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BRIEF COMMUNICATION

Cocaine and Level of Arousal: Effects on Vigilance Task Performance of Rats

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GRILLY, D. M. AND T. W. GROGAN. *Cocaine and level of arousal: Effects on vigilance task performance of rats.* PHARMACOL BIOCHEM BEHAV **35**(1) 269–271, 1990.—Rats were food-reinforced for pressing one of two levers in an operant chamber, with the correct lever being indicated by the position of a briefly illuminated light. After stable accuracy levels were achieved, the rats were tested after an injection of either saline or cocaine (2.5 mg/kg) under two conditions. In the "low arousal" condition, animals were tested during the light phase of a 12-hr light-dark cycle and were fed approximately 5 hr prior to testing. In the "high arousal" condition, animals were tested during the dark phase after approximately 28-hr food deprivation. As expected, accuracy was higher and median choice and food retrieval latencies were shorter under the high arousal condition. Contrary to predictions, cocaine enhanced accuracy under both conditions. These results indicate that cocaine-enhanced performance in some tasks is not necessarily dependent on the animal performing at suboptimal arousal levels.

Cocaine Performance Vigilance Level of arousal Rats

DESPITE recent concerns over the abuse of cocaine, there has been little empirical study of cocaine's effects on task performance. It is clear that users claim that it enhances their performance (1). What is not clear is whether these claims are based on a distortion of the user's subjective judgement or to an actual facilitation of performance. And if the latter is true, does cocaine, as some have suggested (1, 6, 11), simply bring performance deteriorated by boredom or fatigue back to baseline levels? For example, Fischman and Schuster (2) noted that cocaine reduced or eliminated the effects of 24- and 48-hr sleep deprivation in human cocaine users with respect to subjective judgements of drowsiness, confusion, vigor, and arousal; cocaine also reversed the effects of sleep deprivation on omission errors in a simple signal-detection reaction-time task, but did not significantly improve performance in non-sleep deprived subjects. However, the nonsleep deprived subjects may already have been performing at close to maximal levels, and, therefore, ceiling effects may have prevented any cocaine-induced enhancement from being observed.

Recently, while investigating the effects of cocaine on the performance of rats in 2-choice, discrete-trial tasks, we found that low doses of cocaine (2.5 mg/kg SC) significantly enhanced accuracy in a task heavily dependent on vigilance (also termed sustained attention) (5). Thus, it does appear that low doses of cocaine can enhance choice performance in some tasks. However, we conducted our investigations exclusively during the light phase of the light-dark cycle. It has been well documented that there is a diurnal rhythm in rats with respect to a variety of behavioral and physiological measures of arousal, e.g., food intake, body temperature, metabolism, sleep, activity, time estimation, and postreinforcement pause in FI schedules of reinforcement (7–10). That is, rats display maximal signs of arousal around four hours after the beginning of the dark cycle (of a 12-hr light-dark cycle) and minimal signs of arousal around four hours after the beginning of the light cycle. Therefore, it is possible that our animals' baseline arousal was suboptimal and that the facilitative effects of cocaine we observed were the results of cocaine's bringing the animals up to normal (i.e., optimal) arousal levels.

The present study was designed to investigate this possibility by testing the effect of 2.5 mg/kg cocaine in the vigilance task described in (5) under conditions expected to induce low and high levels of behavioral arousal. An important aspect of our procedure was the requirement that, prior to treatment, the animal's accuracy levels were maintained at levels which allowed both enhancements and decrements to be observed.

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METHOD

Animals

Fourteen male Sprague-Dawley rats (purchased from Hilltop Lab Animals) were used. At 100 days of age their individual weights were determined and maintained at these levels (mean = 325 g, range = 290–360 g) through food restriction (see the Procedure section). Water was available at all times in their cages. The animals were maintained in a 22°C, 50% humidity facility under a 12-hr light-dark cycle (lights on 0800 hr).

Apparatus

Two operant chambers were interfaced with Apple IIe 64K microprocessors, which controlled experimental events and collected data. Two levers were located at one end of the chambers. Located between the two levers was a food tray, into which single 45 mg food pellets were delivered as reinforcers. A microswitch was activated when the rat's head was inserted into the opening. The cue lights were located directly above each lever, and a house light was located in the middle of the ceiling. Further details of the apparatus can be found in (4).

Procedure

The initial training of the rats was the same as described in (5). Training sessions of 100 trials each were conducted between 1400 and 1900 hr. During the sessions, there was no illumination in the room containing the operant chambers. Trials began with the house light in the chamber coming on. Prior to cue light presentation, the rat had to have its head out of the food tray and had to refrain from pressing either lever for 1.0 sec. The cue light above one of the levers was then illuminated briefly (there was a minimum of 1.7 sec between house light onset and cue light onset). Following cue light termination, if the lever beneath the cue light was pressed, food was delivered (accompanied by a 40 msec light presentation inside the food tray), and 1.0 sec after the rat inserted its head in the food tray, the house light was turned off. If the other lever was pressed, the house light was turned off. Intertrial intervals were between 7 and 10 sec. The position of the cue light was randomly determined except that there were no more than six successive trials with the light present in the same position and, within a session, the total number of trials with each cue did not differ by more than two.

The duration of the cue light was set for each rat depending on its performance. At the beginning of training in the vigilance task, the cue light duration was set at 1.8 sec. If an animal's accuracy exceeded 87% in two successive sessions, the cue light duration was decreased by 0.3 sec; if the animal's percentage of correct responses dropped below 75% for two successive sessions, the cue light duration was increased by 0.15 sec. This "titration" training procedure continued until the animal met the criteria for testing, i.e., its overall percentage of correct responses was maintained between 75 and 87 over four successive 100 trial sessions without a change in cue light duration. Final cue light durations ranged from 1.2 to 2.1 sec.

The animals were tested 15 min after an SC injection of either saline or 2.5 mg/kg HCl (dose expressed as the salt given in a volume of 1.0 ml/kg) under either a low or high level of arousal with the order of treatment randomized for each rat. A minimum of three days separated each treatment. On nontreatment days, the animals were fed between 1930–2000 hr. For the low arousal condition, the animals were fed their daily ration of 12 g of Purina mouse chow at the beginning of the light cycle (0800–0830 hr) and tested 4.5–6.5 hr later (i.e., at 1230–1430 hr). For the high arousal condition, the animals were tested 3.5–5.5 hr after the beginning of the dark cycle (i.e., at 2330–0130 hr) and were food deprived for approximately 28 hr.

TABLE 1

GROUP MEANS (SEM INDICATED IN PARENTHESES) FOR PERCENTAGE CORRECT, MEDIAN CHOICE LATENCY SCORES, AND MEDIAN FOOD RETRIEVAL LATENCY SCORES AS A FUNCTION OF DRUG TREATMENT AND AROUSAL CONDITION

Drug Treatment	Level of Arousal	Percentage Correct	Choice Latency (sec)	Food Retrieval Latency (sec)
Saline	Low	78.5 (1.6)	1.01 (0.22)	1.09 (0.11)
Saline	High	86.3 (1.2)	0.56 (0.09)	0.87 (0.11)
Cocaine	Low	82.1 (1.7)	0.77 (0.11)	1.09 (0.12)
Cocaine	High	90.2 (1.7)	0.45 (0.05)	1.00 (0.12)

RESULTS

The following behavioral measures were derived for each animal under each condition: 1) accuracy (percent correct responses); 2) median choice latency (time between cue light offset and lever-press); and 3) median food retrieval latency (time between lever-press and food tray entry). The individual scores were then used to derive group mean values, which are displayed in Table 1. Statistical significance was assessed using 2×2 repeated measures ANOVA.

One animal completed only 6 trials in 45 min under the cocaine-low arousal condition. This animal was subsequently retested under this treatment condition three weeks later and completed only 2 trials. This animal's data were excluded from further analysis. All other animals completed each of the 100 trial sessions within 30 min.

Accuracy was significantly affected by both drug treatment, $F(1,12) = 9.40$, $p < 0.01$, and level of arousal, $F(1,12) = 51.70$, $p < 0.01$, but there was no significant interaction between these variables. Accuracy was higher following 2.5 mg/kg cocaine than following saline and higher under the high arousal condition than under the low arousal condition.

Median choice latency was longer under the low arousal condition than under the high arousal condition and longer following saline following cocaine. However, only the main effect of arousal condition was significant, $F(1,12) = 15.48$, $p < 0.01$.

Median food retrieval latency was significantly shorter under the high arousal condition than under low arousal condition, $F(1,12) = 7.82$, $p < 0.025$. Although this effect was most prominent following saline treatment, neither the main effect of drug treatment nor the interaction between drug treatment and level of arousal was significant.

DISCUSSION

This experiment demonstrated that conditions expected to produce low and high levels of arousal in rats significantly affected their choice task performance, i.e., accuracy was higher, choice latency was shorter, and food retrieval was shorter in the high arousal condition than in the low arousal condition. Furthermore, a low dose of cocaine significantly enhanced accuracy under both conditions. In accordance with our previous findings (5), these results indicate that low doses of cocaine can enhance accuracy in choice tasks that require the organism to maintain a readiness to respond to a simple stimulus which occurs periodically over time. The present results extend these observations by indicating that the

facilitation is not restricted to conditions under which the organism is performing at suboptimal levels because of fatigue or lack of motivation. Previous attempts to demonstrate cocaine-enhanced performance in nonfatigued subjects [e.g., (2)] may have been unsuccessful because task performance was already close to ceiling levels.

Most studies concerned with the abuse liability of cocaine have focused on its biochemical effects in the brain mediating its euphoriant properties, whereas little research has been done on the reinforcing properties of cocaine derived from its potential performance-enhancing effects (1,3). It is clear, from this and our earlier study, that cocaine has such a capability. We conclude that the ability to enhance performance in some tasks may be another factor in cocaine's efficacy as a drug reinforcer.

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