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# Effects of Pentobarbital on Punished Behavior at Different Shock Intensities[1]

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WITKIN, J. M. AND J. E. BARRETT. *Effects of pentobarbital on punished behavior at different shock intensities.* PHARMAC. BIOCHEM. BEHAV. 5(5) 535–538, 1976. – Key-pecking by two pigeons was maintained initially under a schedule where the first response after five minutes had elapsed produced food. When every 50th response produced shock, responding was suppressed (punishment). Although rates and patterns of punished responding remained comparable when the shock intensity was reduced by half, pentobarbital produced much greater increases in both overall and local rates of responding at the lower shock intensity. Pentobarbital also produced larger increases in the low rates of responding immediately following shock when the lower intensity shock was in effect.

Pentobarbital Punishment Shock intensity

PUNISHED behavior, suppressed by the response-dependent presentation of a stimulus, is usually increased by appropriate doses of benzodiazepines, barbiturates, and related compounds [2, 3, 8, 9, 10, 11, 12, 13, 16, 19, 22]. The intensity of the punishing stimulus (usually electric shock) is often an important parameter of the degree of punished behavior and of the effects of a variety of drugs [8, 17, 18, 20, 21]. In a study by McMillan, pigeons responded under a multiple fixed-ratio, fixed-interval schedule (mult FR FI) where each key peck produced shock [17]. When the shock intensity was low and responding was not greatly suppressed, diazepam and pentobarbital had little effect on punished responding, a finding also reported by Geller, Kulak and Seifter, with chlordiazepoxide [8]. When the shock intensity was at higher values (4.3 and 5.2 mA), responding occurred at a near zero rate of a few responses per hour. Diazepam produced larger increases in responding punished by the 4.3 than the 5.2 mA shocks. Similar results were obtained with pentobarbital only in the FI component. Ray also varied shock intensity in a discrete trial procedure over a threefold range without changing the characteristics of the behavior under control conditions; meprobamate produced effects inversely related to the shock intensity [20].

The present study was undertaken to extend these findings with pentobarbital to conditions where punished behavior (1) occurs out of the context of a multiple schedule; (2) occurs at more than a near zero rate; and (3) is suppressed by the intermittent presentation of electric shock. All of these procedural variations have shown to be important determinants of the effects of drugs on punished responding [7, 13, 15, 16, 18].

## METHOD

### *Animals*

Two male White Carneaux pigeons were maintained at approximately 80% of their ad lib body weight. Water and grit were continuously available in separate living cages. Both birds had been exposed previously to schedules of food and shock presentation and to drug injections, including pentobarbital.

### *Apparatus*

The experimental chamber, measuring 22 x 27 x 31 cm, was equipped with a translucent response key (R. Gerbrands Co.) 2 cm in dia., located in the center of the front panel, 23.5 cm above a wire mesh floor. The key could be transilluminated by a pair of green 7 W lamps. Directly below the key, 8 cm from the floor, was a rectangular opening through which mixed grain could be presented. A minimum force of 0.15 N applied to the key produced the click of a relay mounted behind the front panel and defined a response. The experimental chamber was located in a sound and light attenuating enclosure quipped with white noise and an exhaust fan.

Shock was delivered through gold wire electrodes implanted around the pubis bone [1]. The 200 msec shocks were 120 V AC 60 Hz, delivered through a variable resistance. A phone jack connected to a swivel located at the top of the chamber was plugged into a receptacle on the bird's harness. The resistance of each bird was checked at the time of implantation and frequently thereafter throughout the course of the experiment. Experimental

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events were scheduled and recorded using relay equipment located in a separate room.

*Procedure*

Both pigeons initially responded under a fixed-interval 5-min schedule of food delivery (FI 5-min); i.e., the first response after a 5-min period elapsed produced food. A fixed-ratio 50-response schedule (FR 50) of electric shock presentation was then arranged conjointly with the FI schedule. Under this schedule every 50th response produced an electric shock and the first response to occur after 5 min produced 4-sec access to mixed grain. When food was presented, the keylight was extinguished and the food tray illuminated. After food presentation, the chamber was dark for 60 sec during which time responding had no scheduled consequences (timeout). If no response occurred within 60 sec after the 5-min FI had elapsed, time-out occurred and food was not presented (60 sec limited hold). The 50-response shock presentation ratio reset after each timeout.

Shock intensity was initially 6 mA for P-8 and 4 mA for P-2200. Dose effect curves for pentobarbital were obtained once responding had stabilized. The shock intensity was then reduced to 3 mA for P-8 and 2mA for P-2200 and responding was again allowed to stabilize (approximately 2 weeks). The effects of pentobarbital were then evaluated at the lower shock intensities.

*Drug Procedure*

Pentobarbital sodium was dissolved in 0.9% sodium chloride. Solutions were injected into the breast muscle in a volume of 1.0 ml/kg of body weight immediately before the session. Control injections consisted of an equal volume of the vehicle. Given that responding was stable, drugs were administered Tuesdays and Fridays, with Mondays and Thursdays serving as non-injection control sessions. The birds received the injections in an irregular dose series which included the injection vehicle. Doses (in terms of the salt) and vehicles were administered on at least two separate occasions. Sessions were conducted Sunday through Friday and consisted of 18 presentations of the FI schedule (approximately 100 min). Average session rates of responding were computed in responses per second from elapsed time meters and digital counters. Local response rates occurring in successive tenths of the interval were also cumulated over the entire session.

## RESULTS

Prior to the introduction of shock, response rates were 0.58 for P-8 and 1.32 for P-2200. These rates were reduced to approximately 0.08 and 0.10 for P-8 and P-2200, respectively, after shock was introduced and responding had stabilized. Responding under the conjoint schedule of food and shock presentation was generally typical of that found with FI schedules, except that responding occurred at lower rates throughout the interval [6,22]. Figure 1 (Panels A and B) shows that, for P-8 an initial period of little or no responding was followed by an increased response rate that continued until food was delivered. Responding by P-2200, however, often decreased slightly toward the end of each FI cycle (Fig. 1, Panels A and B). Overall response rates and patterns of responding were remarkably comparable, despite a two-fold difference in shock intensity. When the higher shock intensity was in effect, however, there was often a complete cessation of key pecking after a shock delivery; occasionally, food was not produced at the end of these intervals during which a

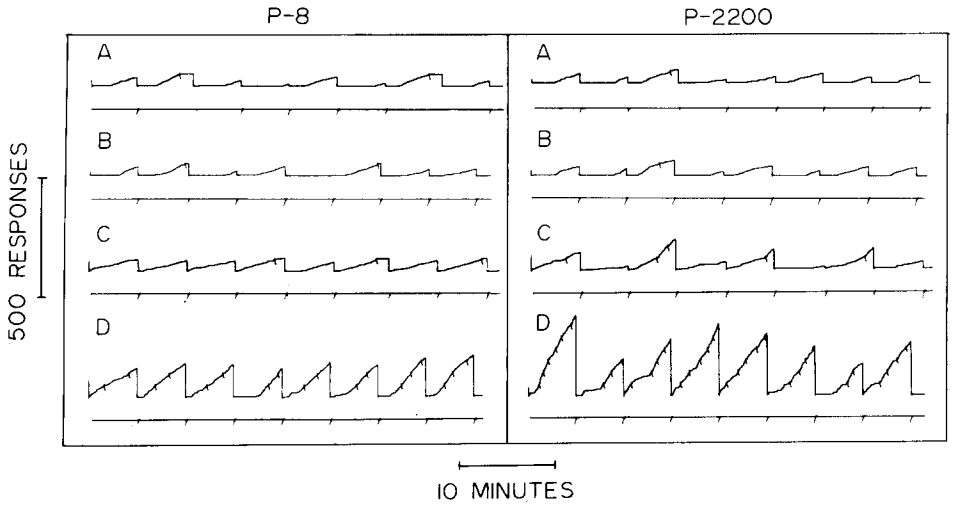


FIG. 1. Cumulative response records taken from representative portions of experimental sessions of P-8 and P-2200. Ordinate: cumulative responses; Abcissa: time. The response (upper) pen reset to baseline after each time-out. Shock presentations are indicated by the short diagonal strokes on the response record. Food delivery is indicated on the event (lower) line. The paper did not move during timeout. Panel A: control performances for P-8 and P-2200 at the higher shock intensity (6 mA and 4 mA respectively). Panel B: control performance under the lower shock intensity (3 mA for P-8 and 2mA for P-2200). Panel C: effects of 10.0 mg/kg pentobarbital when the shock intensity was high. Panel D: effects of 10.0 mg/kg pentobarbital at the lower shock intensity.

response produced shock (Panel A). Lower shock intensities (Panel B) did not produce as marked a disruption of ongoing behavior as occurred at the higher shock levels.

The effects of pentobarbital on punished responding at the two different shock intensities are shown in Fig. 2. Doses of 1.0 to 10.0 mg/kg pentobarbital had little effect on overall rates of responding at the higher shock intensities. Only 5.6 mg/kg (P-2200) and 10 mg/kg (both birds) produced small increases in overall rates of punished behavior. Although there was, at most, an increase of only 0.025 responses per sec when the lower shock intensity was in effect, pentobarbital produced substantially greater increases in punished responding of both birds at the lower shock level. For P-8 these increases occurred at all doses, whereas for P-2200 this effect occurred with the doses where small increases were obtained previously at the higher shock intensity (5.6 and 10 mg/kg).

The effects of 10 mg/kg of pentobarbital on the rates and patterns of responding at the two shock levels can be seen in Fig. 1 (Panels C and D). Pigeon P-8 responded at a fairly constant rate throughout the interval, with the initial pause greatly reduced or absent. Responding was somewhat more erratic for P-2200 with pentobarbital at the higher shock intensity.

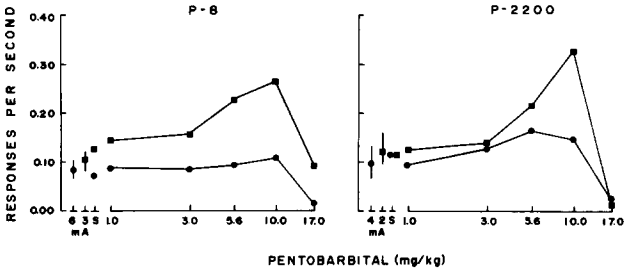


FIG. 2. Effects of pentobarbital on punished responding at two different shock intensities. Means and ranges of control rates and ranges are given at the different shock levels. Squares represent responding punished at the lower shock intensity. Circles represent responding at the higher intensity. S denotes saline injections.

For both birds, pentobarbital produced larger increases in the low rates of responding that occurred immediately following shock presentation at the lower shock intensity. Increases in punished responding were greatest early in the FI, before any shock occurred, when the lower shock intensity was in effect. These effects can also be seen in Figure 3 which shows the effects of pentobarbital on average local response rates throughout each tenth of the fixed-interval. In general, lower local response rates were increased to a substantially greater extent than higher rates, regardless of the shock intensity. However, comparable local response rates occurring when the shock intensity was lower were increased to a much greater degree.

## DISCUSSION

In this study, pentobarbital produced much larger increases in punished responding when the shock intensity was relatively low. The control rate and temporal pattern of responding were quite similar at both shock intensities even

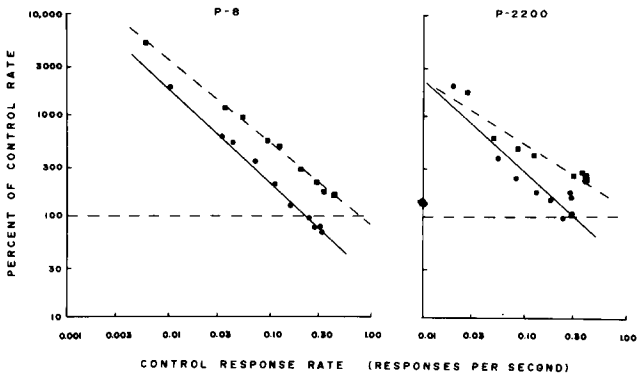


FIG. 3. Effects of 10.0 mg/kg pentobarbital on local rates of punished responding at the higher and lower shock intensities. Filled squares represent local response rates at the lower shock intensity; filled circles, response rates at the higher intensity. Both abscissa and ordinate are log scales. Abscissa: average control rate of responding during individual 30-sec segments of the 5-min fixed-interval schedule. Ordinate: response rate after drug as a percentage of control rate.

though this parameter was decreased by half. Because of the relative invariance in response rate with the shock intensities used in the present study, the conjoint schedule of intermittent food and shock presentation may be particularly useful where shock intensity manipulations need be unconfounded by correlated changes in baseline response rate.

The rate of responding, the rate of shock presentation, and the context in which punished responding occurs are all important variables controlling the manner in which drugs interact with punished behavior [7, 13, 15, 16, 18]. That the data reported here are comparable to results obtained by McMillan [17], despite procedural differences between these studies, points to the importance of the punishing stimulus intensity in modifying the behavioral effects of drugs.

The response-produced delivery of electric shock at the higher intensity usually had larger effects on ongoing behavior whether or not pentobarbital was administered. Larger increases in responding that occurred immediately after a lower intensity shock do not, however, account in total for the differential effects of pentobarbital reported here. Pentobarbital produced greater increases in responding that occurred early in the FI under the lower intensity even before any shock was presented (see Fig. 1).

It is interesting to note the similarity in the present data to those of McKearney [14]. In that study, responding in alternate periods of an FI schedule was decreased by the presentation of a houselight which was not present during food delivery (continuous houselight procedure). When the intensity of the houselight was varied over a wide range, the response rate occurring in these periods remained fairly constant. As the houselight intensity was decreased, the effects of 17.0 mg/kg amobarbital increased from a marginal effect to over a 300-fold increase in response rate. Similar results were obtained when responses in alternate periods produced the stimulus change (response-produced houselight procedure). Thus, it appears that both punishing and discriminative stimuli may modify the rate-dependent effects of the barbiturates.

McMillan [17,18] has suggested that the effects of the

benzodiazepines and barbiturates on punished behavior are an inverted U-shaped function of shock intensity. The ascending limb of this relationship is based in part on manipulations in shock intensity which substantially alter the rate of responding [10, 17, 18]. The rate of responding is, however, an important determinant of the behavioral effects of these drugs [4, 5, 16, 22]. The present data along with that of McMillan [17,18] and Ray [20] suggest rather that the effects of pentobarbital, diazepam, and meprobamate are inversely related to the punishing stimulus intensity when rates of responding do not covary with shock intensity manipulations

It has been a subject of much concern as to whether or not drugs affect comparable rates of punished and unpunished behavior differently. With meprobamate and chlordiazepoxide Cook and Catania demonstrated larger increases in punished responding than in unpunished responding occurring concurrently at an equivalent rate [2]. Similar results have been reported with diazepam and chlordiazepoxide [4]. Wuttke and Kelleher [22] showed that matched rates of punished and unpunished behavior were affected in an equivalent manner by various benzodiazepines. Using multiple FI schedules, McMillan [16] demonstrated that pentobarbital and chlordiazepoxide increased punished responding occurring early in the FI proportionally more than comparable rates of unpunished responding. The data on the effects of barbiturates, benzodiazepines, and related drugs on behavior punished with different shock intensities suggests that punished responding may be increased to a greater, lesser, or an equivalent extent as similar rates of unpunished responding, depending on the shock intensity. It is apparent that statements relating to the differential effects of drugs on punished and unpunished behavior per se need much further clarification. Punishment is not a unitary process and attempts to describe categorically the effects of drugs on "punished behavior" are likely to yield oversimplified or erroneous conclusions. As McMillan [16,18] has pointed out, an analysis of a host of schedule parameters is necessary for a thorough understanding of the multiple relationships determining the effects of drugs on punished behavior.

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