Reactivity in the hippocampectomized gerbil¹

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Gerbils (Meriones unguiculatus) suffering bilateral hippocampal destruction, destruction of the posterolateral neocortex, and normal animals were presented auditory and visual stimulation at both high and low intensities. Hippocampectomized Ss showed enhanced reactivity in the high intensity conditions. The greatest level of reactivity occurred following the visual stimulation. Animals with destruction restricted to neocortex did not differ from normal animals in any of the four conditions.

It has been reported that tactile and visual stimulation disrupt the performance of hippocampally damaged rats engaged in a straight runway task less than that of normal animals or animals with only neocortical destruction (Raphelson, Isaacson, & Douglas, 1965; Wickelgren & Isaacson, 1963). In view of these results, the effects of bilateral hippocampal destruction have been interpreted as deficiencies in reactivity while engaged in the performance of behavioral tasks (Raphelson et al, 1965).

The present study is a preliminary investigation of the effects of different intensities of visual and auditory stimulation upon gerbils while they were enclosed in a restraining chamber. The extent of the total motor reactions to the stimuli were recorded.

Method. Ss were 12 adult male Mongolian gerbils (*Meriones unguiculatus*). Four Ss received bilateral hippocampal lesions, four received lesions of the cortex overlying the hippocampus, and four served as unoperated controls.

An apparatus for measuring activity was constructed from a postal scale, a crystal microphone, and a Bausch and Lomb V.O.M. 5 recorder. The point of the postal scale was connected to the pressure transducer of the microphone with surgical thread and the leads of the microphone were connected to the recorder. In this manner deflections of the postal scale platform would be recorded on a continuous paper graph. An individual container, a standard 2 lb can with a 2-1/2 in. x 4-1/2 in. screened window on the side, was provided for each S. Since the Ss seemed agitated when first placed in the restraining device, 40 g of cedar chip nesting material from each Ss home cage was placed in their

respective containers. Placing each S in its container 4 h per day for 2 weeks was found to be sufficient for all Ss to adapt to the apparatus.

At the start of each experimental session, an S was placed in its container and onto the postal scale platform. The S then received 20 exposures of one of four stimulus conditions: (1) a light flash from an Ultra-blitz 220 flash gun (high light condition), (2) a light flash from the same unit with the light reduced approximately 50% with neutral density filters (low light condition), (3) a 1 sec noise burst from a 901-B Grason-Stadler noise generator set for 80% output (high noise condition), (4) a noise burst from the same generator set for 40% output (low noise condition). The flash unit and speaker were mounted 12 in. from the Ss container and stimulus presentations were spaced 15 sec apart. Each S received each stimulus condition once during the course of the study. The order of stimulus condition presentations was randomized and each S received a two day rest between sessions.

A continuous recording of activity was made during each experimental session. The reactivity level of each S was scored, in arbitrary units, for each 3 sec interval following a stimulus presentation. An arbitrary unit of reactivity was defined as a deflection of the recorder pen 1 unit from the "0 line" on Bausch and Lomb recording paper (Cat. No. 37-01-31). The score for each 3 sec interval was the average arbitrary units of reactivity recorded during the interval.

Surgery and histology. All operations were performed under barbiturate anesthesia. In the hippocampally damaged group, the skull was opened and the cortex overlying the hippocampus was removed by aspiration. The exposed hippocampus was then removed as completely as possible in the same manner. In the cortically damaged group, the hippocampus was similarly exposed but left intact.

After the experiment, Ss with lesions were sacrificed with sodium pentobarbital, intracardially perfused with 10% formalin and the brains removed. Following infiltration and embedding with paraffin, serial sections between 15-20 μ were made throughout the damaged areas. Examination of the brains revealed extensive bilateral lesions involving the hippocampus (40-75%) and overlying cortex in all hippocampectomized Ss. The amount of cortex removed in the cortically damaged group was somewhat less (approximately 20%) than that removed during hippocampal operations. Reconstructions of all lesions are shown in Fig. 1.

Fig. 1. Reconstructions of the lesions sustained by Ss with hippocampal and neocortical damage at three levels throughout the lesioned areas.

Fig. 2. Average reactivity level, in arbitrary units, for each group in each stimulus condition.

Results. The average reactivity level of each S group in each stimulus condition is shown in Fig. 2. A 3 by 4 by 2 by 2 by 20 analysis of variance with S groups, Ss within groups, stimulus intensity, sensory modality, and trials as factors was performed on the data. The results are shown in Table 1. Individual comparisons among pairs of means were performed using Tukey's multiple comparison method (Tukey, 1951). Within the high intensity light condition and the high intensity noise condition, hippocampally damaged Ss were found to be significantly more reactive than either the cortically damaged or normal Ss. Cortically damaged Ss were not significantly different from normal Ss. Within the low light and low noise conditions, the comparisons were not significant. The overall mean of the two high intensity conditions was found to be significantly greater than that of the two low intensity conditions. The mean reactivity level of the hippocampally damaged Ss in the high intensity conditions was found to be significantly greater than that in the low intensity

Table 1

Summary of Analysis of Variance Performed on Reactivity Data

Source of Variance	DF	MS	F
1. groups	2	9174.00	108.18*
2. error term (1)	9	84.81	
3. high-low intensity	1	15909.17	109.87*
4. groups x high-low	2	6422.00	44.26*
5. error term (3-4)	9	144.80	
6. light-noise	1	5463.00	35.48*
7. groups x light-noise	2	1106.00	7.19
8. error term (6-7)	9	153.90	
9. high-low x light-noise	1	1407.00	6.17
10. groups x high-low x light-noise	2	957.40	4.20
11. error term (9-10)	9	228.10	
12. trials	19	43.00	2.35
13. groups x trials	38	46.68	2.30
14. error term (12-13)	171	20.27	
15. high-low x trials	19	36.74	2.37
16. groups x high-low x trials	38	22.28	1.44
17. error term (15-16)	171	15.52	
18. light-noise x trials	19	28.05	1.89
19. groups x light-noise x trials	38	21.78	1.47
20. error term (18-19)	171	14.86	
21. high-low x light-noise x trials	19	13.23	.90
22. groups x high-low x light-noise x trials	38	15.04	1.02
23. error term (21-22)	171	14.82	

* $p < .001$

conditions. This same comparison was insignificant for both cortically damaged and normal Ss. The overall mean of the two light conditions was found to be significantly greater than that for the two noise conditions. The mean reactivity level of the hippocampally damaged Ss in the two light conditions was significantly greater than that in the noise conditions. This comparison was not significant for the cortically damaged and normal Ss. The high-low intensity by treatment interaction becomes clear upon referring to Fig. 2. It may be seen that the performance of the hippocampally damaged Ss changes radically between the high and low intensity conditions, while less dramatic changes are evidence for both cortical and normal Ss.

Discussion. The findings of increased reactivity to stimulation in the hippocampectomized gerbil appear contradictory to the findings of Wickelgren & Isaacson (1963) and Raphelson et al (1965). A number of factors may be involved. The Ss in the previous studies were engaged in the performance of a runway task during the period they received novel stimulation; those in the present study were not. A number of studies have shown that the "attention" of a hippocampally damaged animal may be captured by a "prepotent" stimulus leading to the perseveration of a particular behavior pattern (Douglas, 1967). Moreover, it has been demonstrated that the training conditions, as well as other factors, influence the degree to which perseveration of a response will occur in the hippocampally damaged animal (Kimble, Kirkby, & Stein, 1966; Isaacson, Olton, Bauer, & Swart, 1966; Isaacson, 1967; Stein & Kirkby, 1967). In the present study Ss were not engaged in any goal-oriented behavior problem.

Stimulus intensity and sensory modality may also be factors. The hippocampally damaged Ss in the present study displayed enhanced responsiveness only to high intensity stimulation, particularly the high light condition. The distracting stimuli used in previous studies may simply not have been of sufficient intensity, or of the optimal sensory modality relative to the task, to disrupt performance. A final consideration is the nature of the Ss used in the present study. Little work has been performed on the delineation of behavior patterns in the gerbil. The work that has been done suggests that the gerbil is strikingly different from the rat in many respects (Glickman & Hartz, 1964; Nauman, 1963; Schwentker, 1963). It is possible that hippocampal destruction in the gerbil produces alterations in behavior quite different from those produced in the rats.⁴

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NOTES

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