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EFFECTS OF A PRE-AVERSIVE STIMULUS UPON ODDITY PERFORMANCE IN MONKEYS[1]

DONALD C. KRUPER

MONTEFIORE HOSPITAL *and* UNIVERSITY OF PITTSBURGH

Two monkeys (*Macaca mulatta*) were trained to perform an oddity discrimination using automatically projected patterned stimuli. After criteria for both response and discrimination stability were met, a tone followed by shock was superimposed upon the ongoing behavior. Each 60-sec tone was terminated with the onset of a 0.3-sec, 1 to 1.5-ma electric shock. During the tone, baseline responding was partially suppressed but discrimination performance was little altered from the pre-tone period. When shock was raised to 2 to 3 ma, responding was further suppressed, but discrimination performance was again essentially unaltered.

Studies of the conditioned emotional response (CER) procedure (Estes and Skinner, 1941; Brady and Hunt, 1955) have shown that a stimulus preceding an aversive stimulus disrupts ongoing operant behavior. Few studies, however, have investigated the effects of such pre-aversive stimuli upon response variables other than rate. Migler and Brady (1964) used a two-response chain to separate the effects of a pre-aversive stimulus on the baseline rate of responding from its effects on the temporal distribution of these responses. A schedule of differential reinforcement of low response rate (DRL) decreased the number of two-response chain sequences (a press of lever A followed by a press of lever B), but had little effect on the temporal distribution of the intervals within the sequences. Thus, although partial suppression of responses occurred during the pre-aversive stimuli, the temporal discrimination was not disrupted.

The present experiment, designed to study the effects of pre-aversive stimuli upon baseline performance on an oddity discrimination by monkeys, focussed on changes in accuracy of discrimination and response rate.

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METHOD

Subjects

Two monkeys (*Macaca mulatta*), #224 and #233, weighing 4.2 and 4.1 kg respectively, served. Both had had laboratory experience in a visual exploration study about one year earlier. During that experiment they were exposed to 144 electric shocks of about 4-ma intensity and 0.5-sec duration while viewing another monkey. Correct responses were reinforced with Ciba banana-flavored pellets (1 g) and D & G pellets (0.7 g). While the pellets were being delivered from the hopper to the food trough 30 cm below, a small light glowed over the trough. During the first 30 to 40 sessions, food intake was manipulated over a wide range. After being reduced 15% to 20% below normal quantities for several sessions, pre-experimental quantities of food were reinstated a few weeks before the aversive stimuli were introduced. During subsequent testing, the animals were maintained on a normal quantity of food, which consisted of earned reinforcers supplemented with Purina Monkey Chow.

Apparatus

Standard electromechanical control equipment, including programming and recording units were located in a sound-deadened area adjacent to the test room. In the oddity task, three geometric-design stimuli were projected through transparent plastic panels which served as the response mechanisms. Two of the stimuli were identical; the third, or correct stimulus, differed from the others. The panels

(50 by 90 mm) were mounted behind a metal frame with access holes 40 mm in diameter. Edges of the access holes were 35 mm apart. Pressing the odd panel changed the set sequentially; pressing either of the other panels rescheduled the same set of stimuli. When the limit of 21 sets was viewed, the equipment reset automatically. Although the simplest solution was for the subject to respond to the odd stimulus, responses to a sequence of 21 position or 21 single-pattern discriminations produced the same number of reinforcements. The stimuli,

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from set 1228-7 (Rev. B) of Foringer's Stimulus Images, were projected as white figures on a dark ground by one-plane digital display units (Industrial Electronic Engineers, Inc.).

Procedure

Subjects #224 and #233 required 104 and 113 thirty-minute sessions respectively to establish the oddity discrimination and stabilize response rate. During the first phases of shaping, each response to an unlighted panel was reinforced. Next, an oval image was projected upon each panel simultaneously and was terminated with a reinforcement when the subject responded. A new trial began when the stimuli reappeared 1 sec later. Position response preferences were eliminated, when they developed, by withholding reinforcement for responses on the preferred panel. The intertrial interval was then extended to 5 sec. In the absence of stimuli, a panel press did not constitute a trial; it was not reinforced, but was recorded. Such responses were frequent early in training but infrequent (mean of 6.3 per session for #224 and 1.8 for #233) during the pre-CER phase, and nearly absent at the end of testing.

Sets of oddity test stimuli were introduced and after several sessions with these stimuli (34 for #233, 11 for #224), differential intertrial intervals were added to improve performance. At that time #233 was at about 60% accuracy and #224 was at about 35%. The intertrial interval was 10 sec after an error and 2 sec after a correct response. As testing continued, intertrial intervals were slowly reduced to 1 sec. Within 30 sessions #224 passed the 90% accuracy level; #233 had passed 90% within 15 sessions.

Several different schedules of reinforcement were explored after the oddity stimuli and before tone and shock were introduced. For #224, the schedule sequence included 31 sessions of reinforcement for each correct response (CRF), followed by eight sessions of reinforcement for every second correct response (FR 2), six of CRF, two of FR 2, and four more of CRF. Reinforcement was then programmed to follow the first correct response after expiration of a variable interval (VI) with a mean value of 30 sec. After 15 sessions of VI 30-sec and 10 of VI 10-sec, VI 30-sec was used for the remainder of the experiment. Subject #233 received 24 sessions on CRF before being shifted to FR 2 for 25 sessions, FR 3 for two sessions, FR 2 for three, and then VI 30-sec for the remainder of the study.

Before introducing the pre-aversive stimulus, baseline responding was stabilized to two criteria, one based upon response stability in which the number of responses was the basic datum, and the other based upon discrimination stability in which the percentage of correct responses was the basic datum. The scores during seven 60-sec periods (later identified as the pre-aversive stimulus periods) were compared, as a ratio, to scores for equal control periods immediately preceding the former. When the score for the pre-aversive stimulus periods was less than the score for the control periods, indicating suppression of response rate or poorer discrimination during the pre-aversive stimuli (−), the formula was

$$\frac{\text{pre-tone} - \text{tone}}{\text{pre-tone}}.$$

When the score for the pre-aversive stimulus periods was greater than for the control periods, indicating facilitation of response rate or better discrimination during the tone (+), the formula was

$$\frac{\text{tone} - \text{pre-tone}}{\text{tone}}.$$

As with other ratios used in similar studies

$$\left(\frac{\text{tone}}{\text{pre-tone}}, \frac{\text{tone}}{\text{pre-tone} + \text{tone}}\right)$$

sensitivity of the present ratio varied somewhat within the limits of the scale, especially with low figures. Using percentage of errors instead of percentage of correct responses as a guide to accuracy would lead to greater variability in the discrimination ratio. An example of the wide differences possible is the comparison of discrimination ratios for data tabulated at 95% and 90% correct for the pretone and tone periods respectively, to the same results tabulated as 5% and 10% errors. In the former the ratio is −0.053 but in the latter, −0.500. Comparison of the various indices showed that the present discrimination ratio based on percent correct was representative of the effects of the pre-aversive stimulus upon discrimination performance, while less variable than other indices.

When suppression and discrimination ratios were maintained for at least three sessions with no more than a ±0.20 deviation from zero, baseline responding was considered stable. After these criteria were achieved, the pre-aversive stimulus (tone) was introduced, thus raising the sound pressure level of the testing chamber 4 db beyond background white noise of 64 db intensity. Seven 60-sec presentations of the tone were made during each session, varying the onset time of the tones from day to day.

Adaptation to the tone was carried out during the pre-CER Phase until the previous stability criteria were again met. Subject #233 required eight sessions and #224 nine. At this time a 0.3-sec scrambled electric shock of 1 to 1.5 ma and 100 kohm resistance was delivered through the grid floor and walls as soon as the tone ended.

After 10 sessions of data collection at the 1 to 1.5-ma level of shock (CER Phase I), 10 additional sessions were given at a level of 2 to 3 ma (CER Phase II). Subject #224 developed a pattern of decreasing response rate before pre-aversive stimulus presentations, suggesting that some temporal conditioning was occurring. Because seven presentations may not have provided enough variability in the time of pre-aversive stimulus onset, the number of presentations was reduced to four after 20 sessions. Consequently, during CER Phase III, the subjects received six different patterns of four tone-shock trials per session, varied from day to day. During this phase, #224 was tested for 30 sessions and #233 for 13.

RESULTS

Figure 1 illustrates individual session data for each animal. With shocks of 1 to 1.5 ma both subjects showed irregular suppression. When the shock level was increased to 2 to 3 ma during CER II and CER III, both subjects suppressed to a greater degree, but rarely completely.

Although poor discrimination performance during pre-aversive stimulus periods can be seen in some sessions, discrimination, on the whole, showed less effect than response rate. The discrimination ratio data in Fig. 1 show that, generally, accuracy during the 60-sec pre-aversive stimuli differed little from the 60-sec control periods preceding the stimuli.

In addition, the mean percentage of correct responses during the pre-aversive stimuli was compared to the mean percentage during the control periods in each phase (Table 1). These scores, as well as the discrimination ratios, showed relatively minor effects of the pre-aversive stimuli upon accuracy.

Effects on overall discrimination performance can be inferred from the 60-sec control period data of Table 1. The temporary drop in mean discrimination scores for #224 during CER II and CER III evidenced some disruption, although performance of #233 continued to improve during those phases.

Overall response rates changed relatively little throughout the experiment, although pronounced suppression occurred during pre-aversive stimuli presentations in the later stages of testing. These and other results are shown in the sample cumulative records of Fig. 2.

DISCUSSION

The lack of pronounced or reliable change in discrimination performance by monkeys during presentations of a pre-aversive stimulus agrees with the findings of Migler and Brady (1964) for rats. In both studies, response rate was partially suppressed during the pre-aversive stimulus without significantly impairing discriminative performance. Although the former study required a temporal discrimination and the present experiment involved a visual pattern discrimination, the question of possible disruptive effects of a pre-aversive stimulus upon a discriminative baseline task was tested in both.

Unlike most previous experiments in which the CER procedure has been imposed upon an ongoing baseline, both the Migler and Brady study and the present one permitted measure-

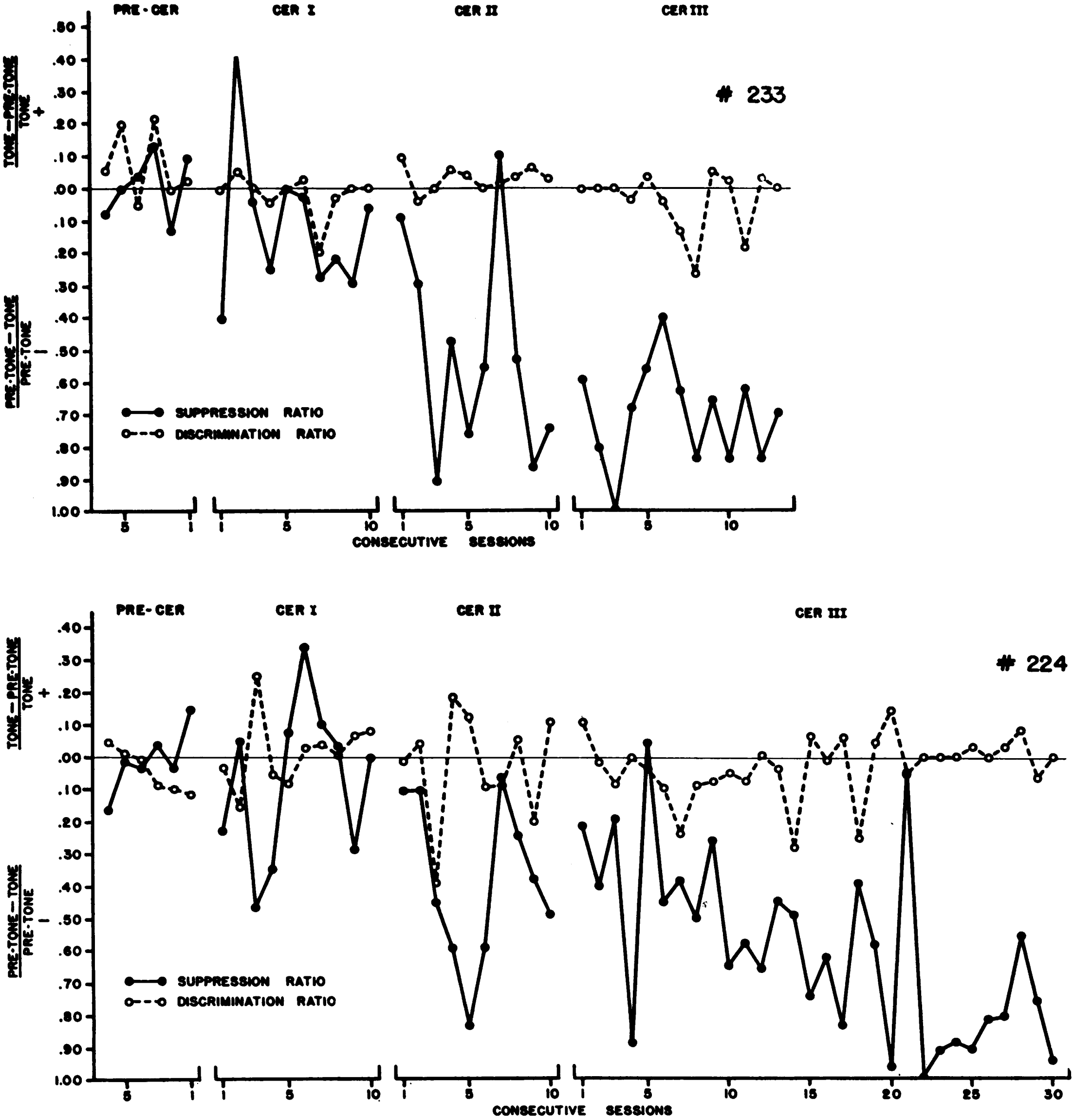

Fig. 1. Suppression and discrimination ratio scores for consecutive sessions.

ment of two components of the baseline task: rate of responding and accuracy of discrimination. The two components in the present experiment were the panel press itself and the location of the press. The three alternatives for the location of the press should logically make that component the more complex and as a result, more sensitive than response rate to disruption by the CER procedure. The present data did not confirm this supposition.

Extensive overlearning, or at least very high levels of discriminative performance, developed in this experiment may have prevented disruption of the oddity task. More data on this point may be obtained by introducing the pre-aversive and aversive stimuli earlier in the discrimination training or by using tasks of greater complexity.

Although the effects found here cannot be generalized to subjects that have not had prior experience with shock, the response suppression is similar to that expected from monkeys that have not been exposed to shock before CER training. Further testing will also be re-

Table 1

Discrimination accuracy, as percentage of correct response, on oddity during pre-aversive stimulus periods and equally long control periods which preceded each stimulus. The data for daily sessions have been summed, with the means and standard deviations (underlined) shown for each phase. The number of sessions in each phase were: Pre-CER, 6; CER I, 10; CER II, 10; and CER III, 13 for #233 and 30 for #224.

	#233			#224		
Phase	*60-Sec Control Period*	*Pre-aversive Stimulus Period*	*Difference*	*60-Sec Control Period*	*Pre-aversive Stimulus Period*	*Difference*
Pre-CER	82.7 17.00	88.1 12.90	+5.4	87.4 4.58	83.2 7.41	−4.2
CER I	96.3 3.37	94.2 5.89	−2.1	75.8 11.64	76.9 9.76	+1.1
CER II	95.8 3.78	99.6 1.26	+3.8	84.6 6.74	82.6 13.30	−2.0
CER III	97.7 2.44	94.0 9.50	−3.7	94.6 5.50	92.2 8.85	−2.4

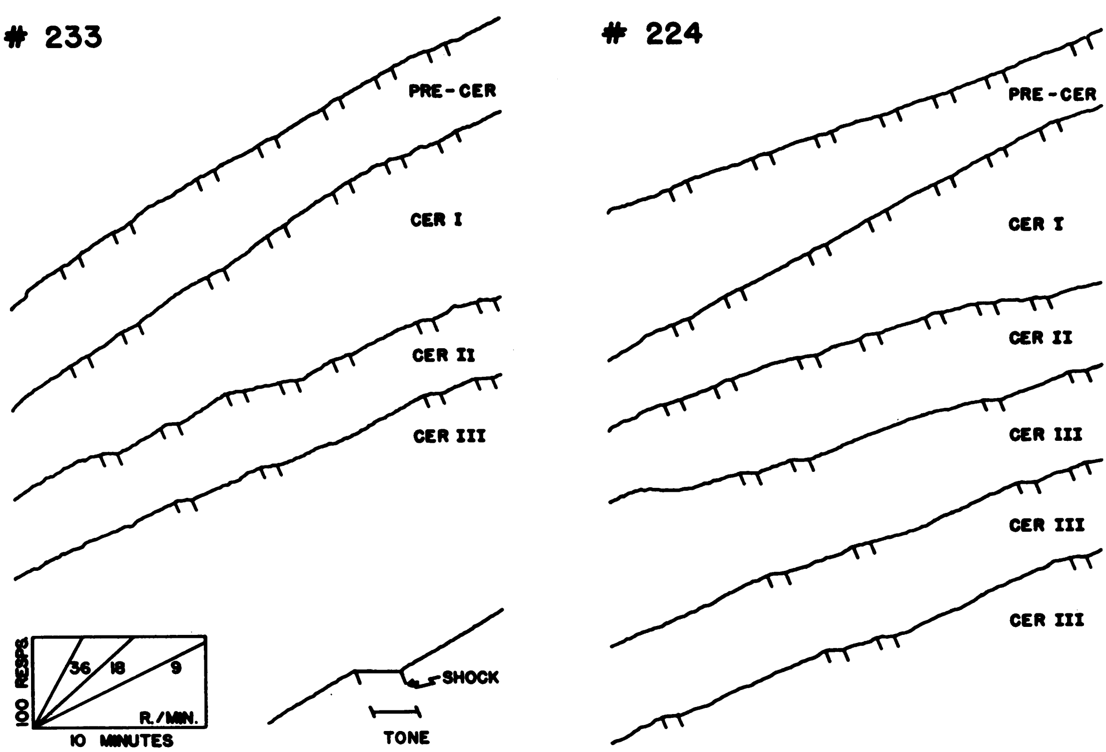

Fig. 2. Sample cumulative records for each phase of the experiment. In each of the CER Phases the curve is for the 10th session, with the 20th and the 30th session of CER III included for #224.

quired to determine whether prior shock experience is an important variable related to accuracy of discrimination.

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