0-48

Journal of Comparative and Physiological Psychology
1964, Vol. 58, No. 2, 296–298

SUPPLEMENTARY REPORTS

APPETITIVE AND AVERSIVE GENERALIZATION GRADIENTS IN AMYGDALECTOMIZED MONKEYS[1]

ELIOT HEARST AND KARL H. PRIBRAM

Clinical Neuropharmacology Research Center[2], *National Institute of Mental Health*

Stanford University

Generalization gradients along a light intensity dimension were obtained from monkeys before and after bilateral amygdalectomy. Both appetitive and aversive gradients were unaffected by the lesion. No evidence was found to support a previous suggestion that some of the complex behavioral effects of amygdalectomy are due to a disturbance in stimulus generalization.

Schwartzbaum and Pribram (1960) analyzed the behavioral deficits of amygdalectomized monkeys in a visual-brightness transposition task and suggested that these impairments may reflect a more basic disturbance in stimulus generalization. In the present study we tested this possibility by determining whether amygdalectomy alters generalization gradients along a visual-brightness continuum.

In prior work (Hearst, 1962), differences were observed between the slopes of gradients for food-controlled and shock-controlled behavior. Therefore, in the present experiment some *S*s were trained on a food-reward schedule, and other *S*s on a shock-avoidance schedule.

METHOD

Subjects and Apparatus

The *S*s were 12 young rhesus monkeys (11 male, 1 female). Food-reinforced *S*s received 80–100 Foringer monkey pellets during experimental sessions. Shock-avoidance *S*s were fed 100 pellets daily after testing.

In most of the work we employed the same test chamber and accessory equipment as had been used in earlier studies (Hearst, 1962). The amount of illumination in the chamber was the dimension along which stimulus generalization was tested. Methods of varying and measuring the different illuminations have been described in the earlier report. A second chamber (used only for the 22½-hr. food-reward *S*s) was very similar to the above; however, the house light was mounted at a different position in the ceiling and this meant that the illumination in *S*'s working area was dimmer than in the first chamber.

Surgery and Anatomy

Eight of the 12 *S*s were given one-stage bilateral removals of the amygdala. Details of the surgical technique have been described elsewhere (Pribram & Bagshaw, 1953). Two control *S*s (one avoidance *S* and one 46-hr. food-deprived *S*) were first shaved and then anesthetized, but no operation was performed on them. The two control *S*s in the 22½-hr. food-deprived group were neither operated upon nor anesthetized.

Cross sections and reconstructions of the lesions showed that practically all of the amygdala had been bilaterally removed in every *S*. Occasionally a small tag of amygdaloid tissue remained dorsomedially, but was never present on both sides. No remnants remained anteriorly, ventroposteriorly, or laterally.

Procedure

Preoperative training. The 12 *S*s were tested in three experimental groups of four *S*s each. One group was composed of *S*s that pressed a lever to avoid shock. The *S*s in the other two groups pressed a lever to obtain food; one of these groups was trained and tested under 46 hr. of food deprivation, and the other under 22½-hr. deprivation.

After lever-press conditioning, food reward *S*s were placed on a 1-min. variable-interval (VI) schedule for a total of 9–10 sessions. Throughout all these training periods the house light was on continuously at its maximum intensity (34.1 ft-c, measured at the monkey's head level, for the 46-hr. group, and 13.1 ft-c, measured at the grid floor of the chamber, for the 22½-hr. food group).

The shock avoidance *S*s were trained to press the lever on a Sidman-type avoidance schedule (Sidman, 1953) in which every response postponed shock for 20 sec. (R-S = S-S = 20 sec.). Just as with the food-rewarded *S*s, the house light was on continuously at its maximum intensity throughout

[1] We acknowledge the expert assistance of Joe Whitley during all phases of the experiment. This work has been supported in part by United States Public Health Service Grant MH 03732-05.

[2] This center is located at Saint Elizabeths Hospital, Washington 20, D. C.

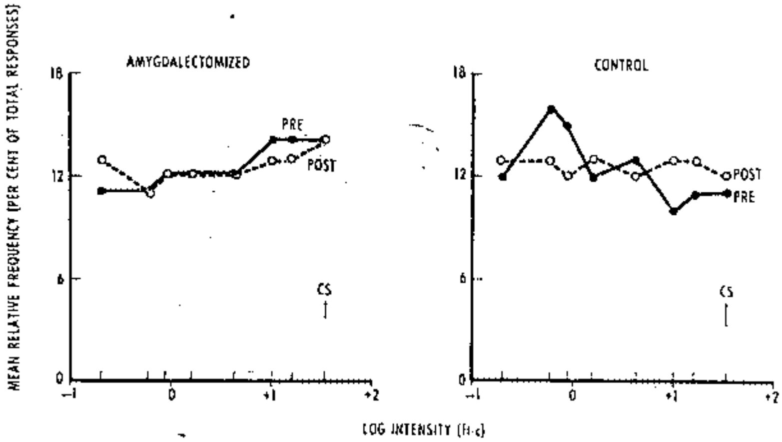

FIG. 1. Pre- and postoperative generalization gradients for amygdalectomized ($N = 3$) and control ($N = 1$) *Ss* in the shock avoidance group.

all 10 training periods prior to generalization testing.

Preoperative generalization test. Generalization tests began immediately after a 15-min. period of lever pressing under the previous reinforcement conditions. During generalization testing, lights of eight different intensities were presented in a mixed order, 12–15 times at each intensity. Each presentation of a given stimulus lasted 30 sec. The *Ss* could obtain neither food nor shock during the generalization test.

Operative and recovery period. Three *Ss* in the shock-avoidance group and three *Ss* in the 46-hr. food group were amygdalectomized on the first, second, or third day of this period. The most variable preoperative performer in each of these groups was used as a control *S*; we wanted to make the amygdalectomized group as large as possible here, because extensive control data were already available from the similar studies of Hearst (1962).

In the 22½-hr. food-reward group, two matched subgroups ($N = 2$) were set up after preoperative generalization testing, and *Ss* in one of these subgroups were amygdalectomized.

The preoperative food-deprivation regimens

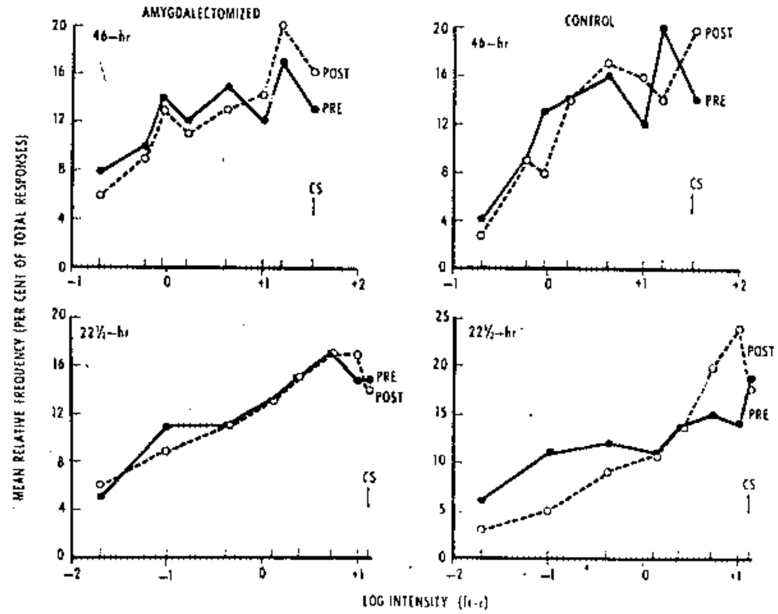

FIG. 2. Pre- and postoperative generalization gradients for amygdalectomized and control *Ss* in the two food reward groups, one of which was trained and tested under 46 hr. of food deprivation ($N = 3$ amygdalectomized *Ss*; $N = 1$ control *S*) and the other under 22½ hr. of food deprivation ($N = 2$ amygdalectomized *Ss*; $N = 2$ control *Ss*).

were reinstated as soon as possible after the operations, and were maintained for at least a week before retesting was started. Thus, there was a 9–13 day rest period between surgery and postoperative training for all *S*s.

Postoperative training and generalization test. The *S*s were returned to their respective food reward or shock-avoidance schedule for 7–8 additional sessions. On the next day a generalization test was given in the same manner as previously.

Results and Discussion

The preoperative data of Figures 1 and 2 confirm the earlier results of Hearst (1962) in that the avoidance gradients were much flatter than the appetitive gradients. Analyses of variance supported this conclusion by revealing significant differences among the response frequencies to the eight light intensities in the 46-hr. food-reward group ($p < .05$), and in the 22½-hr. food-reward group ($p < .01$). No significant differences in response to the eight light intensities occurred in the gradients of the avoidance *S*s ($F = .03$, $df = 7/21$).

Amygdalectomy had no effect on generalization gradients in either type of behavioral situation. The postoperative avoidance gradient for the amygdalectomized group in Figure 1 was as flat as it had been preoperatively. Moreover, no individual *S* in this group showed any appreciable postoperative change in gradient slope; if one uses as a measure of gradient steepness the index suggested by Hiss and Thomas (1963)—namely, the percentage of total number of generalization test responses made to the CS—none of the amygdalectomized *S*s showed more than a 1.3% increase or decrease over preoperative values.

Figure 2 displays the generalization data for the two food-reward groups. It is clear that gradients did not become flatter after amygdalectomy. This result indicates that the lesion does not impair the visual discriminative capacity of *S*s, as was also found by Pribram and Bagshaw (1953).

Figure 2 also shows that gradients are not selectively sharpened by amygdalectomy. The same conclusion may be drawn from an analysis of the individual curves: Two of the five amygdalectomized *S*s displayed sharper gradients postoperatively (i.e., there were 6.8–7.4% increases in the percentage-of-response-to-the-CS measure), two others showed 3.0–6.5% decreases in the same measure, whereas the gradient of the other *S* was essentially unchanged postoperatively (+0.3%). The three control *S*s exhibited equivalent results, since postoperative changes in the slope index ranged from a 3.9% decrease to a 6.4% increase.

In this study generalization gradients were unaffected by amygdalectomy. This finding does not support Schwartzbaum and Pribram's (1960) hypothesis of a generalization disturbance in amygdalectomized monkeys. Thus their results require some other explanation than the proposed "undergeneralization" hypothesis.

REFERENCES

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

Hiss, R. H., & Thomas, D. R. Stimulus generalization as a function of testing procedure and response measure. *J. exp. Psychol.*, 1963, **65**, 587–592.

Pribram, K. H., & Bagshaw, M. Further analysis of the temporal lobe syndrome utilizing frontotemporal ablations. *J. comp. Neurol.*, 1953, **99**, 347–375.

Schwartzbaum, J. S., & Pribram, K. H. The effects of amygdalectomy in monkeys on transposition along a brightness continuum. *J. comp. physiol. Psychol.*, 1960, **53**, 396–399.

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

(Received October 28, 1963)