

INSTRUMENTAL CONDITIONED REFLEXES WITH . SEXUAL REINFORCEMENT IN RATS

Józef BECK

Department of Mother Welfare, Research Institute of Mother and Child Health,
Warsaw 20, Poland

The purpose of the present work was to elaborate a method of investigation of the instrumental CRs with sexual reinforcement. The examination of such reflexes in various experimental situations gives more precise information about sexual drive levels than simple observation of sexual behavior. Moreover, this is the only way for obtaining exact data concerning the changes in the drive level in females during the mating behavior. As in natural conditions the intervals between copulations, which can be treated as the indicator of these changes, are imposed by the male.

There is a small number of findings concerned with instrumental sexual reflexes (Sheffield et al. 1951, Denniston 1954, Kagan 1955, Beach and Jordan 1956, Bermant 1961, Peirce and Nuttall 1961, Bolles et al. 1968) in comparison to those which concern instrumental alimentary or defensive reflexes. Therefore, a comparison between unconditioned alimentary and sexual reflexes seems desirable and scientifically interesting.

Both reflexes belong to the group of preservative reflexes (Konorski 1970). While the biological role of the unconditioned alimentary reflex is preservation of individual life, the sexual reflex is responsible for continuation of the life of the species. In both unconditioned reflexes two components are observed: the drive and the consummatory responses. For the unconditioned alimentary reflex the drive is hunger, manifested by behavior directed to reach food and the consummatory reaction is the act of food digesting. The sexual drive is manifested in two forms, as behavior directed to the act of copulation (the so called detumescence drive), or as the behavior directed to a close contact with an animal of the opposite sex (so called — contactive drive). For the detumescence

drive the consummatory reaction is copulation, and the excitation of the exteroceptors within the external sexual organs is the US. For the contactive drive the consummatory reaction consists in remaining in close contact with an animal of the opposite sex, while the stimulation of exteroceptors caused by this animal's presence (the view, smell, touch, etc.) plays a role of the USs. Both forms of drives evoke a strong motor arousal, which can allow the rat to establish an instrumental CR. During copulation an alternating excitation of the drive center and consummatory center takes place. As a result of this process the drive satisfaction, connected with ejaculation, in males is observed.

It is not quite clear which acts of copulation have a purely consummatory character and which ones belong to the drive. Probably the last act related to the drive is the beginning of the intromission, whilst its continuation seems to belong to the consummatory reaction.

In the majority of mammals the penis is not taken out from the vagina during the series of copulatory movements preceding the ejaculation. The exceptions are some rodents and among them the rat.

In the male rat, the ejaculation is preceded by a series of separate copulations connected, or not connected, with intromission of the penis into vagina (Larsson 1957, Dewsbury 1967). Because of this the rat seems to be a subject particularly suitable for studies concerning instrumental sexual reflexes.

In the present work the method of studying the instrumental sexual reflexes in rats was elaborated. This method makes possible the investigation of instrumental sexual reflexes in the same experimental conditions for animals of both sexes, enabling the authors to obtain simultaneously exact data concerning the behavior of both sexes before as well as after copulation. The observation of the behavior of both animals before and after copulation provides a more precise estimation of the relation between the character of reinforcement and the changes in the drive level than observation where the animal is used as a subject only. This is caused by the fact that the degree and character of sexual reinforcement is determined by the behavior of both animals. Moreover, this method allows the experimenter to establish instrumental sexual reflexes in the animal that was used as reward in the previous training, and subsequently to observe simultaneously the CRs in both animals.

METHODS

The subjects were 8 male and 5 female adult rats. The animals were kept in reversal day-night conditions with 10 hr dark and 14 hr light period. The experiments were carried out after 4-6 hr from the begin-

ning of the dark period. The estrus was induced in previously spayed females by injection of $10\text{ }\mu\text{g}$ of estradiol benzoate 30 hr before a session and $500\text{ }\mu\text{g}$ of progesterone 4–6 hr before a session. The repeated daily injections of these hormones in the same doses prolonged estrus for the next 4 days.

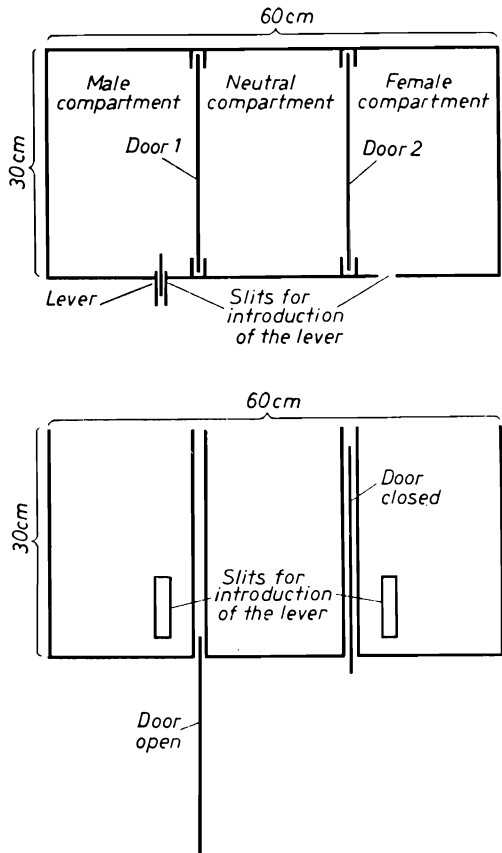


Fig. 1. Chamber for the investigation of the instrumental conditioned reflexes with sexual reinforcement. A, upper view; B, lateral view.

The chamber for the investigation of instrumental sexual reflexes (Fig. 1) was 60 cm long, 30 cm wide, and 30 cm high and was divided by two doors into three equal compartments $20 \times 20 \times 30$ cm each. In the frontal wall of each external compartment there were slits 2×8 cm in which levers were placed. The mirror above the chamber allowed the observation of the animals. During the training of the CR a 30 cm long plastic rod, subsequently replaced by a special lever, was used as a manipulandum. The lever was either attached to the wall of the subject compartment or was introduced only in moments of the instrumental response. The arm of this lever was 3 cm long.

The presence of the lever in the compartment was the CS. Lever pressing was reinforced by opening of the door to the subject compartment securing thus the contact with the animal of the opposite sex.

During the training of the instrumental sexual reflexes either both doors or only one, namely that from the trained subject compartment, were closed. The animals were put in two external compartments of the chamber (males always into the left and females into the right one). The middle compartment (named neutral) was empty or was joined with that of the animal which was used as a reward (this compartment will be called the reward compartment). When the subject had touched the rod, the door from its compartment was opened, allowing the subject to enter the neutral compartment. Subsequently, the door from the reward compartment was opened, making possible the contact between the two animals. During the contact of the animals which took place in the joined neutral and reward compartments, the door from the subject compartment was closed. Immediately after copulation or after 60 sec of the contact between animals, the door of the subject compartment was opened and the subject had a possibility to return to its compartment. If it did not, it was caught by the tail and put back into its compartment. When the subject had learned to make presses, the rod was gradually shortened to about 3 cm and substituted by the lever.

The experiments were performed in three variations. In the first the subject was a male, in the second it was a female, and in the third one, both animals played the role of subject as well as rewards.

RESULTS

Sexual behavior of rats

The male rat allowed to contact with the estrus female begins to copulate after short courting during which usually some sniffing of the female takes place. At the onset of the copulation the male mounts the female. As a response to mounting the female raises her perineum and arches her lumbar region (i.e. the so called *lordosis* takes place), making possible the penetration of the penis into the vagina (*intromission*). During the intromission a very short pelvic thrust in the male is seen. Immediately after intromission the male demounts the female and begins to lick its penis. Sometime the male is unable to introduce the penis into vagina. This is manifested by a series of quick pelvic thrusts. Such behavior is called *an attempt*. For both the intromission and the attempt the common term copulation is used. The intercopulatory interval ranges usually from a few seconds to half a minute. After a series of copulations ejaculation

occurs. In male rats the ejaculation is accompanied by a longer (lasting up to 1-2 sec) and more distinct pelvic thrust connected usually with contraction of the dorsal muscles and abduction of the forelegs. The intercopulatory interval after the attempt is usually shorter than after intromission. The longest interval, lasting a few minutes is observed between ejaculation and the next copulation. The adult male rat can perform several series of copulations ended by ejaculations during one hour.

Instrumental sexual reflexes in male rats

Before the beginning of the training of the instrumental sexual reflexes the male rat was put into a neutral compartment together with the estrus female which was used subsequently as a reinforcer. Immediately after copulation, or if copulation did not occur, after 60 sec, the male was put back to his compartment. Afterwards a plastic rod 30 cm long was introduced through the slit into the compartment. Following an accidental touching of the rod, the first and the second doors were opened, and contact with the female was allowed. Usually after 10-20 such trials the male learned to press the rod. For learning this copulation was not necessary, the external contact between animals having been quite sufficient. Immediately after copulation or after the contact with female lasting 60 sec, the door from the male compartment was opened and the male was caught by the tail and transported into his compartment. After a few such operations the male learned to return to his compartment without any intervention of the experimenter. Sometimes this return reaction was learned before the instrumental sexual reflexes was established.

When the rod pressing reaction had been established, the segment of the rod sticking out to the subject compartment was gradually shortened to about 3 cm. Afterwards, the rod was substituted by a lever. The number of the lever presses required for opening of the compartment was increased from one in the first sessions to six in later sessions.

After the male rat with a well established instrumental sexual reflexes had been put into his compartment he usually began to press the lever after 20-30 sec (Fig. 2A). When in effect of the instrumental reaction the first door had been opened, the male went to the neutral compartment (Fig. 2BC). Afterwards the first door was closed and the second was opened allowing him to contact with the female (Fig. 2D). Then usually copulation took place (Fig. 2E) preceded sometimes by some naso-nasal and nasoanal contacts. Immediately after copulation the male began to lick its penis (Fig. 2F) and subsequently returned to his compartment (Fig. 2G). In this compartment he often finished licking its penis, and

remained quiet till the next instrumental response. After ejaculation the male was motionless and showed no interest in the lever for a few minutes.

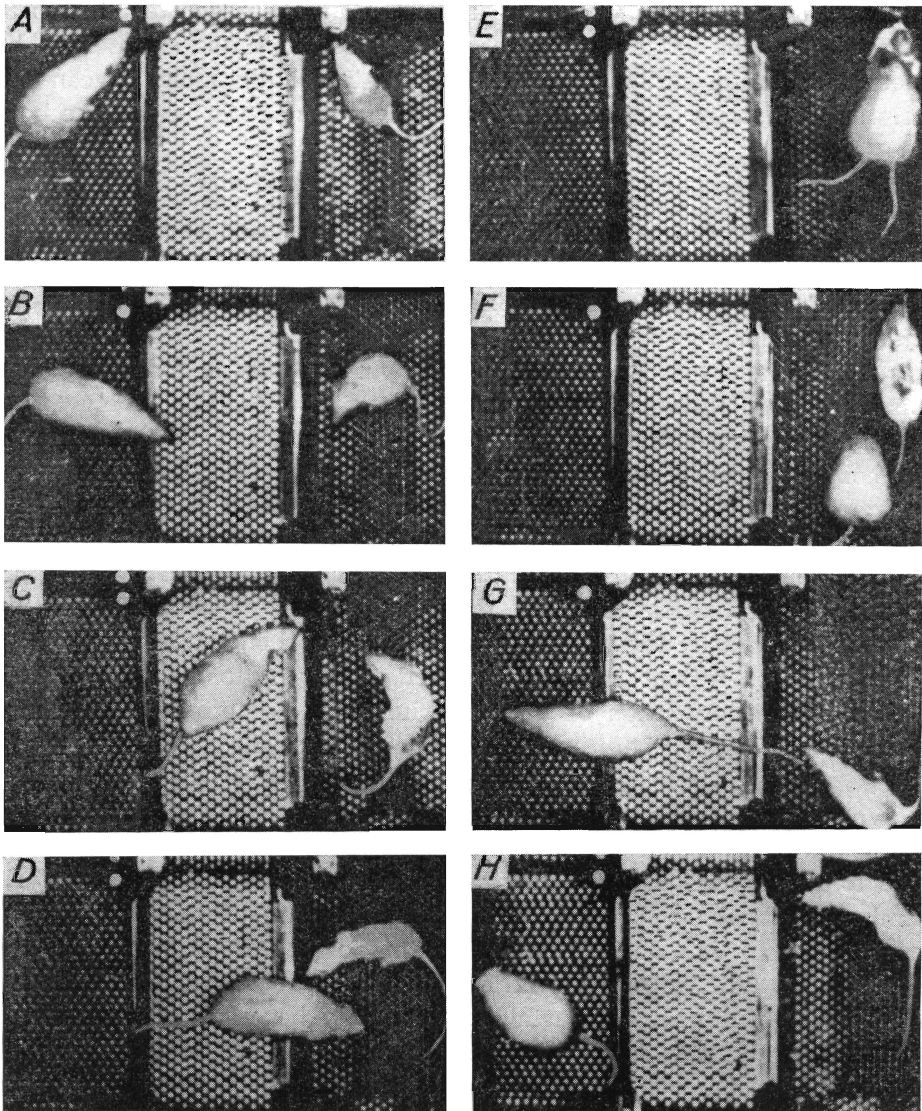


Fig. 2. The instrumental CR with sexual reinforcement in the male rat. The white point in the upper right corner of the left compartment shows the place for lever introduction. *A*, the instrumental response; *B*, the first door is open, the male is going into the neutral compartment; *C*, the male in the neutral compartment; *D*, the opening of the second door, the male is coming into the female compartment; *E*, copulation; *F*, the penis licking reaction; *G*, the male is returning to his compartment; *H*, the male during the interreaction interval.

Instrumental sexual reflexes in female rats

The method for the training of instrumental sexual reflexes in females was similar to that for males. The main differences was consisted in that in these experiments only the door from the subject compartment was

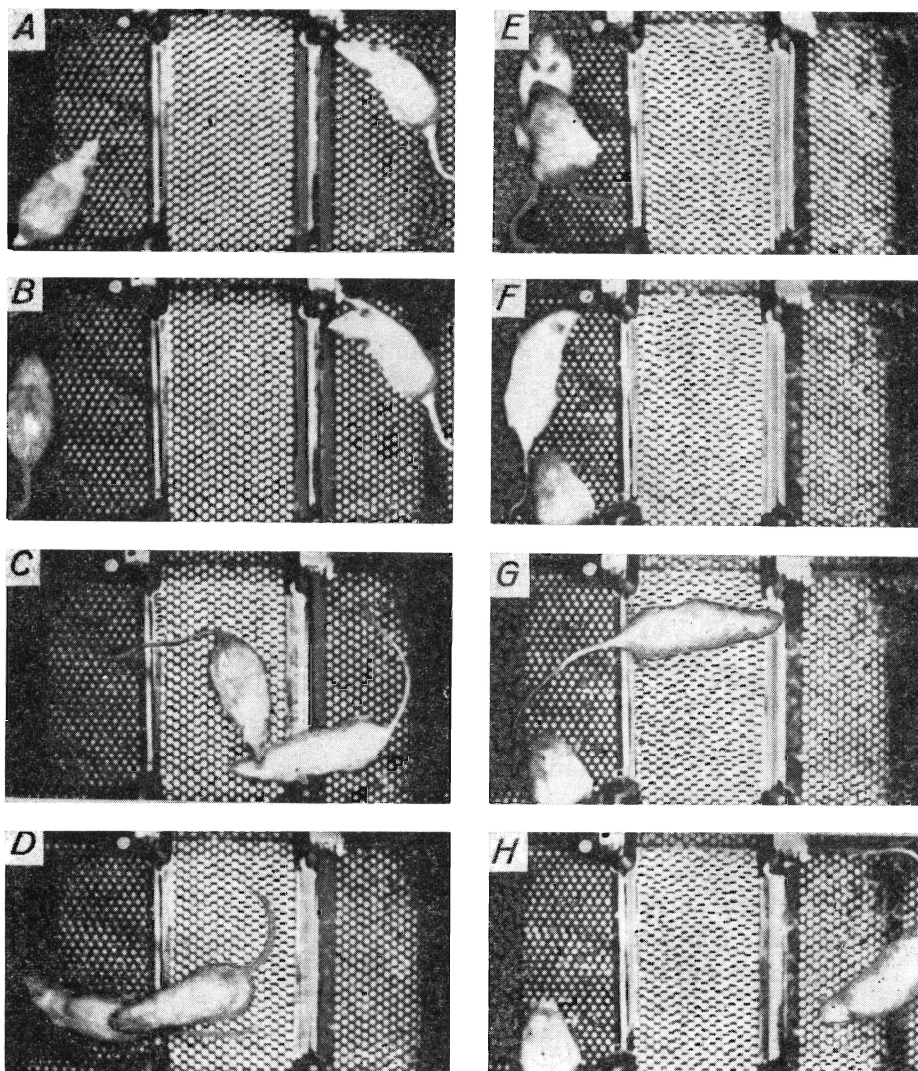


Fig. 3. The instrumental CR with sexual reinforcement in the female rat. The white point in the upper left corner of the right compartment shows the place for lever introduction. A, the female before the instrumental response; B, the instrumental response; C, D, the female is going into the male compartment; E, copulation; F, G, the female is returning to her compartment; H, the female during the interreaction interval.

closed, and the contact with the male followed immediately the instrumental reaction.

Contrary to the males the females returned to their compartment just after copulation without any intervention from the side of experimenter. The training of the instrumental reaction was as easy as in males.

When the female with a well established instrumental sexual reflexes, was put in her compartment, usually after 20–30 sec she began to press the lever (Fig. 3B). After the door had been opened, the female went to the male compartment (Fig. 3CD) where copulation took place (Fig. 3EF). Subsequently she came back to her compartment (Fig. 4GH).

In experiments in which the subject was female, the interreaction intervals were the same as in experiments in which the subject was a male, however, the postejaculatory intervals were shorter. During the interreaction intervals the females similarly to the males showed no interest in the lever.

Sometimes, as a side effect of the administration of the sexual hormones used for inducing the estrus, bleeding from the genital tract was observed to occur in females. In such cases intromissions caused screeching in females followed immediately by an aggressive reaction against the male. Subsequently, the instrumental reaction was inhibited. Similar screeching followed by an aggressive reaction directed towards the male occurred sometimes after ejaculation.

*Instrumental sexual reflexes trained simultaneously
in male and female rats*

For these experiments only males highly active sexually with well established instrumental sexual reflexes were used. The female was taught to perform the instrumental reaction when the male was in the neutral compartment following his instrumental reaction. After the touching of the rod by the female the second door was opened and the animals were allowed to contact.

During these experiments two levers were used. One of them was attached to the wall of the male compartment whereas the second one was introduced to the female compartment only for the instrumental reaction. In this way each trial was initiated by the male, since only after this response the lever was introduced into the female compartment. The instrumental sexual reflexes investigated simultaneously in male and female is shown in a series of photographs in Fig. 4.

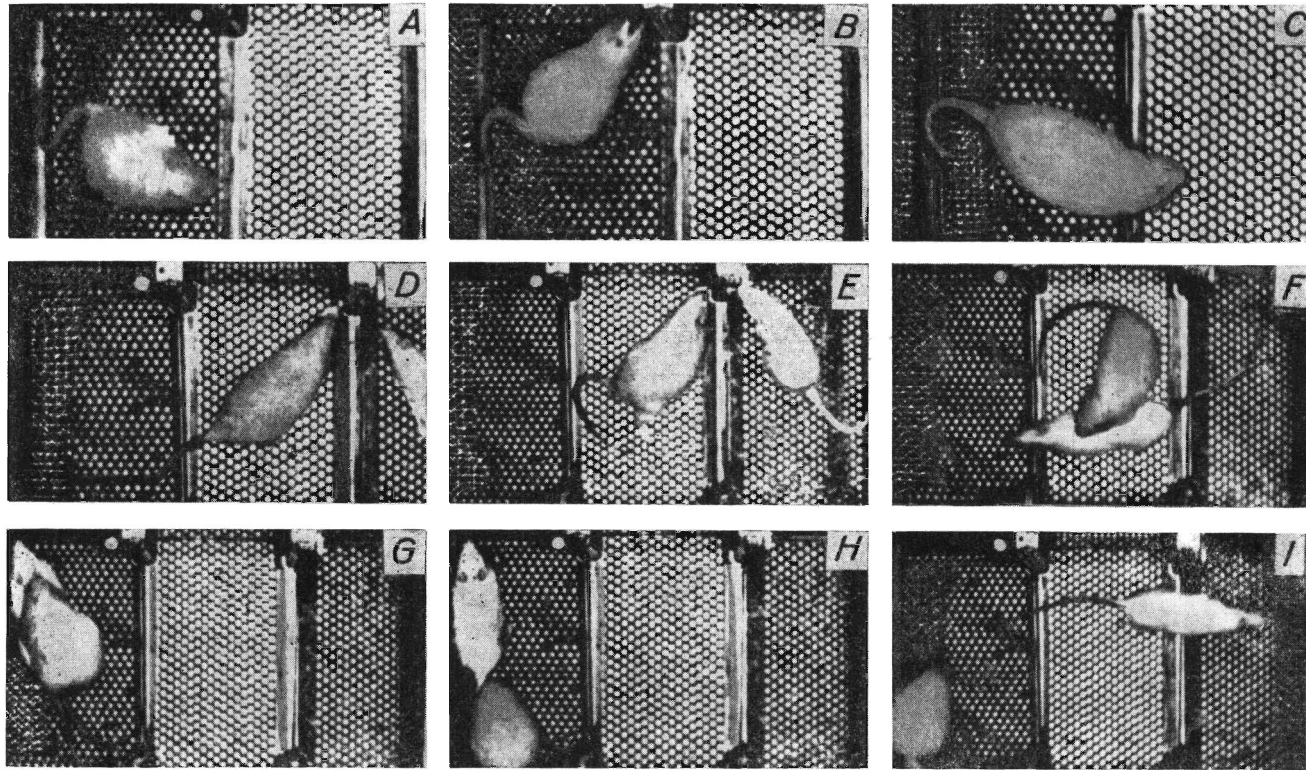


Fig. 4. The instrumental CR with sexual reinforcement observed simultaneously in the male and in the female. The places for lever introduction are marked same as in Fig. 2 and Fig. 3. *A*, the male before the instrumental response; *B*, the instrumental response in the male; *C*, the male is going out of his compartment; *D*, the male in the neutral compartment; *E*, the instrumental response in the female; *F*, the female is going out of her compartment; *G*, copulation; *H*, the penis licking reaction; *I*, the female is returning to her compartment.

DISCUSSION

Of the above presented results we should begin with the elaboration of instrumental sexual reflexes in male as well as in female rats. This indicates the existence of a sexual drive in both sex animals. The CR was trained in female rats as easily as in males, because of the high level of motor excitation showed by them during the estrus. The interreaction intervals observed with female subjects were approximately the same as with males, whereas the interval between ejaculation and the next instrumental response was shorter than in males but longer than their interreaction intervals.

The longer duration of the postejaculatory interval in the male is obvious, because ejaculation is connected with a longlasting drive satisfaction. As far as females are concerned it is possible that ejaculation which is connected with a deeper and more longlasting intromission, causes a stronger excitation of vaginal exteroceptors followed by a longer drive satisfaction period. Another observation is the fact that female screech followed by an aggressive reaction directed towards the male immediately after ejaculation seems to occur frequently. This might suggest that ejaculation evokes a pain reaction which causes a temporal inhibition of the sexual drive. The inhibition of the CR observed in females with metrorrhagia seems to support this concept. This inhibition was very often preceded by screeching during intromission followed by an aggressive reaction against the male.

The use of lever pressing as an instrumental reaction was prompted by the need of a quantitative estimation of the changes in the drive level. Such a response was used for the same purpose by Denniston (1954) in males, and Bermant (1961) in females. The difference between their method and ours consists in the fact that in their experiments the animal used as a reward was put into the chamber immediately after the instrumental reaction and taken out just after copulation.

The possibility of the free return of the subject to its compartment allowed us to observe the behavior of both animals just after copulation. Similar reactions occurring spontaneously in the female rats were described by Peirce and Nuttall in 1961. The authors explained it by such a strong inhibition of drive during intromission that the animal avoided a new sexual contact for some time. Spontaneous appearance of this reaction could be easily observed in females which are mobile just after copulation, while it was never observed in natural conditions in males immobilized by the penis licking reaction. In the experiments presented here this reaction never occurred spontaneously in males, but was easily trained.

The training was performed, as it has been described above, by means of catching the male by the tail during the licking of the penis and putting him back into his compartment. After this operation the males very often returned to the penis licking reaction.

This phenomenon allows us to assume that the return reaction is connected with avoiding the interruption of the consummatory reaction part of which seems to be the licking of the penis. A similar situation is often observed in alimentary behavior when the animal after having obtained food goes to a quiet place to eat it without being disturbed.

As noted before, instrumental reflexes can be established also in noncopulating males. Obviously their formation is based on the contactive drive. The appearance of the first copulation in these animals long after the instrumental sexual reflexes had been established could suggest that the contactive drive has a strong facilitatory role with regard to the detumescence drive.

The question arises, whether the contactive drive and the social drive belong to the same category. It is impossible to answer this question on the basis of the present results, and it will be the subject of some further studies.

The formation of instrumental sexual reflexes on basis of the contactive drive may suggest that this method can be easily adopted to the investigation of instrumental CRs established on the basis of other drives, such as maternal drive, social drive, etc.

SUMMARY

1. Experiments were performed on adult rats of both sexes. Instrumental CRs with sexual reinforcement were investigated in a chamber divided by two doors into three equal compartments.

2. During the experiment the animals were put into two external compartments. As a result of lever pressing, which was used as an instrumental response both doors were opened making possible the contact between the two animals. After this contact the subject had a possibility of a free return to its compartment.

3. There were three variations of the experiments. In the first the subject was a male and a female was used as the reward, in the second the subject was a female and a male was used as the reward, and in the third both animals played a role of subject as well as of reward.

The author wishes to express his gratitude to Professor Jerzy Konorski for his kind aid and advice during carrying out of this study as well as in the preparation of the manuscript.

REFERENCES

- BEACH, F. A. and JORDAN, L. 1956. Effects of sexual reinforcement upon the performance of male rats in a straight runway. *J. Comp. Physiol. Psychol.* 49: 105-111.
- BERMANT, G. 1961. Response latencies of females rats during sexual intercourse. *Science* 133: 1771-1773.
- BOLLES, C. R., RAPP, H. M. and WHITE, G. C. 1968. Failure of sexual activity to reinforce female rats. *J. Comp. Physiol. Psychol.* 65: 311-313.
- DENNISTON, R. H. 1954. Quantification and comparison of sex drives under various conditions in terms of learned response. *J. Comp. Physiol. Psychol.* 47: 437-440.
- DEWSBURY, D. A. 1967. A quantitative description of the behavior of rats during copulation. *Behaviour* 29: 154-178.
- KAGAN, J. 1955. Differential reward value of incomplete and complete sexual behavior. *J. Comp. Physiol. Psychol.* 48: 59-64.
- KONORSKI, J. 1970. Integrative activity of the brain. An interdisciplinary approach. Univ. Chicago Press, Chicago. 531 p.
- LARSSON, K. 1956. Conditioning and sexual behavior in the male albino rat. *Acta Psychol. Gothoburg.* 1: 1-269.
- PEIRCE, J. T. and NUTTALL, R. L. 1961. Self-paced sexual behavior in the female rat. *J. Comp. Physiol. Psychol.* 54: 310-313.
- SHEFFIELD, F. D., WULFF, J. J. and BACKER, R. 1951. Reward value of copulation without sex drive reduction. *J. Comp. Physiol. Psychol.* 44: 3-9.

Received 8 October 1970