EFFECT OF PSYCHOTROPIC DRUGS ON CAPACITY FOR MENTAL AND PHYSICAL WORK IN RATS

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Substances facilitating a self-stimulation response (amphetamine, cocaine, caffeine, morphine, benactyzine, phenobarbital, meprobamate, diazepam, chlordiazepoxide) and also electrical stimulation of systems of positive brain reinforcement, accelerate the development of ability of rats to pass through a maze. Amphetamine, cocaine, caffeine, morphine, benactyzine, phenobarbital, and electrical stimulation of the positive reinforcement systems increase the duration of forced swimming of the animals. Meprobamate, diazepam, and chlordiazepoxide have no effect on this parameter. It is postulated that the ability of psychotropic drugs to activate positive reinforcement systems is linked with their action on the capacity for mental and physical work.

KEY WORDS: psychotropic drugs; self-stimulation; capacity for mental work; capacity for physical work.

Negative emotions disturb the course of behavioral responses, modify the adequacy of the response to testing stimuli, and inhibit investigative activity [5, 6, 13]. Positive emotions (in particular, those formed in animals in response to electrical stimulation of positive reinforcement systems), on the other hand, facilitate the formation and course of conditioned reflexes [7, 14].

Psychostimulants, narcotic analgesics, tranquilizers, and barbiturates are known to induce a positive emotional state and euphoria in man [11, 17]. It has been shown in animals that these drugs stimulate brain systems responsible for the formation of positive emotions. Some of them facilitate impulse summation in the CNS during nociceptive stimulation [4], stimulate conditioned-reflex activity [12], and increase the capacity for physical work [1] in animals, as well as increasing the capacity for certain forms of mental and physical work in man [10, 20]. Stein [18] connects the stimulant effect of amphetamine on certain forms of animal behavior with its activating effect on positive reinforcement systems.

The object of this investigation was to study the effect of various classes of psychotropic drugs on the speed of training of rats in a maze and the duration of forced swimming.

EXPERIMENTAL METHOD

1. Maze. Experiments were carried out on 210 male albino rats weighing 250-300 g. Capacity for mental work was assessed by the ability of the animals to learn to find the way through a maze [2] to a de-energized area to avoid painful electric shocks transmitted through the floor. Experiments were carried out daily. Once a day, after receiving the drug, the animals were placed in the maze. The mean number of days required to achieve consistently successful performance in 80% of the animals in response to injection of isotonic NaCl solution was taken as the control. The conditioned reflex was regarded as stabilized when the animal passed through the maze three times in succession in under 20 sec. The number of mistakes – entering the wrong passage or going back through the maze – also was recorded.

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TABLE 1. Effect of Psychotropic Drugs on Capacity of Rats for Mental and Physical Work

Drug	Dose (mg/kg)	Maze		Duration of swimming
		speed of learning (days)	No. of mistakes (%)	
Control	—	10,8 (12,2—9,4)	100	9 min 5 sec (9 min 45 sec-8 min 20 sec)
Amphetamine	0,5	6,3 (7,4—5,2)	78	
	1	—	—	12 min (13 min 25 sec-10 min 35 sec)
Cocaine	10	7,4 (8,3—6,5)	55	13 min 40 sec (14 min 50 sec-12 min 10 sec)
Caffeine	30	8,0 (9,0—7,0)	45	11 min 5 sec (11 min 50 sec-10 min 25 sec)
Morphine	3	7,7 (8,7—6,7)	55	12 min 50 sec (13 min 35 sec-11 min 5 sec)
	5	7,0 (8,5—5,5)	60	
Phenobarbital	10	9,1 (10,6—7,6)	115	11 min (11 min 30 sec-10 min 30 sec)
Benactyzine	1	7,5 (9,1—5,9)	72	11 min 50 sec (13 min 10 sec-10 min 40 sec)
	15	7,9 (9,0—6,8)	74	9 min 20 sec (10 min-8 min 40 sec)
Meprobamate	20	9,6 (11,4—8,2)	106	9 min 55 sec (10 min 30 sec-9 min 20 sec)
Chlorodiazepoxide	3	7,9 (9,3—6,5)	45	8 min 30 sec (9 min-8 min)
	0,5	7,9 (8,9—6,9)	65	8 min (8 min 35 sec-7 min 25 sec)
Diazepam	1		—	6 min 10 sec (6 min 50 sec-5 min 30 sec)

TABLE 2. Effect of Electrical Stimulation of the Positive Reinforcement Systems on Capacity of Rats for Mental and Physical Work

Animals	Maze		Duration of swimming
	Speed of learning (days)		
Control	11,2 (12,9—9,5)	100	4 min 10 sec (5 min-3 min 20 sec)
Experimental	6,6 (8,0—5,2)	38	Immediately after self-stimulation for 4 min 30 sec (5 min 10 sec-3 min 50 sec)
			After imposed stimulation for 5 min (5 min 50 sec-4 min 10 sec)
			5 min after self-stimulation for 6 min 25 sec (7 min 25 sec-5 min 25 sec)

2. Swimming. Experiments were carried out on 180 rats weighing 180-240 g. The animals swam carrying a weight (8.5% of the body weight) in a tank measuring 70 × 55 cm in water at a temperature of 24-25°C. The criterion of the period of capacity for physical work was the time at which the rat sank to the bottom of the tank and was unable to rise up to the surface again.

The drugs amphetamine, cocaine, caffeine, morphine, benactyzine, phenobarbital, diazepam, meprobamate, and chlordiazepoxide were studied in doses close to those facilitating the self-stimulation response. The drugs were injected intraperitoneally 30-40 min before the experiment.

3. Self-stimulation. Experiments were carried out on 68 male albino rats weighing 250-300 g. Monopolar nicroelectrodes (diameter 250 μ) were inserted from both sides into the medial forebrain bundle at the level of the lateral hypothalamus [8]: 1.5 mm caudally to the bregma, 1.5 mm from the median suture, and 9 mm from the surface of the skull. The operation was carried out under pentobarbital anesthesia (40 mg/kg). The rats were trained to press on a pedal to receive the brain stimulus (a sinusoidal current, 50 Hz, 30-40 μA) 7 days after the operation. Pressing on the pedal triggered off a volley of pulses 0.5 sec in duration. After self-stimulation for 10 min the rats were placed in the maze. Animals undergoing a mock operation acted as the control. The experiments with swimming were carried out with animals in which the intensity of self-stimulation was not less than 1000 in a 10-min interval. On the first day the time during which each rat swam without electrical stimulation of the brain was measured. On the second day the animals were placed in the tank immediately after self-stimulation, after imposed stimulation for 10 min (to exclude the role of fatigue from pressing on the pedal), or 5 min after self-stimulation. Special experiments showed that the control animals swam for virtually the same lengths of time on the 1st and 2nd days.

EXPERIMENTAL RESULTS AND DISCUSSION

The results are given in Tables 1 and 2.

Maze. The time taken by the control rats to acquire the ability to run consistently successfully through the maze averaged 10.8 days. Amphetamine, cocaine, caffeine, morphine, benactyzine, diazepam, chlordiazepoxide, and meprobamate (15 mg/kg) and phenobarbital (5 mg/kg) speeded up the learning process ($P < 0.05$). Meprobamate (20 mg/kg) and phenobarbital (10 mg/kg) did not give a statistically significant effect but they increased the number of mistakes slightly.

The mean learning time for the control rats undergoing the operation was 11.2 days. Animals placed in the maze after self-stimulation learned almost twice as quickly to run through it and they made far fewer mistakes.

Swimming. The duration of swimming by the rats was increased ($P < 0.05$) by amphetamine, cocaine, caffeine, morphine, benactyzine, and phenobarbital. Meprobamate, chlordiazepoxide, and diazepam (0.5 mg/kg) had no effect, and diazepam in a dose of 1 mg/kg shortened the period of swimming ($P < 0.05$). The duration of swimming by rats placed in the tank immediately after self-stimulation and imposed stimulation showed only a tendency toward an increase. A considerable increase ($P < 0.05$) in the duration of swimming took place only when the animals were placed in the tank 5 min after self-stimulation.

These results, in the writers' opinion, suggest some connection between the properties of the psychotropic drugs to activate the mechanism of positive emotions and their ability to stimulate the capacity for mental and physical work.

The development of positive emotions under the influence of psychotropic drugs takes place by various mechanisms [9, 15, 16]. By their ability to facilitate the self-stimulation response the psychotropic drugs can be divided into two groups: a) psychostimulants, narcotic analgesics, barbiturates, and benactyzine – substances lowering the threshold of the self-stimulation response and increasing the number of self-stimulations at the optimal current strength, and b) tranquilizers, with no effect on the response threshold, but increasing the number of self-stimulations at the optimal current strength. Since the response threshold is a more stable criterion in the self-stimulation phenomenon than the number of self-stimulations at a certain current strength, it can be postulated that the effect of activation of the positive reinforcement systems by the first group of drugs is mainly direct and is stronger than the effect of the second group of drugs. That could be why the first group of drugs in these experiments were able to improve the capacity for both mental and physical work. Substances of the second group (tranquilizers) evidently can activate the systems of positive emotions indirectly, by lowering the activity of the systems forming negative emotions [3], which are functionally connected with the positive reinforcement systems [19]. The ineffectiveness of the tranquilizers, excluding benactyzine, in the swimming experiments was probably, therefore, the result of qualitative and quantitative differences in the positive emotional state evoked by them.

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