

circled dots in the accompanying chart) had apparently changed but little in weight. The other 9 rats were killed after various intervals. With one exception, the remaining kidneys showed a progressive increase in weight, varying from about 30 per cent in 7 days to 120 per cent in 48 days. The body weight simultaneously decreased 10 to 38 per cent. Histological study indicated that the increase in renal weight after unilateral nephrectomy was due chiefly to increased dilation of the tubules, but partly to glandular hypertrophy. No change in weight or structure of the kidneys was apparent in 6 control (nephritic) rats kept for corresponding periods after the same operative procedure, but without nephrectomy.

### 197 (2720)

#### The relation of learning and retention to the extent of cerebral lesions in the rat.

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In a preliminary study of the mass factor in neural function, lesions of various sizes were produced in the visual areas<sup>1</sup> of the cerebral cortex of fourteen rats. The animals were then trained in a habit of brightness discrimination, and the amount of practice required for learning, as indicated by the total number of errors made before the habit was perfected, was correlated with the locus and extent of the lesions. The destructions involved from 13 to 40 per cent of the entire cerebral cortex. The operated animals required an average of 148.4 trials for learning, with an average of 45.6 errors. The average for 60 normal animals in the same problem is 139.7 trials with 41.5 errors. The difference is not significant. All parts of the occipital third of the cerebral cortex were explored in this series, and the rate of learning is apparently unaffected by the locus of the injury. The rank-order correlation between the amount of cortex destroyed and the number of errors made in learning is 0.084. The rate for

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<sup>1</sup> Lashley, K. S., *Am. J. Physiol.*, 1922, lix, 44.

initial learning of brightness discrimination, after lesions to the visual area, is independent of the extent of the lesion.

In a second series, twenty-three normal animals were trained in the same habit. When learning was completed, lesions of various loci and magnitude were produced in the occipital cortex. Seven days after operation the degree of retention of the habit was measured in terms of the numbers of errors made before accurate discrimination was re-established. This amount of practice required for relearning was correlated with the locus and extent of the lesions. The injuries involved from 1.5 to 31.6 per cent of the total cortex; the errors made in relearning ranged from 0 to 83. The rank-order correlation between the extent of the lesion and number of errors in relearning is  $0.864 \pm 0.037$ . In the series of animals every possible part of the occipital third of the cortex was destroyed by the smaller lesions with little disturbance to the habit; whereas in the cases with extensive lesions and serious habit disturbance, every part of the occipital cortex escaped injury in one animal or another. The degree of retention is therefore independent of the locus of the lesion, but directly proportional to its extent.

The possibility that the results are due to the general shock of operation is ruled out by the fact that equally extensive injuries in the frontal, orbital, and parietal areas and basal ganglia produce no disturbance of visual discrimination. The high correlation in retention tests, and the lack of any significant correlation in initial learning, indicate that the results are due not to a total blinding of part of the visual field (as in hemianopsia) but rather to some factor of mass action in the central associative mechanism.

Clinical studies of man have indicated that small lesions in the cerebrum may produce no symptoms, and that, especially in the association areas, severe and long continued disturbances of behavior result only from extensive injuries. The present study points to a much greater precision in this quantitative relationship than has been recognized in the clinical literature.