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A CONDITIONED REINFORCER MAINTAINED BY TEMPORAL ASSOCIATION WITH THE TERMINATION OF SHOCK

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Two experiments were conducted to determine whether a stimulus can be established as a positive conditioned reinforcer by associating it with the termination of shock, but without training the animal to make any response in its presence. In the first, six rats were conditioned to press a bar to terminate shock on a variable ratio schedule; white noise was then substituted as the immediate consequence, with the shock terminating 30 sec after the last press in its presence. It was found that the rate of pressing in the absence of noise depended on the contingency between the pressing and the noise. The second experiment sought to determine whether the difference in rates before and after the onset of the noise was due to the reinforcement of prior responding by the onset of the noise or to the suppression of subsequent responding by differential reinforcement of competing behavior. Six more rats were trained in the same manner, but with shock terminating 30 sec after the onset of the noise, regardless of what the animal did in its presence. Again the rate was higher before the onset of the noise, indicating that pressing was indeed maintained by the noise as a conditioned reinforcer.

The present study is an attempt to simplify the procedures and extend the findings of an earlier study (Dinsmoor and Clayton, 1963). Prior to that study, evidence for the acquisition of positively reinforcing properties by a stimulus associated with the termination of shock (reviewed by Beck, 1961) seemed extremely weak. In view of the difficulties encountered by previous investigators, we attempted to arrange conditions as favorable as possible for substantiating this relationship before going on to examine the limits of these conditions. Accordingly, we established a behavioral chain that included two components: (a) in the presence of shock, rats were provided with a white noise on a variable ratio schedule for pressing a bar; (b) in the presence of the noise, they were allowed to terminate the shock, after 30 sec, by nosing a pigeon key. Under this procedure, substantial rates were maintained on both responses.

Later in the same study, the animals still pressed the bar to produce the noise when nosing of the key was no longer required to end the shock and had long since extinguished. This suggested that previous theorizing (reviewed by Myers, 1958, and by Kelleher and Gollub, 1962) concerning the need to establish a stimulus as a discriminative stimulus for some response in order for it to function as a conditioned reinforcer was not valid. If so, it should be possible to simplify our initial training procedure and establish the noise as a conditioned reinforcer without ever training the animals to make a response in its presence. The present experiments sought to test this hypothesis.

EXPERIMENT I

Subjects

Six male albino rats, ranging in age from 180 to 250 days at the beginning of training, were provided with free access to food and water in their home cages but not in the experimental box.

Apparatus

The experimental box measured 9⅞ in. long, 5⅝ in. wide, and 6¾ in. high on the inside. The floor consisted of five lengths of ⅝ in. diameter brass tubing, the side walls of aluminum, and the ceiling of transparent plastic. A crossbar 2½ in. long and 5/16 in. in diameter was mounted on a Switchcraft Lev-R

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Switch No. 3002 laterally centered 3½ in. above the floor at one end; the switch was adjusted to require a press of 26 g to separate normally closed contacts. The experimental box was enclosed in a light-proof and sound-resistant chamber furnished with a 15 CFM blower.

A current-stabilized shock stimulator (Dinsmoor, 1960, 1961) delivered 0.8 ma of half wave rectified direct current through a Lon R. Davis GS-255 Grid Scrambler (polarity alternator) to the five-tube grid floor and to the walls and bar, which together served as the sixth electrode. The white noise stimulus produced a 2 db increase over the ambient level of approximately 60 db inside the box. The experimental procedure was programmed with electromagnetic circuitry and the data were collected on digital counters and cumulative recorders.

Procedure

The experimental sessions were conducted at approximately the same time each day, with occasional omissions, and lasted 5 hr. During the first session, whenever shock was presented, the animal was required to press the bar from one to five times (VR 3) in order to terminate it. Once terminated, the shock remained off for 120 sec.

During the second session, whenever shock was presented, the animal was required to press on the same VR schedule to produce white noise; the noise and the shock terminated 5 sec after the onset of the noise, if there were no more responses, or 5 sec after the last of any responses occurring in its presence. During the third session, the interval between onset of the noise and termination of both stimuli was increased to 10 sec, during the fourth, to 20 sec, and thereafter, to 30 sec. Data were collected for four more sessions at the 30-sec interval to determine the mean level of performance under this procedure, but no attempt was made to determine the maximal level that could be achieved with continued training.

During the next series of sessions, the animals were no longer required to press the bar to produce the white noise (non-contingent procedure). The mean number of seconds required by each animal to produce the noise on the four previous sessions (range: 10.7 to 38.7) was used as a temporal criterion for that animal. When this criterion had been met, the noise was presented, regardless of how many presses had occurred or when the animal had last pressed. The criterion for terminating the stimuli, once the noise had appeared, remained the same as before. This procedure was continued until the rate of pressing on four successive sessions showed a substantially lower value. In view of the danger of the animal learning competing forms of behavior for minimizing the effects of long-continued shock, the procedure was terminated before extinction was complete.

Finally, the original training procedure, in which a variable number of presses was required to produce the noise, was restored. This procedure was maintained until the mean rate for four successive sessions was substantially higher than the terminal rate under the noncontingent procedure. Again, no attempt was made to determine asymptotic values.

Results and Discussion

The typical pattern of behavior generated before production of the white noise on each cycle is illustrated in Fig. 1. Under the variable ratio schedule for production of the noise (records A and D), local rates were high, with occasional pauses, which were more prominent for animals with lower overall rates. This is the pattern to be expected, assuming that the noise

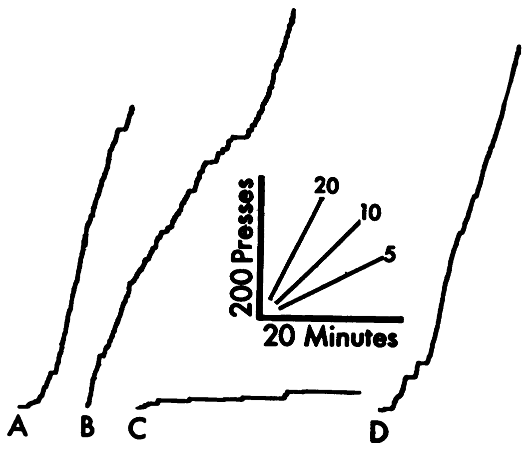

Fig. 1. Cumulative records of pressing by Rat B8 during periods when shock was present but noise was absent. Record A is for the last day of training, B for the first day of the noncontingent procedure, C for the last day of the noncontingent procedure, and D for the last day of reconditioning. The insert shows slopes corresponding to rates of 5, 10, and 20 responses per minute.

Table 1

Mean presses per minute before onset of noise for last four sessions under each procedure (Experiment I).

Rat	*A9*	*B8*	*B15A*	*F11A*	*J9*	*J10*
Training Rate	16.4	19.1	8.3	6.0	27.5	15.8
No. Non-contingent Sessions	24	16	15	11	24	9
Non-contingent Rate	6.8	0.6	0.6	2.0	37.9	2.5
Reconditioned Rate	20.5	18.3	3.5	11.8	—	10.4

is the reinforcer, and tends to substantiate that assumption. The behavior obtained by the end of the non-contingent phase (record C) was strikingly different: although occasional bursts are evident in the record, on most cycles the animal failed to respond. This looks like the type of performance to be expected late in extinction, following reinforcement on a ratio schedule.

The performance after onset of the white noise on each cycle is illustrated in Fig. 2. Under the contingent procedure (records A and D), it was characterized by a series of bursts, separated by pauses. The bursts represent extensions of the performance observed in Fig. 1. When the noise appeared during a sequence of rapid responding, the animal did not immediately stop, but made a few more responses before pausing. Under the non-contingent procedure, most of these bursts immediately disappeared (record B), since the animal usually was not responding when the noise appeared. Note that the length of the pause that may be recorded is limited to 30 sec, since this is the criterion for ending the noise and the shock, and consequently the recording, on each cycle.

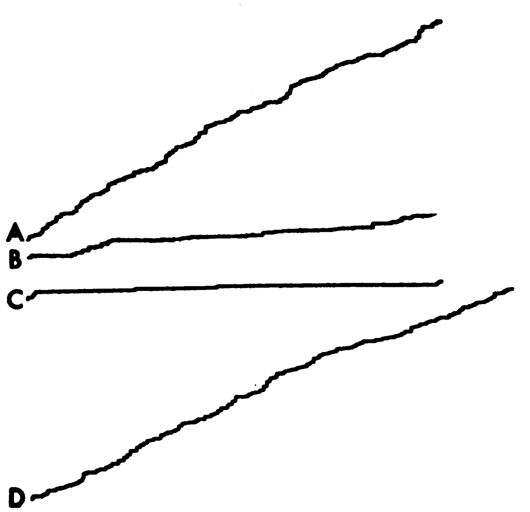

Fig. 2. Cumulative records of pressing by Rat B8 during exposure to white noise for the same days as shown in Fig. 1.

A major line of evidence for asserting that the onset of the white noise constitutes a reinforcing event is presented in Table 1, which shows the rate of pressing for the last four sessions of training, the non-contingent procedure, and reconditioning for each of the six rats. The purpose of the non-contingent procedure, in which the noise was presented on an arbitrary schedule rather than being left contingent upon the animal's response, was to show that the relationship between the noise and the response played an important role in maintaining the performance.

Under these conditions, Rat J9 continued to respond at a high rate for 24 more sessions. Apparently this animal's behavior provided a sufficient number of accidental pairings between the response and the noise to preserve and even to increase its rate of pressing on a superstitious basis. Since there seemed to be ample evidence for the maintenance of this animal's responding beyond the point where it could be attributed to primary reinforcement earlier in training, and little likelihood that a substantial increment in rate could be obtained with a more precise contingency further data were not collected.

Rates of the other five animals declined substantially when the contingency was eliminated between pressing and production of the noise. In each case, when the rate had dropped to a level that seemed sufficiently low to demonstrate an effect but before it reached a level that might make reconditioning difficult, the original contingency was reinstated. Restoring the contingency between the response and the noise produced substantial increases in rate for all five animals.

The differential effect of the contingent and non-contingent procedures indicates that the onset of noise was indeed the reinforcing event.

It is true, of course, that changing the criterion for producing the noise also changes the criterion for terminating the shock, since the latter event is timed from the onset of the noise. But the terms contingent and non-contingent merely distinguish two classes of procedural rule for generating distributions of temporal intervals between events. It is the set of intervals, not the rule, as such, that impinges upon and controls the behavior. The distinction is illustrated by Skinner's (1948) finding that a variety of responses could be maintained in pigeons on a superstitious basis when there was no connection, other than accidental, between occurrence of any response and delivery of reinforcement. It is therefore necessary to examine the temporal relationship between responding and each of the possible reinforcing events.

If, as we maintain, the white noise served as a conditioned reinforcer, then the contingent procedure always provided immediate (zero delay) reinforcement following some instance of the barpressing response. The non-contingent procedure, however, introduced a delay of varying length, since the interval between the last pre-noise response and the onset of the noise depended on the point within the criterion interval at which the animal happened to make that response. At this point on the delay-of-reinforcement gradient, *i.e.*, close to the zero end, an additional delay that might be small in absolute magnitude would be large in relative magnitude, and it seems entirely plausible that it could produce a large change in subsequent performance.

The question remains as to whether the differential effects obtained under the two procedures could not be attributed to the change in the contingency between bar pressing and termination of the shock rather than to the change in the contingency between bar pressing and onset of the noise. The termination of the shock was delayed for at least 30 sec under the contingent procedure and for 30 plus a few more seconds under the non-contingent procedure. Even if it is assumed that behavior can be maintained at a 30-sec delay, in the absence of any conditioned reinforcer, it is difficult to see how the addition of an increment that would remain small in proportion to the total delay could produce such a large difference in the resulting performance. It therefore seems very doubtful that differences in the contingency between bar pressing and the termination of shock can account for the effect obtained. The noise must have been the effective reinforcer.

Another kind of evidence indicating that the white noise was reinforcing was the difference between the rates of pressing before and after noise appeared during each period of shock. Unfortunately, rates calculated from data obtained under the response-contingent procedure for the production of the noise would be misleading. In the first place, the length of the sampling period for behavior before onset of the noise was itself behaviorally determined, since it was extended by pausing but terminated by responding. Secondly, the rate during the first few seconds of noise was inflated because the noise was typically produced during a burst of responding, which did not immediately terminate when the noise appeared (Fig. 2A *vs.* B). Under the non-contingent procedure, however, termination of one sample and initiation of the other was scheduled arbitrarily, without reference to the animal's behavior. Since the animal would not have had much opportunity to modify its pattern of performance during the first session of the non-contingent procedure, following the response-contingent training, this seemed the best session on which to compare the respective rates. The data for six rats are presented in Table 2. In all cases, the rate before onset of the noise is several times higher than the rate in its presence.

As pointed out earlier (Dinsmoor and Clayton, 1963), discriminative performance to the presence and absence of noise implies selective reinforcement, *i.e.*, that pressing before onset

Table 2

Mean presses per minute before and after onset of noise on the first session under the non-contingent procedure (Experiment I).

Rat	*A9*	*B8*	*B15A*	*F11A*	*J9*	*J10*
Before Noise	15.8	19.4	12.4	7.6	31.6	18.0
During Noise	1.0	1.0	2.7	0.9	3.6	2.6

of the noise is reinforced but that pressing after noise onset is not. The only known event that follows one but not the other is the onset of the noise itself. An alternative formulation that deserves examination, however, is that the low rate of pressing in the presence of the noise might have been due to differential reinforcement of behavior incompatible with pressing, since an interval of 30 sec without a press was required to terminate the shock. To provide a test situation for examining the same discrimination without differential reinforcement for non-pressing, a second experiment was conducted in which termination of the shock was not affected by the presence or absence of bar presses during the noise but occurred arbitrarily 30 sec after its onset.

EXPERIMENT II

Six more male white rats were used, varying in age from 180 to 250 days at the beginning of training. The apparatus was identical to that used in the first experiment. The training procedure was also identical, except that presses occurring in the presence of the noise did not postpone termination of the noise and the shock. For a final test session, the noise was presented arbitrarily each time, 20 sec after the initiation of the shock, regardless of the number of presses that had occurred. This session is comparable to the first non-contingent session in the previous experiment, except for the difference in the effects of pressing during the noise.

Results and Discussion

The rates of pressing for the individual animals, both preceding and during the noise, are presented in Table 3. As might be expected, since there is no provision for preventing adventitious reinforcement during the noise, rates in the presence of this stimulus tend to be higher than they were in the first experiment. However, they still fail to approach the rates observed for the same animals before onset of the noise. Eliminating the differential reinforcement of non-pressing behavior, which might have accounted for the difference in rates observed in the first experiment, did not prevent the formation of a similar discrimination in the second. The conclusion seems almost inescapable that pressing before onset of the noise is reinforced in a way that pressing after onset of the noise is not, *i.e.*, that the noise serves as a conditioned reinforcer.

The finding that a stimulus can be established as a conditioned reinforcer without requiring the subject to make any response in its presence at any time to secure the primary reinforcer would seem to have important implications for the class of theories that assert that the effectiveness of a reinforcer depends on the strength of the behavior that occurs in its presence. Since termination of shock was used as the primary reinforcer, it was not even necessary for the animal to make a consummatory response in the presence of the stimulus, as in experiments in which food was used to maintain the behavior. In particular, this finding calls into question the generality of the suggestion (*e.g.*, Keller and Schoenfeld, 1950) that utilization as a discriminative stimulus is a necessary condition for the establishment of a stimulus as a conditioned reinforcer. (For a review of the literature, see Kelleher and Gollub, 1962). The possibility that some form of respondent activity was elicited by termination of the shock and was conditioned to the onset of the noise, cannot, of course, be ruled out. Another loophole that would seem difficult to eliminate in this type of research is the possibility that some form of superstitious behavior (Skinner, 1948) may have become established in the presence of the noise. The operation of pairing a reinforcer with a neutral stimulus involves repeated presentation of the reinforcer in the presence of the stimulus, and any form of behavior that is common in the presence of that stimulus will repeatedly be followed by the reinforcer. Thus,

Table 3

Mean presses per minute before and after onset of noise on noncontingent test day (Experiment II).

Rat	*A12B*	*A13C*	*C10*	*C14B*	*D14W*	*D15W*
Before Noise	10.4	29.7	35.2	15.3	8.6	10.7
During Noise	2.5	14.5	19.3	9.6	0.8	5.6

the noise may have come to serve as a discriminative stimulus for some such activity.

It can be stated, however, that the reinforcing effect of the noise does not depend on the deliberate establishment of any operant or on the particular form of behavior that is maintained in its presence. In a previous study (Dinsmoor and Clayton, 1963) rats were required to nose a pigeon key to terminate the shock; in the first of the present experiments, they were required to refrain from pressing; and in the second experiment, no requirement whatever was imposed. In all three cases, we were able to maintain substantial rates of pressing on a variable ratio schedule of production of the noise.

REFERENCES

Beck, R. C. On secondary reinforcement and shock termination. *Psychol. Bull.*, 1961, **58**, 28-45.

Dinsmoor, J. A. Arc suppression in shock circuits. *J. exp. Anal. Behav.*, 1960, **3**, 15-16.

Dinsmoor, J. A. A wide-range constant-current shock stimulator. *J. exp. Anal. Behav.*, 1961, **4**, 273-274.

Dinsmoor, J. A. and Clayton, Marilyn H. Chaining and secondary reinforcement based on escape from shock. *J. exp. Anal. Behav.*, 1963, **6**, 75-80.

Kelleher, R. T. and Gollub, L. R. A review of positive conditioned reinforcement. *J. exp. Anal. Behav.*, 1962, **5**, 543-597.

Keller, F. S. and Schoenfeld, W. N. *Principles of psychology*. New York: Appleton-Century-Crofts, 1950.

Myers, J. L. Secondary reinforcement: A review of recent experimentation. *Psychol. Bull.*, 1958, **55**, 284-301.

Skinner, B. F. "Superstition" in the pigeon. *J. exp. Psychol.*, 1948, **38**, 168-172.

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