Effects of Drugs on Stimulus Control of Behavior.
I. Independent Assessment of Effects on Response Rates and Stimulus Control

ABSTRACT

Pigeons were trained to peck one of two concurrently available, differently colored response keys (red or amber) depending on the presence or absence of a houselight that provided general illumination of the experimental chamber. When the houselight was illuminated, only responses on a red key were reinforced (red-key responses designated $S^D$ responses; amber-key responses designated $S^A$ responses); when the houselight was not illuminated, only responses on an amber key were reinforced (amber-key responses designated $S^A$ responses; red-key responses designated $S^D$ responses). Under one procedure, every $S^D$ response was reinforced (fixed-ratio 1 schedule), whereas under a second procedure, the first $S^D$ response after the elapse of a 5-min interval was reinforced (fixed-interval 5-min schedule). Both the rates of responding and the stimulus control over responding exerted by the houselight were assessed. Under the fixed-ratio 1 schedule, all of the drugs decreased rates of $S^D$ responding and, with the exception of pentobarbital, did not affect low rates of $S^A$ responding. Pentobarbital increased $S^A$ responding and decreased stimulus control over responding at doses below those that produced substantial decreases in responding. Under the fixed-interval schedule, low to intermediate doses of $d$-amphetamine and cocaine increased $S^D$ responding but did not affect $S^A$ responding. Pentobarbital produced small increases in both $S^D$ and $S^A$ responding. Promazine increased red-key $S^D$ responding and substantially increased red-key $S^A$ responding. Under the fixed-interval schedule, stimulus control was decreased only at the highest doses that also produced substantial decreases in response rates. Thus, changes in response rate occurred at doses below those that decreased stimulus control. Effects of pentobarbital on stimulus control of responding, however, were modified by the schedule under which responding was maintained.

Schedule-controlled behavior is usually studied as repetitive responses of a subject that vary in rate of occurrence depending on experimental conditions such as the prevailing discriminative stimuli, the schedule of reinforcement and the history of the subject (see reviews by Morse, 1966; Zeiler, 1977). Whereas drugs can have pronounced effects on schedule-controlled responding, the mechanisms by which they exert those effects are not always clear (Laties and Weiss, 1969). One possible type of drug effect is an alteration of the control exerted by discriminative stimuli. Discriminative control over behavior is typically evidenced by a high rate of responding in the presence of one stimulus and a low rate in the presence of another stimulus. Many drugs decrease the difference between the rates of responding in the presence of the two stimuli suggesting that the control over behavior exerted by the stimuli is diminished.

Changes in rates of responding after drug administration, however, often are related to the rate of responding before drug administration; normally low rates of responding often are increased whereas higher rates are decreased (Dews, 1958a; Kelleher and Morse, 1968). Thus, when discriminative stimuli differentially control high and low response rates, changes interpreted as changes in stimulus control can also be interpreted as rate-dependent drug effects (Thompson, 1978). For example, Laties and Weiss (1966) found that promazine and chlorpromazine increased low rates of responding during portions of a fixed-interval schedule that were correlated with distinctive stimuli and no likelihood of reinforcement. As Laties (1972) notes, the results from that study could be interpreted as either a decrease in control exerted by the stimuli or an increase in the normally low response rates.

The present study was designed to determine the degree to which drug-induced changes in rates of schedule-controlled behavior might be due to changes in discriminative control over responding. Changes in rates of responding and changes in stimulus control were assessed independently in a procedure that closely approximated those typically used in studying...
schedule-controlled responding. Pigeons were trained to respond to one of two colored keys depending on the presence or absence of a houselight providing general illumination of the experimental chamber. Thus, the degree to which the houselight controlled the particular key on which the pigeon responded could vary independently of the rate at which the subject responded.

Methods

Subjects. Four male and one female White Carneaux pigeons (Hillside Pigeon Farms) were food-deprived until they reached 80% of their unrestricted feeding weights (470–520 g). They were maintained at those weights throughout the experiments by postsession feeding in their separate home cages in which water and grit were continuously available. Three pigeons (P-2, P-23 and P-637) had extensive experience under a variety of schedules of reinforcement and with drug administration. The other two (N-75 and N-1870) were experimentally naive.

Apparatus. The experimental chamber was constructed of Plexiglas (three walls and ceiling) and aluminum (front wall) and measured 33.5 cm high by 30.5 cm long by 30.5 cm wide. With the exception of the front wall and a 6.0 cm by 6.5 cm portion of the side wall, the inside of the chamber was painted flat black to reduce reflections. Two response keys (R. Gerbrands Co., Arlington, MA, model B) were mounted on the front panel 25.5 cm above the wire mesh floor and each 3.0 cm from the vertical midline of the wall. Either key could be transilluminated by amber, green, white or red colored bulbs (7.5 W, 115 V a.c.) which were shielded from behind. A minimum force of 15 g (0.15 N) on either key produced a click of a relay mounted behind the front wall and was recorded as a response. A single clear bulb (6 W, 115 V a.c.) was centered at the top of the front wall and could provide overall illumination (houselight). The feeder opening was centered 8 cm above the floor; when the feeder was activated it was illuminated by two clear (6 W, 115 V a.c.) bulbs. The chamber was enclosed within an outer shell which contained a ventilating fan, white masking noise and a wide angle lens for viewing. Electromechanical scheduling and recording equipment was located in an adjoining room.

Procedure. The two experimentally naive pigeons (N-75 and N-1870) were trained to peck the left key under a schedule in which food was presented independently of responding at varying intervals when the left key was red and never when the left key was green (Gamzu and Schwartz, 1973). During these training sessions, the color of the left key changed each 60 sec and the right key was constantly white.

After key pecking was established, all subjects were trained on a conditional discrimination procedure. The two keys were transilluminated with different colors (red or amber) and the houselight was either on or off. When the houselight was on, pecks on the red key (S\textsuperscript{R}) produced food (4-sec access to mixed grain); pecks on the amber key (S\textsuperscript{A}) produced a short (300 msec) blackout of the response keys. When the houselight was off, pecks on the amber key (S\textsuperscript{A}) produced food and pecks on the red key (S\textsuperscript{R}) produced the 300-msec key blackout. Thus, the color which was S\textsuperscript{R} or S\textsuperscript{A} was conditional upon the illumination of the houselight.

Each peck also randomly switched the position of the key colors (i.e., which key, right or left, would be red and which amber); the houselight remained either on or off until a response produced food. After food presentations, neither the houselight nor the keys were illuminated for a 60-sec duration (timeout). After the timeout, the keys were transilluminated again and the houselight was either on or off until the next food presentation. The presentations of the houselight occurred in a random sequence.

When less than 10% of the responses were emitted on the S\textsuperscript{A} keys, three of the pigeons (P-2, N-75 and N-1870) were studied under a fixed-interval schedule. Under the fixed-interval schedule, the first S\textsuperscript{R} response produced food which was followed by the timeout. All prior responses (both S\textsuperscript{R} and S\textsuperscript{A}) produced the 300-msec key blackout and randomly changed the key color positions. The duration of the fixed-interval was gradually increased over sessions to 5 min. The remaining pigeons (P-23 and P-637) continued under the initial conditional discrimination where each S\textsuperscript{R} response produced food (fixed-ratio 1 schedule). Sessions were terminated after 20 timeouts (100 for P-23 and P-637), or approximately 100 or 120 min, and were conducted once per day, 5 days per week.

When performances showed no day-to-day trends by visual inspection of the data, drug experiments were initiated. Immediately before some experimental sessions (typically Tuesdays and Fridays with at least 2 days between), the subjects were injected i.m. with either promazine HC1, d-amphetamine SO, cocaine HC1, pentobarbital Na or saline (0.9% NaCl). Sessions on Thursdays preceding drug sessions served as the control reference. Each dose (in milligrams per kilogram of body weight) was typically administered twice and the sequence of doses was mixed. An entire series of doses for one drug was completed before the administration of the following drug and the sequence of different drugs was as listed above. The drugs were dissolved in saline and doses are expressed as the total salt.

Analysis of results. Both S\textsuperscript{R} and S\textsuperscript{A} responses were counted separately when the houselight was on and off and the total response counts were segregated according to position (e.g., right S\textsuperscript{R} responses, houselight on, vs. left S\textsuperscript{R} responses, houselight on). Response rates were calculated by dividing the cumulative response counts by the appropriate elapsed times. Responses were also counted separately in successive 1-min portions of the fixed interval. Because control rates of responding increased systematically throughout the interval, these data allowed an assessment of the degree to which the drug effect depended on the control response rate.

Stimulus control was assessed by a method analogous to that used by Grier (1971) for measuring sensitivity in a signal-detection analysis. The measure of sensitivity relates the tendency to respond appropriately in the presence of the stimulus with the tendency to respond inappropriately (that is, as if the stimulus were present) in its absence. Thus, the measure separates stimulus control, or sensitivity, from bias toward one of the response alternatives (Green and Swets, 1966). As responding was not confined within a trials procedure, a point was plotted on coordinates corresponding to the proportion of S\textsuperscript{R} responses when the houselight was on and the proportion of S\textsuperscript{A} responses when the houselight was off. Stimulus control was computed according to the formula provided by Grier (1971) which provides a nonparametric estimate (Pollack and Norman, 1964) of the area under a curve (the operating characteristic) intersecting the point. The curve defines all points of equal stimulus control but with varying tendencies to, in the present case, respond on a key of one color (Green and Swets, 1966).

The index A' can, for the present purposes, vary from 0.5, indicating no stimulus control (as the proportion of appropriate responses in the presence of the stimulus is equal to the proportion of inappropriate responses in the absence of the stimulus), to 1.0, indicating perfect stimulus control (as the proportion of appropriate responses in the presence of the stimulus is 1.0 and the proportion of inappropriate responses in the absence of the stimulus is zero). Bias (B") for a response to one key color was also computed according to a formula provided by Grier (1971). The index B" can vary from 1.0, presently representing an extreme bias toward the amber response key, to –1.0, presently representing an extreme bias toward the red response key. A value for B" of zero represents no color bias. Because response rates varied across fifths of the fixed-interval, it was possible to compute A' and B" for varying response rates.

Results

Control performances. A representative performance under the fixed-interval schedule is shown in figure 1 (control). Responses on the red and amber keys (regardless of position) were recorded on the top and bottom cumulative records, respectively. The lower event line was displaced downward when the houselight was off and amber was S\textsuperscript{A} and up when the houselight was on and red was S\textsuperscript{R}. Responding on the S\textsuperscript{A} key followed a pause and then rapidly accelerated to a high constant rate that was maintained until food presentation. This
pattern occurred whether amber or red was $S^o$. Responding on the key on which the $S^a$ was displayed also followed pauses of varying lengths; however, it occurred at a much lower rate that remained constant or decreased slightly as the interval progressed.

Measures of performance under the fixed-interval schedule are summarized in figure 2. The top panels show average rates (in responses per second) of $S^o$ (filled symbols and $S^a$ (open symbols) responding and the middle panel shows average rates (in responses per second) of all responding ($S^d$ and $S^o$) across successive minutes of the fixed interval. The bottom panel shows the degree of stimulus control (measured by $A'$) across successive minutes of the fixed interval. As rates of responding varied over a greater than 10-fold range, stimulus control of responding was relatively invariant.

Generally, subjects studied under the fixed-interval schedule showed a bias toward the red key (table 1). These measures, however, were highly variable as evidenced by the mean S.D.s given for the control values obtained during each drug series. For the most part, these bias were due to a greater tendency to peck the red key when it was $S^a$ than to peck the amber key when it was $S^o$; however, there was also a slightly greater tendency to peck red when it was $S^d$ than to peck amber when it was $S^o$ (fig. 2).

Performances under the fixed-ratio 1 schedule were characterized by relatively short latencies to respond after the onset of stimulus lights and a high degree of stimulus control (P-23, $A' = 0.98$; P-637, $A' = 1.00$). Latencies to respond were shorter when the houselight was on than when it was off. One pigeon (P-23) showed a pronounced bias toward the red key while the other showed minimal or no bias resulting in the moderate average bias given in table 1.

**d-Amphetamine effects.** Under the fixed-interval schedule, low to intermediate doses of d-amphetamine increased overall response rates on the $S^o$ key (figs. 1 and 3); rates of responding when the $S^o$ was red were slightly higher than those when the $S^o$ was amber across the range of doses. The temporal pattern of responding was also changed by d-amphetamine; the transition to responding occurred earlier in the interval and there were incidences of lowered response rates near the end of the interval (fig. 1). The low response rates on the $S^o$ keys were either not appreciably affected or decreased by d-amphetamine (figs. 1 and 3). Decreases in $A'$ were slight and only occurred at the highest dose that also produced substantial decreases in response rates. No systematic changes in $B''$ were produced by d-amphetamine (table 1).

Local rates of responding on the $S^o$ keys within portions of the fixed interval were affected in a manner that was systematically related to the control response rate (fig. 4). The lower rates, from early portions of the interval, were increased; higher rates, from later portions of the interval, were increased less or decreased. Local rates of responding on the $S^a$ keys also were affected in a manner that depended on the control response rate; however, rates of $S^a$ responding were not increased to the same extent as comparable rates of $S^o$ responding. Additionally, some local rates of red $S^a$ responding were increased, whereas the amber $S^a$ responding was not affected.

Under the fixed-ratio 1 schedule, d-amphetamine generally produced only dose-related decreases in $S^o$ response rates (fig. 5). Low rates of responding on the $S^o$ keys were unaffected. Only at the highest dose was $A'$ decreased and no systematic changes occurred in $B''$ (table 1).

**Cocaine effects.** Under the fixed-interval schedule, an in-
Intermediate dose of cocaine slightly increased $S^D$ overall response rates on both the amber and red keys (figs. 1 and 3). The temporal pattern of responding was modified such that transitions to responding generally occurred earlier in the interval. The low response rates on the $S^R$ keys were not affected by low to intermediate doses and were decreased at the highest dose (fig. 3). Slight decreases in $A'$ occurred only at the highest dose which also produced large decreases in response rate. No systematic changes in $B^*$ occurred over the range of doses studied (table 1).

As with d-amphetamine, relatively low local rates of $S^D$ responding, from early portions of the fixed-interval, were increased whereas higher rates from later portions of the fixed-interval were increased less or decreased (fig. 3). Local rates of

![Graphs showing effects of drugs on responding rates and stimulus control](image-url)
Under the fixed-ratio 1 schedule, low to intermediate doses (1.0–5.6 mg/kg) of pentobarbital did not significantly alter $S^B$ response rates, whereas higher doses decreased those rates (fig. 5). At doses of 5.6 and 10.0 mg/kg, rates of responding on the $S^B$ keys were increased above control levels. At doses of 5.6 mg/kg and greater, $A'$ was decreased in a manner that depended on dose. Decreases in $A'$ under the fixed-ratio 1 schedule occurred at doses below those that virtually eliminated responding and at doses lower than those that decreased $A'$. Under the fixed-interval schedule the one subject with a bias toward the red key showed less bias after pentobarbital.

**Promazine effects.** Under the fixed-interval schedule, promazine increased overall rates of $S^B$ responding on the red key with little effect on $S^D$ responding on the amber key. The temporal patterns of responding on both keys were modified such that there was more responding in the early portions of the fixed interval (fig. 1). At higher doses, responding on both $S^B$ keys was decreased but to a greater extent on the amber key. When the red key was $S^D$, overall rates were increased; however, there was little or no effect on responding when the amber key was $S^B$ (fig. 3). Small decreases in stimulus control occurred across a range of doses (3.0–30.0 mg/kg) but were not dose dependent and were due primarily to effects on one pigeon (P-2) that showed quite large increases in responding on the red $S^B$ key. Generally, promazine produced a greater increase,

**Fig. 4.** Effects of d-amphetamine, cocaine, pentobarbital and promazine on local rates of responding within the fixed-interval schedule. Abscissae, control response rate (responses per second); ordinates, rate after drug as a percentage of control rate. Coordinates are logarithmic. Symbols for response rates are as in figure 3. Lines were fitted to the points for $S^D$ responding by the method of least squares. Response rates below 0.01 responses per second were not plotted. Note that all of the drugs studied had effects on $S^D$ responding that depended on the control rate and that only with pentobarbital did the effects on $S^D$ responding approach the trend seen with $S^B$ responding.

$S^B$ responding were sometimes increased and depended on the control response rate; however, rates of $S^B$ responding were not increased to the same extent as comparable rates of $S^D$ responding (fig. 4). Additionally, local rates of $S^D$ responding on the amber key were not increased, whereas there was an occasional increase in local rates of $S^B$ responding on the red key.

Under the fixed-ratio 1 schedule, cocaine decreased responding on the $S^D$ keys (fig. 5). At the two highest doses that substantially decreased $S^D$ responding, $A'$ was slightly decreased. No systematic changes in $B'$ occurred over the dose range studied (table 1).

**Pentobarbital effects.** Increases in $S^D$ responding under the fixed-interval schedule were obtained at intermediate doses of pentobarbital on both the amber and red keys (figs. 1 and 3); however, the increases on the amber key were small. The temporal pattern of responding was altered such that responding occurred earlier in the interval and did not accelerate as high a rate as under control conditions. Additionally, responding occasionally occurred on the $S^D$ key throughout the interval (fig. 1). Average rates of responding on the $S^A$ keys were increased at intermediate doses (figs. 1 and 3); the increases in responding on the amber $S^A$ key were smaller than those on the red $S^A$ key, but reliable (average control rate: 0.02 ± 0.01 responses/sec; 10.0 mg/kg of pentobarbital: 0.04 ± 0.00 responses/sec). The highest dose studied was the only one that decreased $A'$ below control levels. That dose also produced a shift in response bias away from red (table 1).

Low local rates of $S^D$ responding from early portions of the fixed interval were increased, whereas higher rates of responding were increased less or decreased (fig. 4). Low local rates of responding on the $S^A$ keys were also increased and those increases approached those found with $S^D$ responding.
or less of a decrease, in responding on the red keys regardless of whether the key was $S^D$ or $S^A$, resulting in a negative value for $B^-$ (table 1).

Local rates of responding show that comparable rates of red or amber $S^D$ responding were affected by 3.0 mg/kg of promazine somewhat differently (fig. 4). The relatively higher $S^D$ rates from later portions of the interval were decreased more if those rates were on the amber key. As with $d$-amphetamine and cocaine, local rates of $S^A$ responding were generally not affected in a manner similar to local rates of $S^D$ responding.

Under the fixed-ratio 1 schedule, promazine produced dose-related decreases in responding on the $S^D$ keys, although not affecting the low rates of responding on the $S^A$ keys (fig. 5). Decreases in $A'$ only occurred at the highest dose studied. No systematic changes in $B^-$ were observed after promazine administration (table 1).

**Discussion**

In the present study, responding was maintained under a conditional discrimination such that the particular colored key on which the subject made its response depended on the presence or absence of a second stimulus. This complexly controlled performance was in many respects similar to schedule-controlled responding under less complex procedures (cf., Ferster, 1960). As under more conventional fixed-interval schedules, responding on the $S^D$ keys under the fixed-interval schedule was characterized by a pause and an acceleration to a high rate of responding that was maintained up to food presentation (Dews, 1970; Ferster and Skinner, 1957). Additionally, responding under the fixed-ratio 1 schedule occurred after a pause that was much shorter than those occurring under the fixed-interval schedule.

Under the fixed-interval schedule, stimulus control of responding, as measured by $A'$, was independent of the rate at which the subject responded in the fractional portions of the fixed interval. These results are similar to earlier findings that accuracy in discriminations can be independent of probability of responding (Nevin, 1967). Under some procedures, however, accuracy (stimulus control) can vary with probability of response (Boren and Golub, 1972; Nevin, 1967). Thus, for independent assessment of drug effects on stimulus control and response rate, the particular schedule employed can be a critical variable.

Effects of the four drugs studied on rates of responding were similar to those obtained previously. The psychomotor stimuliants, $d$-amphetamine and cocaine, increased $S^D$ responding under the fixed-interval schedule in a manner that depended on control response rate, as has been found previously under less complex procedures with pigeons (Smith, 1964) and monkeys (Kelleher and Morse, 1964, 1968; Spealman et al., 1977). Average low rates of $S^A$ responding were not increased by those drugs, as has been found previously with amphetamines in pigeons (Dews, 1955; Spealman et al., 1978) and monkeys (Katz, 1982). Also in the present study, local rates of $S^A$ responding were not affected in a manner similar to comparably low rates of $S^D$ responding, as has been found in a comparison of similar rates of responding during fixed-interval and timeout periods (Katz, 1982). The differences in effects of $d$-amphetamine on $S^D$ and $S^A$ responding may be related to the notion that some minimal tendency to respond must be present before amphetamines substantially increase low rates of responding (cf., Kelleher and Morse, 1968; Verhave, 1958). In general, although the present procedure was more complex than other procedures used previously for the study of schedule-controlled responding, the results on response output were similar to earlier results obtained under less complex procedures.

Pentobarbital produced modest increases in overall rates of $S^D$ responding with local rates from within the fixed-interval exhibiting a dependence on control rate, as has also been found previously with barbiturates under different procedures (Dews, 1964; McKeary, 1970; Rutledge and Kelleher, 1965). In contrast to effects found with $d$-amphetamine and cocaine, low average rates of $S^A$ responding were increased by pentobarbital. Previous studies of barbiturate effects on $S^A$ responding have found increases if $S^A$ responding was under conditional stimulus control (Dews, 1955) or if responding occurred during multiple $S^A$ periods within fixed-interval schedules (Dews, 1964; McKeary, 1970). Thus, the effects of pentobarbital on response output in the present study are similar to those obtained previously under different procedures.

Promazine increased overall rates of $S^D$ responding in the fixed-interval as well as changing local rates in a manner that depended on control rate. These effects are similar to those previously reported for promazine in pigeons (Dews, 1958b; Laties and Weiss, 1966; Leander, 1975). Increases in $S^A$ responding in the present study also occurred with promazine, although only reliably when the red key was $S^A$. Increases in responding during periods of nonreinforcement were reported by Laties and Weiss (1966). Thus, the effects of promazine on response output in the present study, as with the other compounds, are similar to those obtained previously under more conventional procedures.

Several previous studies have shown drug effects on schedule-controlled responding to depend on the presence or absence of discriminative stimuli (Laties, 1972; Laties and Weiss, 1966; Leander and McMillan, 1974; McKeary, 1970). For example, in the study by Laties and Weiss (1966), amphetamine increased low rates of responding under a fixed-interval schedule more than under a fixed-interval schedule with added "clock" stimuli. Promazine, on the other hand, had more similar effects on responding with and without the clock stimuli. These studies, although implicating stimulus control as an important feature in determining the way the drug affected behavior, did not, however, demonstrate that the drug affected stimulus control. Comparisons of drug effects in the presence or absence of discriminative stimuli can only demonstrate a role of the stimulus in modulating drug effects. An important feature of the present procedure is that it provides a metric of stimulus control that is independent of other behavioral measures and can be used to gauge direct drug effects on stimulus control.

Comparing effects of all of the drugs studied on response rates and stimulus control (A') under the fixed-interval schedule shows that changes in rates of schedule-controlled responding occur over a range of doses below those that affect visual stimulus control. Generally, only at the highest doses, where response rates were substantially decreased, did the drugs produce decreases in A'. To the degree that A' is a general indicator of stimulus control of behavior, these results indicate that drug-induced changes in stimulus control contribute minimally, if at all, to the observed drug-induced changes in response output at low to intermediate doses.

Cocaine, $d$-amphetamine and promazine were lacking appreciable effects on stimulus control under both schedules studied. These results under divergent schedule conditions indicate that
they may be widely generalizable. Under the fixed-ratio 1 schedule, however, pentobarbital decreased A' at doses below those that decreased A' under the fixed-interval schedule and at doses that did not substantially reduce response output. Thus, it appears that the potency with which pentobarbital affects stimulus control can be modulated by the conditions of the experimental setting.

In studying effects of drugs on stimulus control, some investigators have chosen discrete trials procedures in order to avoid complications of interpretation arising from free-operant responding and rate-dependent drug effects (e.g., Evans, 1976). The difference in effects of pentobarbital on stimulus control under the present fixed-interval and fixed-ratio schedules emphasizes that the schedule under which the drug effect is studied can be a critical feature (Dews, 1963). Changes in stimulus control that occur under one condition may not apply generally.

There are a number of procedural differences between the fixed-ratio 1 and fixed-interval schedules that may have contributed to the observed differences in effects of pentobarbital on stimulus control. Under the fixed-interval schedule, stimulus control was independent of response rate. Nevin (1967) has found that under schedules with ratio characteristics, the degree of stimulus control over responding can vary with probability of response, whereas it does not under schedules with interval characteristics. Ratio vs. interval contingencies may also influence whether certain drugs affect stimulus control.

Further studies delineating conditions under which stimulus control is affected by pentobarbital should be conducted. For example, a generalized effect on stimulus control under the fixed-ratio 1 schedule should occur across stimulus modalities, given comparable degrees of control. Additionally, the effect should also depend on the degree of control (Dews, 1971). With the present procedures, it is possible to equate the degree of control exerted by various discriminative stimuli and to make meaningful comparisons between the effects of drugs on performance comparably controlled by dissimilar discriminative stimuli.

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**References**


Send reprint requests to: Dr. Jonathan L. Katz, NIDA, Addiction Research Center, P.O. Box 5200, Baltimore, MD 21224.