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Schedule-Induced Drinking and Thirst: A Pharmacological Analysis[1]

D. J. SANGER

Department of Psychology, University College, P. O. Box 78, Cardiff, CF1 1XL, United Kingdom

AND

P. K. CORFIELD-SUMNER[2]

Department of Psychology, University of Birmingham, P. O Box 363, Birmingham, B15 2TT, United Kingdom

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SANGER, D J AND P K CORFIELD-SUMNER *Schedule-induced drinking and thirst A pharmacological analysis* PHARMAC BIOCHEM BEHAV 10(4) 471–474, 1979 —Similar levels of water consumption were induced in two groups of rats by means either of prior fluid deprivation or a schedule of food pellet delivery Injections of d-amphetamine (0 25, 0 5, 1 0 and 2 0 mg/kg) had similar attenuating effects on drinking induced by both procedures Chlordiazepoxide (2.5, 5 0, 10 and 20 mg/kg), however, exerted differential actions on schedule-induced and deprivation-induced drinking. Drinking induced by deprivation was facilitated by all doses of this drug while the higher doses decreased levels of schedule-induced drinking This result emphasises the difficulties involved in using the concept of thirst in explanations of behavior and of drug action

Schedule-induced drinking Thirst d-Amphetamine Chlordiazepoxide Rats

WHEN rodents or primates are deprived of food and then subjected to sessions during which they obtain intermittently delivered food pellets they show a pattern of excessive post-food drinking This behavior has been called by Falk [6] schedule-induced or adjunctive drinking and has been subjected to extensive experimental investigation in recent years (see review in [3]). Several theoretical accounts of such schedule-induced drinking have been put forward recently which have attempted to deal with this behavior in ethological [7], physiological [21], or physiological and motivational [10] terms

Staddon and his colleagues [18, 19, 20] have carried out a number of sophisticated experimental and theoretical analyses of the behavior which occurs during the intermittent scheduling of different events and have drawn attention to several organising principles said to underly this behavior These behaviors, it has been maintained, are produced by underlying "moods" or "states" of the organism so that schedule-induced drinking, for example, is produced by a state which "resembles thirst " As Staddon points out, one method of investigating such states is by studying the effects of various test stimuli presented to the animal while it is considered to be in the state which is of interest. Thus, for instance, the actions of certain manipulations on schedule-induced drinking may be expected to be similar to the effects of the same manipulations on drinking induced by prior water deprivation if both behaviors are produced by thirst Staddon does in fact draw attention to several similarities between schedule-induced and deprivation-induced drinking [18], and other workers have also made comparisons between these patterns of behavior [16, 22, 23].

One particular set of test stimuli which may be used to investigate similarities between schedule-induced and deprivation-induced drinking are psychoactive drugs. Drinking induced by water deprivation is known to be affected by administration of several drugs and recent work has shown that similar drugs also affect schedule-induced drinking. In a recent review similarities between the effects of drugs on drinking induced by these two procedures were pointed out [16]. Amphetamines, for example, have been shown to reduce both deprivation-induced and schedule-induced drinking [4, 5, 8, 11, 14, 17, 22] while chlordiazepoxide has been found to enhance drinking in both sets of circumstances [1, 2, 9, 11, 12, 15] However, because of the difficulties of comparing across studies involving a variety of procedural and other differences it seems clearly desirable that direct

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comparisons should be made between the actions of drugs on drinking induced by fluid deprivation and by intermittent food pellet delivery. In the present paper such a study is reported involving the actions of d-amphetamine and chlordiazepoxide.

METHOD

Animals

The animals were 12 experimentally naive female hooded rats weighing between 300 and 350 g at the beginning of the experiment During the experiment all animals were individually housed and were maintained at 85% of preexperimental body weights

Apparatus

The experiment was carried out in standard operant test chambers (Campden Instruments Ltd.) housed in sound-attenuating and light-proof outer cubicles. The chambers were modified as described previously [15] so that each animal could obtain access to a metal drinking spout attached to a plastic water bottle. Programming of the experiment was carried out by means of standard electromechanical equipment which also recorded licking. Volumes of water consumed were also measured

Procedure

The rats were randomly divided into two equal-sized experimental groups and the members of one group were deprived of water for 23 hr of each day The six rats in the second group had water available at all times. On each day each animal was placed into a test chamber for 30 min During that period each rat received thirty 45 mg food pellets and water was available from the spout For the six members of the water-deprived group the food pellets were available in the food tray at the beginning of each daily session. For the members of the second group the pellets were delivered at one minute intervals throughtout the session in order to produce schedule-induced drinking in these animals After each session the animals were returned to their home cages and were given enough food to maintain constant body weights The water deprived animals were also given access to a water tube for 30 minutes after which time water was removed until the following day's experimental session.

After stable baselines of drinking had been established (approximately 30 sessions) each animal was given several intraperitoneal injections of d-amphetamine sulfate (0 25, 0 5, 1.0 and 2 0 mg/kg) and chlordiazepoxide hydrochloride (2 5, 5, 10 and 20 mg/kg). Doses were administered in a mixed order which was different for each animal and at least three non-drug days intervened between successive drug days The injection volume was 2 ml/kg body weight and saline injections were given on non-drug days Injections were given 30 min before sessions.

RESULTS

The water deprived rats showed a substantial amount of drinking during daily experimental sessions and also consumed all the food pellets available during the sessions The rats in the second group also consumed the food pellets, delivered in this case at 60 sec intervals, and after several sessions they began to develop the characteristic pattern of post-pellet schedule-induced drinking. The session duration

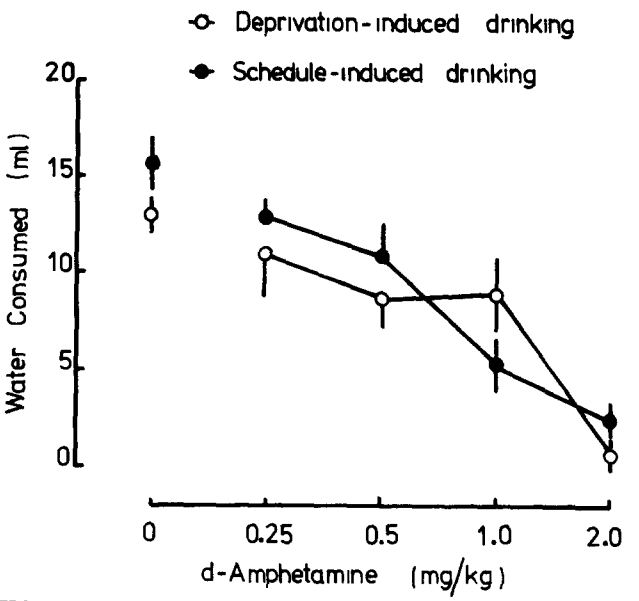

FIG 1 Dose response curves showing the effects of d-amphetamine sulfate on volumes of water consumed during water-deprivation-induced or schedule-induced drinking Each point shows the mean ± standard error of volumes consumed by six rats Different groups of rats were used in the two conditions

of 30 min had been chosen on the basis of preliminary work in order to attempt to produce similar water intakes in both groups of animals. After approximately 20 daily sessions drinking stabilised at similar levels in all animals, mean intake in the water-deprived rats being 13 ml and mean intake of the schedule-induced drinking rats being 15 6 ml The difference between these values was not statistically significant

The effects of d-amphetamine on the mean volumes of water consumed are presented in Fig 1 The figure shows that this drug produced a dose related decrease in both schedule-induced and water-deprivation-induced drinking A repeated measures analysis of variance applied to these data showed a statistically significant dose effect ($F=31.99$, $p<0\ 001$), a non-significant effect of condition and also a non-significant interaction

Chlordiazepoxide exerted different effects on drinking in the two groups of rats. Figure 2 shows that drinking induced by water deprivation was facilitated by all doses of this drug while schedule-induced drinking was attenutated at the higher doses (10, 20 mg/kg) At the lowest dose (2.5 mg/kg) five of the six rats in the schedule-induced drinking group showed small increases in the volumes of water consumed. These differences between the effects of the drug on the two types of drinking were confirmed by the results of a statistical analysis which showed a statistically significant effect of dose ($F=10\ 48$, $p<0\ 001$), a significant effect of condition ($F=12\ 38$, $p<0\ 01$) and also a significant interaction ($F=17.06$, $p<0\ 001$)

DISCUSSION

In this experiment d-amphetamine was found to reduce the water consumption of rats produced either by fluid deprivation or by means of a schedule of intermittent food

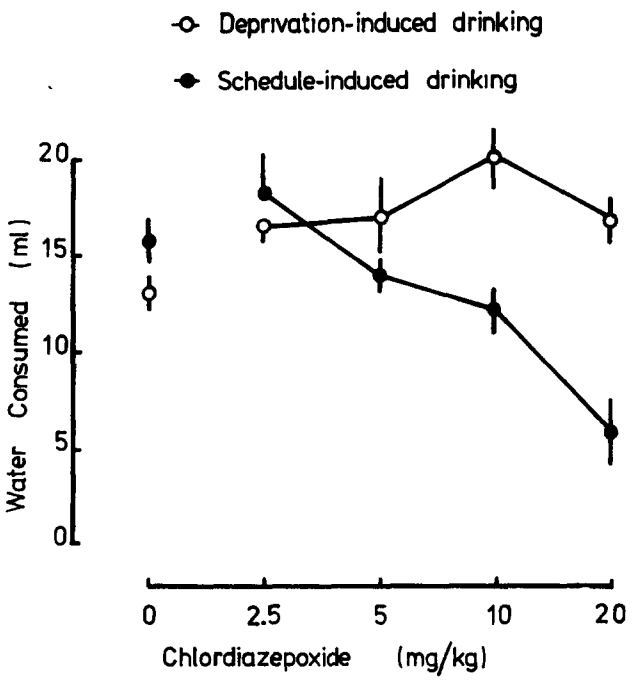

FIG 2 Dose response curves showing the effects of chlordiazepoxide hydrochloride on volumes of water consumed during water deprivation-induced or schedule-induced drinking Each point shows the mean ± standard error of volumes consumed by six rats Different groups of rats were used in the two conditions

pellet delivery. This result is thus consistent with previous studies which have shown that deprivation-induced [4, 8, 11] and schedule-induced [5, 14, 17, 22] drinking can be attenuated by administration of amphetamine. The present experiment, however, also extends previous research in demonstrating that when the control levels of water intake and the food-deprivation states of the rats in the two conditions are similar the effects of d-amphetamine are not only qualitatively but also quantitatively similar Thus, considered in isolation, this result could be taken as consistent with the view that drinking induced by water deprivation or by means of intermittent delivery of small food portions may be produced by similar mechanisms such as a state of thirst

The actions of chlordiazepoxide observed in this experiment, however, indicate that such a conclusion cannot unequivocally be drawn Previous research has shown that chlordiazepoxide and other anxiolytic agents can increase levels of water consumption produced either by fluid deprivation [9, 11, 12] or by schedules of food delivery [1, 2, 15]. The present results showed that chlordiazepoxide increased levels of water intake in the water-deprived animals at all the doses used while only the lowest dose (2 5 mg/kg) produced a small increase in consumption in the rats displaying schedule-induced drinking. At the higher doses (10, 20 mg/kg), in fact, schedule-induced drinking was significantly reduced Thus chlordiazepoxide exerted differential actions on deprivation-induced and schedule-induced drinking

These results demonstrate that pharmacological agents may (as in the case of d-amphetamine) or may not (as with chlordiazepoxide) exert identical effects on similar levels of drinking induced by water deprivation and by schedules of reinforcement. This may be considered consistent with previous studies which have demonstrated that the effects of drugs on behavior are not determined by the topography of the behavior itself but rather by a variety of factors including the patterning of the behavior and the particular environmental events under the control of which the behavior is being emitted [13] The effect of chlordiazepoxide may also be taken as providing little support for the view that schedule-induced drinking is produced by a state of thirst [18] since this drug exerted different actions on the two types of drinking. Staddon [18] has pointed out, however, that we might not expect schedule-induced and deprivation-induced drinking to be identical because of the different temporal patterns of drinking. It seems quite possible that the different effects of chlordiazepoxide shown here might be related to this difference in temporal properties since deprivation-induced drinking was characterised by a large amount of drinking early in each session followed by little drinking while schedule-induced drinking consisted of a draught taken after each pellet delivery. However, these results nevertheless point to the difficulties involved in using hypothetical mediating variables such as thirst in attempting to explain both behavior itself and the effects which drugs exert on behavior

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