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Mental Rehearsal of a Task Under Ethanol Facilitates Tolerance[1]

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VOGEL-SPROTT, M., E. RAWANA AND R. WEBSTER. *Mental rehearsal of a task under ethanol facilitates tolerance.* PHARMACOL BIOCHEM BEHAV 21(3)329–331, 1984.—Male social drinkers learned a motor-skill task and then drank the same dose of ethanol (0.66 g/kg) on five sessions. Sessions 1 and 5 provided pre- and post-treatment measures of performance under ethanol. During treatment sessions, one group (P) practiced and another (M) mentally rehearsed the task after ethanol was administered. A control group (C) rested. On the posttreatment session, groups P and M did not differ and both were less impaired (i.e., more tolerant) than C. These results suggest that the development of ethanol tolerance is sensitive to the same training procedures which facilitate drug-free learning of a task.

Ethanol Tolerance Learning

TOLERANCE, the decreased response to a drug dose after repeated administrations, has been attributed to the development of some type of drug-compensatory reaction which counteracts the drug effect [6, 8, 17]. Although some investigators endorse ethanol exposure per se as the cause of tolerance [3,5], others emphasize learning factors [2, 6, 9, 16]. For example, studies holding ethanol exposures constant [1, 10, 18] demonstrate that social drinkers and animals develop tolerance more quickly with task practice under drug, and that the reinforcement schedules during this practice can predict the rate of tolerance development. Such evidence has led some investigators to conclude that tolerance is learned [18].

One interesting implication of this learning interpretation is that task practice under ethanol may not be the only way to accelerate the development of tolerance. Other training techniques which facilitate the learning of a task may also facilitate the acquisition of tolerance. One such technique is "mental rehearsal," a cognitive exercise in which an individual just imagines performing and does not physically practice on the task [4, 7, 14, 15]. Studies investigating mental rehearsal often employ three groups of subjects who have some practice on a task and then receive either mental rehearsal, or actual practice, or a rest. Subsequent performance generally indicates that mental rehearsal is as effective, or better than practice, and both treatments are better than a rest [12,13]. Similar effects on the development of ethanol tolerance would be predicted if it is partly a consequence of learning drug-compensatory task behavior. This paper reports the results of two studies which confirm this hypothesis.

METHOD

The first experiment employed 21 male social drinkers (19 to 25 years of age) who volunteered to participate in an alcohol study. None of the subjects had any history of problem drinking and all agreed to fast for four hours before each alcohol session and to abstain from any drugs, including alcohol for 24 hours prior to each alcohol session. Subjects were paid $45.00 for their participation in the experiment.

Subjects were randomly assigned to one of three equal size groups. All received approximately 45 minutes of practice on a Pursuit Rotor (PR) task (i.e., tracking a 30 rpm light target with a photosensitive hand stylus). Performance was assessed by the time on target (TOT) during a 50 second trial. By the conclusion of the training, subjects' TOT scores no longer changed significantly over trials. A subject's best TOT score during training was henceforth employed as the criterion for reinforcement (25 cents) which was administered for every subsequent trial in which his TOT equalled or exceeded his criterion score. These trials occurred during five subsequent weekly drinking sessions. On each session, 0.66 g ethanol per kg body weight was administered in the form of three drinks served at 20 minute intervals. Blood alcohol concentrations (bac) were determined at 20 minute intervals during a session by an Intoxylizer (Omicron Corp.).

Pretreatment and posttreatment effects of ethanol on performance were measured on Sessions 1 and 5 respectively. On each of these sessions, subjects performed two PR trials drug-free and then entered a waiting room to receive the ethanol dose. They returned to the testing room to per-

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form the task four times, 40, 60, 80 and 100 minutes after the first drink was presented. A subject's mean TOT on the drug-free tests was subtracted from each of his scores under ethanol so that a negative difference indicated that performance was poorer under drug. The subject's four measures of alcohol-induced change in performance were averaged to indicate his mean change in performance during the session.

Sessions 2, 3, and 4 administered different treatments to each group. Group P received task practice under ethanol. A total of eight trials occurred on each session; two before, and six after drinking commenced. The first trial under ethanol occurred 40 minutes after the first drink was presented, and trials were repeated at 20 minute intervals thereafter. Group M received mental rehearsal treatment. This group also had eight PR trials on each session, but these occurred *before* ethanol was administered. Forty minutes after drinking commenced, the subjects entered the testing room and were seated so that the PR apparatus could not be seen. A tape-recorded message instructed subjects to imagine specific movements involved in the PR task and to assess the adequacy of their score on an imaginary PR trial. The duration of the mental rehearsal, and its temporal occurrence (six times at 20 minute intervals) was identical to the schedule of ethanol practice trials received by group P. A control group (C) had eight PR trials, and then ethanol was administered in a different waiting room where subjects listened to music, played cards or read magazines while their bac was measured six times at 20 minute intervals during a session.

The second study, conducted by a different experimenter, served to test the reproducibility of the findings when mental rehearsal instructions were less explicitly detailed. In this case, the experimenter merely asked subjects in the M group to imagine performing the PR and to judge the adequacy of their score on this imaginary trial. This experiment employed 5 subjects in each of the three groups. In all other respects, the two studies were identical.

RESULTS

Group by experiment variance analyses were performed on: subjects' age, drug-free TOT scores, bac on drinking sessions, and pretreatment (session 1) scores of ethanol-induced change in performance. None of these analyses yielded any significant effects ($p>0.40$). Because no significant interaction or main effects of experiments were obtained, the data from the two experiments were combined and all analyses were based upon 36 subjects.

The mean age of the subjects was 20.8 years±0.40 standard error of the mean (SEM). The mean peak bac occurring during ethanol sessions was 86 mg/100 ml, and pretreatment performance under ethanol was impaired by an average of −3.74 seconds, ±0.30 SEM; a 13% reduction in tracking efficiency. There was no significant correlation between a subject's drug-free TOT score and the amount of pretreatment impairment displayed (r=0.15, >0.40).

Pretreatment scores of change under ethanol were used as a covariate in the variance analysis of posttreatment scores. A significant treatment effect was obtained, $F(2,29)=8.36$, $p<0.001$, with no experiment, $F(1,29)=0.95$, $p>0.34$ or interaction effects, $F(2,29)=1.82$, $p>0.20$. The posttreatment group means, adjusted for the effect of the covariate, are shown in Fig. 1. The means of groups P and M do not differ significantly ($p>0.86$) and display no detectable impairment under ethanol. The performance of these groups is actually better than their drug-free level of achievement ($p<0.01$). In contrast, group C displays significantly poorer performance under ethanol than drug-free ($p<0.02$) and its mean differs from each of the other two groups ($p<0.001$).

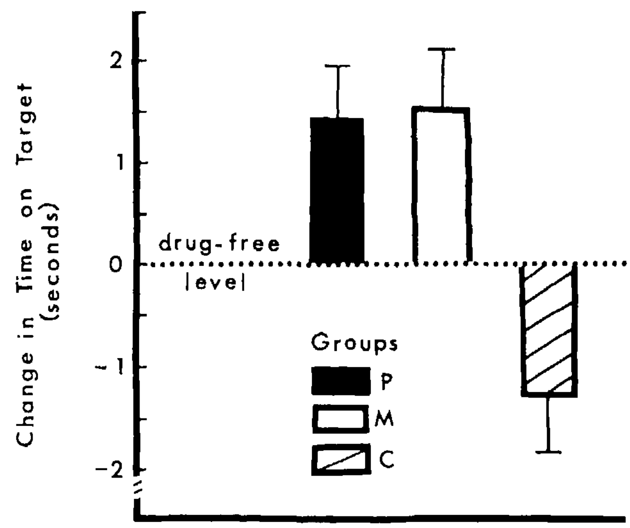

FIG. 1. Change in performance under ethanol in three groups during the posttreatment drinking session. Means are adjusted for the covariate (pretreatment change under ethanol) and vertical bars show the standard error of the means.

DISCUSSION

Evidence that repeated mental rehearsal of a task under drug hastens ethanol tolerance is a novel finding. However, in the context of response acquisition without drug, mental rehearsal and actual practice would both be expected to be effective training techniques [12,13]. From this perspective, their efficacy in accelerating ethanol tolerance carries the broad implication that drug-compensatory task responses may be sensitive to a wide variety of training procedures which facilitate drug-free learning of a task.

The results of the present study provide a basis upon which to explore the components in mental rehearsal training which may importantly contribute to its tolerance-facilitating effect. In the present study, mental rehearsal under ethanol occurred repeatedly in a distinctive testing room in the presence of the task. Thus environmental cues for testing and mentally-evoked cues for task performance could be paired temporally with a drug-induced compensatory response [6], and come to serve as conditioned stimuli for compensatory performance. It may be, therefore, that classical conditioning was one influential component in the mental rehearsal effects observed.

The post-treatment performance of groups M and P in the present study might be considered to provide some circumstancial evidence for the occurrence of a drug-compensatory response. Since they performed significantly better under ethanol than drug-free, their training treatments may have accelerated the development of the compensatory response so that its post-treatment strength exceeded the moderately impairing effect of the ethanol dose employed.

Although the post-treatment performance of Group C was still impaired by ethanol (mean change in TOT=−1.27±0.54), their initial mean impairment on the pretreatment test had been -3.38 ± 0.42. Thus the C group also showed some, though much less development of tolerance during the course of the experiment. Since the reinforced task practice under ethanol during the pretreatment session provided a potential learning opportunity, the effect of this learning and that of repeated drug administrations may have jointly contributed to the tolerance developed by group C.

The introduction of learning variables to account for the development of ethanol tolerance does not imply that tolerance is not mediated physiologically, for all forms of tolerance (and learning as well) presumably have some physiological correlates. The present data, however, clearly suggest that the acceleration of ethanol tolerance, defined behaviorally, is influenced by environmental and cognitive training factors, and not solely by drug exposure.

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