Deficits in reversal learning in Burmese cats with bilateral association-area lesions*

JOEL L. DAVIS†
Department of Psychobiology, University of California, Irvine, Calif. 92664
and
ROBERT W. LEARY
University of Oregon, Eugene, Oreg. 97403

Pure-bred Burmese cats, with complete bilateral association-area lesions, were impaired in learning successive discrimination reversals.

Association-area lesions in cats impair performance on a variety of learning tasks. Lesions in the anterior association areas produce transitory *delayed response* impairment (Warren, 1964), alternation and *delayed alternation* impairment (Yamaguchi et al, 1957), permanent *discrimination reversal* learning impairment (Warren, 1964), *conditioned inhibition* impairment (Konorski & Lawicka, 1964), impairment of *double alternation* tasks (Warren, 1964), and behavior requiring use of response-produced cues (Wagman, 1968). Posterior association-area lesions in cats produce transitory *learning set* deficits (Meyer, 1958) and hinder *complex visual discriminations* (Hara, 1962). Lesions in the posterior association areas (AMSA, PMSA) and the pericruciate area (PCA) prevent *sensory preconditioning* (Thompson & Kramer, 1965) and seriously impair *audio-visual conditional* learning (Thompson & Johnson, 1966). Association-area lesions also affect *auditory frequency* discrimination (Thompson & Smith, 1967).

The following study was the last in a series that attempted to discern closely the deficits associated with extensive bilateral association-area lesions, i.e., lesions which cover completely both anterior and posterior association cortex. The reversal problem was picked in order to assess postional tendencies and rate of acquisition.

METHODS

The Ss were two male (Ss 1 and 6) and three female (Ss 2, 4, and 5) pure-bred adult Burmese cats. Their previous WGTA experience included a variety of object discrimination, auditory discrimination, and learning-set problems in the 3 years prior to this study (Stevens, 1965; Davis, 1967).

Each cat was presented with randomly paired multidimensional stimulus objects. The object positions were varied on every trial in accordance with a modified Gellerman sequence. After successfully choosing the correct object on eight consecutive trials, the S was given eight more trials (overlearning). At this point, the reward contingencies were reversed, the previously rewarded object now being not rewarded, and vice versa. In this fashion, successive reversals were obtained with a single pair of stimuli over a 15-day period with exactly 50 trials given each day. For the purpose of scoring reversals, Trial 1 on a new day was treated as though it were an extension of the previous day's trials. Therefore, it was possible to have the sequence of eight criterion trials or eight overlearning trials take place over a 2-day period.

Ss 2, 4, and 5 had received bilateral cortical lesions (done by J.L.D.) approximately 7 months prior to this study. All three Ss had postoperative testing experience on object discrimination, auditory discrimination, and learning-set problems (Davis, 1967). Anatomically, the bilateral ablations were intended to include the following: middle suprasylvian gyrus, the anterior third of the lateral gyrus, both banks of the cruciate sulcus, and area on the anterior cingulate gyrus slightly ventral to the cruciate sulcus. After completion of testing, the animals were given a brief neurological examination; the brains were perfused, examined grossly, stained, and sectioned.

RESULTS

Behavioral

Mean total errors to criterion were 31.6 for the control group and 103.5 for the lesioned group (see Fig. 1). Over the total of 750 trials, the experimental group averaged 4.0 completed reversals, while the control groups averaged 8.0 (Fig. 1). Surprisingly, mean error scores on the eight overlearning trials were 1.0 and 2.0, respectively, indicating greater accuracy among cortically damaged cats. The Mann-Whitney test yielded significant Us, $p < .05$, for group comparisons on all three of these measures. Analysis of positional responses revealed no lesion effect. In an earlier postoperative study with these cats (Davis, 1967), discrimination problems without reversal showed a significant but relatively small decrement in the operated Ss. Evidently, the reversal requirement severely strained the capabilities of these animals.

Anatomical

Anatomical reconstruction of the lesions (Fig. 2) shows total ablation of the middle suprasylvian gyrus (AMSA and PMSA) on the right hemispheres. The middle suprasylvian lesions on the left hemispheres are not as extensive but are complete. The left and right lateral gyri are adequately lesioned in all animals. Finally, there is a bilateral loss of cortex in the pericruciate area (PCA), but the lesion does not extend to the bottom of the cruciate sulcus in any animal. The optic radiations were not damaged, and the LGN appeared normal.

DISCUSSION

The slower attainment of criterion and the greater frequency of errors in the operated animals indicates a learning deficit. The nature of the deficit receives some light from an examination of the scores on the eight overlearning trials: the rather surprising fact that lesioned cats were more consistent in choosing the correct stimulus can be interpreted as both greater stereotypy and a reduction in normal variability. A response once learned was less susceptible to change in these Ss. An alternative explanation is that the slower learning of the experimental Ss was associated with more practice of the correct response and more inhibition of the incorrect response.

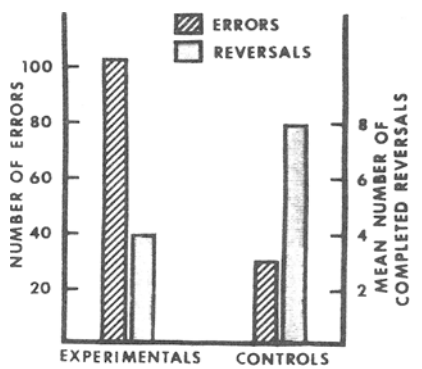

Fig. 1. Mean number of errors to criterion and mean number of completed reversals for experimental and control animals.

*This research was supported by Grant GB-1853 from the National Science Foundation and Grant NB-02161 from the National Institutes of Health.

†Present address: Department of Psychology, Northern Illinois University, DeKalb, Ill. 60115.

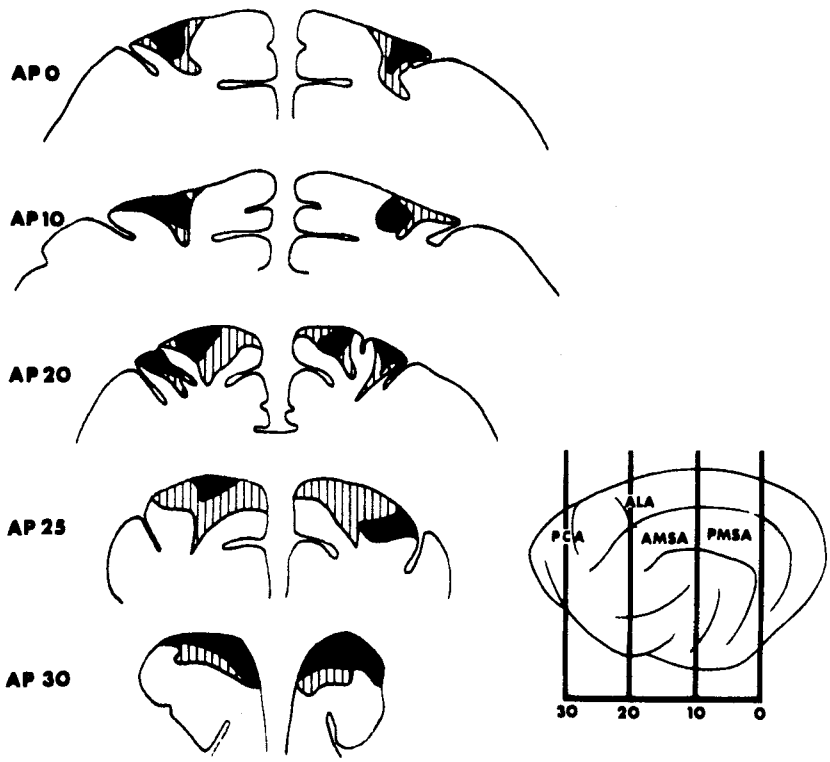

Fig. 2. Anatomical composite reconstruction of lesions. Solid areas represent the minimal lesion and hatched areas the maximal lesion in the three experimental animals.

Although the reversal learning deficit was clearly established over the 15 days and 750 trials reported here, the cats had previously been through a 7-month postoperative period. This was judged sufficient to allow for any temporary behavioral fluctuations associated with the lesions to diminish.

REFERENCES

DAVIS, J. L. Learning defects in cats with bilateral association area lesions. Unpublished MS thesis, University of Oregon Medical School, 1967.

HARA, K. Visual defects resulting from prestriate cortical lesions in cats. Journal of Comparative & Physiological Psychology, 1962, 55, 293-298.

KONORSKI, J., & LAWICKA, W. Analysis of errors by prefrontal animals on the delayed response test. In J. M. Warren and K. Akert (Eds.), *The frontal granular cortex and behavior.* New York: McGraw-Hill, 1964. Pp. 271-294.

MEYER, D. R. Some psychological determinants of sparing and loss following damage to the brain. In H. F. Harlow and C. N. Woolsey (Eds.), *Biological and biochemical bases of behavior.* Madison, Wis: University of Wisconsin Press, 1958. Pp. 173-192.

STEVENS, D. A. A comparison of learning in rhesus monkeys, cebus monkeys, lemurs, and Burmese cats. Unpublished doctoral thesis, University of Oregon, 1965.

THOMPSON, R. F., & SMITH, H. E. Effects of association area lesions on auditory frequency discrimination in the cat. Psychonomic Science, 1967, 8, 123-124.

THOMPSON, R. F., & JOHNSON, R. H. Role of association areas of the cerebral cortex in auditory-visual conditional learning in the cat. XVIII International Congress of Psychology, 1966, 1, 319.

THOMPSON, R. F., & KRAMER, R. F. Role of association cortex in sensory preconditioning. Journal of Comparative & Physiological Psychology, 1965, 60, 186-191.

WARREN, J. M. The behavior of carnivores and primates with lesions in the prefrontal cortex. In J. M. Warren and K. Akert (Eds.), *The frontal granular cortex and behavior.* New York: McGraw-Hill, 1964. Pp. 168-191.

WAGMAN, A. M. Effect of frontal lobe lesions upon behavior requiring use of response produced cues. Journal of Comparative & Physiological Psychology, 1968, 66, 69-76.

YAMAGUCHI, S., WARREN, J. M., & HARA, K. Alternations and delayed alternation by cats with premotor lesions. Journal of Comparative & Physiological Psychology, 1963, 56, 824-828.