The first contention of Koob et al. is that a relatively arbitrary, environment-dependent behavioral plasticity governs the nature of the behavior exhibited. However, in a number of species, electrical stimulation of specific sites in the hypothalamus can induce behavioral responses that are not solely dependent on characteristics of the test environment (2). Results from our own experiments demonstrate that it is possible to elicit qualitatively dissimilar responses within the same animal by simply stimulating different hypothalamic areas. For example, electrical stimulation of the dorso-medial nucleus of the hypothalamus of an adult male rhesus monkey will induce sexual behavior directed toward a receptive female. When, in the same setting, at any time before or after the evoked sexual response, one delivers the electrical stimulus in another area of the hypothalamus (for example, the ventromedial nucleus or the lateral preoptic area) it is possible to induce an aggressive response directed toward the same female who was the object of the sexual response. These results suggest to us a degree of specificity for some behaviors elicited by electrical stimulation of the brain that stands in contrast to the nonspecific, situationally dependent responses of eating, gnawing, biting, and licking that can be induced by painful stimulation, by tail pinch, or by electrical stimulation of a number of areas of the central nervous system, including regions of the hypothalamus.

A second contrast between our findings and those observed with tail pinch is that electrically elicited sexual and aggressive responses virtually always occur the first time an appropriate stimulus is presented. These responses are characterized by latencies that remain stable over many months. Latency to physical contact, from the onset of stimulation of aggression-producing sites, is usually less than 0.1 minute, even on the occasion when the behavior is first elicited. This short latency includes times spent chasing a fleeing target animal. Furthermore, the duration of the stimulation-bound attack is determined by the duration of the stimulation, because the attacks cease promptly when the stimulating current is turned off. Flynn and his colleagues have likewise reported that latencies to stimulus-bound attack remain stable and depend on stimulus characteristics. The exception is that latency to actual physical contact (rather than to directed movement) tends to increase slightly over days of stimulation (2).

Valenstein et al. (4) have demonstrated plasticity of behavioral responses to electrical stimulation of the hypothalamus under certain conditions. Such plasticity is not without limits. Valenstein has pointed out, for example, that aggression, but not eating or gnawing, can be induced in the rat by stimulating the ventromedial hypothalamus (5). It is likely that plasticity of the type described either by Valenstein or by Koob et al. is limited to oral responses involving chewing or gnawing. Our studies of electrically elicited social behavior in primates contrast starkly and qualitatively with such studies of oral behaviors. We believe that this contrast emphasizes the usefulness of electrical stimulation of the brain as a tool for examining neural systems underlying specific behavioral patterns.

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References and Notes
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Koob et al. (1) have suggested that the arousing consequences of mechanically induced tail pinch are sufficient to motivate both the learning of a T-maze discrimination and its reversal. Although the ascription of motivating properties to tail pinch is clearly established by their results, the subsequent interpretation of these findings in terms of an arousal mechanism may in fact be premature.

Tail pinch is a psychophysiologically complex stimulus, and it embodies both arousing and aversive properties. For example, all eight rats in our laboratory subjected to a 20-second tail pinch from a hemostat showed vocalizing, attempted flight, and aggressiveness (biting, directed at the hemostat or, when possible, the experimenter). Such signs of pain were also present in the experiment of Koob et al.: "Rats that ran to the incorrect goal box characteristically vocalized, defecated, and chased their tails." It is therefore of interest that (i) biting and gnawing, the major consummatory responses to tail pinch reported by Koob et al., may be elicited by aversive stimulation such as shock (2), (ii) repetitive aversive stimulation increases a variety of unconditioned behaviors similar to those reported (for example, unconditioned response sensitization, pseudconditioning) (3), and (iii) a variety of aversive stimuli may motivate learning (4). One possible alternative explanation of tail-pinch learning might therefore rest upon the reduction of an aversive state, if, for example, chewing or biting a goal object reduced the pain of tail pinch. Other forms of peripheral stimulation are known to reduce pain (5).

It is possible that tail pinch and other aversive events energize a fairly general adaptive coping response, the purpose of which is aversion reduction. A prepotent and species-specific defense response (either flight or flight) may thus eventually give way to other responses (including gnawing) if the initial responses are unsuccessful. In fact, Koob et al. show such behavior to occur.

Since tail pinch is both arousing and aversive, and since aversion may account for the reported phenomena with at least the same parsimony as arousal, no compelling reason exists for the choice of either possible interpretation. It might be noted that the studies of brain stimulation, which Koob et al. suggest support their hypothesis, also demonstrate both arousal and some degree of motivation, be it incentive or aversive in nature (6). Given the aversive properties of an arousing stimulus (such as tail pinch) and the arousing properties of an aversive stimulus (such as shock), both factors might be argued to be intrinsically related and jointly necessary for the learning described by Koob et al. Furthermore, neither factor by itself has yet been adequately dissociated and shown to be sufficient for learning.

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3. G. R. Wendt, Arch. Psychol. N.Y. 19, 123 (1930); C. L. Prosser and W. S. Hunter, Am. J. Physiol. 117, 609 (1936); I. Gormezano, in Experimental
Perachio and Herndon have made one important technical point, which concerns the amount of eating and gnawing by unpinched rats, and two theoretical points: (i) the specificity of electrically induced sexual and aggressive behavior in contrast to the apparent nonspecificity of tail-pinch-induced behavior, and (ii) the short latencies of electrically induced sexual and aggressive behavior compared to the time taken for tail-pinch-induced oral behavior to emerge.

With regard to eating by unpinched rats, a 2-minute habituation period was given in the open field before each tail-pinch trial. During these habituation periods, only an occasional bite at the food was observed; the same result has been obtained with rats tested with pieces of wood. Unpinched rats were not run in the original maze study, but control trials have since been run with both food and wood. In 100 trials, a group of six rats did not show a side preference, and eating or gnawing was confined to an occasional bite. There were no significant eating or gnawing by unpinched rats, and tail pinch was necessary to produce learning of the T-maze.

Perachio and Herndon state that our conclusion (1) that both tail pinch and electrical brain stimulation may act through a common mechanism is not warranted on the evidence provided. We are not suggesting that tail pinch and brain stimulation produce absolutely identical effects, but rather that they share the property of inducing activation in a nonspecific way and that this nonspecific activation may be all that is necessary to produce new learning.

The ability of electrical brain stimulation to produce sexual and aggressive behavior may indicate that it is more specific in its effects than tail pinch or electric shock, which may produce only "nonspecific, situationally dependent responses of eating, gnawing, biting, and licking." However, sexual behavior and aggressive behavior can be produced by electric shock (2), and tail pinch may also elicit sexual behavior and maternal behavior (3). The relative strength of these responses compared to tail-pinch-induced oral behavior should be investigated.

Perachio and Herndon also suggest that the short, stable latencies they see with electrically induced sexual and aggressive behavior indicate that this behavior is qualitatively different from tail-pinch-induced behavior; we propose that the difference is merely quantitative. Most rats eat the first time they are pinched (4), and the decrease in latency occurs rapidly during the first four or five sessions (5) until the rats start eating as soon as the pinch is applied; the eating generally stops as soon as the pinch is removed. The rats' reactions are often defensive in nature; for example, they sometimes run around the open field, bite at the clip, or lick their tails until they come across a food pellet whereupon they bite at the food and then settle down in a normal eating posture. The decrease in latency thus reflects the replacement of competing defensive responses by eating; the rats learn to overcome the aversive effects of the pinch, and once they have learned, the eating latency remains low on subsequent trials. The same is true of behavior elicited by electrical stimulation of the lateral hypothalamus; the decrease in latency with experience probably reflects the rats' overcoming the aversive effects of the stimulation (5). At some sites, however, electrical brain stimulation may produce only very small aversive effects, especially since the level of stimulation can be carefully controlled so that very short latencies may be seen from the outset. Therefore, differences in latency may reflect the aversiveness of the stimulation; this is a quantitative rather than a qualitative difference.

Nevertheless, the representation of different motor routines in the brain (for example, eating versus sexual behavior) means that it might be possible to stimulate selectively the neuronal systems that specifically code these routines and separate them anatomically. Different behavior elements can be elicited by stimulating different sites, but different responses are associated to different degrees. For example, in the oppossum, hypothalamic stimulation that elicits eating will also elicit mating, but not threat (6). The most obvious anatomical separation is between eliciting approach responses from the lateral hypothalamus and eliciting defensive responses from the medial hypothalamus (7). Similar results have been obtained with stimulation in the mesencephalon and pons (8), which suggests that this lateral grouping of approach responses and medial grouping of defensive responses extends to lower brain structures.

Therefore, it is not possible to decide whether the particular response elicited from a particular site on any one occasion is determined by preferential activation of a neuronally discrete system interdigitated with other systems or by the environmental influences on the animal during the activation of a single, non-specific system. Moreover, since a non-specific stimulus, tail pinch, is sufficient to produce a variety of different responses, it is not necessary to hypothesize the existence of separate motivational systems. Thus, when the lateral hypothalamus is stimulated a general approach system may be activated, and when the medial hypothalamus is stimulated a general defensive system may be activated. At the same time, connections to specific motor routines may be activated, which may account for the different elements of specific behavior patterns that can be produced by stimulation at different sites.

Animals will self-stimulate from electrodes in the lateral hypothalamus and will escape from stimulation of the medial hypothalamus; these effects may be the result of activation of these same approach and defensive systems, which appear to retain their lateral and medial organization throughout a large part of the brain (9). Further, a rewarding lateral hypothalamic site can be made aversive merely by increasing the current. In general, low-intensity stimulation is pleasurable and high-intensity stimulation is aversive; the relative intensity of a stimulus may to a large extent determine whether it is rewarding or aversive (10). Thus, a low-intensity stimulation or arousal may activate the approach system and be interpreted as rewarding, and high-intensity stimulation may activate the defensive system and be interpreted as aversive.

Katz makes the important point that the behavioral effects of tail pinch may be due equally to aversive consequences or to appetitive consequences. The question is whether tail-pinch-induced behavior can be regarded merely as a coping response to an aversive stimulus or as genuine appetitive behavior. If the behavior is merely a coping response to a stressful stimulus, then reducing the stress with a minor tranquilizer should reduce the tail-pinch-induced behavior.


5. Albee, J. Org. Psychol. Biol. Med. 19, 125 (1975). Also, hand wringing and agitated activity are typically seen in cases of chronic pain (for example, cancer) and may be interpreted as maneuvers to reduce the extreme aversiveness of this condition.


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Tail Pinch Versus Brain Stimulation: Problems of Comparison
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