discharge of prolactin induced by suckling, acquire certain properties; and through which neurohumoral pathways do these stimuli operate to influence gonadotrophic activity?

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3. C. E. Grosvenor, *Endocrinology* **76**, 340 (1965). This same possibility was suggested some 35 years ago by B. P. Wiesner and N. M. Sheard [*Maternal Behaviour in the Rat* (Oliver and Boyd, London, 1933)].
4. We thank A. Como, P. Gantcher, R. Glass, M. Lubin, R. Ostro, and S. Rose for assistance. Supported by grant GB5231 from NSF and NIH grant 1RO1HDO3651.

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Hypothalamic Motivational Systems: Fixed or Plastic Neural Circuits?

We have described (*1*) a procedure for modifying the behavior elicited by hypothalamic stimulation. The new behavior competed effectively with the initial behavior and was elicited by the identical stimulus parameters, and we concluded that "there is considerably more plasticity in establishing connections between hypothalamic circuits and motivated behavior than commonly advanced interpretations of 'stimulus-bound' behavior suggest."

An alternative hypothesis was advanced by Wise (*2*) who reported that, when the current was high enough, electrodes could elicit more than one behavior pattern. Finding that the threshold for eliciting a particular behavior tended to decline over time, Wise concluded that the second or third behavior emerging in our studies with one stimulus intensity resulted from the gradual decline in threshold of the neural circuits responsible for the behavior. Wise maintains that there are separate "fixed neural circuits, functionally isolated from each other," and that the threshold changes in these circuits create the impression of plasticity. Since this argument may appeal to those who think that the hypothalamus contains discrete neural circuits related to each motivational system, we feel impelled to reply. Our procedure was misunderstood, and additional supporting experimental data (not available to Wise) prevent us from accepting the alternative explanation of our results.

Wise assumed that the first behavior pattern which we observed in response to stimulation was elicited at threshold currents that were obtained by gradually raising the intensity. The implication is that if we used suprathreshold currents, the second behavior would have been observed from the beginning of the experiment. Our procedure did not involve threshold values, and we did not state that it did. Indeed, others have thought that we had obtained several behavior patterns from stimulation at the same site because the current was too high. In our first report, the current was two to three and one-half times the threshold for eliciting the behavioral response. Only subsequently have we used threshold values (we obtained similar results). Thus, our earlier results were criticized both because the current used was too high and because the current used was too low.

In other experiments (not included in our abbreviated report in *Science*), we either raised the current as high as possible without damage to the animal, or stimulated the animal over several weeks of testing at the first current level (*3*). In most cases, when the first goal object to which the animal responded was still available, a second stimulus-bound behavior pattern was not displayed. In animals stimulated over several weeks, the threshold changes reported by Wise should have occurred.

Only after we removed the first goal object did the second behavior pattern gradually emerge. In the experiment reported by Wise, the first goal object was removed when the current was raised. We used stimulation without the initially preferred goal object (and did not manipulate the current) to obtain a second behavior pattern. Wise's procedure confounds current manipulation with the effect of removing the initially preferred goal object. No quantitative or qualitative information is provided on the time course of emergence of this second behavior. Nor does Wise consider the difficulties posed for the position of completely independent neural circuits by the fact that a second behavior pattern is hard to demonstrate even at high current levels, in the presence of the first goal object.

In our experience the emergence of the second behavior, even at higher current levels, may take several hours of intermittent stimulation. Once this new behavior is associated with the stimulus, it is possible to elicit it with lower current. The relevant point is that it is not the stimulation which produced the lower threshold, but the acquisition of the behavior pattern.

The threshold for eliciting behavior by electrical stimulation may decline over successive test sessions. Many factors probably contribute to this decline; among these are variables related to an increased readiness to respond in a particular way and factors related to stimulus-generalization gradients. We noted this decline in behavioral threshold in the context of self-stimulation experiments, and cautioned against assuming that the excitability of the neural elements directly activated by the electrical stimulus are responsible (*4*). Wise seems to imply that the repeated stimulation lowers the threshold, and has overestimated the amount of stimulation necessary to produce a second behavior in our experiment. We had written that most animals required only one night of intermittent stimulation for the new behavior to emerge, and in subsequent experiments a much shorter period was often required. Wise implied that our experiments usually involved several nights of stimulation. Furthermore, our statement, "The earlier the onset of the first behavior during the preliminary stimulation sessions and the more consistently this behavior was displayed, the sooner the animal switched to a second behavior pattern . . ." has been ignored, apparently because it is not consistent with the hypothesis that the stimulation per se is responsible for lowering the threshold.

Although Wise presented some useful data, we still maintain that the relationship between the activation of hypothalamic neural circuits and stimulus-bound behavior is plastic. This conclusion has been strengthened by further experimentation with a greater variety of behavior patterns (*3*).

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