SOCIAL REINFORCEMENT OF OPERANT BEHAVIOR IN RATS:
A METHODOLOGICAL NOTE

MYCROFT J. EVANS, ADAM DUVEL, MICHELE L. FUNK,
BROOKE LEHMAN, JOHN SPARROW,
NATHAN T. WATSON, AND ALLEN NEURINGER

REED COLLEGE

An apparatus was developed to study social reinforcement in the rat. Four Long-Evans female rats were trained to press a lever via shaping, with the reinforcer being access to a castrated male rat. Responding under a fixed-ratio schedule and in extinction was also observed. Social access was found to be an effective reinforcer. When social reinforcement was compared with food reinforcement under similar conditions of deprivation and reinforcer duration, no significant differences were observed.

Key words: social reinforcement, operant response, fixed ratio, extinction, lever press, rats

Despite the considerable research on operant responding in rats, few studies have used social interactions as a reinforcer. Indications that such interactions may serve as reinforcers come from a number of findings. Pairs of rats tend to approach and stay close to one another (Latané, 1969), and rats housed individually are less healthy and exhibit signs of stress when compared with rats housed communally (Ader, 1965; Ader & Friedman, 1964; Hatch, Wiberg, Balazs, & Grice, 1963). There is also more direct evidence. Angermeier (1960) trained rats to press a lever to interact physically with another rat; Davis and Pérusse (1988) showed that contact with a human experimenter could reinforce operant responses in rats; and an undergraduate senior thesis in our laboratory showed that female rats could be conditioned to press a lever when reinforced with access to a male rat.¹

To study social reinforcement in rats, we constructed an apparatus that provided female rats with access to a castrated male rat. A castrated male was used to enable us to study social, rather than sexual, reinforcement. We compared responding for social reinforcement with that for food under similar circumstances. Because social reinforcement requires an extended interval to occur, for comparison purposes we provided an equal period of access to food. The main question was whether access

to social interaction would reliably reinforce operant responding in rats.

METHOD

Subjects

Eight experimentally naive female Long-Evans rats, 113 days old at the beginning of the experiment, were randomly divided into two groups of 4 animals each. Behavior of one group was reinforced with 45 s of access to a compartment containing another rat (social group), and that of the other group was reinforced with 45 s of access to an identical compartment containing a food dish and water (food group). Four castrated male Long-Evans rats, previously used as breeders, served as the social reinforcers. Prior to the beginning of the experimental procedures, all females were housed in pairs with free access to food. During the experiment, females in the food group were housed in pairs, with water continuously available in the home cage but food available only during a 2-hr period following daily experimental sessions. Females in the social group were housed individually, with water and food continuously available in the home cage. Just prior to the beginning of the experiment, each of the 4 females in the social group was paired for 48 hr with one of the males. This assignment was maintained throughout the experiment, with a given male consistently serving as the reinforcer for a given female. Following experimental sessions, as well as on nonexperimental days, a 2-hr period of social interaction with the same male was provided in the male's home cage. Thus, subjects in the food

Reprints can be obtained from A. Neuringer, Department of Psychology, Reed College, Portland, Oregon 97202.

¹ Callard, M. D. (1988). *The power of social interaction as a reinforcer in female rats*. Unpublished undergraduate senior thesis, Reed College, Portland, Oregon.

Fig. 1. The apparatus, consisting of the operant compartment containing a lever on the left and a goal or reinforcement compartment containing a castrated male rat or food biscuits on the right. A cantilever door between the two compartments was operated by a solenoid, as shown below.

group were deprived of food for 21.5 hr but were housed with another rat, and subjects in the social group were deprived of social contact for 21.5 hr but had continuous access to food in their home cages.

Apparatus

Each of four experimental chambers consisted of two adjacent compartments (24.3 cm by 30.5 cm by 17.8 cm; Figure 1), with an operant compartment on the left and a goal, or reinforcement, compartment on the right. (A similar apparatus was described by Watson, 1992.²) The front walls and tops of each compartment were constructed of Plexiglas,

with both tops separately hinged to enable the experimenter to retrieve the rat from either compartment. The other walls and base were made of aluminum, and the floor was made of steel wire mesh. The operant compartment had a Gerbrands rat lever mounted 8 cm above the floor centered on the rear wall. The wall connecting the two compartments had a hole (4.2 cm diameter) 1 cm above the floor, with a lip protruding 1.7 cm into the reinforcement compartment. This hole was large enough for the female subject to pass through freely, but was too small for the larger male to pass through. An aluminum cantilever door between the compartments controlled passage through the hole. When the door was in its up position, the female could pass from operant to reinforcement compartment; when down, passage was prohibited. The cantilever door

² Watson, N. T. (1992). *Social reinforcement of alcohol drinking in the rat*. Unpublished undergraduate senior thesis, Reed College, Portland, Oregon.

was raised and lowered by a 28-VDC solenoid mounted behind the cages (lower portion of Figure 1), with the solenoid controlled by an Apple® Macintosh 512K computer via a Meta Research® interface module. The computer also monitored responses on the lever. Movement of the female into the reinforcement chamber was not automatically recorded but was observed by the experimenters. Chambers were located on two shelves, two chambers side-by-side per shelf, with one shelf above the other, in a small, dimly lighted laboratory room (2.4 m high by 2.4 m long by 1.8 m wide). Two experimenters were present at all times, with each experimenter responsible for two chambers.

Procedure

Habituation and shaping. Each female was habituated to the operant and reinforcement compartments of the experimental chamber, then to the noise of the cantilever door raising and lowering, and then to the presence of the appropriate reinforcer. During an initial 2-hr habituation session, each of the animals was placed in the operant chamber with the cantilever door continuously opened and the appropriate reinforcer present in the reinforcement compartment. For the females in the food group, the reinforcement compartment contained a dish filled with small pieces of the same food biscuits as were provided in the home cage (Harlan Teklad Rodent Diet). For the females in the social group, the reinforcement compartment contained the male rat with whom the subject was housed for 2 hr each day.

In a second 35-min habituation session, the cantilever door repeatedly (and response-independently) opened for a 45- to 60-s period. Five seconds before the end of this "reinforcement period," an intermittent tone sounded. If the female had entered the reinforcement compartment, the top of the cage was opened, the female was lifted out by the experimenter and returned to the operant compartment, and the cantilever door was closed. This occurred for both social and food groups. Thus, each reinforcer—food or social—was terminated with the animal being removed from the reinforcement compartment and returned to the operant compartment. If the female had not entered the reinforcement compartment, then the door simply closed. The 4 rats in the social

group were observed at one time and the 4 rats in the food group at a different time, with 1 animal per experimental chamber in each case.

When subjects consistently entered the reinforcement compartment after the cantilever door was raised and interacted with the male (two sessions required for the social group) or consumed food (three sessions required for the food group), lever-press shaping was initiated, with successive approximations to a lever-press response reinforced. During the shaping procedure, 2 animals were studied simultaneously in two chambers, with one experimenter devoting full attention to a single subject. As described above, each reinforcement began by raising the cantilever door and consisted of a 45-s period of access to food or to the male rat. At the end of the reinforcement period, the female was gently removed by an experimenter and replaced into the operant compartment. Lever presses during reinforcement were tallied but did not result in additional reinforcement. Sessions were 35 min in duration (including the time devoted to reinforcement).

Because some of the females in the food group did not always enter the reinforcement compartment during the habituation and shaping phases, this group's procedure was modified. First, whenever a subject remained immobile for an extended period, she was retrieved from the operant compartment, petted for a short time, and then returned to the chamber. Second, a dish filled with water was added to the reinforcement compartment; third, bits of cookies and raisins were mixed with the chow biscuits; and fourth, the 2-hr period of free access to food following sessions was provided in the reinforcement compartment rather than in the home cage. Once the food subjects were consistently entering the reinforcement chamber, the food reinforcer was returned to crumbled biscuits; this reinforcer was maintained for the remainder of the experiment, with water present in the reinforcement compartment. After 10 sessions (including habituation), the force necessary to operate the levers, which had been 0.35 to 0.40 N, was lowered to 0.20 N for all subjects.

Fixed ratio. Following successful shaping, defined as 10 or more lever-press responses during a session, a fixed-ratio (FR) requirement was gradually increased until the subjects were responding regularly on an FR 3 (three

Table 1

Number of sessions for each subject in each condition.

Condition	Rats in food group				Rats in social group			
	2068	2069	2070	2071	2072	2073	2076	2077
Habituation	3	3	3	3	2	2	2	2
Shaping	7	5	8	5	5	10	5	2
FR 1	1	2	1	3	4	0	5	3
FR 2	2	2	0	2	1	1	0	1
FR 3	6	7	7	6	6	6	6	10
Extinction 1	3	3	3	3	3	3	3	3
Extinction 2	3	3	3	3	3	3	3	3

responses per reinforcer) schedule. This transition took from one to five sessions, depending upon the subject's rate of responding (see Table 1). All rats were then maintained under the FR 3 schedule for at least six sessions. Each of the FR 3 sessions began with an FR 1 contingency that, over the course of the first few reinforcers (no more than five), was raised to an FR 3. Reinforcement duration remained at 45 s, and session length was 35 min throughout.

Extinction 1. Following FR 3 training, three sessions of extinction were given, during which lever presses had no effect (i.e., the cantilever door remained in its closed position throughout, and the reinforcement cage was empty). Sessions were terminated after 35 min.

Extinction 2. Three additional extinction sessions were provided, during which the males were present in the reinforcement compartment for the social group and food was present for the food group. This extinction was performed in order to explore the effects of the activities of the male in the reinforcement compartment (scratching the cantilever door and making noise) on the female's responding. At the beginning of each session, the subject was placed in the reinforcement compartment for 1 min in order to discriminate the presence of the food or social reinforcer. As in the first extinction phase, lever presses had no effect, the cantilever door remained in its closed position, and sessions were terminated after 35 min.

RESULTS

Social interaction with a castrated male rat was an effective reinforcer for shaping and maintaining lever presses. The females learned to respond in fewer sessions on average under conditions of social reinforcement (7.3 sessions including habituation) than under food reinforcement (8.5), but this difference did not reach statistical significance, $t(6) = 0.724$.

Figure 2 shows total responses emitted during the last five FR 3 sessions for each subject. Mean number of responses per session across the five sessions was 51.9 for the social group and 38.3 for the food group, but this difference was not statistically significant, $t(6) = 1.645$. Figure 2 also shows responding during the two extinction phases for each subject. Mean number of responses per session in the first extinction phase, when the reinforcement compartment was empty, was 26.3 for the social group and 34.5 for the food group. During the second extinction phase, when the male or food was present but inaccessible, these averages were 19.9 for the social group and 13.5 for the food group. These group differences were not statistically significant in either extinction phase, $t(6) = 0.806$ and 1.74, respectively.

Figure 3 shows cumulative response records from the 5th session of FR 3 training for each of the 8 subjects. The cumulative records were generated by computer from the time of occurrence of each response. The upward ticks indicate a 45-s period of reinforcement. The cumulative record was stopped during this 45-s period; therefore, the total extent along the x axis differed as a function of number of reinforcements, and the few responses during the reinforcement periods were omitted from this graph. Postreinforcement pausing and scalloped patterns of responding were present in subjects from both groups. The cumulative response curves were similar across the two conditions.

DISCUSSION

The present study demonstrated that female rats could be conditioned to press a lever with

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Fig. 2. Responses per session for each of the 4 subjects in the social group (top) and the 4 subjects in the food group (bottom) during the last five sessions of FR 3 contingencies and three sessions for each of two extinction periods. The lines connect arithmetic means for each group.

Fig. 3. Cumulative response records for each of the 4 subjects in the social group (top) and the 4 subjects in the food group (bottom) during the last FR 3 session. The session began with an FR 1 contingency that, over the course of the first few reinforcers, was raised to FR 3. Each upward tick indicates a 45-s reinforcement period, during which the cumulative record (time along the x axis) was stopped. Because these records were generated on a computer screen, the "grainy" aspects evident during pauses

access to a male rat as a reinforcer. With similar parameters for deprivation and duration of reinforcer access, the socially reinforced subjects responded similarly to other female rats whose behavior was reinforced with food. Time to shape the operant response, response rates under FR 3 contingencies, and responses during extinction did not differ significantly between the social-reinforcement and food-reinforcement conditions.

The apparatus used in this experiment may have some disadvantages. First, experimenters were continuously present, which may have been a source of possible distraction to the subjects. Second, at the end of each reinforcement period, the subjects were removed by the experimenter from the reinforcement compartment and returned to the operant side of the apparatus. This handling may have interfered with ongoing behavioral events or may have caused emotional distress. Alternatively, the handling may have served as a reinforcer (Davis & Balfour, 1992). Third, the opportunity to explore a novel environment—the reinforcement compartment—may have been reinforcing. Fourth, the raising and lowering of the cantilever door sometimes startled subjects, especially early in training. In all cases, the potential disadvantages were the same for animals in the social and food groups.

The present apparatus also has some advantages. First, the unencumbered social interactions provided by our apparatus may be especially important given Latané's work describing the diminishing attractiveness of increasingly immobile rats (Latané, 1969). Other types of apparatus do not permit the natural social interactions allowed by the present apparatus. Examples of other types include a chamber containing a reinforcing rat that is "wheeled" into and out of the operant chamber (Timberlake & Grant, 1975); a reinforcing animal that is tethered and "forced" into or out of the operant chamber; or reinforcement by sight or contact through a screen (Angermeier, 1960). Second, it was relatively easy to habituate the socially reinforced rats to the chamber and to shape their lever-press responses. From the beginning of training and throughout the experiment, rats receiving so-

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are due to the drawing procedures and resolution of the screen and do not indicate responses.

cial reinforcement readily entered the reinforcement compartment and interacted with the males. Third, operant responding in the apparatus was systematically related to the contingencies of social reinforcement, the relationships observed being similar to those maintained by analogous food-reinforcement contingencies.

The food-reinforcement procedure was unusual in that it involved 45 s of free access to a dish filled with food. This was done in an attempt to keep parameters as similar as possible across the two groups. Early in the experiment, despite being deprived of food for 21.5 hr, the rats in the food group often did not consume the reinforcer. They were occasionally observed to carry the biscuits into the operant compartment, rather than eat in the reinforcement compartment. Therefore, a number of changes were instituted, including providing these subjects with their daily 2-hr free access to food in the reinforcement compartment. These changes were effective in establishing the food as a readily ingested reinforcer, with the ingestion occurring in the reinforcement compartment. However, comparisons across reinforcers are always difficult. Parametric study is necessary to compare the effects of amounts or durations of reinforcement, levels of deprivation, different topographic response requirements, and so forth.

Castrated male rats were used as reinforcers to enable us to study social, rather than sexual, reinforcement. The distinction between sexual and social interaction is not clear-cut, however, and it is possible that sexual, rather than social, interactions may have contributed to the reinforcing properties of access to a conspecific. This possibility must be considered whenever the behavior of interest is social interaction. On the other hand, we observed no instance of a male mounting a female. One reason to use males as reinforcers, rather than females, was their relatively large size; the female subject could enter and leave the reinforcement compartment but, because of his large size, the male was confined to the reinforcement compartment. An alternative would be to use a large female as the reinforcer and a young or smaller female as the subject. Of course, possible differences between reinforcement by different genders should be studied. Another alternative would be to place a collar around the reinforcing animal but not around the subject.

The present findings suggest that experimental analysis of social reinforcement in the rat may be instructive. Unfortunately, as is the case for social behavior in general, disappointingly little has been done in the way of systematic investigation of social reinforcement (Benton & Brain, 1988). Relationships between animals affect their survival, with conspecifics often providing warmth, protection from predators, increased foraging efficiency, and defense of scarce resources against other groups of conspecifics (Alcock, 1993). Deprivation from social interactions can have detrimental effects. For example, in group-housed mice, brief periods of social isolation are stressful, as evidenced by stress-induced analgesia (Puglisi-Allegra & Oliverio, 1983). Social interactions occur more frequently than food-seeking and sexual activities in many species (Fagan, 1981). Furthermore, contact with conspecifics is critical to normal development in many species (Harlow & Harlow, 1962). Each of these studies suggests that social interactions may serve as reinforcers and that such reinforcement may help to account for a wide variety of activities. For example, social learning and imitation, observed in many species, may involve social reinforcement (Zentall & Galef, 1988). Social reinforcement may also prove to be useful for experimental analyses of other phenomena. Many drugs affect the motivation of subjects to eat or drink, and social reinforcement could be especially useful when studying the effects of drugs on operant responding.

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