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AN EXPERIMENTAL SOCIAL RELATION BETWEEN TWO MONKEYS[1]

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A technique was developed for studying the reinforcement of one organism by another. Two pairs of monkeys served as subjects in adjoining but separate lever-pressing chambers. However, they were in visual, aural, and tactile contact with each other. After both pairs were trained to tolerate delays of reinforcement and one pair was trained under stimulus control to exchange reinforcements, monkey A of each pair pressed a lever to feed monkey B, and monkey B pressed to feed monkey A. The experiment sought to determine if this social interaction could be maintained. With a free responding procedure where the monkeys could work at any time in any order, the social relation proved unstable. After several oscillations in which one monkey did most of the responding and the other monkey did most of the eating, the reinforcement frequency for both pairs of animals decreased to very low levels. The final outcome would have been starvation had the experimenter not intervened.

This research was concerned with a basic social interaction—the reinforcement of one organism by another. The aim was to develop a technique for studying this interaction in the laboratory under clearly defined circumstances. The technique was arranged to permit some aspects of a controlled laboratory environment and some aspects of naturalistic observations. The advantages sought were a setting where naturalistic social phenomena could be studied, where the social behavior could be submitted to an experimental analysis, where the behavior could be observed objectively, and where a record of the entire development of the social interaction could be obtained.

Laboratory studies with similar objectives have been described. Baron and Littman (1961), following an unpublished demonstration by O. H. Mowrer, put a pair of rats in a box with a lever at one end and a food pellet dispenser at the other end. The problem was that when one rat pressed the lever and produced a pellet, the other rat, waiting at the other end of the box, ate the food. In eight out of nine pairs the response rates of both rats declined to low levels after 10-20 sessions. However, one pair developed a worker-"parasite" relation where one rat did all of the lever-pressing. The authors explained this pattern by noting that the worker rat often pressed many times in rapid succession to produce a pile of food pellets. Then, the worker ate a portion of the pellets before the parasite could consume them.

Other related studies have dealt with "altruistic" behavior in animals. Rice and Gainer (1962) described a situation in which one animal would relieve another animal's "distress". The distress was produced by suspending a rat from the floor in a harness. It was found that a second rat would press a lever to lower the suspended and squealing rat to the floor. In another experiment on "altruism" in animals, Massermann, Wechkin, and Terris (1964) arranged that a rhesus monkey would be reinforced with food for pulling a chain in either of two stimulus lights. However, a second monkey would be shocked after a chain pull in one of the lights. Twelve out of 15 experimental monkeys decreased chain pulling in the stimulus where the response produced food plus shock-to-the-other-monkey. Using humans as subjects, social interactions have often been explored in the laboratory. Human studies especially relevant to the present research were published by Azrin and Lindsley (1956), Sidowski, Wyckoff, and Tabory (1956), and Lindsley (1963).

For the present experiment a laboratory

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technique was devised to study a situation in which two monkeys reinforce each other (*i.e.*, the interreinforcement process). The monkeys were placed in adjoining chambers with only an open grill between them. The social interaction of interest required the operation of levers. Each monkey's chamber contained a lever and a food pellet dispenser. Unlike the usual experimental arrangement, however, when monkey A pressed its lever, monkey B's pellet dispenser operated; and when monkey B pressed its lever, monkey A's pellet dispenser operated. Within this context lay a basic problem: could a stable social relationship be established and maintained under these conditions? More specifically, how could the two monkeys be trained to feed each other? Then, if they could be so trained, would they continue to give each other an adequate diet when the special training conditions were removed?

METHOD

Subjects

Four stumptail macaque monkeys (*Macaca speciosa*) were divided into two pairs. Both members of the first pair (Si and Al) were males, while the second pair included one male (Fib) and one female (Moll).

Apparatus

Each monkey was housed 24 hr a day in an operant conditioning chamber (Foringer and Co.) with grills on the floor and one side. On one wall were three levers, a food pellet dispenser (for .8 g Dietrich and Gambrill pellets), and a water dispenser. When the lever farthest from the front grill was pressed 11 times, about 8 ml of water was released into a tube which the monkey could suck. The front lever was unused in this experiment. The center lever operated the pellet dispenser in the other monkey's chamber. A small projector (Industrial Electronic Engineers, Inc.) above the center lever was used to present visual stimuli.

The two chambers for each pair of monkeys could be pushed together so that the grills were separated by less than 1 in., thus creating many possibilities for social interaction. For example, grooming could easily take place. They could also hear the pellet dispensers, see the other monkey eat, hear the rattle of the levers, *etc.* The grill prevented such interactions as copulation and fighting.

The experimental procedures were programmed by relay equipment. A "white" masking noise prevented the monkeys from being disturbed by relay clicks or extraneous sounds.

Procedure

The first goal was to train each pair of monkeys to reinforce each other with food. The following methods were devised. The monkeys were first trained individually to press the center lever by reinforcing each response with a food pellet. Then, to permit them to tolerate the delays of reinforcement likely to occur when the two monkeys were placed together, the individual monkeys were taught to press a lever and then to wait a period of time until the pellet was delivered.

With the first pair (Si and Al), red and white stimulus lights were used to facilitate training. If the monkey pressed the lever when the white light was on, the red light replaced it. Then, after a delay, a pellet was delivered. The delay was first set at 0.5 sec and was gradually lengthened to 30 sec over 11 daily sessions. Any lever press in the red light extended the delay period. When the final performance was established, the white light came on, serving as an S^D for lever pressing; if the monkey pressed its lever, then the red light came on, serving as an immediate conditioned reinforcement; and, after a variable delay ranging from 1 to 30 sec, the pellet was delivered in the presence of the red light. This procedure employed a technique for maintaining behavior with prolonged delays of reinforcement described by Ferster (1953), Azzi, Fix, Keller, and Rocha e Silva (1964), and Ferster and Hammer (1965).

The next step was to train the animals to reinforce each other. Two monkeys were placed in adjacent cages with each monkey's lever arranged to operate the other's pellet dispenser. In Si's cage the white light was on, and in Al's cage the red light was on. When Si pressed the lever, Al received a pellet in the presence of a red light. Immediately Si's light turned red and Al's white. When Al pressed, Si received a pellet and so on. Note that the stimulus conditions and response requirements in the social situation were consistent with the individual pre-training situation. The procedure was successful in

that the monkeys responded quickly during the first session they were together and within 1 hr had fed each other a normal daily ration. By the nature of the procedure the monkeys were alternating food reinforcements on a one-for-one, *quid pro quo* basis.

Several refinements were added to this basic alternation procedure. (1) If one monkey tried to press its lever "out of turn" in the red light, then the stimulus lights and the house lights were turned off for both monkeys and no reinforcements were delivered. This time out condition lasted for 5 sec. (2) The schedule of reinforcement was changed gradually in steps from continuous reinforcement to a fixed ratio of 32 (FR 32), *i.e.*, each monkey had to press its lever 32 times to operate the other monkey's pellet dispenser. (3) The final step was to replace the alternating red and white lights with a steady, unchanging blue triangle. The blue triangle came on when the session began and remained until each monkey had received its daily ration of 70 pellets. The monkeys' cages were together continuously even though the food session was not in effect.

The second pair of monkeys (Fib and Moll) was pre-trained in a different way. The experimental work was based upon the same principles used with the first pair, but several details were changed. Although the delay-of-reinforcement training of the individual monkeys was programmed the same way, the alternating red and white lights were not used. The steady blue triangle was on throughout the delay-of-reinforcement training and served as a "session-on" signal. The alternation procedure was not used. After training on variable delay of reinforcement, the two monkeys were placed side-by-side in the social situation and permitted to reinforce each other on the free responding procedure described below. They remained on a continuous reinforcement schedule throughout.

As described in the Results section, the training procedure established the desired behavior: both pairs of monkeys fed each other. This was particularly clear for the first pair (Si and Al) since they fed each other stably on the alternation procedure from session 28 through session 83. The final phase of the experiment determined if the monkeys would reliably feed each other when no restrictions were imposed by the experimenter. For both pairs a free responding procedure was arranged so that the monkeys of a pair could reinforce each other in any order at any time. With Si and Al, 32 lever presses were required; with Fib and Moll only one. Otherwise, no restrictions were imposed. The number of sessions devoted to each phase of the experiment are shown in Fig. 2 and 7.

With Si and Al, a daily session was continued until 140 pellets had been divided

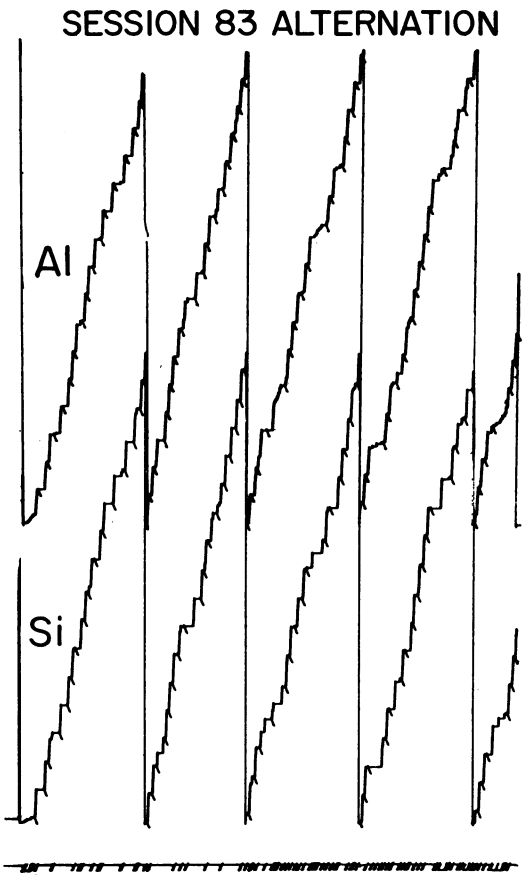

Fig. 1. Final performance established by the alternation procedure. Two cumulative recorders with the same paper speed registered the lever-pressing behavior and the reinforcements for each monkey. For example, the upper record shows Al's lever-pressing and food reinforcements—although the food pellets were produced by Si's behavior. The figure was constructed by making triangular cuts in the records and pushing them together for close comparison. To illustrate from the beginning of the above records, Al made the first run of 32 responses, as shown by the first upward excursion of the pen; the first pellet was thereby delivered to Si, as indicated by the first pip on Si's record. Both pens reset to the baseline at the same time so that the two records could be easily lined up. The time covered by the records shown above was 45 min. The maximum excursion of the pen from baseline to reset point was 540 responses.

between the two monkeys. After the session, each monkey was given an orange. With Fib and Moll, the session continued until one monkey received approximately 70 pellets. Then the other was hand fed enough additional pellets to make a total of 70 for the day. These monkeys were also given an orange after the session.

RESULTS

The cumulative records in Fig. 1 show the final performance established in Si and Al by the alternation procedure. The monkeys responded quite rapidly and delivered to each other their daily food ration in less than 1 hr. The run of 32 responses usually occurred without pausing, and each monkey typically stopped responding immediately after the pellet was delivered to the other monkey. For this reason the pause preceded the reinforcement marked in Fig. 1. With the alternation procedure, behavior was stable from session to session, the fixed ratio characteristics were well maintained, and the general performance would presumably have been maintained indefinitely. In summary, Fig. 1 shows that the first objective of the experiment had been realized. The technique was effective in training and maintaining the social relation of interreinforcement. Although knowledge of the procedure makes clear how each monkey was individually controlled, an outside observer might note only that the monkeys worked to give food to each other.

Figure 2 shows for Si and Al the session-by-session course of the experiment. The first four points (sessions 80-83) illustrate the final high rates of responding generated by the alternation behavior. Rates of 100-140 responses per min were common. On session 84 the alternation requirement was discontinued, and the free responding procedure began whereby each monkey could press its lever and deliver pellets to the other monkey in any order at any time. Although the rates appear to be lower in session 84 than before the procedural change, the change is largely due to the method of calculation. With the alternation technique the denominator used in calculating the response rate was only the time that one monkey was actually "on" and

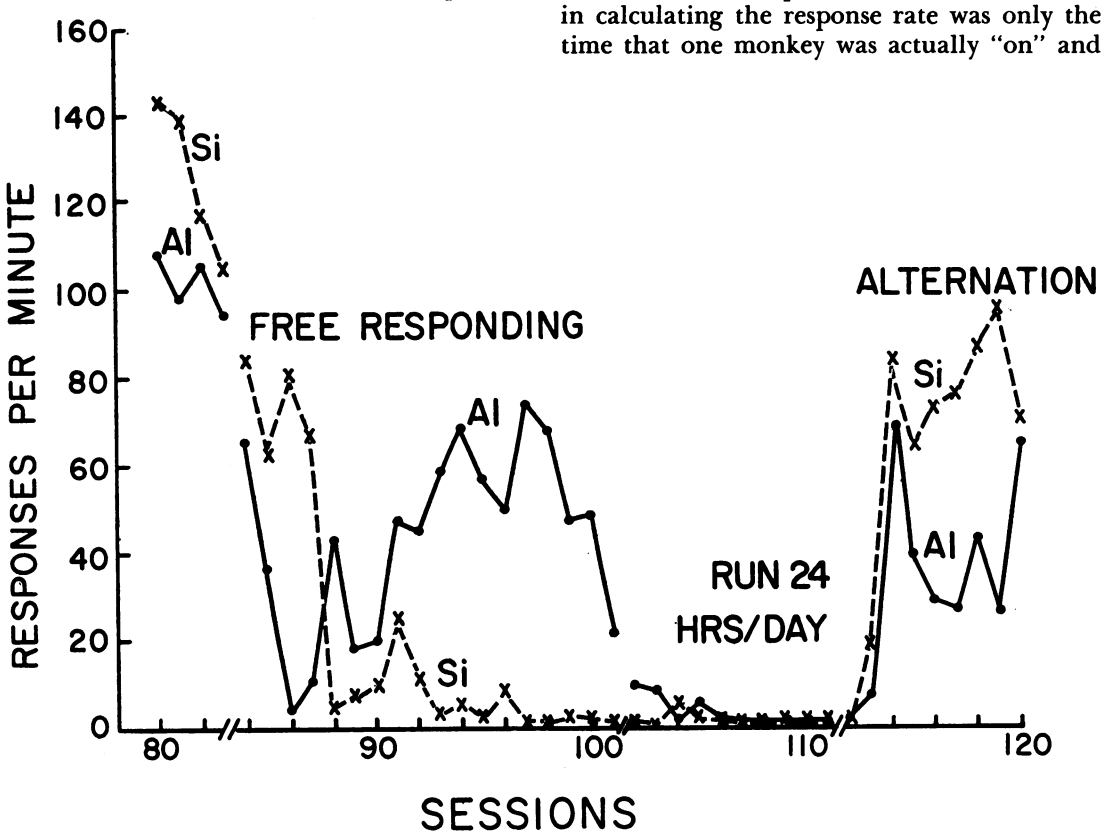

Fig. 2. Changes in response rate during the course of the experiment for Si and Al.

due to respond (about half the session), but with the free responding procedure, the denominator had to be the total session time. Thus, the rates under free responding should be roughly doubled to compare them directly with the rates under alternation.

Both monkeys maintained relatively high rates the first two sessions (84 and 85) under the free responding procedure. By session 86, however, Al's rate had dropped very low. Figure 3 (cumulative records of session 85) shows how the transition took place. At the beginning of this session (as during the entire first session) both monkeys responded rapidly (sometimes simultaneously) so that they received a similar number of pellets. At the end of the session, however, an important change took place. At approximately the fourth reset of the recorder in Fig. 3, Al stopped responding and Si continued. The result was that Al received a number of reinforcements for sitting and not responding. The seeds of social instability had been sown.

This pattern continued through session 86 and most of session 87 and accounts for the low rate shown for Al and the high rate shown for Si in Fig. 2. As illustrated in Fig. 4 (cumulative records for session 87), Si did most of the responding while Al did most of the eating. By the sixth excursion of the pen (see Fig. 4), Si had made more than 3000 lever presses but had received only two reinforcements from Al. A short time later (before the seventh pen excursion), Si began to pause for long periods—a behavioral consequence which probably resulted from the large amount of responding and the small amount of reinforcement. A second consequence of Si's pausing was that the reinforcement frequency for Al dropped. At this point Al's rate increased sharply while Si sat and received a number of pellets. While the reason for the sharp change in Al's behavior is not definitely known, Al's extensive past history with the alternation procedure was probably involved. With that procedure, the reinforcement frequency was increased by responding, since after one monkey emitted a run of responses, it usually received a pellet back from the other monkey.

Although Si had been the higher responder before session 88, Al became the higher responder afterwards. As shown in Fig. 2, Al's rate increased gradually and reached a maximum on session 97. Since Al received only a small proportion of the 140 food pellets allotted to each daily session, the increased responding may have been due in part to increased food deprivation. However, the results with the other two monkeys (and later work with these monkeys) where deprivation was held constant indicated that increased deprivation was not an essential variable for

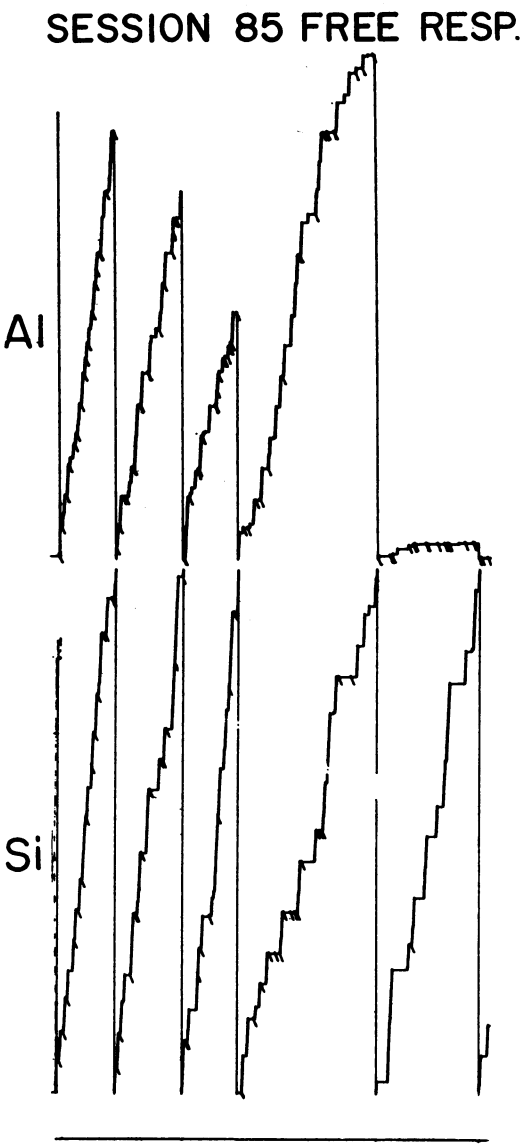

Fig. 3. Cumulative records of session 85, the second session of the free responding procedure. The upper record shows the transition point at which the response rate for Al decreased sharply. (Time of the above records: 44.9 min; response scale: 540 responses maximum excursion from baseline to reset point.)

this type of result. A picture of representative cumulative records for this period is shown in Fig. 5. Al's overall high rate was formed of runs of 32 responses followed by brief pauses. The termination of the run and the initiation of the pause coincided with the click of Si's pellet dispenser and the delivery of the pellet. Si's pattern was usually the same. This performance pattern indicates that each monkey was influenced by the delivery of food to the other.

After session 97, Al's response rate decreased steadily, an effect which would seem to follow from the low rate of reinforcement. From sessions 97-101 Al made more than 4000 responses per session but received an average of only five pellets. At the same time Si's rate remained at its usual low level. The probable reason is not hard to find. Si was receiving an average of 135 pellets per session, the bulk of which were delivered when he was not responding. Thus, Si was frequently reinforced for not responding.

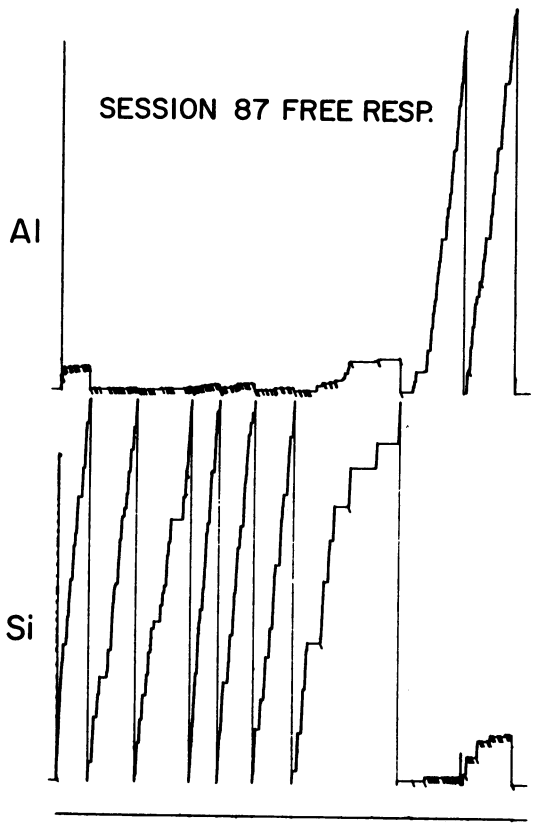

Fig. 4. Cumulative records of session 87, the fourth session of the free responding procedure. The end of this session shows how Si's rate dropped and Al's rate increased. (Time of the records: 57.4 min; response scale: 540 responses maximum pen excursion.)

The normal course of the experiment was changed from sessions 102-106 to modify the monkeys' deprivation levels. Si, who had previously received excessive feeding, was allowed to receive no more than a normal daily ration by terminating the session when he received 70 pellets; then Al, who was excessively deprived, was given supplemental feeding after the session so that he also received a total of 70 pellets per day. As may be seen in Fig. 2, this deprivation change had no apparent effect on the results. Except for the usual orange, the post-session feeding was then discontinued after session 106.

By session 107, the monkeys were responding at such low rates that the daily sessions were allowed to run for 24 hr. Even then, the rates were so low that neither monkey received enough pellets for a maintenance diet. On session 111, the final 24 hr of the free responding procedure, Si received 29 pellets and Al received 8.

The state of the behavior is illustrated in Fig. 6, showing the beginning of session 108. Only a few responses were emitted by Al and none by Si. Following the time shown in Fig. 6, many hours passed with few or no responses by either monkey. It was apparent that the interreinforcement relationship had deteriorated to a very low level, and the likely final consequence was that both animals would eventually starve to death.

At this point, due to concern for the monkeys' health, the procedure was changed back to the alternation requirement. The change was without effect the first session (see session 112 in Fig. 2) so that Si received 11 pellets and Al 12 pellets during the 24 hr session. By the third session (session 113), however, the behavior of both monkeys had recovered so successfully that each received 70 pellets within 59 min. The continued high rates of performance confirmed the previous observation that the alternation procedure provided a stable and reliable support for the social relation.[2]

[2]Since this study was completed, further experimental work has added to the interpretation of this relation as "social". For example, the performance drops to quite low rates when a door is closed between the two monkeys or when one monkey is temporarily removed from its chamber.

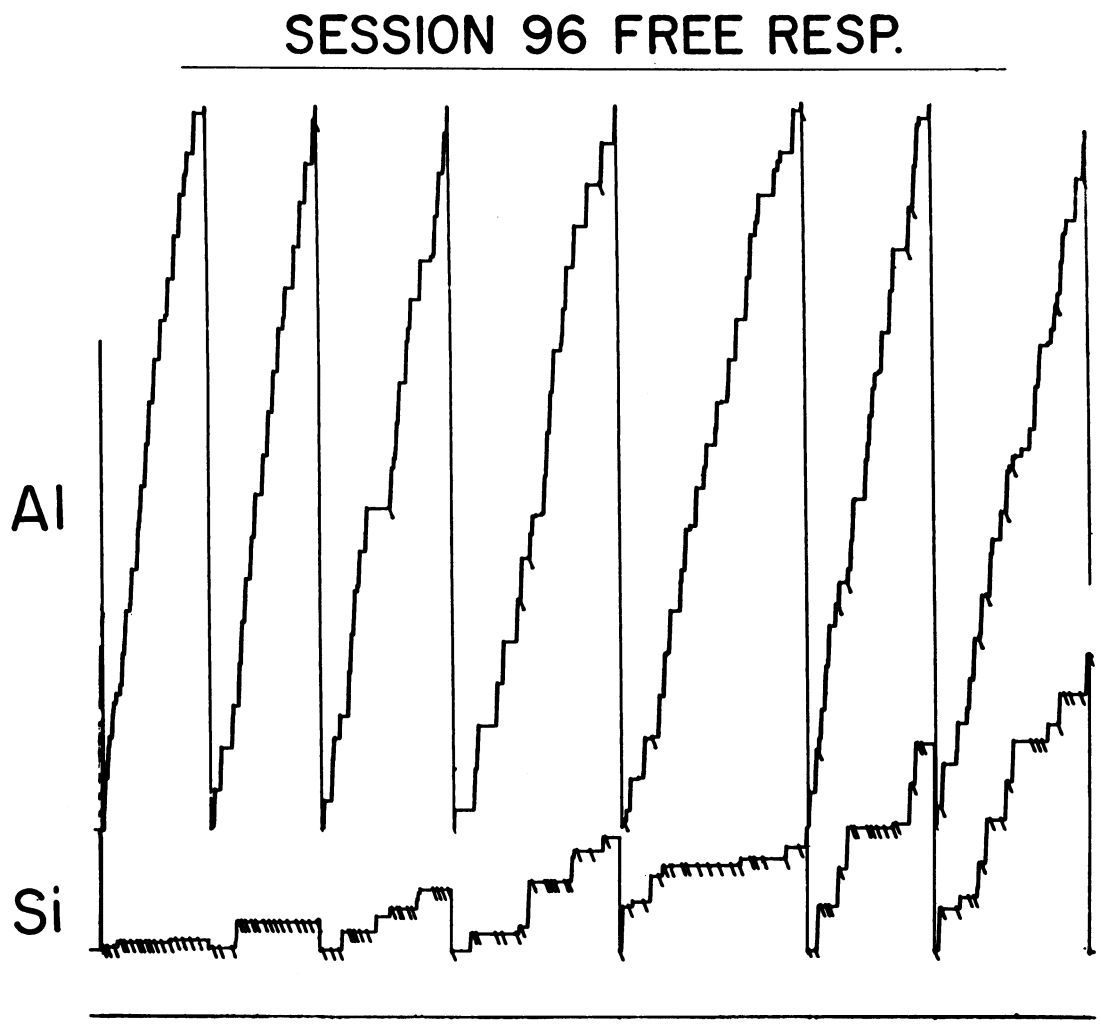

Fig. 5. Performance of the two monkeys after 12 sessions of the free responding procedure. The gradual increase in Si's responding is not typical and did not continue into the next session. (Time of the records: 77.4 min; maximum pen excursion: 540 responses.)

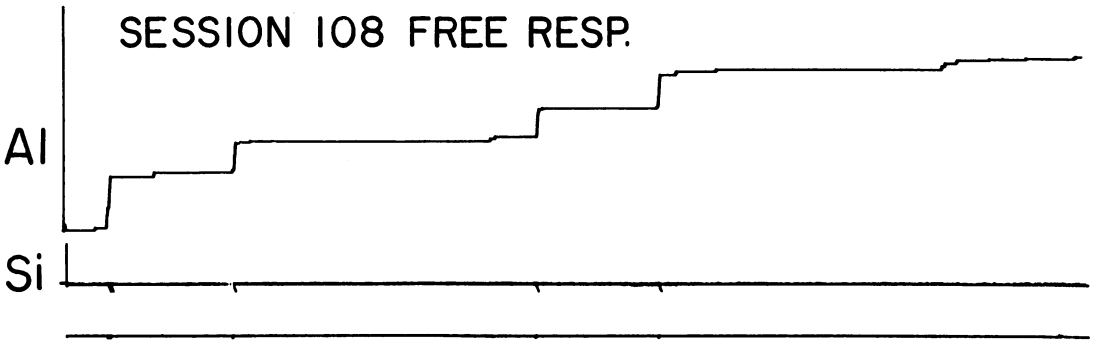

Fig. 6. Cumulative records illustrating the final behavioral state of the social interaction. The first 100 min of session 108 are shown during which monkey Al pressed the lever 169 times. Following the end of the above records, many hours passed with little or no responding by either monkey.

The other pair of monkeys (Fib and Moll) were submitted to a replication in principle of the experiment on Si and Al. Sidman (1960) describes this type of experiment as a "systematic replication" which examines the generality of the basic procedure. The replication differed from the original experiment in that the members of the pair were opposite in sex, the pre-training procedure did not include stimuli during delay training or alternation training, the reinforcement schedule was continuous reinforcement, and food deprivation was held constant by post-session feeding. However, the replication retained the principle of pretraining the monkeys by a delayed reinforcement procedure before determining if they would feed each other under the free responding procedure.

The results of the replication are shown in Fig. 7 in terms of response rates. The rates of both monkeys were quite well maintained for the first five sessions (sessions 28-32). The two monkeys averaged two responses per minute so that four pellets a minute were exchanged. The initial two sessions required less than 30 min for one monkey (Fib) to receive its daily ration while the next three sessions required an average of only 43 min. Thus, simplified pre-training successfully established the interreinforcement relationship.

Although systematically declining, the relationship continued at a substantial rate for a number of sessions. Even at session 45, for example, the rates were 1 response per min for Moll and 0.7 response per min for Fib; in 76 min Fib received 100% of his ration while Moll received 81%.

The trend, however, was always downward so that by session 57 the response rates approached near-zero levels. At this point, in order to maintain a constant deprivation, the sessions were terminated after 8 hr for the usual post-session feeding, even though neither monkey received 70 pellets. As shown in Fig. 7, the near zero rates continued.

Finally, on session 63 the conditions were made more stringent to see if higher response rates could be recovered. The post-session feeding was discontinued so that the deprivation level could increase, and the sessions were

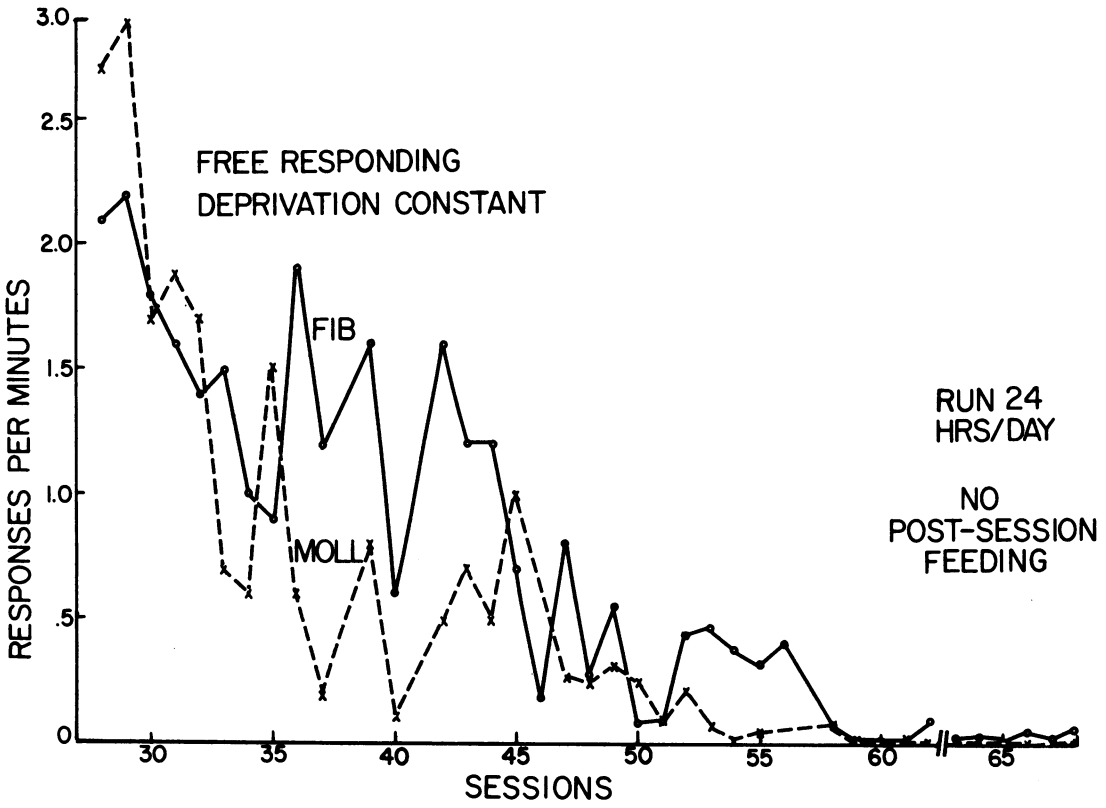

Fig. 7. The effect of the free responding procedure on response rate of Fib and Moll.

allowed to run 24 hr a day. Over the next five days Moll received an average of 38.6 pellets a day while Fib received only 6.4. Although the first monkey might have survived for a substantial time at this dietary level the second monkey surely would not have. The general conclusion of the replication was the same as for the first experiment. The interreinforcement relationship between the two monkeys deteriorated to such low levels that adequate dietary requirements were not maintained.

DISCUSSION

This study has described: (1) a technique for studying a social relation between two animals, including a training procedure; (2) an alternation procedure for maintaining a stable social relation; and (3) the finding that the social relation will not be reliably maintained by a free responding procedure.

The social situation contained aspects of both a free, naturalistic environment and a controlled laboratory study. The experiment dealt with the phenomenon of interreinforcement which has been reported in both the ethological and the experimental literature. For example, Furaya (1957) reported that feral Japanese monkeys often groom each other, and Goodall (1965) described mutual grooming in chimpanzees as one of the most important social activities. Reciprocal food sharing has been reported in juvenile gibbons by Berkson and Schusterman (1964), and Itani (1958) has observed a dominant monkey to give up food to an inferior monkey after mounting it. Miles (1963) tells of observing an old male chimpanzee who delicately removed a cinder from the eye of his female mate.

As in a natural environment, the subjects of the present experiment and the basic situation (rather than the experimenter) exercised control over the critical variables. On the other hand, the laboratory contributed (1) the special environment of chamber, levers, pellet dispensers, *etc.* which set some of the conditions of the experiment; (2) the experimental analysis of the social interaction; (3) the past history of training which established the interreinforcement repertoire; and (4) the objective recording of the social behavior. The recording was particularly important because it permitted an understanding of how the social interaction developed. A similar history in the natural environment is extremely difficult to acquire.

In this study a technique was found to establish an interreinforcement relationship. The pre-training involved alternation of reinforcements and/or delay of reinforcement. As long as the procedure coerced an alternation of reinforcements, a pair of subjects worked rapidly and reliably provided a daily ration for each other. However, with the noncoercive, free responding procedure, the social relation proved to be unstable. After one or more oscillations of "taking turns" in which one monkey did most of the work and the other did most of the eating, the interaction deteriorated to a very low level; starvation was the probable outcome had the experimenter not intervened. Both pairs of monkeys showed the same terminal pattern after somewhat different pre-training and under somewhat different conditions.

One major source of social instability was the reinforcement of non-social behavior. The free responding procedure permitted one monkey to reinforce the other merely for sitting and eating. As a consequence, the frequency of sitting and eating increased. A second major source of instability interacted with the first. When the sitting monkey was reinforced for non-responding, the working monkey was then forced to respond many times without reinforcement, or at least with extremely delayed reinforcement. Thus, responding by one monkey to feed the other was likely to be inadequately reinforced. Both sources of instability combined to reduce the frequency of the social behavior.

The above analysis is supported by the successful maintenance of the interreinforcement relationship on the alternation procedure. This procedure does not permit the inappropriate reinforcement of non-responding since one monkey cannot receive even two pellets in a row for sitting. At the same time the alternation procedure is more likely to reinforce appropriate responding. A monkey can increase its own frequency of reinforcement by responding and delivering a reinforcement to the other monkey. Since a pellet is often returned quickly, the social behavior is likely to be adequately reinforced.

The above analysis of the social interaction emphasizes the reinforcement contingencies of

the individual member of the social pair. The approach is to explain how the relevant variables affect the individual participant. In this way the interaction can be accounted for by established principles of individual behavior without requiring special "social" formulations. From this point of view the major problem of the analysis seems to be the complexity of the social interaction due to the inconsistency, the intermittency, and the number of controlling variables programmed by one organism for another.

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