possible relation between level of cognitive ability and the self-stimulation score. Results from 9 retardates with Down's syndrome, 10 technicians selected for average intelligence (Peabody IQ between 90 and 110), and 13 Ph.D. scientists indicate a definite positive relation between intelligence level and the self-stimulation score (Fig. 2). The scientists scored higher than the technicians, who in turn outscored the retardates (*17*). For a majority of the Down's syndrome patients, the amplitude of the self-evoked response actually exceeded that of the machine-evoked potential. In contrast, all but one of the subjects with normal intelligence showed the expected self-stimulation effect. These results could enhance the usefulness of the sensory evoked potential for understanding and perhaps measuring the biological substrate of individual differences in behavioral intelligence.

Finally, because initial results had implicated foreknowledge or short-term memory as a correlate of the self-stimulation effect, we conducted seven experiments on E.W.P.S. exploring the possible effects of delaying delivery of self-administered stimuli by a fixed time. We found that the self-stimulation score decreased linearly with progressively longer delays of the stimulus, but that even with delays of up to 4 seconds some residual self-stimulation effect remained, in that the amplitude of self-evoked responses still fell below that of machine-evoked responses. These results indicate that the brain studied could functionally "remember" for up to 4 seconds that it had stimulated itself. The paradigm of self-stimulation with delay should prove useful for studying short-term memory function at the fundamental electrocortical level (*18*).

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18. It came to our attention after completion of this study that our findings of a self-stimulation effect in human electrocortical responses relate to and show consistency with earlier work with monkeys [S. S. Fox, *J. Comp. Physiol. Psychol.* **58**, 225 (1964)].
19. Supported by NICHD grant P01-HD-05317 and by NIH general research support grant S01-RR-05609.

29 January 1973; revised 19 March 1973

Induction of Mating Behavior in Rats by Luteinizing Hormone–Releasing Factor

Abstract. *Ovariectomized female rats treated with estrogen, in dosages too low to provoke mating, displayed this behavior when given subcutaneous injections of synthetic luteinizing hormone–releasing factor (LRF) 48 hours later. Two hours after the injection of LRF, components of female sexual behavior appeared. The lordosis reflex followed mounting by the male, and darting and hopping behavior was quite prevalent. On the other hand, treatment with estrogen followed by luteinizing hormone, follicle-stimulating hormone, or thyrotropin-releasing factor did not induce copulatory behavior. The results suggest that LRF may play a role in induction of mating behavior.*

It has been clearly demonstrated that sexual behavior in subprimate female mammals is dependent on the ovarian steriods, estrogen and progesterone (*1*). In the female rodent, there is a clear relationship between the ovarian cycle on the one hand and rhythms of sexual receptivity on the other (*2*). Removal of the ovaries results in the complete cessation of estrous behavior. The heat response can be reinitiated by exogenous treatment with daily doses of estrogen over a period of days (*3*) or with relatively small doses of estrogen followed by progesterone (*4*). The ovarian cycle is regulated by the gonadotropins from the anterior pituitary: follicle-stimulating hormone (FSH) to stimulate follicular development and luteinizing hormone (LH) to produce ovulation and formation of the corpora lutea (*5*). The output of ovarian steroids is similarly under the control of the gonadotropins (*6*) which, in turn, are under hypothalamic regulation mediated by hypothalamic-releasing factors (*7*). These factors are released into the capillaries of the hypophyseal portal system of veins and are carried down the pituitary stalk to reach the pituitary sinusoids where they trigger release of

Table 1. Summary of the lordosis-to-mount ratio data for ovariectomized female rats under various hormonal treatments tested 50 hours after the initial injections of estrogen. The injections, all subcutaneous, were: E, 0.25 mg of estrone at 0 hours; P, 1 mg of progesterone at 48 hours; LRF, 500 ng of luteinizing hormone–releasing factor at 48 hours; LH, 12 μg of luteinizing hormone per 100 g at 48 hours; FSH, 50 μg of follicle-stimulating hormone per 100 g at 48 hours; TRF, 500 ng of thyrotropin-releasing factor at 48 hours.

Item	Group 1: E alone	Group 2: E + P	Group 3: E + LRF	Group 4: E + LH	Group 5: E + FSH	Group 6: E + TRF
Total number of tests	28	18	21	14	13	16
Number of tests where at least one lordosis occurred	2	18*	18*	1	0	1
Percent responding	0.07%	100%	86%	0.07%	0.00%	0.06%
Cumulative number of mounts	273	223	364	153	147	160
Cumulative number of lordoses	8	193	283	2	0	3
Mean lordosis-to-mount ratio (L/M)	0.02	0.86	0.77	0.01	0.00	0.01

* Significantly different ($P < .001$) from all other groups by chi-square test.

pituitary hormones. Extracts of hypothalamic tissue can trigger release of LH (*8*), and the active factor has been purified and separated from other factors effecting release of other pituitary hormones (*9*). A decapeptide, thought to represent the natural product, has recently been synthesized (*10*) and shown to release LH in a variety of mammalian species including the human (*11*).

In the normal female rat, a preovulatory discharge of gonadotropins, presumably triggered by release of luteinizing hormone–releasing factor (LRF), occurs on the afternoon of proestrus and is followed a few hours later by the onset of heat (*2, 12*). It therefore seemed of some interest to inquire whether or not hormones released during the preovulatory discharge, such as LRF or the gonadotropins FSH and LH, might be involved in the induction of mating behavior. Furthermore, the areas regulating gonadotropin secretion, on the one hand, and mating behavior, on the other, overlap in their central nervous system distribution. Luteinizing hormone–releasing factor is found in a band of tissue extending from the medial preoptic region through the ventral hypothalamus to the median eminence-arcuate region from which LRF is presumably released in juxtaposition to the portal capillaries (*13*). On the other hand, the primary region concerned with mating behavior in the female rat appears to be the preoptic area, since lesions in this area abolish mating behavior (*14*), whereas implantation of estrogen into the area evokes it (*15*).

It was therefore particularly intriguing to consider the possibility that LRF might be released from terminals of LRF-containing neurons in the preoptic area on the afternoon of proestrus and that this LRF might interact with cells concerned in the mediation of sex behavior to aid in its induction after a delay of several hours. Consequently, we evaluated the effect of LRF and gonadotropins on mating behavior in ovariectomized, estrogen-primed female rats.

Eighteen ovariectomized female, Sprague-Dawley rats (250 to 300 g) (Simonsen Laboratories, Gilroy, California), known to mate vigorously with appropriate hormonal therapy, were selected for study. They were housed under conditions of controlled temperature (74° to 77°F; 23.3° to 25°C) and lighting (lights on midnight to 2 p.m.) and given free access to Purina Lab Chow and water (*16*).

Each ovariectomized female was injected with 0.25 mg of estrogen (Theelin, estrone, in oil; 1 mg/ml) and then placed in one of six experimental groups. Group 1 consisted of animals given estrogen only, while group 2 was composed of estrogen-primed animals given 1 mg of progesterone (Lipolutin in oil; 25 mg/ml) at 42 hours. In the remaining groups, 3 to 6, the estrogen-primed animals were given one of the following hormones subcutaneously at 48 hours: LRF (500 ng), LH (24 μg/100 g), FSH (50 μg/100 g), or thyrotropin-releasing factor (TRF; 500 ng).

In all estrogen-primed females the mating test was begun 48 to 49 hours after the initial injection of estrogen and the rats were also tested subsequently at 50 and 56 hours. Female sexual behavior was expressed as the ratio of the number of lordosis responses (L) to mounts (M) (that is, mounts alone, mounts with intromissions, and mounts with intromissions and ejaculations) by the male sexual partner (L/M: lordosis-to-mount ratio). After estrogen-priming, each female rat was tested once every 7 days by being placed in a mating arena with a sexually active male. The mating session started when a male "mounted" a female and was terminated at the end of 15 minutes or when the male partner ejaculated, whichever came first. After each male was used, he was allowed a 5- to 6-day rest period before being used again as a sexual partner.

The quantity of estrogen injected was deliberately chosen to be so low that it would have little effect on sex behavior. Thus, in the animals injected with estrogen alone (group 1, Table 1), there was very little response to the presence of the male. Lordoses in response to the male sexual contacts were seen in only 2 of the 28 tests in 13 animals, and the total number of lordoses was only 8 out of 167 mounts. Even in the two instances where there was some responsiveness, the L/M ratio was 3/18 and 5/27, respectively.

As expected, all of the ovariectomized females treated with estrogen followed by progesterone (group 2) displayed lordosis behavior at 48 hours after the initial injection of estrogen (6 hours after progesterone). The L/M ratio was 0.86. This behavior could be evoked by the male for 6 to 8 hours.

By contrast, FSH and LH in amounts thought to be in excess of those discharged in the preovulatory surge of gonadotropins (*17*) did not enhance sex behavior above the level found in animals given estrogen alone. In only 1 of 12 tests was there a response in animals given LH. The L/M ratio was only 2/12. All of the other animals given either LH or FSH failed to exhibit a lordosis response.

In dramatic contrast were the results obtained in estrogen-primed females treated with LRF (group 3). The facilitation of the lordosis reflex by LRF was first noted in 50 percent of the animals one-half hour after the injection of LRF. During this time, all animals, including those displaying lordosis behavior, exhibited a large amount of hind kicking and squealing. But, by 2 hours after injection of releasing factor, nearly all (19 out of 21) estrogen-primed, LRF-treated animals displayed the lordosis pattern. Coitus behavior could be induced by the male for at least 6 hours. The

mean L/M ratio at 2 hours was 0.77. These results clearly show that LRF facilitates the occurrence of lordosis in estrogen-primed females.

To determine if the response to LRF was specific, another releasing factor, TRF, was tested. This one seemed particularly appropriate since it is localized to the bed nucleus of the stria terminalis (*13*), a region near the LRF-containing and sex behavior centers. There was lordosis in only 1 of 16 tests with TRF, and in this instance the L/M ratio was low at 3/18.

The present results demonstrate that LRF exerts a facilitatory effect on the induction of mating behavior similar to progesterone. After an injection of LRF, ovariectomized female rats, pretreated with estrogen, displayed a lordosis pattern that differed little from that produced by progesterone, while only a few females exhibited the lordosis pattern in response to estrogen alone or estrogen in combination with LH, FSH, or TRF.

Although the estrogen-primed, LRF-treated animals showed mating behavior, it would be incorrect to characterize the behavior displayed as typical of "estrous behavior" as seen in the intact female rat. Female rats at a high level of sexual receptivity display a characteristic behavior including adoption of a stiff-legged, hopping gait, darting, and rapid vibratory movements of the ears (ear wiggling). In the present experiment, the majority of animals displayed hopping and darting behavior, but no ear wiggling was observed, so it is difficult to make any statement on the normality of the behavior patterns.

The dose level of LRF used in the present study was selected on the basis of other experiments by Zeballos (unpublished data) which indicated that this dose produced a large increase in LH release. A dose fivefold smaller produced only a very small effect on LH, so the dose used here is probably within the physiological range. If LRF is indeed released locally into the preoptic area when the LRF-secreting neurons are active, then very high concentrations might reach the cells concerned with the mating response. Thus, it is tempting to postulate that LRF released on the afternoon of proestrus may be involved after a delay in initiating mating behavior in female rats. It is still too early to say whether or not it is required for mating behavior. Lesions which eliminate LRF from this part of the nervous system would be required in order to test the possible requirement for the factor in inducing mating behavior.

The results are of extreme interest, since they indicate that another hormone in addition to estrogen and progesterone can induce mating behavior in the female rat. Particularly intriguing is the fact that this hormone is normally found in that area of the nervous system which is involved in mediating mating. It will be of extreme interest to determine if LRF can enhance mating behavior in males as well as females and to determine if these results obtained in a lower form have any application to humans. In this connection, one must be cautions, since ovarian steroids have little effect in inducing acute mating responses in the human subject. If indeed LRF can induce mating in humans, the implications would be far-reaching.

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18. This research was supported by PHS grant NS-10434. We are indebted to Dr. S. N. Preston of Parke, Davis and Company for their donation of Theelin and Lipolutin utilized in this experiment and to Dr. Romano Deghenghi, Ayerst, Ltd., Montreal, for the generous supply of LRF. LH (NIH, S-9) and FSH (NIH, P-1) were gifts of the Endocrinology Study Section, NIH. We also acknowledge the excellent technical assistance of Mrs. Betty Turicchi.

12 March 1973

Eye-Tracking Patterns in Schizophrenia

Abstract. *A significant number of schizophrenic patients show patterns of smooth pursuit eye-tracking patterns that differ strikingly from the generally smooth eye-tracking seen in normals and in nonschizophrenic patients. These deviations are probably referable not only to motivational or attentional factors, but also to oculomotor involvement that may have a critical relevance for perceptual dysfunction in schizophrenia.*

Eye-tracking difficulties in a simple test of smooth pursuit eye movements seem to be related to schizophrenic pathology. We report a study of 25 psychotic patients, 8 nonpsychotic patients, and 33 normal persons in the eye-tracking task.

The experimental task required the subject to watch an oscillating pendulum suspended at eye level 1 m from the seated subject. The pendulum excursions corresponded to 20° of visual angle. The period of oscillation was 2 seconds and thus the maximum eye velocity during nonerror tracking would be 31.4° per second. Silver–silver chloride skin electrodes were applied at the outer canthi of both eyes, and a ground electrode was applied to the middle of the forehead. Changes in field potential generated by the corneoretinal potential were recorded on a Beckman type R Dynograph as eye movements in the horizontal plane. Channel 1 of the Dynograph yielded readings of actual eye movements, and