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BRIEF COMMUNICATION

Post-Learning Ethanol Effects on a Water-Finding Task in Rats

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MELIA, K. F., C. L. EHLERS, C. J. LEBRUN AND G. F. KOOB. *Post-learning ethanol effects on a water-finding task in rats.* PHARMACOL BIOCHEM BEHAV 24(6) 1813–1815, 1986.—Ethanol's post-training facilitation of memory was examined using a latent learning paradigm known as the "water-finding task." Rats were assigned to one of two ethanol groups ($E_{0.75\ g/kg}$ or $E_{1.5\ g/kg}$) or to a control group (saline) and individually placed in a novel open field containing a drinking tube. Following this exposure, subjects were immediately administered intraperitoneal (IP) injections of either the saline or ethanol and 48 hours later, re-introduced to the field. Initial latencies to contact the tube each time were recorded. A linear regression analysis of trial 2 latencies regressed onto trial 1 latencies indicated a statistically significant effect of ethanol on the relation between initial and subsequent latencies. Though the control rats' trial 2 latencies were completely random with respect to their previous speeds ($r_{SAL}=-0.07$), the ethanol rats' trial 2 latencies were positively correlated with initial speeds ($r_{E0.75}=0.35$, $r_{E1.5}=0.67$). These results suggest that under conditions of post-training ethanol, trial 2 behavior is more similar to, or controlled by, trial 1 behavior and are consistent with the argument that, under certain training and testing contexts, ethanol can come to exert control over a response's recurrence.

Memory Stimulus control Water-finding task Ethanol

MANY activities are repetitive in nature. In a behavioral analysis, recurring (i.e., steady-state) behavior is studied as it is a function of schedule and stimulus control. For example, if an animal's response, such as a lever press, is seen to occur repeatedly under conditions that reward lever pressing, then that recurrence is said to be a function of the control exerted by a reinforcement schedule (cf. [4]). When an animal's response is produced only in the presence of a specific stimulus (e.g., a light), the recurrent response is said to be under close stimulus control (cf. [15]). Behavior may also become rigid or perseverative in its recurrence and is then understood as functionally insensitive to more recent sources of schedule and stimulus control. The converse is equally possible. If a recurrent response is "state-dependent," it is completely and exquisitely sensitive to some precise source of control.

Behavior that re-occurs in the absence of obvious contingencies of schedule and stimulus control is often referred to as "memory." Words recalled minutes after they've last been heard, faces recognized years after they've last been seen, and maze turns made hours after they've last been reinforced, are all instances of "memory" as studied in the laboratory.

Even though remembering is complex, as a behavior it shares the simple property of recurrence with all other responses that are seen to repeat across time. So, when accuracy on a test of memory is seen to increase or decrease as a function of an experimental treatment, it is not altogether clear how the performance was affected. Was there true facilitation or debilitation of something specific to *delayed* response accuracy? Or was there merely change in a more fundamental aspect of responding, one which might be common to other instances of recurrent behavior?

Previous human memory research has demonstrated a facilitatory effect on human recall when low doses of ethanol are consumed immediately *after* exposure to the material to-be-remembered [9–11]. The following experiment was initially conducted in order to systematically explore this effect in the rat using a latent learning paradigm known as the "water-finding task" (see [3,5]). If post-exposure ethanol facilitates remembering, then rats given ethanol immediately after exploring an open field containing water might be expected to re-find the water source more quickly than a group of control rats (assuming equal levels of water deprivation at time 2). While this particular relationship was not observed, the results nevertheless have important implications for memory task performance when memory is reconsidered from a stimulus control perspective.

METHOD

Sixty-four male Wistar rats (138–264 g) were used. While

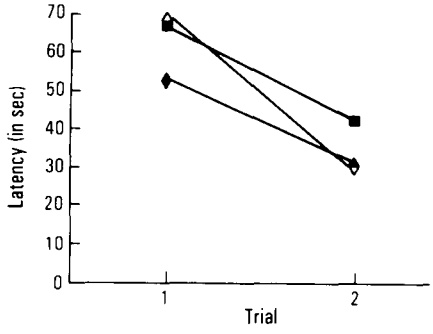

FIG. 1. Mean latencies to the drinking tube at trial 1 and trial 2 as a function of treatment group, (◆)=SAL, n=21; (◇)=$E_{0.75}$, n=21; (■)=$E_{1.5}$, n=22.

TABLE 1
REGRESSION OF TRIAL 2 LATENCIES ONTO TRIAL 1 LATENCIES

Treatment Condition	Correlation Coefficient	Regression Equation
SAL	r=−0.07	Y′=−0.05X + 33.48
$E_{0.75\ g/kg}$	r= 0.35	Y′= 0.20X + 15.70
$E_{1.50\ g/kg}$	r= 0.67*	Y′= 0.81X − 12.78

*$p<0.001$.

the lack of female subjects necessarily limits the generality of the findings, the omission was a pragmatic one. Because female rats are subject to more pronounced infradian cycles, their use allows the possibility of more day-to-day behavioral variability.

Subjects were housed under standard laboratory conditions, with a 12 hr light/dark cycle and ad lib access to food and water. Prior to training, each animal was individually handled for several minutes on at least three different occasions in order to habituate subjects to this form of stimulation.

The test apparatus was built according to the specifications described by Major and White [8]. It consisted of an open rectangular box (37×64×46 cm) over a steel rod floor. In the middle of one of the long sides was an alcove (11×13×46 cm) containing a standard metal drinking tube situated 8.5 cm off the grid floor. The drinking tube and floor were connected to a drinkometer circuit. Licks directed to the tube closed the circuit, resulting in an audible click.

For training, a rat was placed individually into the corner of the open field and allowed 5 min to explore the environment. During this time, the rat's initial latency to enter the alcove and lick the water tube was recorded (trial 1 latency). Immediately following the open field exposure, each subject was administered one of three previously assigned drug treatments: intraperitoneal saline, a moderate dose of ethanol ($E_{0.75\ g/kg}$), or a higher dose of ethanol ($E_{1.5\ g/kg}$), and returned to its home cage. Approximately 30 min later, ad lib access to water was withdrawn. Forty-eight hours later, each animal was re-introduced to the open field and a second latency (trial 2 latency) to make contact with a dry drinking tube was measured. Latencies were measured with the experimenter blind as to each subject's group assignment.

RESULTS AND DISCUSSION

A two-way analysis of variance of repeated measures revealed a significant effect of trials only, $F(1,61)=20.45$, $p<0.001$. Mean latency to the drinking tube was lower at trial 2 than at trial 1. There was no significant effect of drug, $F(2,61)=0.48$, $p<0.95$, and no drug × trials interaction, $F(2,61)=0.71$, $p<0.50$ (Fig. 1). At first glance then, it would appear that the post-injection of ethanol did nothing to modify subsequent behavior. Presumably, the water deprivation made water-finding and drinking relatively high priority responses, speeding their occurrence across all treatment groups. But, in addition to the analysis of variance, correlational and regression analyses were also conducted. These subsequent analyses suggest a rather different interpretation of the data.

While it was the case that all groups ran faster at test, the ethanol rats' lower latencies were also found to be positively correlated with trial 1 speeds. Moreover, the ethanol correlations increased significantly with dosage ($r_{E0.75}=0.35$ and $r_{E1.5}=0.67$), while in contrast, the control trial 2 latencies were essentially random with respect to previous speeds ($r_{SAL}=-0.07$). These relationships suggest that under conditions of post-exposure ethanol, trial 2 behavior can come to be more similar to trial 1 behavior than without exposure to ethanol.

When trial 2 latencies were regressed onto trial 1 latencies using drug as a grouping variable, an interaction was obtained, $F(4,58)=3.8$, $p<0.01$, indicating a statistically significant differential effect of drug on the relation between trial 1 and trial 2 latencies (see Table 1). However, since only the higher dose ethanol regression was itself statistically significant, $F(1,20)=16.06$, $p<0.001$, it would appear that, if there is control over present latencies as a function of past latencies, it requires a moderately potent ethanol dose.

These results lend some support to the notion that ethanol can act retroactively to facilitate performance on a memory task. Despite the fact that the predicted interaction between drug and trial was not observed, the obtained correlations remain consistent with an analysis of recurrent behavior as a function of recurrent stimulus control.

Consider that most accounts of memory, both human and animal, stress the importance of retrieval cues in reinstating previous behavior [12]. In such theories, successful remembering requires the availability at test of contextual stimuli present during acquisition (see for example [13, 14, 16–18]). Remembering is thought to be cue-dependent, and the greater the strength, or the number, of contextual stimuli present at test, the greater is the probability that the acquired response will be repeated.

It may be that part of ethanol's potentiating effect on memory lies in its ability to enhance this relationship between responses and contextual stimuli present at acquisition, but *only* when the sources of the contextual cues are inherently weak. For example, with humans, Mueller *et al.* [10] found that recall, but not recognition, was significantly enhanced by post-exposure ethanol consumption. In recall tests of memory, subjects have few time-of-test cues similar

to those stimuli present at the time of original learning. (The typical test paradigm is simply a blank piece of paper and a pencil.) At test, subjects must covertly generate their own set of potentially correct responses and then decide which among these were items initially present at acquisition. Because of the lack of overlap between contextual stimuli present during acquisition and contextual stimuli present during test, recall tasks typically generate relatively weak stimulus control. On the other hand, in recognition, the most salient contextual stimuli present at acquisition (the to-be-remembered words, themselves) are also present at test and must literally only be recognized.

Similarly, on a task for which there is no explicitly reinforced response (such as in the present latent learning paradigm), there would also be, at best, only weak contextual control established. Without a required response, there is no critical reinforcing event with which contextual stimuli might become correlated. Under such circumstances, the internal effects of ethanol may become a more critical enhancer of any weak contextual control recently established. In this regard, it is already known that behavior left largely uncontrolled by external stimuli becomes more sensitive to control by endogenous stimuli (i.e., drug effects), but that this does not occur if the behavior is first brought under control by external stimuli [6,7]. Possibly then, one result of retroactive ethanol context enhancement may be that behavior tends to repeat itself. In the present study, for example, the route taken to the drinking tube, or the number of pauses, sniffs or rears may have been significantly more recurrent in the ethanol rats, thereby indirectly affecting the correlated latencies observed.

These correlations are consistent with the argument that, given ineffective contextual stimuli, post-exposure ethanol can come to exert control over a response's recurrence (i.e., "retrieval"). And albeit preliminary, they may well have relevance for the interpretation of more complex drug by performance interactions (for example, verbal recall, e.g., [10]; passive avoidance, e.g., [1]; and spatial learning under intoxication, e.g., [2]). To the extent that the re-occurrence of behavior at many levels of sophistication can be understood in terms of reinstated stimulus and schedule control, there is common ground to be explored here between the present finding of current behavior correlated with past activity and more sophisticated phenomena such as that studied under the rubric of memory.

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