CONDITIONED LEARNING IN PREGNANCY

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The various aspects and correlates of learning in man as well as in animals have been widely studied and are well-documented (4 - 7, 10). However, information pertaining to various processes of learning during the reproductive phases of life, uncontaminated by variable factors like drugs, has been relatively scarce. In this communication a preliminary study of conditioned avoidance learning in rats during the phases of mating, pregnancy and lactation is reported.

MATERIALS AND METHODS

Sixty-eight albino Norwegian rats of both sexes, aged 18-24 weeks and weighing 180-280 *g*, were trained in a delayed discriminated conditioned avoidance response, using a simple pole-climbing apparatus (2). The parameters of training were : conditioned stimulus (CS), a bell; paired 3 sec later with the unconditioned stimulus (UCS), a foot-shock about 2 *mA* strong for 7 more sec ; 10 trials per session at 1 min intervals ; sessions on every other day. The correct response was pole-climbing by the rats which was taken as the conditioned avoidance response (CAR) or the escape response (ER) depending on whether it was elicited by the CS or the UCS, respectively. In either case, pole-climbing terminated the CS (or UCS) which served as a reinforcement for the CAR (5). A failure in showing the CAR was invariably punished by electric shock that acted as a negative reinforement.

The rats were subjected to training sessions on alternate days; each session consisted of 10 trials given at 1 min intervals. The actual numbers of avoidance and escape responses in each session were recorded as well as the reaction time (RT) to elicit the CAR and the conditioned emotional response (3). The main criterion for a full training was taken as a repetition of 100% CAR in two successive sessions or less than 5% error (ER%) in three consecutive sessions (i.e., one error out of 30 trials). The progress of training was assessed from four different criteria: the number of sessions required for a 100% CAR, a stable and small RT, a minimal or nil error in the post-acquisition trials and a moderate degree of conditioned emotional response (CER).

The CER was assessed from the gross emotional behaviour of the rats as manifested by the pole-clinging, trembling of the vibrissae and of the whole body, squeaking, defaecation, micturition and so on. The incidence of the secondary conditioned response (8) was also included in the assessment of the CER. An arbitrary scale based on a 5-plus rating scale of the emotional manifestations was adopted for the gross quantitation of the CER (Table I), the details of which have been reported elsewhere (1).

TABLE I

An arbitrary scale for quantitation of the conditioned emotional response in the rat.

1. Persistent pole-clinging and/or intermittent squeaking, increased frequency of defaecation and micturition, shivering of whiskers/head	.. 1+ to 2+
2. Jumping on to the pole before the presentation of the conditioned stimulus (i.e., Secondary Conditioned Response)	.. 2+
3. Continuous squeaking, trembling of the whole body plus pole-clinging, defaecation etc.	.. 3+
4. Secondary Conditioned Response plus any one or more of the symptoms listed above	.. 3+ to 5+

The rats were divided into four groups according to the experimental design . (i) 12 female rats were fully trained (i.e., having acquired 100% CAR) and served as the control group throughout the experimental period ; (ii) 12 male and 12 female rats, also fully trained, were placed in breeding cages with a male and a female in each cage and their performance was tested every day; (iii) another 12 mating pairs of naive rats were put in breeding cages and training was c mmenced concomitantly, i.e., training and mating were going on at the same period; (iv) eight other female rats were fully trained and then housed in individual breeding cages to simulate the isolated conditions of the mated females of groups II and III, the males of which were separated after one week. These rats also served as a second control group. Training sessions for the mated rats were continued until a few days before parturition and were resumed 2 weeks after the delivery of the litters. Training of the control rats was also carried on simultaneously. The statistical significance of the results was ascertained by the student *t*-test.

RESULTS AND DISCUSSION

The results are summarised in Table II.

Training phase:

The data from the training and subsequent performance of the male rats were not included in the Table since these did not vary significantly in the different phases. There was only a small increase in error during the first few days in the mating phase. The subsequent performances of the control females (group I) were close to those in their training phase and hence were not entered in the Table either.

The female rats of the groups I, II and IV showed minor variations in the process of initial acquisition of the CAR; however, the mean figure for the number of sessions, RT, ER% and the CER of each group were in close agreement with one another. The results of the group III rats, with coincident training and mating, however, exhibited significant increases in the number of sessions required for a 100% CAR ($P<0.01$), in the reaction time ($P<0.001$) and in the frequency of error in performance ($P<0.001$) when compared with the corresponding data of any other group during the initial training phase. These features of deteriorated performance could possibly be attributed to the somatic and hormonal influences engendered by the mating situation concurrent with the training phase in group III rats.

TABLE II

C.A.R. training and performance of female rats in various reproductive phases.

Rat Groups (with numbers)	*Training phases*	*Number of sessions for 100% CAR*[1]	*Reaction time in seconds (RT)*[1]	*Extent of error (ER%)* [1]	*Degree of CER*[2]
I (12)	Initial training	7.3 ± 0.3	1.9 ± 0.09	2.5 ± 0.9	3+
II	Initial training	7.4 ± 0.3	1.9 ± 0.07	3.0 ± 1.2	4+
(12)	Mating/gravid		2.6 ± 0.13**	27 ± 2.3**	0
	Post-partum		2.1 ± 0.10	15 ± 1.7**	2+
III	Initial training/mating	9.0 ± 0.5*	2.6 ± 0.11*	11 ± 2.0*	3+
(12)	Gravid		2.7 ± 0.13*	28 ± 2.5**	1+
	Post-partum		2.2 ± 0.10	11 ± 2.1*	0
IV	Initial training	7.0 ± 0.4	1.5 ± 0.17	5 ± 1.7	3+
(8)	Isolation (gravid)		1.1 ± 0.12	4 ± 0.7	2+

[1]mean of the groups ± S.E.; [2]mode of the groups
* values significantly increased ($0.05 > P < 0.001$) from those of the controls (Groups I & IV);
** significant increases from their own figures during intitial training.

Gravid phase :

The rats in group II showed striking changes in performance during the gravid phase. There were significant increases in the RT ($P<0.001$) and ER% ($P<0.001$) when compared with their own corresponding figures in the initial training phase and obviously, with those of the control group or of the unmated group IV rats which were then in isolation. But the most remarkable change was the total abolition of the CER in these rats. They seemed quite unperturbed by the CS and exhibited little or no emotional reaction even to the UCS when they deserved it. The rats in the mating-cum-training group III showed a similar comparative increase in ER% ($P<0.001$) and a subtotal abolition of the CER, but the RT was not significantly increased from their own control since that was already high in their initial training phase (Table II).

The possibility that isolation in the breeding cages could have induced such changes was eliminated by the data of group IV rats which were kept in isolated cages for the same duration as of pregnancy but did not show any deterioration in performance relative to their initial training, although there were small reductions in RT, ER% and CER which could be interpreted as improvements as expected from a continuous training.

Post-partum phase :

These changes in the various parameters of CAR-performance induced by pregnancy in the rats of groups II and III persisted to some extent in the post-partum phase also. These were less marked though, and the figures tended to return to the pre-gravid control levels. But the error in performance relative to that in the control groups still remained significantly high ($P<0.01$) in both groups. The CER was almost nil in all rats of group III and in some rats of groups II when individual results were considered (Table II).

More than half of all the post-partum rats (mostly from group II) were lactating when training was resumed 2-2½ weeks after delivery. The lactat ng rats of both groups II and III exhibited certain differences in performance from the weaned ones (mostly from group III). In general, the CER was reappearing in all of the 14 lactating rats except one and persisted as long as lactation lasted. Secondly, the extent of error, which was much less than in their gravid phase, still remained significantly higher ($P<0.05$) in the regrouped lactating rats than in the weaned ones when compared with their individual errors during initial training. These distinctive features in the lactating rats might be explained by the influence of concern and anxiety inherent in the nursing of young ones which jeopardised CAR-performance and revived the CER. The weaned rats were relatively immune to such emotional influences.

Among other effects the most obvious finding was that all pregnant rats, particularly of groups III, produced smaller litters, numbering 3-5, as against 7-10 for normal rats. The emotional stress of aversive conditioning operating during mating and gestation could have been responsible for this effect. The rats were also appreciably less aggressive to handling than normal mothers.

It is apparent from these results that pregnancy and associated reproductive events caused a deleterious effect on the acquisition and performance of a conditioned avoidance response, as manifested by the increased reaction time and the increased extent of error. The dexterity and speed of learning were also reduced, presumably, by the sexual influences operating in the mating phase that was noticed in the female rats of group III. However, the reduction or abolition of the emotional reactions to the noxious and aversive situation of CAR-training, which is thought to have strong motivational properties (9), was the most striking effect. The female reproductive hormones, particularly progesterone, might be involved in this attenuation of emotional reactions which eventually led to a deterioration in CAR-performance during pregnancy and pseudopregnancy. This possibility has been explored further and the findings are reported in another communication (1).

SUMMARY

Four groups of white Norwegian rats were trained in a discriminated conditioned avoidance response (CAR). Group I consisted of control females; groups II and III had 12 pairs of male and female in each; group IV had 8 females which served as isolation controls for mated rats.

Group II rats were fully trained and group III was undergoing training when they were mated. As the training was continued, the pregnant females of both groups suffered from significant deterioration in CAR-performance; the reaction time for CAR and the frequency of error were increased while the conditioned emotional response was almost totally suppressed. Group III females also required a longer time for 100% acquisition of CAR.

This deterioration persisted in the parous rats in the post-partum phase also, particularly, in the lactating mothers.

The reasons for such deterioration in conditioned behaviour during the reproductive phases are discussed implying the possible role of the reproductive hormones.

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