Nesting material as a reinforcement for operant behavior in the rat*

NANCY N. OLEY and BURTON M. SLOTNICK†
Columbia University, New York, N.Y. 10037

Paper strips served as an adequate reinforcement for the acquisition and maintenance of fixed-ratio barpressing in two pregnant rats. Prior to parturition, only a small daily nest was built and barpressing occurred only in the dark part of the lighting cycle. Following parturition, barpressing for nesting material greatly increased, and sustained periods of responding alternated with nest-building and pup-care activities.

Prior investigations of nesting behavior in rodents have typically allowed the animal free access to a large amount of nesting material. Nesting behavior is assessed by the amount of material used and the quality of the nest constructed. While these techniques have yielded orderly measures of nesting behavior as a function of such variables as temperature (Kinder, 1927), hormonal status (Lisk, Pretlow, & Friedman, 1969), and strain differences (Layne, 1969), the technique does not lend itself to a detailed quantitative analysis of nesting activity or allow continuous monitoring of such behavior. Recent studies demonstrating the operant-reinforcing properties of stimuli that elicit species-specific behaviors (King & Weisman, 1964; Campbell & Pickleman, 1961; Jansen et al, 1969; and Wilsoncroft, 1969) suggested the possibility of using an operant technique to do this. Teitelbaum (1966) has discussed the advantages of bringing species-specific behaviors under operant control for purposes of quantitative analysis and assessing motivational properties of such behavior.

The reinforcing properties of a stimulus that does not reduce a primary-drive state is also of interest within the larger context of biological reinforcement. In the system proposed by Glickman & Schiff (1967), activation of neural pathways mediating species-specific behaviors is the necessary condition for what is generally termed reinforcement. Within this framework, stimuli that reduce primary-drive states are only one class of stimuli that can potentially reinforce a motor sequence. Further extension of the operant technique to nesting and other species-specific behaviors is therefore relevant to the experimental verification of the Glickman and Schiff theory.

The present report presents preliminary data demonstrating the reinforcing

properties of nesting material for the pregnant and lactating rat.

METHOD

Two virgin female Wistar-strain rats, 90-120 days old at the start of training, were used as Ss. They were individually housed and tested in a 14 x 26 x 7 in. wire-mesh cage. The rear corner of the cage was partially isolated by a 1½-in.-high, 5-in.-long metal strip to encourage nestbuilding in only one area. Food pellets were kept in a closed mesh container to prevent their use as nesting material. A paper-delivery mechanism was placed at the opposite end outside the cage. This consisted of a 1,000-ft roll of 1-cm-wide Dictum Recorder Tape (Link Paper Co., Engelwood, N.J.) fed between two rollers

by a high-torque 60-rpm motor. The response manipulandum was a Lehigh Valley rat bar. Experimental contingencies were automatically programmed and data recorded in an adjacent room.

The animals were housed with males and placed in the test apparatus 2-5 days following detection of sperm in the vaginal smear. Both Ss were maintained on an 8 a.m. to 10 p.m. light-on cycle throughout the experiment. For initial training the bar was placed next to the paper delivery input to the cage and a 4-in.-long strip of paper was fed into the cage each time the animal pressed the bar. After 1 or 2 days the bar was moved 6 in. away from the reinforcement mechanism and a fixed-ratio (FR) reinforcement schedule instituted. Rat 1 was maintained on FR 2 and Rat 2 on FR 5 during gestation. For the latter animal only, the ratio requirement was raised from FR 5 through FR 40 during the first 6 days of the postpartum period. Both animals had continuous access to the bar and reinforcement. Paper strips collected in the cage were removed once each day, generally during the middle of the light-on period. Data were gathered from Rat 1 during the months of May and June when the average laboratory temperature was approximately 70°F and from Rat 2 during June and July when the average room temperature was approximately 80°F.

Fig. 1. (A) Characteristic cumulative records of responding during the prepartum period. (B) Postpartum responding of Rat 2 on higher fixed ratios.

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†Present address: Section on Limbic Integration and Behavior, National Institutes of Mental Health, Bethesda, Maryland.

Fig. 2. Nest size during gestation and postpartum period.

days are illustrated in Fig. 2. Prior to parturition, Rat 1 constructed a small nest each day. On postpartum Days 1-3 it built a nest approximately nine times the size of the prepartum nests. Rat 2, tested during the summer, built no nest prior to parturition but constructed a large nest on the day of parturition and maintained a high level of nesting behavior on subsequent days. During the postpartum period both rats constructed similar size nests, although Rat 2 (working on the higher FR schedules) made between 10 and 20 times as many responses as did Rat 1. Further postpartum responding is not illustrated in Fig. 2, since manipulations of reinforcement size, ratio requirement, and litter size during this period did not yield consistent results.

During the prepartum period, initiation of responding appeared to be under the control of the light-dark cycle for both animals. Little or no responding was seen following daily removal of the nest or for the remainder of the light-on period. Responding generally began during the first hour of the dark period and terminated with the onset of the next light period. Following parturition, initiation of responding occurred almost immediately after nest removal, and the distribution of responses during the 24-h period appeared quite independent of the lighting cycle. This pattern is illustrated in Fig. 3, which shows the distribution of responding during the last 3 days of pregnancy and the first 3 postpartum days for Rat 1. Responding in each 24-h period occurred in distinct bouts. During the prepartum period, interbout intervals are relatively short (generally less than 1 h). However, following parturition, periods of sustained responding are broken by more lengthy interbout intervals. Observation of the animals indicated that nest-building and pup-care activities, particularly nursing, account for the long postpartum interbout intervals.

DISCUSSION

Although the present study presents only preliminary data concerning operant analysis of nesting behavior, the results obtained are comparable to those reported by Richter (1955). In both reports peak nest size was seen at least 24 h postpartum, and prepartum, but not postpartum, nest building appeared correlated with room temperature and activity cycle.

The present results also relate to the question of what defines a reinforcer. Implicit in the Glickman & Schiff (1967) proposal and the writings of ethologists (Tinbergen, 1951) is the suggestion that

RESULTS

Initial shaping of the barpress response required only the delivery of several free reinforcements. No disruption of responding was seen when the bar was moved farther from the reinforcement mechanism. Typically, the animals would press the bar until reinforcement was delivered, quickly chew through the paper strip when it entered the cage, and allow it to drop to the floor. A number of pieces of paper were collected in this way before they were retrieved to the nest site. Figure 1A shows typical FR 2 and FR 5 performance. Nesting activities, grooming, and exploratory behavior were observed during the longer no-response pauses in the record.

Introduction of the larger FR requirements during the postpartum period for Rat 2 resulted in only an initial disruption of performance. After receiving several reinforcements at each new ratio, responding at that ratio was maintained with no evidence of schedule strain. Figure 1B shows examples of FR 20 and FR 40 responding. Characteristically, interresponse intervals were very short, and responding stopped abruptly when reinforcement was delivered. At low-ratio requirements the animal would collect several reinforcements before carrying them to the nest site. At higher ratios it would generally retrieve each reinforcement to the nest site as soon as it was delivered.

Changes in the nest size during pregnancy and for the first few postpartum

Fig. 3. Distribution of responses with respect to time of nest removal and the light-dark cycle. Arrows indicate the time at which the nest was removed. Barpressing during the light-on period is represented by the striped bars.

the opportunity to engage in the consummatory or terminal response of a complex behavioral sequence may act to strengthen appropriate appetitive (instrumental) behavior. Demonstrations of the reinforcing properties of young for the postpartum rat (Wilsoncroft, 1969), nesting material for the hamster (Jansen et al, 1969), and the imprinting object for the duckling (Campbell & Pickleman, 1961), as well as the results of the present report, support this view and further extend the category of environmental events that may serve to reinforce new learning.

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Effect of ECS on one-trial learning following continuous- and partial-reinforcement training*

A. GRANT YOUNG and E. H. GALLUSCIO
Louisiana State University, Baton Rouge, La. 70803

Thirty-two naive male albino rats were trained to leverpress for sucrose using a discrete trial procedure. Half of the Ss were trained on a continuous-reinforcement schedule (CRF) and the other half were trained on a fixed-ratio schedule (FR). Following acquisition, for half of the Ss in each group, a leverpress produced footshock followed by ECS. For the remaining Ss a leverpress produced footshock only. Results showed that suppression of the leverpress response due to footshock was reduced by the ECS, regardless of the acquisition reinforcement schedule. Results also showed that FR-trained Ss failed to show the partial-reinforcement effect in extinction.

The fact that electroconvulsive shock (ECS) seems to produce retrograde amnesia (RA) when administered shortly after a learning trial is well established (Lewis, 1969; Spevack & Suboski, 1969). The selective disruption of recent memory by ECS has been accounted for by the concept of memory consolidation, which suggests that the fixation of the physiological substrate of memory is time-dependent (McGaugh, 1966). It is assumed that following registration of an experiential event, some type of short-term process maintains the memory trace until a

more permanent physical trace is fixed. Although the short-term process is susceptible to disruption, the structural changes effected by the consolidation process are relatively impervious to amnesic agents. Presumably, then, the massive electrical interference of ECS disrupts the consolidation process and thereby prevents the permanent fixation of the memory trace.

Although a number of studies (e.g., Heriot & Coleman, 1962; Madsen & McGaugh, 1961) have shown that a single ECS does not appear to be aversive, Hudspeth, McGaugh, & Thompson (1964) have shown that repeated ECS treatments are aversive. Spevack & Suboski (1969) have suggested that only those

experimental procedures in which the amnesic and aversive effects of ECS have separable behavioral outcomes bear on consolidation theory. A typical procedure is to administer aversive stimulation, such as footshock, upon the emission of a previously learned response. The aversive stimulation results in a suppressed rate of responding; however, if ECS is administered shortly after the aversive stimulation, the result seems to be RA for this one-trial learning.

Recently Young & Galluscio (1970) reported findings that do not support a consolidation interpretation of the effects of ECS. In that study two groups of rats were trained to leverpress, one group on a continuous-reinforcement schedule (CRF) and the other on a fixed-ratio schedule (FR 5). Upon completion of acquisition, on pretest day a leverpress was followed by footshock. For half the Ss in each group, footshock was followed by ECS; the other half received no ECS. All Ss were then tested during an extinction session. Results showed that during extinction the CRF group that received ECS following footshock made significantly more responses than did the CRF group that received footshock only. However, both FR 5 groups showed significantly suppressed response rates, not significantly different from each other, although one group had received footshock plus ECS and the other group had received footshock only. Thus, ECS did not eliminate suppression of response rate following training on a FR schedule.

Although these findings do not support consolidation theory, they are difficult to interpret because it is not clear whether ECS failed to eliminate suppression in the FR group due to the partial reinforcement schedule itself or due to the high response rate that a partial reinforcement schedule generates.

The present study was therefore designed to evaluate the effect of ECS on response suppression following training under FR and CRF conditions with relative response rates during training controlled by the use of a discrete-trial procedure.

SUBJECTS

The Ss were 32 naive male albino rats, 150-175 g in weight at the start of the experiment.

APPARATUS

The apparatus consisted of two identical Scientific Prototype operant chambers, each enclosed in a sound-insulated, ventilated box. Each operant chamber had a grid floor, and fitted on the end wall was a retractable lever and a liquid dipper that dispensed .01 ml of a 40% sucrose solution, used as reinforcement. All E-controlled events were operated by an electronic

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