*RATE-DEPENDENT EFFECTS OF DRUGS:
MODIFICATION BY DISCRIMINATIVE STIMULI
OF THE EFFECTS OF AMOBARBITAL ON
SCHEDULE-CONTROLLED BEHAVIOR¹*

JAMES W. MCKEARNEY

HARVARD MEDICAL SCHOOL

Food-deprived pigeons responded under a 10-min fixed-interval schedule of food presentation. During even-numbered minutes of the schedule, the discriminative stimuli were the same as those present when food was delivered. During odd-numbered minutes there was either a change in keylight color or a change in overhead illumination, either for the entire duration of the odd-numbered minutes, or for 3-sec after each response. Responding during even-numbered minutes showed the usual pattern of positive acceleration; responding during odd-numbered minutes was similarly graded, but rates were much lower. The response-rate-increasing effects of amobarbital were inversely related to control rates of responding for both even- and odd-numbered minutes. However, when the stimulus change during odd-numbered minutes was either keylight color or a change from a darkened to a brightly illuminated chamber, increases in responding were considerably less than predicted on the basis of the effects on responding during even-numbered minutes. When the stimulus change was from a darkened to a dimly illuminated chamber, control rates of responding changed little, but increases in responding during odd-numbered minutes after amobarbital were considerably greater, and of the approximate order expected on the basis of control rate.

The rate of occurrence of a behavior is an important determinant of the effects of drugs on it (Dews, 1958; Kelleher and Morse, 1968). For example, Dews (1958) showed that the same doses of methamphetamine that either have no effect or decrease responding under schedules that engender high rates of responding, increase responding under schedules that generate relatively lower control rates of responding. The rate-dependent effects of the amphetamines have been confirmed by other investigators (*e.g.*, Smith, 1964; Clark and Steele, 1966), and similar results have been obtained with other sympathomimetic amines (McMillan, 1968 *a, b*), barbiturates (Waller and Morse, 1963), meprobamate and chlor-diazepoxide (Cook and Kelleher, 1962; Cook

and Catania, 1964), cocaine, pipradrol, and imipramine (Smith, 1964).

Although the control rate of responding is an important determinant of the effects of drugs on schedule-controlled behavior, it is not, of course, the sole determinant. For example, amphetamines do not generally increase rates of responding suppressed by the presentation of electric shock (Geller and Seifter, 1960). The present paper describes an effect of non-noxious stimuli in changing the effect of a drug at a given rate of responding.

Advantage has been taken of the wide range of response rates engendered by a fixed-interval (FI) schedule. Under a fixed-interval schedule of food presentation, food is presented after the first response to occur after a fixed period of time has elapsed. The pattern of responding consists of an initial period of little or no responding followed by acceleration of responding to a terminal rate that is continued until food is presented. The rate of responding can be reduced by introducing an additional intermittent stimulus (S^A) which is never present when food is presented; if S^A periods are repeated, a wide variety of response rates is engendered. Rates of responding in the presence

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of S^D (i.e., the stimulus present at the time of food-presentation) range from near-zero at the beginning of the fixed-interval to as many as one or more responses per second at the end of the interval. Rates of responding during S^A are similarly graded, but absolute rates of responding are much lower than during S^D . Using a schedule of this type, Dews (1964) found that amobarbital increased response rates of pigeons proportionally more during S^A than during S^D periods. However, the proportional increases in response rate after amobarbital were found to be an inverse function of control response rates during individual S^D and S^A periods; that is, low rates under either S^D or S^A were increased proportionally more than high rates. The effects of amobarbital depended on the control rates rather than on the presence or absence of S^A .

In the present experiments, the dependence of the effects of amobarbital on control response rate, and changes in this dependency as a result of introduction of various types of discriminative stimuli, are explored.

METHOD

Subjects and Apparatus

Adult male White Carneaux pigeons, maintained at approximately 80% of free-feeding body weight, served as subjects. All had been exposed to various schedules of food presentation. Experiments were conducted in standard chambers (Ferster and Skinner, 1957), housed in ventilated, sound-attenuating enclosures. A translucent plastic pecking key, which could be transilluminated by various colored lights (keylights), was mounted on one wall of the chamber; a peck of at least 15 g (0.147 N) force interrupted an electrical contact, and was recorded as a response. Immediately below the key was an opening through which food

(grain) could be presented. White noise was always present in the experimental chambers.

Procedure

All pigeons responded under a 10-min fixed-interval schedule of food presentation; that is, food was presented for 3 sec after the first response to occur after 10 min. A 1-min timeout period, during which all lights were extinguished and responding had no scheduled consequences, followed each food presentation. If no response was made within 30 sec of the end of 10 min, the timeout was presented automatically, and food was not available until the end of the next fixed interval (30-sec limited-hold). Daily sessions terminated after eight presentations of the timeout period.

During even-numbered minutes (2, 4, 6, 8, and 10) of the fixed interval, stimulus conditions were identical to those present at the time of food presentation (S^D). During odd-numbered minutes (1, 3, 5, 7, and 9), an S^A condition prevailed. The specific stimulus conditions present in even- and odd-numbered minutes of the fixed interval were different in different experiments (Table 1).

During the Response-Produced Keylight procedure, a red keylight was present continuously during even-numbered minutes, whereas each response produced a 3-sec change of the keylight color to green during odd-numbered minutes. With the Continuous Keylight procedure, a red keylight was again continuously present during even-numbered minutes, whereas the key was continuously green during each odd-numbered minute. Under both keylight procedures, a 25-w overhead light (houselight) was continuously present during each FI.

During the Response-Produced Houselight procedure, the overhead lamp (houselight) was out during even-numbered minutes, while

Table 1
Summary of Experimental Procedures

<i>Procedure</i>	<i>S^D (Even Min)</i>	<i>S^A (Odd Min)</i>
Response-Produced Keylight	red Keylight ^a	peck produces 3-sec green Keylight
Continuous Keylight	red Keylight ^a	green Keylight for duration of minute
Response-Produced Houselight	no Houselight ^b	peck produces 3-sec Houselight
Continuous Houselight	no Houselight ^b	Houselight on for duration of minute

^aHouselight illuminated during entire FI.

^bRed Keylight on during entire FI.

each response during odd-numbered minutes produced a 3-sec illumination of the house-light. Finally, under the Continuous House-light procedure the lamp was out during even-numbered minutes and on for the duration of each odd-numbered minute. Under both houselight procedures, the red keylight was present during the entire FI.

In separate experiments under the house-light procedures, the effects of decreasing the intensity of the overhead illumination were investigated; this was accomplished by placing series resistance of either 300, 500, or 700 ohms (in that order) in the houselight circuit.

Amobarbital sodium was dissolved in 0.9% sodium chloride solution, and was prepared in several concentrations so that the volume injected was always 1.0 ml/kg of body weight. All doses are expressed in terms of the total salt. Drugs were injected intramuscularly, 15 min before the session, no more than twice per week.

Analysis of Results

Drug effects are expressed both as absolute and percentage changes in response rate. Mean rates of responding during several (3 to 10) normally executed sessions interspersed among the various drug sessions were taken as the control performance.

In order to analyze separately the effects of drugs on responding during individual S^D and S^A periods, rates of responding were recorded separately for each 1-min segment of the fixed interval, cumulated over a session. Because response rates during individual 1-min periods of the FI varied over as much as a thousand-fold range, these results were plotted on logarithmic coordinates.

EXPERIMENT I

Experiment I compared the effects of amobarbital on responding under the Response-Produced Keylight (Birds 464, 286, 295) and Continuous Keylight (Birds 245, 294, 130) procedures.

RESULTS

Control performances under both procedures resembled those that Dews (1962) described for a similar procedure. Average rates of responding were very low during S^A periods.

Rates of responding during S^D periods were higher, and retained the overall positive acceleration characteristic of responding under fixed-interval schedules. Although rates of responding during S^D did not systematically differ among birds responding under the two procedures, the birds under the Response-Produced Keylight procedure consistently responded at higher rates during S^A periods than did the birds under the Continuous Keylight procedure. Average rates of responding during S^D and S^A periods for each bird are summarized in Table 2.

Table 2

Average rates of responding (response/sec) during S^D and S^A under the Response-Produced and Continuous Keylight procedures.

Procedure	Bird	S^D	S^A
Response-Produced Keylight	464	0.786	0.106
	286	1.102	0.097
	295	0.676	0.077
Continuous Keylight	294	0.703	0.003
	245	0.526	0.005
	130	0.740	0.009

Figure 1 summarizes the effects of amobarbital on average rates of responding during S^D and S^A periods under both keylight procedures. Amobarbital produced marked dose-dependent increases in total S^D and S^A response rate under both procedures.

The effects of selected doses of amobarbital on responding during individual S^D and S^A

Fig. 1. Effects of amobarbital on responding under a 10-min fixed-interval schedule with multiple S^A periods. Open symbols: S^D responding. Closed symbols: S^A responding. Circles: Response-Produced Keylight procedure. Triangles: Continuous Keylight procedure. C: control response rates (mean of 15 nondrug sessions per bird, three birds per data point). Each point is the mean of two injections given to each of three birds.

periods under the Response-Produced and Continuous Keylight procedures are shown in Fig. 2 and 3, respectively. At these doses, increases in rates of responding during individual 1-min periods were inversely related to

Fig. 2. Effect of amobarbital on responding during individual 1-min segments of the fixed-interval schedule with multiple S^A periods under the Response-Produced Keylight procedure. Ordinate: rate after amobarbital expressed as percent of control. Abscissa: control rate during individual 1-min segments of the FI. Ordinate and abscissa are logarithmic. Open circles: S^D . Closed circles: S^A . Number of control sessions and number of injections per data point are the same as in Fig. 1. Regression lines were fitted by the method of least squares.

control rates during these periods (as indicated by the sloping regression lines). But, under both procedures, the S^A data points were considerably below the regression line fitted to the S^D points; that is, the increases in S^A responding were less than would be expected if

Fig. 3. Effect of amobarbital on responding during individual 1-min segments of the fixed-interval schedule with multiple S^A periods under the Continuous Keylight procedure. Ordinate: rate after amobarbital expressed as percent of control. Abscissa: control rate during individual 1-min segments of the FI. Ordinate and abscissa are logarithmic. Open circles: S^D . Closed circles: S^A . Number of control sessions and number of injections per data point are the same as in Fig. 1. Regression lines were fitted by the method of least squares.

the magnitude of the increase depended solely on the control rate of responding. If the rate-enhancing effects of these drugs depended only on control rates of responding, all data points should have fallen along a common regression line.

EXPERIMENT II

The results of Exp. I differ from those previously obtained under a very similar procedure. In Dews' (1964) experiment, the effects of amobarbital depended only on the pre-drug rate of responding, and the points for S^D and S^A periods fell on the same regression line. Dews, however, used a houselight instead of a keylight change, as in Exp. I here. Experiment II was therefore carried out in the same manner as Exp. I, except that the discriminative stimulus was houselight instead of keylight change.

RESULTS

The control performances here were similar to those of Exp. I. As with the keylight procedures, rates of responding during S^A were always higher under the Response-Produced Houselight procedure than under the Continuous Houselight procedure (Table 3). The effects of amobarbital on responding during S^D periods were also similar to those obtained under the procedures of Exp. I (Fig. 1); these effects will not be discussed in detail.

Effects of amobarbital on responding under the Continuous Houselight procedure (Birds 200 and 445). The effects of amobarbital on responding during S^A under the Continuous Houselight procedure are shown in the first panel of Fig. 4 (0 ohms). For Bird 445, there was little change in rate of responding at any dose; for Bird 200, however, there was a marked, dose-dependent increase in S^A responding after amobarbital.

Fig. 4. Effect of amobarbital on S^A responding with varying brightnesses of S^A under the Continuous Houselight procedure. Houselight (S^A) intensity was varied by placing varying series resistances in the circuit. Closed circles: Bird 200. Open circles: Bird 445. Each point represents a single administration of amobarbital.

Table 3

Effects of 17.0 mg/kg amobarbital on S^A responding under Continuous Houselight and Response-Produced Houselight procedures (Birds 200 and 445).

Bird	Continuous Houselight				Response-Produced Houselight		
	Ohms	Control ^a	Drug ^a	Percent ^b	Control	Drug	Percent
200	0	0.008	0.156	1950.	0.066	0.166	252.
	300	0.007	0.124	1771.	0.075	0.155	207.
	500	0.008	0.031	388. ^c	0.062	0.208	335.
	700	0.012	0.384	3200.	0.055	0.148	269.
445	0	0.010	0.007	70.	0.062	0.093	150.
	300	0.014	0.085	607.	0.073	0.098	134.
	500	0.018	0.114	633.	0.105	0.135	129.
	700	0.024	0.359	1496.	0.110	0.159	145.

^aResponses per second.

^bResponse rate after amobarbital as percentage of control rate.

^cThe relatively slight response to 17.0 mg/kg amobarbital in Bird 200 under the continuous 500-ohm houselight procedure may have been due to a deteriorated drug solution or an improper injection volume.

The increase in S^A responding for Bird 200 under the Continuous Houselight procedure was far greater, on either an absolute or a percentage-of-control basis, than occurred under either of the procedures of Exp. I. This, in addition to the fact that Bird 445 did not show substantial increases in S^A responding under the same procedure, suggested that some dimension of the S^A , to which different birds might be differentially sensitive, might influence the magnitude of the drug effects. Therefore, in subsequent experiments the intensity of the houselight was systematically varied, and the amobarbital dose-effect relation was redetermined at each intensity.

The effects of amobarbital on S^A responding under the Continuous Houselight procedure at each of the houselight intensities are summarized in Fig. 4. In general, as intensity of S^A decreased, the amount of increase in S^A responding after amobarbital increased, despite the fact that control response rates during S^A changed relatively little as the intensity of the houselight diminished (Table 3).

The effects of selected doses of amobarbital on responding during individual 1-min periods for Bird 200 are shown in Fig. 5. With no added resistance in the houselight circuit (Fig. 5a and 5b), all S^A data points fell below the S^D regression line. When a 300-ohm resistance was in series with the houselight, the effects of 17 mg/kg amobarbital (Fig. 5c) were similar to those obtained with the bright houselight; however, at 30 mg/kg (Fig. 5d), the regression lines for S^D and S^A responding intersected, in-

dicating that increases in S^A responding were of the approximate order to be expected on the basis of a simple rate-dependency. Similar results were obtained with Bird 445 when a 700-ohm resistance was added to the houselight.

Cumulative response records illustrating the effects of 17 mg/kg amobarbital under varying

Fig. 5. Effect of amobarbital on responding during individual segments of the fixed-interval schedule with multiple S^A periods under the Continuous Houselight procedure. Ordinate: rate after amobarbital expressed as per cent of control. Abscissa: control rate during individual 1-min segments of the FI. Ordinate and abscissa are logarithmic. Open circles: S^D . Closed circles: S^A . A and B: with no added resistance in houselight circuit effects of 17.0 and 30.0 mg/kg amobarbital, respectively. C and D: with 300 ohm added resistance in the houselight, effects of 17.0 and 30.0 mg/kg amobarbital, respectively. Each point represents a single determination.

brightnesses of the houselight for Birds 200 and 445 are shown in Fig. 6 and 7. Note that, for both birds, there were sustained periods of responding at high rates during S^A at the lower houselight intensities (e.g., Fig. 6d, 7d and 7e).

Effects of amobarbital on responding under the Response-Produced Houselight procedure (Birds 200 and 445). After the dose-effect curves for amobarbital were established at varying brightnesses of the houselight under the Continuous Houselight procedure, Birds 200 and 445 were placed under the Response-Produced Houselight procedure; again, amobarbital dose-effect curves were determined in the presence of different brightnesses of the houselight. Average control rates of responding during S^A periods are summarized in Table 3.

In contrast to the Continuous Houselight procedure, increases in S^A responding after amobarbital did not vary systematically as the intensity of the houselight was decreased. Though at several drug doses there was substantial responding during S^A under the Response-Produced Houselight procedure, the relative increases (that is, as compared to control rates) were generally not as great. Figure 8 presents cumulative response records illustrating the effects of 17 mg/kg amobarbital

under the Response-Produced Houselight procedure with 700 ohms resistance in the houselight. Note that the increases in S^A responding (Fig. 8b and 8d), were very much less than obtained under the Continuous Houselight procedure at the same houselight brightness (Fig. 6d and 8e).

Table 3 summarizes the effects of 17.0 mg/kg amobarbital on response rate during S^A under both the Continuous and Response-Produced Houselight procedures.

Comparison of drug effects under all procedures (Birds 464 and 130). With Birds 200 and 445 under the houselight procedures, increases in S^A responding after amobarbital were considerably greater than under the key-light procedures in Exp. I. In addition, amobarbital increased S^A responding more under the Continuous Houselight procedure than under the Response-Produced Houselight procedure at equivalent houselight brightnesses. In order to compare more directly the effects

Fig. 6. Effects of amobarbital on responding under the Continuous Houselight procedure with different houselight brightnesses (Bird 200). Pen reset to base at food presentation. Pen deflected downward during S^A periods. A: no drug, no added houselight resistance. B: 17.0 mg/kg amobarbital, no added resistance. C: 17.0 mg/kg amobarbital, 300 ohms added resistance. D: 17.0 mg/kg amobarbital, 700 ohms added resistance.

Fig. 7. Effects of amobarbital on responding under the Continuous Houselight procedure with different houselight brightnesses (Bird 445). Details of recording same as Fig. 6. A: no drug, no added houselight resistance. B: 17.0 mg/kg amobarbital, no added resistance. C: 17.0 mg/kg amobarbital, 300 ohms added resistance. D: 17.0 mg/kg amobarbital, 500 ohms added resistance. E: 17.0 mg/kg amobarbital, 700 ohms added resistance.

Fig. 8. Effects of amobarbital on responding under the Response-Produced Houselight procedure with different houselight brightnesses (Birds 200 and 445). Details of recording same as in Fig. 6. A: Bird 200, no drug, 700 ohms added houselight resistance. B: Bird 200, 17.0 mg/kg amobarbital, 700 ohms resistance. C: Bird 445, no drug, 700 ohms added resistance. D: Bird 445, 17.0 mg/kg amobarbital, 700 ohms added resistance.

of drugs on S^A responding, two birds were studied using several different procedures: Bird 464 with the Response-Produced Keylight (Exp. I), and the Continuous and Response-Produced Houselight (300-ohm resistor) procedures and Bird 130 with the Continuous Keylight (Exp. I), the Response-Produced Keylight, and the Continuous and Response-Produced Houselight (0 or 700-ohm resistor) procedures.

Relative increases in S^A responding (that is, as compared with control rates) were least under the Response-Produced Keylight procedure, and greatest under the Continuous Houselight procedure; intermediate increases

in S^A responding were observed with the Response-Produced Houselight and Continuous Keylight procedures (Table 4). On an absolute basis, rates during S^A after amobarbital were always less under the keylight procedures than either of the houselight procedures, and less under the Response-Produced Houselight than the Continuous Houselight. Differences in absolute S^A rate during the houselight procedures were slight as compared to the differences between rates during the keylight procedure and either of the houselight procedures.

Figure 9 shows the effects of 17 mg/kg amobarbital on responding during individual 1-min segments under several procedures for Bird 464. With the Response-Produced Keylight procedure, the data points for increases in S^A and S^D responding clearly fell along separate regression lines (Fig. 9a) as in Exp. I (Fig. 2). With the Continuous Houselight procedure, however, all data points, whether from S^D or S^A periods, fell much more closely along a single regression line (Fig. 9b). Under the Response-Produced Houselight procedure, the effects were generally intermediate between the effects obtained with the two other procedures. Similar results were obtained with

Fig. 9. Effects of amobarbital (17.0 mg/kg) on responding during individual segments of the FI schedule with multiple S^A periods under three procedures. Details of graphing same as in Fig. 5. A: Response-Produced Keylight procedure. B: Continuous Houselight procedure (300 ohms added resistance). C: Response-Produced Houselight procedure (300 ohms added resistance).

Table 4

Effects of amobarbital (17.0 mg/kg) on S^A responding in Birds 464 and 130 under several procedures

	Bird	Keylight			Houselight (No Resistance)			Houselight (Added Resistance)		
		Responses/sec		% of Control	Responses/sec		% of Control	Responses/sec		% of Control
		Control	Drug		Control	Drug		Control	Drug	
Continuous	464	—	—	—	—	—	—	0.030	0.262	873.
	130	0.009	0.040	444.	0.008	0.140	1750.	0.015	0.806	5373.
Response-Produced	464	0.106	0.185	175.	—	—	—	0.102	0.402	394.
	130	0.094	0.163	173.	0.067	0.319	476.	0.092	0.897	975.

Bird 130 after 17.0 mg/kg amobarbital. Under the Continuous and Response-Produced Key-light procedures, data points for increases in S^D and S^A responding fell along distinctly separate regression lines, while under the Continuous and Response-Produced Houselight procedures (with 700 ohms added resistance) data points for increases in S^D and S^A responding fell along similar regression lines.

Table 4 summarizes the effects of 17.0 mg/kg amobarbital on overall S^A responding of Birds 130 and 464 under the various procedures.

DISCUSSION

At doses that clearly increased responding, the effects of amobarbital depended on the control rates of responding, whether in the presence of S^D or S^A , as is shown by the sloping regression lines (Fig. 2, 3, 5, 9). Relatively low rates of responding during S^A were increased more than higher rates, and relatively low rates during S^D were increased more than higher rates during S^D . However, whether or not low rates of responding in general were increased more than higher rates was shown to depend importantly on the physical intensity and mode of presentation of the discriminative stimuli. Under the Continuous and Response-Produced Keylight procedures, in which a change in keylight color served as S^A , there were always distinctly separate regression lines for S^D and S^A responding; in all cases, the data points for S^A responding fell well below the regression lines for S^D responding, indicating that the increases in S^A responding were considerably less than would be predicted from the effects on S^D rates.

Similar control rates of responding during S^A were engendered by procedures in which S^A stimuli were similarly presented, regardless of whether the keylight or houselight was the S^A . However, in all cases the increase in S^A responding after drug was far greater under the procedures in which the houselight served as the S^A . With the Continuous Houselight procedure, the amount of increase in S^A responding after amobarbital increased as the intensity of the houselight diminished, despite the fact that control rates of responding during S^A changed very little as the houselight dimmed. It is clear that the control rate of responding in the presence of a stimulus does not alone

determine the amount of stimulus control that will be maintained after drug administration.

When the difference in stimulus conditions present during S^D and S^A periods was a change in the color of the keylight, or a change from a darkened to a brightly illuminated chamber, increases in S^A responding after amobarbital were relatively small, and considerably less than expected by extrapolation from the effects on responding during S^D . When the difference in stimulus conditions was a change from a darkened to a dimly illuminated chamber, increases in S^A responding after amobarbital were considerably greater and of the approximate order expected on the basis of control rate. Clearly, the resistance of stimulus control to attenuation by amobarbital was greater in the case of the keylight-color stimulus than in the case of the overhead light stimulus, and greater in the case of the brighter overhead light than in the case of the dimmer overhead light. The present experiments have demonstrated differences in the strength of stimulus control that were undetectable under non-drug conditions.

The proportional increases in S^A responding after drug were typically greater under the continuous S^A procedures than under the response-produced S^A procedures. However, it is difficult to say whether this is a reflection of some difference in the amount of stimulus control exerted by the two types of procedures, or whether this difference was due to the different control rates of S^A responding generated by the two procedures. To sort out the relative contributions of mode of presentation and control rate of responding, similar rates of responding would have to be established under response-produced S^A and continuous S^A procedures.

Laties and Weiss (1966) also studied the dependence of drug effects on rate of responding and on control by discriminative stimuli. Pigeons responded under 5-min FI schedules of food presentation. Under one condition, stimuli remained constant throughout each 5-min period; under the other condition, a different symbol was projected on the response key during each minute of the FI. Under the first condition, the usual pattern of positively accelerated responding prevailed, but under the second condition responding was largely confined to the final minute of the FI. Since food was always presented in the presence of

the stimulus present during the fifth minute, the stimuli present during minutes 1 to 4 were functionally equivalent to the S^A stimuli used in the present experiments. After amphetamine, scopolamine or pentobarbital, increases in normally lower response rates (*i.e.*, those occurring relatively early in the FI) were greatest under the FI schedule without the added "clock" stimuli; after chlorpromazine, however, this differential effect was not as pronounced. Thus, despite the very low control rates of responding during minutes 1 to 4 of the FI "clock" schedule, these rates were not increased as much as those during the early minutes of the simple FI schedule. Laties and Weiss interpret their data to mean that control rates of responding are relatively unimportant determinants of drug effects when behavior is under the control of powerful discriminative stimuli. "Conversely, base-line rate becomes more important in determining drug effects when the control exerted by these stimuli is lessened, as we believe it to be by chlorpromazine" (Laties and Weiss, 1966, p. 395).

The present experiments show that, even under conditions where responding under strong stimulus control is enhanced markedly less than responding not under such control, the increases in responding that do occur are inversely related to control response rates. When S^A was a keylight color change or a relatively bright overhead light, increases in S^A responding after amobarbital were less than expected on the basis of the effects on S^D responding, but the increases in S^A responding that did occur were, nevertheless, inversely related to control rates of responding during S^A . Stated another way, the control exerted by S^A changed the y-intercept of a portion of the drug rate-dependency function without changing its slope. Under conditions of apparently lessened stimulus control (although this was not reflected in control rates of responding during S^A) neither the intercept nor the slope was altered; that is, the magnitude of the enhancement in responding after amobarbital approximated an inverse linear function of control rates of responding during individual

1-min periods, irrespective of whether or not S^A or S^D stimuli were present.

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