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FACILITATION OF AVOIDANCE BEHAVIOR BY UNAVOIDABLE SHOCKS IN NORMAL AND AMYGDALECTOMIZED MONKEYS[1]

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Summary.—When shocks were occasionally delivered regardless of *S*'s behavior, the avoidance response rates of both amygdalectomized and control monkeys were markedly increased. Amygdalectomized *Ss* showed at least as great a facilitation as control *Ss*. The results of this test do not support the general notion that amygdalectomized *Ss* are relatively insensitive to the effects of aversive stimuli.

Ss with bilateral removal of the amygdala have often been described as "emotionally unresponsive" or "tame" because they show diminished fear in the presence of stimuli that are noticeably aversive for normal *Ss* (Pribram & Bagshaw, 1953; Brady, 1960). On this basis one would expect that the free-shock procedure of Sidman, Herrnstein, and Conrad (1957) might have differential effects on normal and amygdalectomized *Ss*. In their experiments Sidman, Herrnstein, and Conrad found that the rate of avoidance responding in normal monkeys could be markedly increased by occasionally shocking *S* regardless of its avoidance behavior. If amygdalectomized *Ss* are generally less responsive to aversive stimuli, free shocks ought to have a smaller effect on their avoidance behavior than on the behavior of control *Ss*. The present experiment was undertaken to test this possibility.

METHOD

Subjects

Eight young rhesus monkeys were used, six of which had been amygdalectomized 6 to 7 mo. previously and two of which were nonoperated controls. All but one of the *Ss* (an amygdalectomized *S*) were males. *Ss* had previously served in an extended series of experiments that compared visual intensity generalization gradients before and after amygdalectomy. Additional details of these experiments will be reported by Hearst and Pribram.[3]

Three of the amygdalectomized *Ss* had been trained to avoid shock before surgery, whereas the other three *Ss* had learned to avoid shock four to five weeks after amygdalectomy. Experimental sessions were scheduled every weekday.

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[3]Cf. E. Hearst, & K. H. Pribram. Appetitive and aversive generalization gradients in normal and amygdalectomized monkeys. (Unpublished manuscript)

Apparatus

Standard operant conditioning equipment, including a Foringer Primate and Carnivore test chamber, response lever and grid shock scrambler, was used. Details of the apparatus have been described in Hearst (1962).

Procedure

Just prior to the present experiment all *Ss* had been given a series of avoidance extinction sessions. At the end of this period all avoidance rates were comparatively low, averaging about 35% of their pre-extinction levels.

Avoidance reconditioning.—The eight *Ss* were reconditioned on a Sidman-type avoidance schedule (Sidman, 1953) in which the response-shock and shock-shock intervals were both 20 sec. By responding at least once every 20 sec. *Ss* could avoid shock entirely. *Ss* remained on this procedure for 5 to 10 daily 2-hr. sessions.

Avoidance response rates over the final four days of this reconditioning period were relatively stable from day to day (see Table 1). The avoidance rates of individual *Ss* ranged within $\pm$ 20% of their levels before avoidance extinction.

Addition of free shocks.—Seven additional avoidance sessions were then scheduled during which unavoidable shocks were superimposed on the avoidance baseline. These free shocks occurred on the average once every 12 min. As a result of this contingency *Ss* received at least 9 to 10 free shocks per 2-hr. session, plus any additional shocks (usually zero in number) that they might receive because of failure to press the lever every 20 sec. Unavoidable shocks were of the same intensity and duration (approximately 4-5 ma., 0.6 sec.) as avoidable shocks.

Anatomy.—Anatomical verification of the lesions is to be reported in detail elsewhere (Hearst & Pribram, see Footnote 3). These reconstructions showed that in all *Ss* the greater part of the amygdaloid complex had been removed. Occasional dorsomedial tags of amygdaloid substance remained posteriorly. Since the posterior edge of the amygdala is difficult to define histologically, we can only say that the remnant never extended forward of the anterior edge of the temporal horn of the lateral ventricle. No remnants remained anteriorly, laterally or ventrally. Incidental damage occurred occasionally and minimally to temporal polar cortex, to the ventral extremity of the putamen and the uncus of the hippocampus. This damage was never bilaterally symmetrical and rarely bilateral. No other pathology was observed to have occurred.

Results and Discussion

The results of this experiment are summarized in Table 1. Even on the very first day of the free-shock procedure the avoidance response outputs of

both groups clearly increased over their levels without the free-shocks. Every one of the eight individual *Ss* exhibited this response facilitation; there was only one instance out of a possible 32 (four pre-free-shock daily values for each of eight *Ss*) on which an individual *S*'s daily output without free shocks exceeded its value on Day 1 with free shocks. On the first day of the free-shock procedure the amygdalectomized *Ss* tended to be less affected by the new procedure than the unoperated *Ss*, but the difference between operates and controls in per cent increase over mean levels without free shocks was not statistically significant ($P = .143$, one-tailed Mann-Whitney U test).

TABLE 1

MEAN DAILY AVOIDANCE RESPONSES FOR THE OPERATED AND UNOPERATED GROUPS

Last 4 Consecutive Days Without Free Shocks				Consecutive Days With Free Shocks						
1	2	3	4	1	2	3	4	5	6	7
Normal Group ($N = 2$)										
2641	3331	2862	2597	4340	4762	4867	5492	5850	5576	4889
Amygdalectomized Group ($N = 6$)										
2458	2360	2529	2793	3405	4559	5351	5820	6225*	6424	6567

*On Day 5, the houselight that illuminated the experimental chamber blew out at an unknown time during the testing of one *S*. The data for this *S* are not included in the Day 5 mean, even though this *S* responded more frequently than on Day 3 and showed only an 11% decrease over its rate on Day 4.

For the remainder of the 7-day free-shock procedure, avoidance outputs generally increased for both groups. Over the seven test days the maximum daily individual response outputs of operated *Ss* ranged from 2.2 to 3.5 times higher than their individual mean levels prior to the introduction of free shocks; the maximum response outputs of the two control *Ss* varied from 2.0 to 2.7 times higher than their earlier levels. Thus, the amygdalectomized *Ss* showed at least as great an over-all facilitation as the unoperated controls.

Even though it appeared to have face validity as a test of emotional responsivity and as a way of evaluating relative sensitivity to aversive stimuli, the free-shock procedure did not differentiate between normal and amygdalectomized *Ss*. The results of Sidman, Herrnstein, and Conrad (1957) were supported, however, in that all *Ss* showed 2- to 3-fold increases in response output after the introduction of free shocks.

These results suggest that considerable caution should be exercised when characterizing amygdaloid *Ss* as relatively insensitive to the effects of aversive stimuli. The avoidance performance of our operated *Ss* was as efficient as that

of normals,[4] and unavoidable shocks resulted in an equivalent facilitation of the avoidance behavior of both operated and control *Ss*.

REFERENCES

BRADY, J. V. Emotional behavior. In J. Field (Ed.), *Handbook of physiology neurophysiology*. Vol. III. Washington, D. C.: American Physiological Society, 1960. Pp. 1529-1552.

HEARST, E. Concurrent generalization gradients for food-controlled and shock-controlled behavior. *J. exp. Anal. Behav.*, 1962, 5, 19-31.

PRIBRAM, K. H., & BAGSHAW, M. Further analysis of the temporal lobe syndrome utilizing fronto-temporal ablations. *J. comp. Neurol.*, 1953, 99, 347-375.

SIDMAN, M. Avoidance conditioning with brief shock and no exteroceptive warning signal. *Science*, 1953, 118, 157-158.

SIDMAN, M., HERRNSTEIN, R. J., & CONRAD, D. G. Maintenance of avoidance behavior by unavoidable shocks. *J. comp. physiol. Psychol.*, 1957, 50, 553-557.

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[4]Both K. Pribram and J. V. Brady in unpublished studies have also obtained little or no difference between amygdalectomized and normal *Ss* in the acquisition and performance of Sidman-type avoidance.