20 randomly sequenced trials.

Miller *et al*. classified the responder monkey's bar-press responses as either intertrial "spontaneous" responses or conditioned responses (CRs). A CR was defined as a bar-press which occurred during an actual six-second CS presentation. It was found that the number of CRs was significantly greater than the number of spontaneous responses per six-second intertrial interval ($p < .001$). In addition, these authors found that an avoidance response was performed in 89 percent of all the trials in cooperative conditioning. This figure was only slightly less than the 94 percent level of shock avoidance responses obtained during individual pre-training when the monkey was supplied with both a CS and a response bar. The results from this experiment confirmed the hypothesis that fear (i.e., the anticipation of shock) can be communicated by facial expressions in the rhesus monkey.

Miller, Banks and Kuwahara (1966) extended the cooperative conditioning paradigm to a situation other than the anticipation of shock. Six adolescent male rhesus monkeys were pretrained individually to make a conditioned response to a red stimulus light in order to obtain a sugar reward. Following this, the monkeys were randomly paired for cooperative conditioning. As in the previous experiment, television equipment was employed to limit the communication from the stimulus monkey to the responder monkey to facial and head gestures only. In addition, electrocardiographs were monitored with both animals.

The results from the cooperative reward conditioning experiment were not as dramatic as those obtained using shock avoidance. Some responder monkeys apparently failed to receive any facial cues from the stimulus monkey which indicated the presence of the CS. This failure to establish communication was apparently the fault of the responder monkey since the stimulus monkey's heart rate during CS onset was comparable to that obtained in individual pretraining. Evidence that the responder monkey did not perceive the stimulus cues came from the inappropriate response patterns and heart rates which were collected. This led Miller *et al.* (1966) to conclude that "it seems clear that communication based on aversive cues is much more universal and powerful among monkeys than is communication based on anticipation of reward."

Although it has been mentioned that the development of social expressions is highly species-specific, it is not a fundamentally innate process. A certain amount of social interaction at an early age is essential for the proper development of social signals. It is well known that rhesus monkeys raised in social isolation for the early part of their lives are inaffective in communicating an affect to other members (Harlow and Harlow, 1965; Mason, 1961). Miller, Caul and Mirsky (1967) compared a group of these socially isolated rhesus monkeys to a group of feral, normally socialized monkeys on performance in cooperative conditioning. It was found that the isolate group and feral group did not differ significantly in instrumental performance or heart rate when tested individually in shock avoidance conditioning. However, when the monkeys were paired in the cooperative conditioning paradigm, the results were dramatic. Isolates were found to make fewer avoidance responses, regardless whether the stimulus monkey was an isolate or a feral. More importantly, the data showed that isolates were almost totally ineffective as stimulus monkeys in communicating an affect. This data corroborates Harlow and Harlow's (1965) conclusion that interaction with group members at an early age is essential for normal social development.

In a review of cooperative conditioning studies and their contribution to the total picture of primate social behavior, Miller (1970) concludes:

> The diversity of approaches is one of the greatest strengths of the scientific study of social communication. The ultimate reference for all experimental studies is still the free-ranging animal in its natural habitat, however, and much more information will be needed regarding normal social behavior under various environmental conditions. Hopefully, parallel investigations in the field, in zoo and laboratory colonies, and in restrictive laboratory experiments will cooperatively and conjointly elucidate the conditions and parameters of primate communication and social interaction. (p. 170)

The approach of the present experiment was basically a comparative one. It has been shown that rhesus monkeys (_Macaca mulatta_) are quite capable of using social signals to express the anticipation of shock in the cooperative conditioning paradigm. It seems likely that this communication of "fear" is possible in other nonhuman species as well. The experimental method used, however, must be fitted to the particular species. With the squirrel monkey (_Saimiri sciureus_), it has already been mentioned that facial gestures appear to play only a minor role in social communication. On the other hand, _Saimiri_ have an elaborate vocal repertoire, which plays an important part in their social organization.

It was the purpose of the present experiment to determine if these vocalizations were sufficient to communicate the anticipation of shock in a cooperative conditioning paradigm.

METHOD

Subjects

The Ss were six female squirrel monkeys (Saimiri sciureus) of undetermined ages, ranging from 525 to 700 grams. They were purchased from a commercial animal importer ten months before the start of the present experiment. Their experimental history included: (1) oddity training on the Wisconsin General Test Apparatus; and (2) intramuscular leg injections of either Metrazol (pentylenetetrazol) or saline solution for 50 consecutive days. The Ss, however, were not used for any experiment for four months before the initiation of the present one. During this "recuperation" period, the Ss were maintained together in a large wire cage in the laboratory, which was equipped with perches and a swing. During the course of the present experiment, the Ss were individually caged and maintained on Purina monkey chow and water ad lib, supplemented with apples, oranges and unsalted sunflower seeds.

Apparatus

Two adjustable restaining chairs of wooden framework were constructed for the Saimiri (Rosenblum, 1968). They were specifically designed to restrict all body movements except for the head and arms. The torso of the monkey was immobilized between a padded back board and a thickly sponged chest plate. The legs were apread apart and fastened to the back board by means of adjustable straps. The chest plate was readily tightened by straps which fastened behind the back board. This apparatus allowed for Saimiri of varying body types and sizes to be restrained within the same chairs.

The standard equipment used consisted of a response bar and stimulus light panel, relay and timing panels, programer, shock generator and counters. The response bar and stimulus panel were firmly mounted 1.5 feet from the floor (thus approximating the eye level of restrained Saimiri). The stimulus panel contained three 0.5 inch diameter lights; one red light between two white lights. These lights operated as a single stimulus unit.

The control apparatus was placed in an isolation room of sufficient distance from the testing room to avoid extraneous cues from interfering. A tape programer was used to present the conditioning stimulus (CS) on a 32-second variable interval schedule. Counters automatically tabulated conditioned responses, total responses and reinforcements.

Pretraining

The initial problem was to get the Ss accustomed to being restrained. This was done by restraining the Ss in pairs for brief periods during the day. The period spent in the restraining chair was extended until two hour durations were reached. All of the Ss logged a minimum of 30 hours in restraint before avoidance training was initiated.

The Ss were always paired during the course of avoidance training so that social vocalizations would tend not to be extinguished within the testing situation. A wooden screen was inserted between the pair of restrained Ss to insure complete visual separation. The stimulus panel and response bar were supplied randomly to one member of the pair. Aluminum shock plates were fastened to the bottom of the feet of this animal. Following a two minute adaptation period, the tape programer was started.

A trial consisted of a 7.5 second interval of light onset followed by a 1.6 ma. shock with a duration of 0.5 seconds. A bar-press during the CS interval terminated the CS and avoided the shock. Shocks could not be avoided merely by keeping the bar in a depressed position. Following 30 trials, the S on the other side of the visual screen was subjected to the same procedure.

After eight sessions (i.e., 240 trials) of avoidance training, an avoidance-escape paradigm was implemented for 90 trials. This was due to the low bar-press rates found in some of the Ss. The general procedure remained congruent with that of avoidance training. The CS, however, was extended to a 15 second interval. If no avoidance response was made during the first 7.5 seconds, the remaining 7.5 seconds of CS was paired with a pulsating 1.0 ma. shock. A response during this interval was recorded as an escape, terminating both the CS and shock.

The last eight sessions represented a reinstatement of the contingencies used in avoidance training as already outlined. A session was increased to 50 trials. One of the Ss died with five sessions remaining. This complication was handled by randomly choosing one of the five remaining Ss to be paired with two animals rather than one. This S therefore, spent more time in restraint, but was not given any more avoidance training than the other Ss. Ss avoiding at least 75 percent of the shocks on the last session of pretraining (i.e., n = 2) were used in the experimental phase.

Experimental phase

The Ss conditioned in shock avoidance to a 75 percent criterion were restrained and paired in the testing room. Two sets of shock plates were wired in series so that the pair received simultaneous and equipotent shocks. One S was designated as the "responder". The responder monkey was positioned within easy reach of the response bar just as in pretraining, but was not supplied with the stimulus panel. Instead, the stimulus panel was relocated to the other side of the visual screen, in full view of the second S or "stimulus" monkey. The tape programer used in pretraining was again used in this phase; trials were identical to avoidance pretraining. The responder and stimulus monkeys remained in cooperative avoidance conditioning for 12 sessions, a session consisting of 25 trials.

RESULTS

Of the five Ss completing all 18 sessions of avoidance training, three failed to reach the 75 percent criterion by the last session and were therefore not used in cooperative avoidance conditioning. S10, S20 and S50 never avoided more than 34 percent of the shocks in any session of pretraining. In contrast, avoidance levels over the last three sessions of pretraining for S30 were 98, 74 and 84 percent; and for S40 they were 54, 42 and 76 percent.

The number of avoidances by S30 and S40 during each session was not an adequate index of the level of avoidance conditioning, however. It was certainly possible that a high response rate would lead to a number of "blind" avoidances just by chance alone. Instead, it was essential to analyze the data in a manner which would allow for determining the relative effect of the CS on the Ss bar-pressing behavior. For this, Miller, Banks and Ogawa (1963) have provided a method in which responses are classified as either (1) inter-trial "spontaneous" responses (SRs), or (2) conditioned responses (CRs) occurring during CS presentation. Any response which occurred within 7.5 seconds of CS onset was classified as a CR. All other responses were recorded as SRs.

It was found that the rate of CRs recorded from S30 and S40 over the last three sessions of pretraining exceeded the rate of SRs. A repeated measures analysis of variance was performed and the difference in rates was found to be significant ($p < .01$). With only S30 (responder monkey) bar-pressing during cooperative conditioning, no statistical test was performed with the data. Figure 1 illustrates the difference in CR and SR rates in late pretraining and cooperative conditioning. Also illustrated is the number of responses recorded during late pretraining and cooperative conditioning for S30 (see Figure 2).

The data obtained from the cooperative conditioning phase is expressed numerically in Table 1. The values found in the "estimated chance avoidances" column were calculated by dividing the number of responses occurring in the absence of the CS by 82. The divisor was derived by dividing the total intertrial time (i.e., 615 sec.) into 7.5 second intervals. This calculation gave the number of spontaneous responses expected during each 7.5 second interval when the CS was not present. The number of avoidances which could be expected to occur by chance alone was estimated by multiplying the number of spontaneous responses per 7.5 second interval by the number of 7.5 second intervals in which a CS was present; i.e., 25.

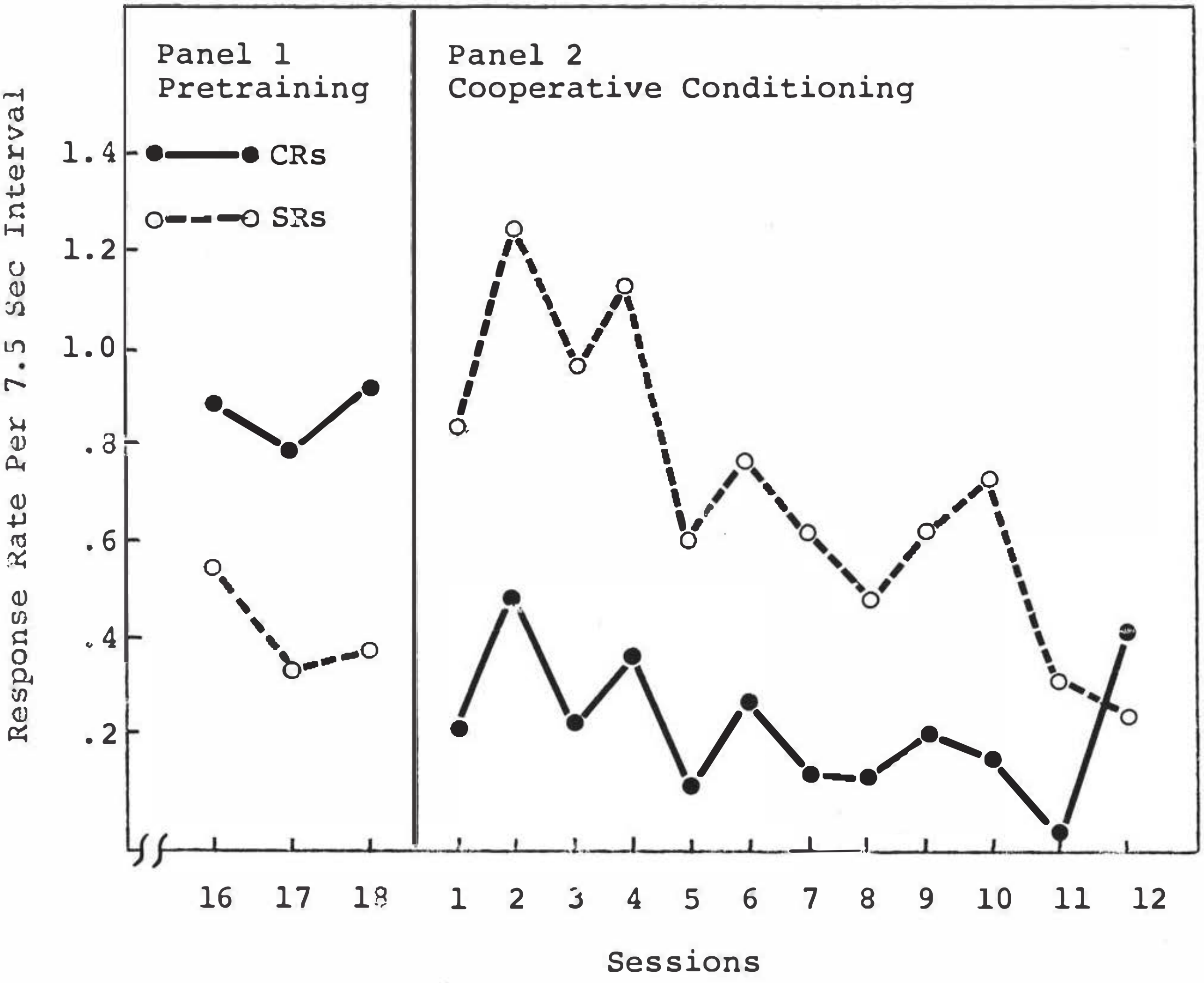

Figure 1

A comparison of the rate of conditioned responses (CRs) made during the 7.5 second CS intervals and spontaneous responses (SRs) made outside the CS intervals in late pretraining and cooperative conditioning.

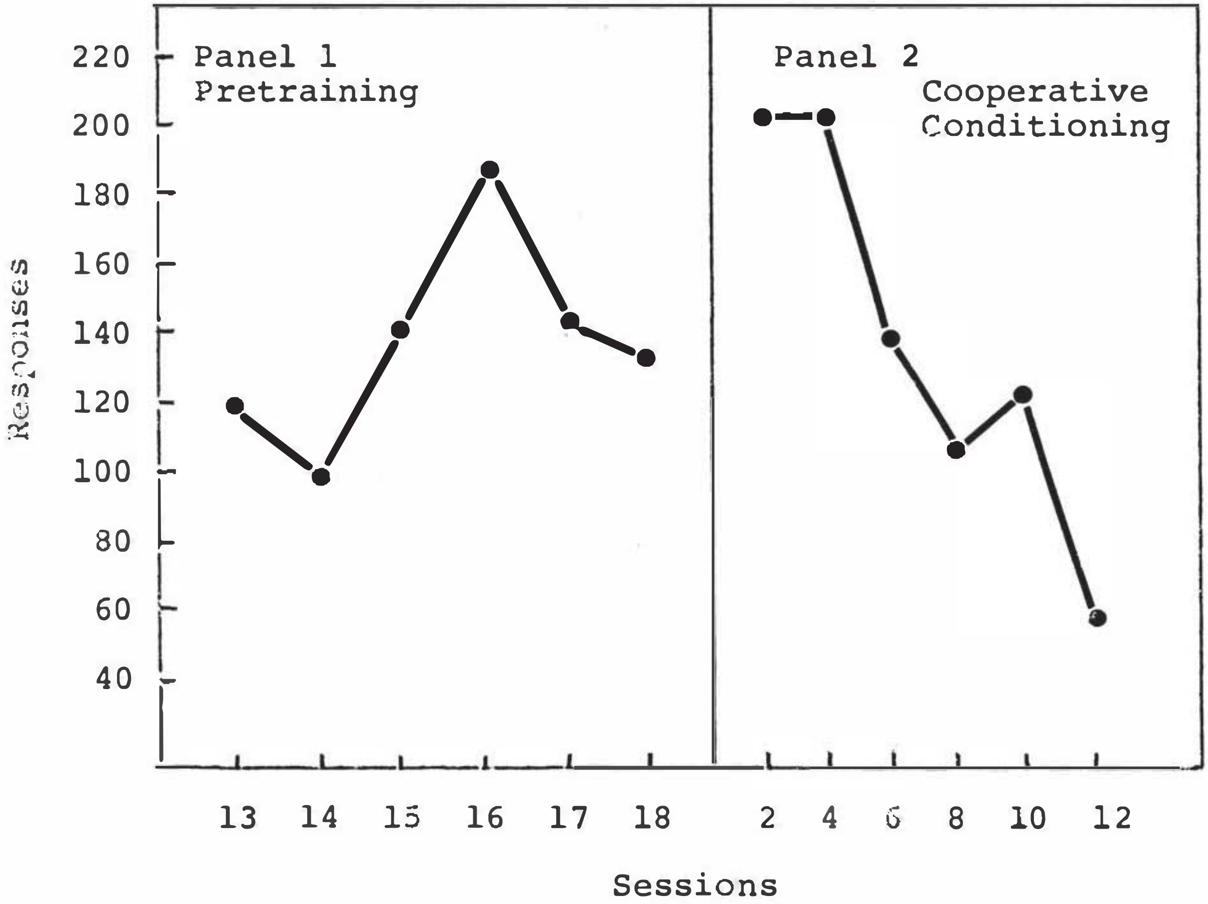

Figure 2

The responder monkey's (S 30) bar-pressing pattern across the end of pretraining and in cooperative conditioning. In cooperative conditioning, the number of responses from two sessions were summed since the number of trials per session was one-half of that in pretraining.

Table 1. Data from responder monkey (S30) in cooperative conditioning. (See text for derivation of estimated chance avoidances.)

Session	CRs	Total Responses	Actual Avoidances	Estimated Chance Avoidances
1	10	80	6	21.3
2	24	124	14	25.0
3	9	90	7	24.7
4	18	111	11	25.0
5	6	59	5	16.2
6	15	80	7	19.8
7	7	58	6	15.4
8	7	49	5	12.8
9	12	61	10	14.9
10	8	64	5	17.0
11	1	29	1	8.5
12	12	36	8	7.3

DISCUSSION

The data obtained from S30 and S40 indicate that *Saimiri* are capable of learning the particular shock avoidance task as outlined in the methods. This finding is not surprising since it had previously been shown that *Saimiri* response rates obtained in avoidance tasks are directly comparable to the rates found with rhesus monkeys and chimpanzees, particularly in Sidman avoidance situations (Kelleher, 1965).

The failure to establish avoidance conditioning to a 75 percent criterion in S10, S20 and S50, however, severely restricted the power of the experimental design. The implementation of a cooperative conditioning paradigm (experimental phase) depended on the successful conditioning of an effective avoidance response in pretraining. Once this was accomplished, then the auditory components of the fear reaction could be used in cooperative conditioning to avoid shock, as had been hypothesized.

The fact that three Ss did not learn the avoidance task is a matter which cannot be dismissed lightly. The previous studies dealing with the cooperative conditioning paradigm have used rhesus monkeys as subjects and obtained generally a higher level of performance in avoidance training. The six rhesus monkeys used by Miller, Banks and Ogawa (1963), for example, all performed at a 90 percent avoidance criterion within 240 trials. Beside the obvious difference in species, the present experiment used a restrainment technique which had not been used in previous investigations. <u>Saimiri</u> were not maintained in restraining chairs throughout the duration of the present experiment as had been the case with rhesus monkeys (Miller, Banks and Ogawa, 1962; Miller, Banks and Ogawa, 1963; Miller, Banks and Kuwahara, 1966). With the use of continuous restraint, begun a minimum of four days before avoidance training, the rhesus monkeys were allowed to habituate to the rather restrictive environment. On the other hand, the <u>Saimiri</u> used in the present experiment were handled daily by the <u>E</u> and maintained in the restraining equipment only during actual testing sessions. This procedure may have had a disruptive effect on avoidance training.

It was observed that restraint brought about the development of some rather idiosyncratic behaviors. <u>S</u>10 developed a persistent habit of facing up toward the ceiling of the testing room and rolling back the eyeballs. In addition, a self-mutilative behavior (i.e., finger nail biting severe enough to cause bleeding) was elicited regularly by restraint in <u>S</u>20 and, to a lesser degree, in <u>S</u>40. These behaviors, which were not consistent with learning the avoidance task, may have been eliminated by using a continuous restraint procedure.

The results obtained from the experimental phase of the procedure do not support the efficacy of cooperative conditioning as a reliable research tool in the investigation of Saimiri vocal communication. It is clearly demonstrated that the stimulus monkey (S40) and responder monkey (S30) were unable to mutually avoid the shock stimulus. After 300 trials, the pair of Ss was avoiding shock only within chance expectations. Previous studies with rhesus monkeys had found that "fear" of a light CS could be expressed through auditory cues (Miller, Banks and Ogawa, 1962) and visual cues (Miller, Banks and Ogawa, 1963) in cooperative conditioning. Further work is required to determine if this discrepancy in results is due to species differences or to some other experimental parameter(s).

The number of responses by S30 across the sessions of cooperative conditioning suggest that the bar-press operant was extinguishing. It is not possible to determine if this was due to the responder or stimulus monkey. The two monkeys had different tasks to learn and the performance of one was directly dependent on the performance of the other; (1) the stimulus monkey had to learn to make some discriminative audition (i.e., conditioned response) in the presence of the light CS; and (2) the responder monkey had to learn to use this auditory cue as the discriminative stimulus for responding. The shock acted on both behaviors simultaneously.

Because only one dependent variable was measured (i.e., number of mutual avoidances), the performance of each monkey in their individual tasks was not directly accessible for analysis. In statistical terms, the pair of monkeys was viewed as a single behaving organism. Indeed, the pattern of bar-presses which would have been recorded had cooperative conditioning been successful would have been as much due to the stimulus monkey's behavior as to the actual bar-press of the responder.

Further research is needed in order to determine the experimental parameters which might allow for successful performance in cooperative avoidance conditioning using Saimiri. The use of only one pair of animals had obvious limitations which need not be discussed formally. In addition, the Ss pre-experimental history (e.g., Metrazol injections) may have been a source of confounding.

Captured Saimiri indeed have a social communication system in which the vocal repertoire assumes an important role (Talmage-Riggs, Winter, Ploog and Mayer, 1972; Winter, 1968; Winter and Ploog, 1967; Winter, Ploog and Latta, 1966). This behavior is readily observable. It becomes another matter, however, to refine an experimental design like cooperative conditioning which would allow for its manipulation.

REFERENCES

Altmann, S. A. Social communication among primates. Chicago: University of Chicago Press, 1966.

Baldwin, J. D. The social organization of a semifree-ranging troop of squirrel monkeys (Saimiri sciureus). Folia Primatologica, 1971, 14, 23-50.

Bernstein, I. S. Primate status hierarchies. In L. A. Rosenblum (Ed.) Primate behavior: Developments in field and laboratory research. New York: Academic Press, 1970.

Carpenter, C. R. A field study of the behavior and social relations of howling monkeys. Comparative Psychology Monograph, 1934, 10 (2), 171-180. Cited from S. A. Altmann (Ed.) Social communication among primates. Chicago: University of Chicago Press, 1966.

Carpenter, C. R. Societies of monkeys and apes. Biological Symposia, 1942, 8, 177-204.

Cooper, R. W. The taxonomy and supply of the squirrel monkey. In L. A. Rosenblum & R. W. Cooper (Eds.) The squirrel monkey. New York: Academic Press, 1968.

Du Mond, F. V. The squirrel monkey in a seminatural environment. In L. A. Rosenblum & R. W. Cooper (Eds.) The squirrel monkey. New York: Academic Press, 1968.

Harlow, H. F. & Harlow, M. K. Effects of various mother-infant relationships on rhesus monkey behaviors. In B. M. Foss (Ed.) Determinants of infant behaviour. London: Methuen, 1965.

Hill, W. C. Tentative identification of laboratory squirrel monkeys (*Saimiri*). *Laboratory Primate Newsletter*, 1965, 4 (3), 1-4. Cited from L. A. Rosenblum & R. W. Cooper (Eds.) *The squirrel monkey*. New York: Academic Press, 1968.

Hopf, S., Hartmann-Wiesner, E., Kuhlmorgen, B. and Mayer, S. The behavioral repertoire of the squirrel monkey (*Saimiri*). *Folia Primatologica*, 1974, 21, 225-249.

Kaufmann, J. H. Social relations of adult males in a free-ranging band of rhesus monkeys. In S. A. Altmann (Ed.) *Social communication among primates*. Chicago: University of Chicago Press, 1966.

Kelleher, R. T. Operant conditioning. In A. M. Schrier, H. F. Harlow & F. Stollnitz (Eds.) *Behavior of nonhuman primates: Modern research trends*. New York: Academic Press, 1965.

Mason, W. A. The effects of social restriction on the behavior of rhesus monkeys: Tests of gregariousness. *Journal of Comparative and Physiological Psychology*, 1961, 54, 287-290.

Maurus, M., Hartmann, E. & Kuhlmorgen, B. Invariant quantities in communication processes of squirrel monkeys. Primates, 1974, 15 (2-3), 179-192.

Maurus, M. & Pruscha, H. Classification of social signals in squirrel monkeys by means of cluster analysis. Behaviour, 1973, 47 (1-2), 106-128.

Miller, R. E. Experimental studies of communication in the monkey. In L. A. Rosenblum (Ed.) Primate behavior: Developments in field and laboratory research. New York: Academic Press, 1970.

Miller, R. E., Banks, J. H. & Kuwahara, H. The communication of affects in monkeys: Cooperative reward conditioning. Journal of Genetic Psychology, 1966, 108, 121-134.

Miller, R. E., Banks, J. H. & Ogawa, N. Communication of affect in "cooperative conditioning" of rhesus monkeys. Journal of Abnormal and Social Psychology, 1962, 64, 343-348.

Miller, R. E., Banks, J. H. & Ogawa, N. The role of facial expression in "cooperative avoidance" conditioning of monkeys. Journal of Abnormal and Social Psychology, 1963, 67, 24-30.

Miller, R. E., Caul, W. F. & Mirsky, I. A. The communication of affects between feral and socially isolated monkeys. Journal of Personality and Social Psychology, 1967, 7, 231-239.

Miller, R. E., Murphy, J. V. & Mirsky, I. A. The modification of social dominance in a group of monkeys by inter-animal conditioning. Journal of Comparative and Physiological Psychology, 1955, 48, 392-396.

Mirsky, I. A., Miller, R. E. & Murphy, J. V. The communication of affect in rhesus monkeys: An experimental method. Journal of the Psychoanalytic Association, 1958, 6, 433-441.

Murphy, J. V. & Miller, R. E. The manipulation of dominance of monkeys with conditioned fear. Journal of Abnormal and Social Psychology, 1956, 53, 244-248.

Murphy, J. V., Miller, R. E. & Mirsky, I. A. Inter-animal conditioning in the monkey. Journal of Comparative and Physiological Psychology, 1955, 48, 211-214.

Nissen, N. W. A field study of the chimpanzee. Comparative Psychology Monograph, 1931, 8 (1), 1-122. Cited from S. A. Altmann (Ed.) Social communication among primates. Chicago: University of Chicago Press, 1966.

Noble, C. S. & Thomas, R. K. Oddity learning in the squirrel monkey. Psychonomic Science, 1970, 19 (5), 305-307.

Ploog, D. W. The behavior of squirrel monkeys (Saimiri sciureus) as revealed by sociometry, bioacoustics, and brain stimulation. In S. A. Altmann (Ed.) Social communication among primates. Chicago: University of Chicago Press, 1966.

Rosenblum, L. A. & Cooper, R. W. (Eds.) The squirrel monkey. New York: Academic Press, 1968.

Rowell, T. E. Variability in the social organization of primates. In D. Morris (Ed.) Primate ethology. London: Weidenfeld and Nicolson, 1967.

Sebeok, T. A. Animal communication. Science, 1965, 147, 1006-1014.

Southwick, C. H. (Ed.) Primate social behavior. New York: Van Nostrand Reinhold, 1963.

Talmage-Riggs, G., Winter, P., Ploog, D. & Mayer, W. Effect of deafening on the vocal behavior of the squirrel monkey. Folia Primatologica, 1972, 17 (5), 404-420.

Thorington, W. T. Observations of squirrel monkeys in a Columbian forest. In L. A. Rosenblum & R. W. Cooper (Eds.) The squirrel monkey. New York: Academic Press, 1968.

von Frisch, K. Uber die "sprache" der bienein. Cited from L. A. Rosenblum (Ed.) Primate behavior: Developments in field and laboratory research. New York: Academic Press, 1971.

Washburne, S. L. & De Vore, I. The social life of baboons. Scientific American, 1961, 85 (6), 29-37.

Winter, P. Social communication in the squirrel monkey. In L. A. Rosenblum & R. W. Cooper (Eds.) The squirrel monkey. New York: Academic Press, 1968.

Winter, P. & Ploog, D. Social organization and communication of squirrel monkeys in captivity. In D. Starck, R. Schneider & H. J. Kuhn (Eds.) Progress in primatology. Stuttgart: Fischer, 1967.

Winter, P., Ploog, D. & Latta, J. Vocal repertoire of the squirrel monkey (Saimiri sciureus), its analysis and significance. Experimental Brain Research, 1966, 1, 359-384.

Wolfheim, J. H. & Rowell, T. E. Communication among captive talapoin monkeys (Miopithecus talapoin). Folia Primatologica, 1972, 18, 224-255.

Zuckerman, S. The social life of monkeys and apes. London: Kegan Paul, 1932.