*REPEATED DIAZEPAM ADMINISTRATION:
EFFECTS ON THE ACQUISITION AND PERFORMANCE OF
RESPONSE CHAINS IN HUMANS*

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The effects of repeated diazepam administration (80 mg) were assessed across a 12-hr time course with humans responding under a two-component multiple schedule of repeated acquisition and performance of response sequences. Subjects resided in an inpatient clinical research ward for the duration of the study. In each component of the multiple schedule, subjects completed sequences of 10 responses in a predetermined order using three keys of a numeric keypad. In the acquisition component, a new response sequence was to be acquired each session. In the performance component, the response sequence always remained the same. After stable responding was obtained and the effects of the placebo assessed, diazepam was administered for 3 consecutive days. The effects of repeated diazepam administration on overall percentage of errors across the two components of the multiple schedule were selective. In the acquisition component, the first dose of diazepam increased percentage errors with the magnitude of effects decreasing across the second and third days of diazepam administration. In the performance component, the percentage of errors was either minimally affected across all 3 days of diazepam administration or substantively increased on Day 1 with subsequent diazepam administrations having minimal effects. Effects on response rate were not selective. Diazepam decreased rates of responding in both schedule components, with the magnitude of effects decreasing across successive administrations. These results replicate previous findings in humans and nonhumans on the selective effects of diazepam on acquisition versus performance baselines. Also, the results suggest that the selective effects do not result from differences in reinforcement rate. Finally, the present results demonstrate that the selective recovery from repeated drug administration previously demonstrated in nonhumans using a repeated acquisition arrangement has generality to human behavior.

Key words: repeated acquisition, multiple schedule, response sequences, diazepam, benzodiazepines, repeated administration, behavioral pharmacology, key press, humans

Repeated acquisition of behavioral chains, originally developed by Boren (1963) and subsequently refined by Thompson (1973), is an effective procedure for studying the acute and chronic effects of drugs on the acquisition of new behavior. In this procedure, reinforcement is delivered contingent on the subject emitting a new and predetermined sequence of responses across several manipulanda. This predetermined sequence is changed each session. After sufficient training, both the number of errors made in acquiring each new sequence and the rate of responding stabilize, thereby providing a stable baseline upon which to examine the effects of drugs or other variables (Thompson, 1973).

Later procedural advancements placed the repeated acquisition procedure in a two-component multiple schedule in which one component is the acquisition component described above and the other component is a performance component (Thompson & Moerschbaecher, 1979). In the performance component, reinforcement is contingent upon the subject emitting the same predetermined sequence of responses each session. This multiple schedule provides an effective baseline to contrast drug effects on the acquisition of new behavior versus the performance of previously acquired behavior. Frequently, drugs produce selective effects across the components; that is, doses of a drug that increase percentage of errors in the acquisition component have no effect on percentage of errors in the performance component. This multiple schedule arrangement has been used effectively with pigeons and monkeys to characterize the effects of a large variety of compounds including anticonvulsants, anticholinergics, antipsychotic

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and antianxiety agents, barbiturates, ethanol, opioids, and stimulants (Barthalmus, Leander, & McMillan, 1978; Moerschbaecher, Thompson, & Winsauer, 1983; Penetar, 1985; Thompson, 1973, 1976).

Recent studies employing the repeated acquisition and performance procedure have demonstrated the generality of the selective drug effects between human and nonhuman behavior under acute dosing regimens (Desjardins, Moerschbaecher, Thompson, & Thomas, 1982; Higgins, Bickel, O'Leary, & Yingling, 1987). In a recent study with humans, for example, the acute effects of ethanol (0, 22, 45, 67, and 90 g) and diazepam (0, 10, 20, and 40 mg) were examined on responding under a multiple schedule of acquisition and performance of response chains (Higgins *et al.*, 1987). The higher doses of ethanol and diazepam increased errors above placebo levels. The increases were selective, however, in that they usually were restricted to the acquisition component with ethanol and, with diazepam, errors increased in the acquisition component at doses that did not increase errors in the performance component. These results are consistent with the acute effects reported for ethanol and diazepam in nonhumans responding under comparable baselines (Barthalmus *et al.*, 1978).

To date, studies using repeated acquisition with humans have employed acute dosing regimens only. Whether similar cross-species generality would be obtained with repeated dosing has yet to be determined. In studies of chronic dosing using pigeons, behavior in the performance condition was shown to be less affected and to recover more completely over time than behavior in the acquisition condition (Hughes, Wasserman, & Hinrichs, 1984; Thompson, 1974, 1977). This effect in nonhumans was found across a wide variety of compounds including cocaine, chlordiazepoxide, chlorpromazine, *d*-amphetamine, diazepam, methylphenidate, and phenobarbital. Such selectivity is important because it suggests that the behavioral effects of drugs can be environmentally modulated not only under acute dosing regimens (see Laties, 1975), but under chronic regimens as well. The purpose of the present study was to ascertain whether this selective recovery from repeated drug administration would be evident in humans.

METHOD

Subjects

Participants were 4 healthy adult male sedative abusers who provided written informed consent. Mean age of subjects was 32.5 years. Subjects reported extensive histories of drug abuse including benzodiazepine use or abuse. Subjects were paid \$100 per week for residing in the research ward but did not receive payment for responding on the repeated acquisition procedure. In our previous study, subjects were not paid for their responses on the procedure; this did not seem to affect the baselines (Higgins *et al.*, 1987).

Setting

Subjects participated while residing in an eight-bed research ward containing a nursing station, patient bedrooms, recreational area, and a dining area (Griffiths, Bigelow, Liebson, & Kaliszak, 1980). Various recreational, reading, and craft materials and exercise equipment were available to subjects at all times other than during experimental sessions. The research nursing staff, who were present 24 hr daily, were blind to drug and dose administered. To verify the absence of current physical dependence, subjects were observed for withdrawal signs during the time they lived on the ward prior to the start of the study. No withdrawal signs were observed.

The participation of a given subject in the experiment sometimes overlapped with another subject's participation. On those occasions, the drug conditions usually were scheduled out of phase in order to maximize the independence of the data from each subject. The number of other residents in the research ward varied unsystematically between two and seven. These other residents also had histories of drug abuse and typically participated in different experiments.

Apparatus

Experimental sessions were conducted in a small room located on the ward. Subjects were seated at a desk on which a Commodore® 64 microcomputer, a color video monitor (Panasonic DT1300), and a numeric keypad (Cardco Cardkey) were located. The numeric keypad consisted of 12 keys (1.3 cm by 1.3 cm) located in a 3 × 4 matrix. The Commodore 64 com-

Illustrative Response Sequence

Video Screen #'s: 0, 1, 2, 3, 4, 5, 6, 7, 8, 9

Correct Response Keys: 3, 1, 2, 3, 2, 1, 3, 2, 1, 3

Fig. 1. Steps involved in moving through a typical 10-response sequence used in the study. At the top, the 0-9 sequence that appeared sequentially in the center of the video screen is presented above the corresponding 10 correct responses on the numeric keypad as each number appeared sequentially in the center of the video screen. Correct responses advanced the video-screen number to the next step in the sequence. Incorrect responses initiated a 2-s timeout; completion of the timeout period returned the subject to the step in the 10-response sequence at which the error had been made. Each completed sequence added one point to a running total and returned the number in the center of the video screen for the start of the next trial (after Higgins et al., 1987, p. 2).

puter controlled the experiment and recorded data.

Procedure

Daily experimental procedures. Throughout the study, subjects followed a daily experimental schedule (described by Roache & Griffiths, 1986). They were required to remain in the ward dayroom area from 8:00 a.m. to 6:00 p.m. except for brief visits to the bathroom as necessary. Subjects were not permitted to consume caffeinated food or beverages. They

were permitted to drink fruit juice, but were not allowed to consume milk or any solid food in the morning. After 1:00 p.m., subjects were permitted free access to noncaffeinated food and beverages. After 6:00 p.m., they were allowed to leave the dayroom area to go to their dormitory bedrooms. Drug was administered at 10:00 a.m. Repeated acquisition sessions were conducted immediately prior to and at 1, 2, 3, 4, 6, 8, and 12 hr after drug administration.

Multiple schedule. Subjects performed under a multiple schedule of repeated acquisition and performance of response sequences (Desjardins et al., 1982; Higgins et al., 1987). In each schedule component, subjects completed 10-response sequences using Keys 1, 2, and 3 of the numeric keypad. As illustrated in Figure 1 (after Higgins et al., 1987), reinforcement delivery was contingent on depressing the keys in a predetermined order in the presence of the numbers 0 to 9, which appeared sequentially in the center of the video screen. For example, in the illustrative response sequence shown in Figure 1, reinforcement was contingent on depressing the keys in an order of 3, 1, 2, 3, 2, 1, 3, 2, 1, 3 in the presence of the screen numbers 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, respectively. Thus, as each number appeared in the center of the video screen in the 0 to 9 sequence, a response on the correct key advanced the subject to the next step in the sequence. Incorrect responses initiated a 2-s timeout during which the color of the screen was gray and responses had no programmed consequences; upon termination of the timeout period, the subject returned to the step in the 10-response sequence at which the error was made. Each completed sequence (i.e., trial) added one point to a running total shown at the top of the screen and returned the number in the center of the screen to zero for the start of the next trial.

In the performance component of the multiple schedule (paired with a green screen), the 10-response sequence remained the same throughout the experiment. The performance sequence for all subjects was to depress the keys in an order of 2, 1, 3, 1, 3, 2, 1, 3, 2, 1 in correspondence with the video screen numbers 0 to 9, respectively. In the acquisition component (paired with a red screen), a new 10-response sequence had to be acquired each

session. The following criteria were used in the selection of sequences for the acquisition component: (a) the performance component sequence was never used in the acquisition component; (b) the first three responses in a sequence were never in a 1, 2, 3, order; (c) consecutive responses were never required on the same key within a sequence; (d) repetitions did not occur in any of the 10 positions in two consecutive acquisition sequences for an individual subject (e.g., if depressing Key 2 was correct in the presence of the video screen 1, then Keys 1 or 3 would correspond with video screen 1 in the next sequence); and (e) subjects were not exposed to any sequence more than once.

Sessions always began in the performance component. Subjects were exposed to each component of the multiple schedule once per session. Each component ended upon completion of 20 trials or after 5 min elapsed, whichever occurred first. For Subject GB, however, each component ended upon completion of 40 trials or after 10 min elapsed, whichever occurred first.

Instructions. Immediately prior to each session of the multiple schedule the following instructions appeared on the video screen (the instructions were not available during the session):

This task involves you pressing three keys labeled 1, 2 and 3 in a particular sequence. Press only one key at a time with your preferred hand. Every time you complete a sequence of 10 correct responses, the top counter advances. Your goal is to advance the counter as quickly as possible.

In the center of the screen, one of 10 numbers is presented. The no. 0 will be presented at the beginning of the sequence. When you make your first correct response, the number in the center will change from 0 to 1. When you make your second correct response the number will change from 1 to 2 and so on until the sequence of 10 correct responses is completed.

If you make an error, the number in the center will be erased for 2 s and the screen will become gray. Do not respond on the keys when the number is not shown. The green screen indicates a performance condition in which the sequence is the same from session to session. The red screen indicates a learning condition in which the sequence is different from session to session.

Press one of the keys when you are ready to begin.

Drug administration. Either drug or placebo was dispensed daily under double-blind conditions. Drug preparation involved the mixture of powdered drug and one of four flavors of unsweetened fruit-drink mix with varying doses of quinine sulfate in order to vary unsystematically the taste of the mixture (Griffiths *et al.*, 1980). Diazepam tablets (Roche Pharmaceuticals) were crushed with mortar and pestle; on control days lactose replaced drug in the powdered mixture (i.e., placebo).

Placebo was dispensed the first 5 to 14 days of the experiment to achieve stability on the acquisition and performance baselines. Diazepam testing began when visual inspection of the data showed no systematic trends across 3 consecutive days of placebo. The 3 days of placebo administration prior to drug testing were used as estimates of control variability. Diazepam testing consisted of the administration of an 80-mg dose daily for 3 consecutive days. This dose of diazepam (eight-fold the recommended dosage for sedative effects; Harvey, 1985) was selected because it produces robust behavioral disruptions (Roache & Griffiths, 1986). In this regard, nursing staff were instructed to awaken subjects if they were sleeping so that the session could be conducted. If after three attempts to rouse the subject he still made no attempt to go to the session room, nurses were instructed to consider the subject unable to perform and to mark that on the data sheets. Only BL was unable to perform during the first day of diazepam at 3 hr after drug administration.

Data Analysis

Overall errors, within-session errors, and response rates were collected and analyzed separately for each component of the multiple schedule. Errors were defined as responses on any key other than the one designated as correct at a particular step in the 0 to 9 sequence. Errors were analyzed as overall percentage of errors by dividing the total number of errors in the component by the total number of responses in that component and multiplying by 100. Within-session errors were analyzed in the acquisition component by determining quarter-life values for each session (Gollub, 1964); that is, the percentage of trials in which 25% of the errors occurred. Quarter-life values were not calculated for the performance component because the relatively low number of

errors in that component could provide misleading quarter-life values. For GB, who received 40 trials of acquisition, quarter-life was calculated for the first 20 trials only. Across subjects, then, the maximum number of trials that could contribute to the quarter-life analysis was 20. Quarter-life values less than 25% indicate that cumulative errors were negatively accelerated and that the sequence was acquired. Quarter-life values equal to or greater than 25% indicate a steady pattern of errors or positive acceleration, respectively, and that the sequence was not acquired. Overall response rates in each schedule component were analyzed as responses per minute by dividing the total number of responses per schedule component by the total number of minutes in each component. The 2-s timeouts that followed errors were excluded in calculations of response rate.

RESULTS

Overall Percentage of Errors

A 12-hr time course for the effects of diazepam in the acquisition and performance components is shown in Figure 2 for individual subjects. At each time point, means for 3 consecutive days of placebo and the individual scores from each of the 3 consecutive days of diazepam are displayed together.

Acquisition. When placebo was administered, errors in the acquisition component ranged from 2.43 to 8.61% across subjects. The first dose of diazepam markedly increased percentage of errors above the range of control values in all subjects with peak effects generally occurring during the first 2 hr postdrug. Percentage of errors remained elevated until the 8- and 12-hr observations, when they usually returned to control values.

The second day of diazepam also increased the percentage of errors above control values in the acquisition component. The magnitude of the increase during peak effect, however, was less than that produced by the first day of diazepam administration. Also, errors usually returned to control values sooner than was observed during the first day of diazepam administration. With Subject GB, for example, percentage of errors returned to near control values by 6 hr after drug administration on Day 2, whereas return to control values occurred 12 hr postdrug on Day 1.

Fig. 2. Individual-subject data for the effects of diazepam on overall percentage of errors as a function of hours postdrug. At each time point, the means of placebo observations and each of the 3 days of diazepam are plotted together. The bars on placebo data represent the range of placebo values.

On the third day of administration, diazepam increased the percentage of errors above control values in Subjects DR and BL but not in Subjects LK and GB. The magnitude of the increases that occurred with DR and BL was less than that observed during the first and second days of diazepam administration, and values usually returned to control levels earlier during Day 3 than Days 1 or 2.

Performance. In the performance component, errors across the 3 days of placebo ranged from 0 to 2%, which is lower than levels observed in the acquisition component. The first administration of diazepam had little or no effect in Subjects DR and LK, with percentage of errors increasing above control levels only at 1 hr after drug administration. For GB and

Fig. 3. Individual-subject data for the effects of diazepam on quarter-life as a function of hours postdrug. At each time point, the means of placebo observations and each of the 3 days of diazepam are plotted together. The bars on placebo data represent the range of placebo values.

BL, however, diazepam clearly increased the percentage of errors on Day 1.

On Days 2 and 3, diazepam continued to have minimal effects on the percentage of errors in Subjects DR and LK. In Subject GB, diazepam produced a relatively small increase in percentage of errors on Day 2 and no effect on Day 3. BL exhibited increases in percentage of errors on Days 2 and 3 with little difference in the magnitude or duration of effects across those 2 days.

Within-session errors. Quarter-life values for the means of 3 days of placebo and each of the 3 days of diazepam in the acquisition component are displayed in Figure 3 for individual subjects. When placebo was administered, quarter-life values ranged from 1.7 to 9.0% across subjects. The first dose of diazepam

markedly increased quarter-life values above control values at most time points for all subjects. Several of the quarter-life values exceeded 25% during peak effect, indicating the absence of within-session error reduction (i.e., no acquisition). Interestingly, peak effects in the quarter-life measure sometimes occurred at different time points than were observed with overall percentage of errors. In DR, for example, peak effect on Day 1 occurred 2 hr postdrug for quarter-life and at 1 hr postdrug for percentage of errors. Quarter-life values usually returned to the range of control variability at 8 or 12 hr after drug administration on Day 1. During the second and third days of diazepam administration, quarter-life values were generally lower than those obtained on Day 1, and effects were of a briefer duration.

To provide a comparison of the within-session distribution of errors for the two schedule components, cumulative errors were plotted. Figure 4 shows representative cumulative data for Subject GB from the final day of placebo and the 3 consecutive days of diazepam at 1 hr after drug administration. When placebo was administered, cumulative errors in the acquisition component were negatively accelerated, and no errors were made in the performance component. The first administration of diazepam produced large increases in errors in both schedule components. The second administration of diazepam increased errors well above control values in acquisition, whereas only one error was made in the performance component. On Day 3 of diazepam administration, the number and distribution of errors in both components were similar to those observed with placebo.

Overall Response Rate

Figure 5 shows the 12-hr time course for the effects of placebo and 3 days of diazepam on overall response rates in individual subjects. At each time point, means for 3 consecutive days of placebo and the individual response rates from each of the 3 consecutive days of diazepam are displayed together.

Acquisition. When placebo was administered, rates of responding in the acquisition component ranged from 66 to 211 responses per minute across subjects. The first day of diazepam administration reliably decreased response rates in the acquisition component at

Fig. 4. Cumulative errors in acquisition and performance components as a function of trials within a session. These data are taken 1 hr after drug administration. Quarter-life values from the acquisition component are provided for comparison purposes.

all time points and in all subjects. Peak effects occurred typically during 1 to 3 hr postdrug with rates generally returning to control values by 8 and 12 hr postdrug. The magnitude of effects on response rate diminished across the 3 days of diazepam in Subjects LK, GB, and BL, but not DR. In the latter subject, response rates were equally suppressed across the 3 days of diazepam administration. The duration of diazepam's effects on response rate also decreased across the 3 days of administration in Subjects LK and GB, but not DR and BL.

Fig. 5. Individual-subject data for the effects of diazepam on overall response rate as a function of hours postdrug. At each time point, the means of placebo observations and each of the 3 days of diazepam are plotted together. The bars on placebo data represent the range of placebo values.

Performance. When placebo was administered, rates of responding in the performance component ranged from 196.2 to 319.0 responses per minute across subjects. In contrast to the selectivity observed with percentage of errors, effects on response rate were similar in the performance and acquisition components. The first day of diazepam administration decreased response rates in the performance component, with peak effects occurring during the first 2 hr postdrug. The magnitude of effects was less on the second and third days of diazepam administration, although response rates remained suppressed below control values across the entire 12-hr time course for all subjects except LK. Subject LK exhibited only minimal effects during the second and third days of administration.

DISCUSSION

Overall, the results of the present study suggest that the effects of repeated diazepam administration in humans are similar to effects reported with pigeons responding under comparable baselines. In studies of chronic administration, behavior in the acquisition component was more sensitive to numerous consecutive drug administrations than behavior in the performance component, as measured by percentage of errors; in other cases, recovery from drug effects developed more slowly or less completely in the acquisition component relative to the performance component (Thompson, 1973). Similar findings were obtained in the present experiment, in which a drug was administered repeatedly on three consecutive occasions. The similarity of the findings provides support for the cross-species generality of the effects of repeated drug administration on the acquisition and performance of response chains.

The present study not only replicated the previous work with pigeons but extended those studies by examining the time course of diazepam's effects. Peak effects on percentage of errors were observed typically during the first 3 hr postdrug in both the acquisition and performance components. However, the percentage of errors usually returned to control values sooner in the performance than in the acquisition component. Across days, the duration of effects seemed to decrease more in performance than in acquisition. These data are consistent with a previous study of time course of the acute effects of atropine on the acquisition and performance of response chains in humans (Higgins, Woodward, & Henningfield, 1989). In that study, 3 mg of atropine resulted in performance tending to return to control values sooner than acquisition did. Collectively, such time-course data suggest that selective effects may be discernible both during peak drug effects and in the time course of drug effects under both acute and repeated drug administrations.

Another finding from this study is that effects of diazepam differed across the various measures. In the performance component, for example, recovery from drug effects developed more completely for percentage of errors than response rate. Additionally, examination of overall percentage of errors and quarter-life

measures illustrates that recovery in the former did not necessarily indicate recovery in the latter measure. For example, with Subjects DR and BL there was no evidence of recovery across days for diazepam's effects on quarter-life at 1 hr postdrug (Figure 3); in contrast, recovery was quite evident in these subjects at 1 hr postdrug for percentage of errors (Figure 1). Such a differential effect across measures is consistent with effects observed in nonhumans using the repeated acquisition procedure. For example, Thompson (1973) found that percentage of errors in pigeons recovered from the effects of a variety of drugs administered chronically, but responding during timeouts did not show any similar recovery.

Two previous studies examining repeated diazepam administration in humans are relevant to the present report. In the first study, the effects of successive administrations of 80 mg of diazepam were examined with sedative abusers using the circular lights procedure (Roache & Griffiths, 1986). In this procedure, subjects pressed a series of 16 buttons as rapidly as possible in response to the randomly sequenced illumination of 16 associated lights. A point was earned for each response. Functionally, this task was a fixed-ratio 1 schedule of point presentation across multiple manipulanda. The first administration of diazepam markedly decreased response rates. The second and third administrations of diazepam produced progressively less impairment with the greatest change in effects occurring between the first and second days of administration. Similar recovery was observed for percentage of errors in the performance component in the present experiment. Thus, both studies demonstrated that recovery is possible even when an 80-mg dose of diazepam is administered. The second study examined the effects of chronic diazepam using traditional human learning and memory procedures (Ghoneim, Mewaldt, Berie, & Hinrichs, 1981). Chronic diazepam (10 to 30 mg) treatment was found to disrupt the acquisition of word lists presented after drug administration but not word lists presented prior to drug administration. This was consistent with the selective effects observed across the acquisition and performance components in the present study and suggests that the selective effects observed in the present study may have generality to other experimental arrangements.

The variables resulting in the differential recovery observed across acquisition and performance baselines are unknown. At least two hypotheses have been put forth. One suggests that stimulus control can account for the selective recovery (Thompson, 1973, 1977), and the other suggests that reinforcement rate is the critical factor (Schuster, Dockens, & Woods, 1966). The stimulus control explanation suggests that the stimuli provided after each response exert stimulus control over responding and that the control exerted by those stimuli is greater in the performance than in the acquisition component (Thompson, 1977; see Laties, 1975, for a review). Thus, tolerance would develop faster for behavior under strong stimulus control than behavior under weak stimulus control (Balster, 1985). The present study did not directly test this hypothesis, and independent manipulation of those stimuli would be required to understand their contribution to the effects observed.

The reinforcement explanation suggests that tolerance tends to develop if drug effects decrease reinforcement frequency (Schuster et al., 1966; see Demellweek & Goudie, 1983, for a review). The present data, although again not designed to examine this issue, suggest that drug-induced changes in reinforcement rate may not play an important role in the selective effects observed. The repeated acquisition procedure used here is essentially a ratio schedule of reinforcement. Under ratio schedules, response rate and reinforcement rate are directly related. Thus, any decrease in response rate results in a decrease in reinforcement rate. Subject DR in the present study exhibited comparable decreases in response rates in the acquisition and performance baselines across all 3 days of diazepam administration. Nonetheless, diazepam's effects on percentage of errors in this subject were selective. Thus, the differences in drug-induced decrements in reinforcement rate do not appear to provide an adequate account of the results obtained. The reasons why the findings of Schuster et al. (1966) do not pertain are unclear, but are not unprecedented (Hoffman, Branch, & Sizemore, 1987). Perhaps other procedural aspects of the study, including the instructions engendering the behavior, may play a role. Ascertaining the specific mechanisms that account for such selective recovery from drug effects will require future studies examining not only

instructional control, stimulus control, and reinforcement rate differences between the components, but also differences in response rate and error rates as well as in the pattern of errors.

Overall, the present results (a) provide a rigorous within-subject characterization of the magnitude and time course of the chronic effects of diazepam on complex operant behavior; (b) provide another clear demonstration that environmental factors can modulate the behavioral effects of benzodiazepines; (c) replicate and extend previous findings from both humans and nonhumans and from both repeated acquisition and other experimental paradigms examining the behavioral effects of diazepam (e.g., Ghoneim et al., 1981; Roache & Griffiths, 1986); and (d) suggest that the selective drug effects observed between acquisition and performance components are not due to differences in reinforcement rate.

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