The effects of magnesium pemoline on Sidman avoidance behavior*

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Two naive male albino rats received sham treatment for a total of 10 sessions, and two other Ss received drug and sham treatment on alternate sessions. All Ss were exposed to a 120-min Sidman avoidance session 2 h after injection. The results indicate that magnesium pemoline temporarily increases overall response rate by producing extended runs of high-rate responding on drug sessions. No session-to-session transfer effects were evident, and considerable overlap of shock rates occurred on experimental and control days. Some comments were made which related the results to the traditional learning-performance distinction.

A number of investigators have demonstrated that magnesium pemoline facilitates avoidance conditioning. These investigators, however, have differed in their interpretation of the mechanism through which the drug operates. Plotnikoff (1966) postulated that the effect was due to an enhancement of memory storage or consolidation processes. One alternative suggested by Frey & Polidora (1966) was that the drug might increase general activity and thereby decrease freezing behavior. The decrease in freezing behavior in turn heightens the probability of occurrence of the avoidance response. A study by Boitano & Boitano (1967) and unpublished work by Murkland (1967) reveals that magnesium pemoline results in an increase in general motor activity, thus offering support for the Frey and Polidora interpretation. Another explanation of the effects of magnesium pemoline is offered by Beach & Kimble (1967), who state that acquisition of discriminated avoidance is augmented by increased reactivity to the conditioned stimulus signaling the aversive event. Additional support for this interpretation is found in work by Cyert, Moyer, & Chapman (1967), which shows that facilitation of avoidance does not occur when a discrete stimulus does not precede shock onset.

The explanations by Frey and Polidora and Beach and Kimble are similar in that both suggest that the drug's influence on a performance factor is responsible for facilitation. They differ from Plotnikoff, who considers facilitation to be a result of the drugs' effect on a learning or memory process. Additional data that bear on these alternative interpretations are clearly desirable.

The present investigation was conducted to examine effects of magnesium pemoline on the development and maintenance of Sidman avoidance conditioning. An attempt was made to separate effects on a rate of responding from those affecting efficiency. In addition, the effects of the drug on retention were examined.

SUBJECTS

The Ss were four naive 60-day-old male albino rats of the Sprague-Dawley strain.

APPARATUS

The test environment was a Gerbrands Model C conditioning chamber with a grid floor. The grids were ½ in. apart and 1/8 in. in diam. Timing, counting, programming, and recording were provided by electromechanical equipment.

PROCEDURE

The experimental design provided both intra- and inter-S replication. Table 1 shows that for Ss R3 and R4 drug and sham treatments were alternately introduced on odd and even sessions. Ss R1 and R2 were sham treated on each of the 10 sessions. Each session was spaced 72 h apart, except for the first two for R2 and R3, which were 96 h apart.

Two hours prior to a session, each S was anesthetized with CO_2 and then gavage injected with solvent or magnesium pemoline suspended in the solvent. Anesthesia was accomplished by submerging the S in an atmosphere of CO_2 for a period of not less than 15 or more than 55 sec. Before the Ss recovered from the anesthesia, injections of 1 cc/kg tragacanth were administered to sham Ss; experimental Ss received, on alternate sessions, injections of either tragacanth or 20 mg/kg of magnesium pemoline suspended in tragacanth.[1] Pilot work has shown that this degree of CO_2 anesthesia does not affect Sidman avoidance but does prevent resistance to gavage injection and accompanying tissue damage. Two hours after injection, the Ss were placed in the previously described conditioning chamber for a 120-min session.

A Sidman avoidance schedule with an S-S interval of 10 sec and a R-S interval of 48 sec was in effect for the session duration. The aversive stimulus consisted of an ac nonscrambled shock delivered in series with a 3,000-ohm power resistor to alternate bars of the grid floor. Maximum shock duration was .5 sec; therefore, a response with a latency of less than .5 sec after shock onset constituted an escape rather than an avoidance response. During Session 1, Ss received a shock of 30 V. This level was chosen because pilot work had revealed that this shock intensity produced an avoidance response but did not lead to competing skeletal responses. In order to prevent adaptation to this low shock level, the voltage was successively increased. Shock level on Sessions 1 and 2, 3-5, 6 and 7, and 8-10 was 30, 40, 50, and 70 V, respectively.

RESULTS

Figure 1 presents the range and mean response rate over all sessions for each control S and response rates of experimental Ss for each session. Inspection of Fig. 1 shows that

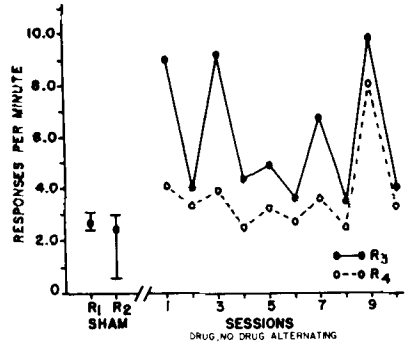

Fig. 1. Mean response rate and range of control Ss over sessions and session-by-session response rates of experimental Ss. Drug and no-drug conditions are represented for experimental Ss on odd- and even-numbered sessions, respectively.

Table 1
Order of Experimental Conditions

Condition	Treatment	Sessions	Ss
Control	Sham	1-10	R1, R2
Experimental	Drug	1, 3, . . . , 9.	R3, R4
	Sham	2, 4, . . . , 10	R3, R4

*Appreciation is extended to Abbott Laboratory for providing magnesium pemoline. Thanks also to John Randolph of Abbott Laboratory for his instruction on preparation of the drug.

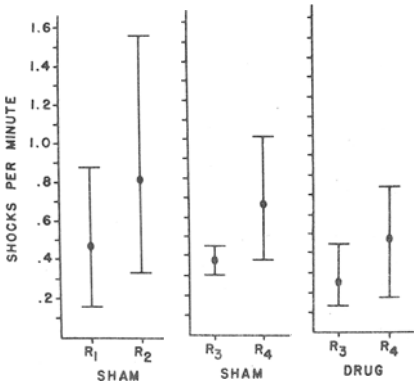

Fig. 2. Mean shock rates and ranges for sham control Ss and experimental Ss on drug and sham sessions.

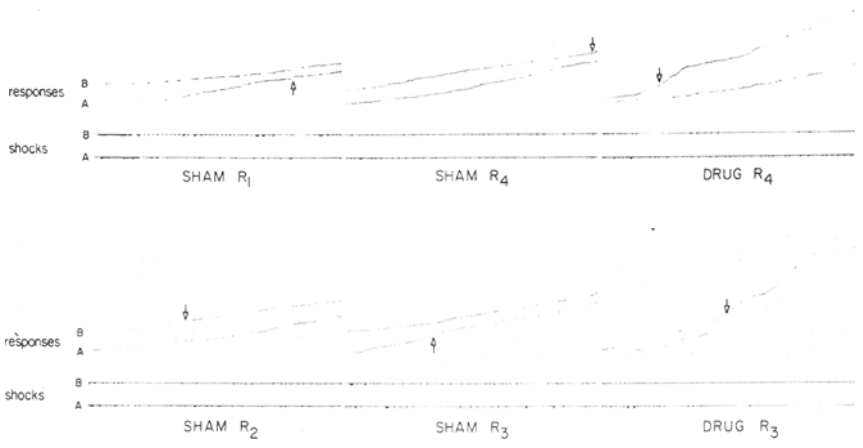

Fig. 3. Cumulative records of the first and last session for sham control Ss and the first and last drug session and sham control session for experimental Ss.

response rate was considerably higher on drug sessions than on sham sessions. It should be noted that rates during sham sessions were similar, thus indicating that the drug only temporarily increased rate.

Figure 2 presents ranges and mean *shock* rates averaged over all sessions for each experimental and control S. Examination of this figure indicates that the means are similar and that ranges for the various conditions overlap. Thus, there was no systematic difference between sham and experimental session shock rates.

Figure 3 presents the cumulative records for the first session (Record A) and last session (Record B) for each condition. Cumulative Records A and B were taken during Sham Sessions 1 and 10, respectively, or during Drug Treatment Sessions 1 and 9 for the experimental Ss. Records from Sessions 1 and 10 are presented for control Ss. These records are representative of all those obtained for a given S. The rate in sham sessions for experimental Ss is approximately equal to rates for control Ss, whereas rates on drug treatment days are considerably higher. The only exception is a low rate for R4 in Session 1. Arrows in Fig. 3 indicate local rate changes which consist of runs of high-rate responding relative to the overall rate of the session. Thus, it appears that the higher overall response rate on drug sessions relative to sham sessions was due to longer runs of high-rate responding during the former condition.

DISCUSSION

One hypothesis which may be drawn from the data is that magnesium pemoline produces a temporary rise in response rate, and successful avoidance is achieved at the expense of efficiency. There exist two possible ways in which an S may avoid shock in Sidman avoidance training. The first possibility is by responding with an interresponse time just less than the R-S interval. This behavior is considered efficient in that a minimum number of responses produce maximum avoidance. The second possibility is through a high overall response rate generated by steady high-rate responding or by spaced responding ending in "bursts." This type of behavior is considered inefficient because more responses are emitted than necessary for total shock avoidance (Sidman, 1958). Typical response rates on drug days in the present study are indicative of inefficient behavior, as response rate is higher than on control days while shock rates do not appear to be significantly different between these days. A more definite conclusion could have been reached concerning the drugs' effect on efficiency by an examination of IRTs; however, the present investigation did not permit this analysis.

A second conclusion is that retention effects, usually attributed to the action of magnesium pemoline, were not present, as the data show no session-to-session or overall changes in shock or response rate to support the existence of an alteration in retention. Plotnikoff (1966) suggested that magnesium pemoline affected retention, but his interpretation was based on changes in performance measures taken after only 10 training trials. Retention effects in the present study may have gone unnoticed because they occurred either earlier or later than the stage of development explored.

A synthesis of the preceding discussion leads to a third, more general, conclusion which bears on the classical learning-performance distinction and suggests that magnesium pemoline exerts its influence on performance variables during Sidman avoidance conditioning. This inference receives general support from Beach & Kimble (1967) and Frey & Polidora (1967), whose interpretations of the drug effects are related to performance factors. Beach and Kimble postulate that the drug facilitates avoidance conditioning by increasing a S's reactivity to a signal which precedes shock onset. Cyert, Moyer, & Chapman (1967) support this interpretation with the finding that there is no facilitation without an exteroceptive warning signal. In the present investigation, however, similar effects were found, although no exteroceptive warning signal was presented. Thus, at least in Sidman avoidance conditioning, performance increases are not dependent on increases in reactivity to an exteroceptive warning stimulus. Frey and Polidora have suggested that magnesium pemoline decreases the freezing response to shock and thus facilitates performance. The same mechanism could account for facilitation in this study, but such an account is only speculative since no attempt was made to observe incompatible behavior.

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