LOCALIZATION OF FUNCTIONS IN THE CEREBRAL CORTEX OF THE RAT

REPORT 3. OPTIC AND AUDITORY CONDITIONED REFLEXES IN RATS AFTER PRELIMINARY EXTIRPATION OF THE CORTEX OF THE TEMPORAL AND OCCIPITAL LOBES AT AN EARLY AGE

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Various workers [1, 4-11, 14] have shown that the removal of various lobes of the brain at an early age from chicks, rats, rabbits, cats, dogs, and monkeys does not lead to disturbances of the motor functions, hearing, or vision, not even of a very slight degree. Indeed, after these operations conditioned reflexes were formed more quickly than in intact animals [4, 6, 7].

In adult rats, skill in distinguishing between light and dark (the experiments of Lashley [12]) was disturbed after injury to the occipital cortex, and skilled movements (Hunter's experiments) after injury to the anterior divisions of the brain. When, however, the corresponding parts of the cerebral cortex injured before the formation of these skills, the animals acquired the skills more rapidly than normal animals. Lashley concluded from these findings that localization of functions did not occur in the cerebral cortex.

In previous reports [2, 3] we described changes in the conditioned-reflex activity of rats after extirpation of the cortex of the temporal and occipital lobes of fully grown animals. The object of the present investigation was to study auditory and optic conditioned reflexes in rats after preliminary removal of the cortex of the temporal and occipital lobes at an early age (in most animals at the age of 2 months). Experiments were carried out soon after the operation. The technique was described in Report 1 [2].

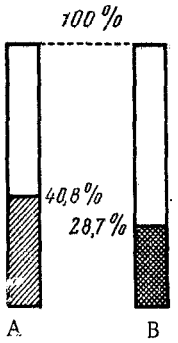
EXPERIMENTAL RESULTS

First series of experiments. The cortex of the temporal lobe was injured in two rats aged 40 days (Nos. M3A and M4A) and in six rats aged 2 months. The animals were used in the experiment on the 3rd-5th day after the operation. A conditioned reflex to a buzzer and to a light was formed simultaneously, i.e., an acoustic and a photic stimulus were applied alternately.

TABLE 1. Number of Correct Reactions in 50 First Applications of the Stimulus

Rat No.	Conditioned reflex to light	Conditioned reflex to buzzer
M3A	25	17
M4A	31	13
M3B	33	20
M4B	33	18
M9	38	28
M26	30	33
M28	29	22
M29	16	1
Mean	29,3	19

It will be clear from Table 1 that after injury to the temporal cortex the number of correct reactions to the buzzer was smaller than to the light, i.e., the conditioned reflex to the acoustic stimulus was more difficult to form than that to the photic stimulus. This means that localization of functions in the cerebral cortex could be observed in the 2-month old rats, and even in the 40-day old animals, in the conditions of formation of reflexes after preliminary injury to the cerebral cortex. These results are not in agreement with Lashley's conclusion [12] that the rate of formation of skill in simple discrimination is not dependent on any one part of the cerebral cortex, although this skill, once formed in normal animals, shows definite localization in the cerebral cortex.



Number of correct reactions to a stimulus addressed to the injured (A) and intact (B) cortical analyzer (as a percentage of the number of applications of the stimulus). Results of experiments on 13 rats.

TABLE 2. Number of Correct Reactions in 50 First Applications of the Stimulus

Injury to occipital cortex			Injury to temporal cortex		
Rat No.	conditioned reflex		Rat No.	conditioned reflex	
	to light	to buzzer		to light	to buzzer
M15	18[1]	20[1]	M21	19	20
M16	9	3	M22	11	13
M13	28	15	M19	7	10
M11	34	20	M20	17	22
M12	15	16	M18	15[1]	21[1]
M10	4	8	M17	10	28
M14	27	14	—	—	—
Mean . . .	19,3[2]	13,7[2]	Mean . . .	13,1[2]	19,0[2]

[1] Number of reactions in 30 first applications of the stimulus

[2] Taking into account the results of the next series of experiments the difference between these indices is statistically significant

As an explanation of why this skill could be formed better in the operated rats than in normal animals, Lashley cited Herrick's statement that the presence of the uninjured cerebral cortex may actually cause delay in the formation of a very simple skill by complicating the process as a result of the bringing into play of cortical associations from other sensory regions. Lashley apparently did not take sufficient account of the time elapsing after injury to the cerebral cortex: in his investigations the rats took part in the experiment on or after the 10th day after the operation, and in our experiments on or after the 3rd-5th day.

Second series of experiments. Injury to the temporal cortex was inflicted on 6 rats and to the occipital cortex in 7 rats. The animals took part in the experiment on or after the 10th-13th day after the operation.

The figure shows that the conditioned reflexes to stimuli addressed to the injured cortical analyzers were formed quicker (by more than 40%) than those to stimuli addressed to the intact cortical analyzers. This difference was statistically significant.

The fact observed by Lashley in his investigations, i.e., that the operated rats were better able than normal rats to distinguish between light and dark, could be an accidental phenomenon as he himself points out. However, in regard to skilled movements, this superiority of the operated rats was proved [13], and Lashley found it difficult to explain this state of affairs.

The results given in Table 2 show that after injury to the occipital cortex a conditioned reflex to light was formed on the 10th-13th day after operation 40% faster than a reflex to sound, while on the other hand, in rats with an injured temporal cortex the conditioned reflex to sound was formed 44% faster than that to light. These reflexes were apparently formed in the phase of exaltation arising after injury to the cerebral cortex. If such a phase in fact occurs, in this case localization of functions could also be demonstrated in the cerebral cortex of rats; the compensatory powers of the cortex are so considerable that the simple reflex was formed very quickly.

Third series of experiments. Conditioned reflexes were formed in two groups of rats. In the rats of group A (control rats and operated rats, taking part in the experiment on the 13th day after injury to the occipital or temporal cortex) a conditioned defensive reflex to a bell was first formed, and after relative consolidation of this reflex, differentiation was formed to the interrupted ringing of a bell. After an interval of 24 h, the formation of a conditioned reflex to a light began, and after this had become relatively consolidated, the formation of differentiation to an interrupted light. In the rats of group B, a conditioned reflex to light was first formed, and then a reflex to the bell. The operated rats of this group also took part in the experiment on the 13th day after operation.

The data in Table 3 show that in the control normal rats the second (positive reflex (to light in group A and to the bell in group B) was formed more easily than the first reflex, and it appeared at a time when the first (positive) reflex was already firmly established. In the rats of group A deprived of their occipital cortex, the conditioned reflex to the light was formed more rapidly than that to light in the control animals; on the other hand, in the rats deprived of their temporal cortex the conditioned reflex to the bell was formed more rapidly than the same reflex in the

TABLE 3. Number of Correct Reactions in 50 First Applications of the Stimulus

Experimental conditions		Rat No.	Conditioned reflex to bell	Differentiation to bell	Conditioned reflex to light	Differentiation to light
Group A	Control	15	26	39	21	44
		4-b	28	41	41	43
		12-b	26	45	49	48
		3-b	28	40	32	42
		Mean	27	41	36,5	41
	Removal of occipital cortex	58	22	43	36	—
		57	39	28	42	31
		59	35	36	43	22
		Mean	32	36	40,3	26,5
	Removal of temporal cortex	65	37	43	31	—
		64	37	35	31	34
		60	40	24	40	34
		Mean	38	34	34	34
Group B	Control	6-b	33	—	32	—
		9-b	43	—	12	—
		10-b	38	—	27	—
		Mean	38		24	
	Removal of occipital cortex	39	39	—	39	—
		40	42	—	32	—
		41	40	—	35	—
		Mean	40,3		35,3	

controls. In group B, the reflex to light in the rats deprived of their occipital cortex was formed much more rapidly than the same reflex in the controls. The remaining positive reflexes in the operated animals were also formed rather faster than in the controls, while the inhibitory reflexes in these animals were formed more slowly.

The results of this series of experiments are in agreement with those obtained in the second series of experiments insofar as the reflexes were evidently formed in the phase of exaltation arising after injury to the cerebral cortex.

Lashley [13] compared the skill of discriminating between light and dark and the skilled movements, which were formed more rapidly in the operated animals than in normal animals, on the one hand and skill in negotiating a maze, formed with great difficulty after injury to the cortex, on the other hand, and observed that the reason for this distinction was not clear. In our experiments the positive reflexes were formed more rapidly in the operated animals than in the controls, but this does not mean that the higher nervous activity of the former had undergone beneficial changes; rather, on the other hand, its inhibitory activity was more severely impaired. This is apparently one of the principal causes of the impaired skill of the rats in the maze.

SUMMARY

Following injury of the cortical temporal lobe of therat brain, the conditioned reflex to sound is elaborated with greater difficulty than to light, if reflexes are elaborated from the 3rd to the 5th post-operative days. However, if reflexes are elaborated from the 10th to the 13th post-operative days in rats with an injured cortex of the temporal lobe, the conditioned reflex to sound is formed more rapidly than to light; conversely in rats with an injured cortex of the occipital lobe the conditioned reflex to light is formed more rapidly than to sound. Evidently in this case,

the reflexes are elaborated at the exaltation phase, occurring after injury of the brain cortex. An attempt was made to determine the significance of injury localization for acceleration of the conditioned reflex elaboration in both cases.

It was possible to determine the significance of localization of the cortical injury for elaboration of conditioned reflexes in two-month and 40-day-old rats. Evidently Lashley did not pay due attention to the time which passed after injury of the cortex in rats, and, therefore, he was unable to detect functional localizations when the cortex was injured before elaboration.

LITERATURE CITED

1. V. I. Gunin. Zh. vyssh. nervn. deyat. 3, 459 (1960).
2. Dang-Tkhu. Byull. éksper. biol., 3, 15 (1963).
3. Dang-Tkhu. Byull. éksper. biol., 6, 19 (1963).
4. T. V. Ivannikova. Functional and anatomical recovery of the cortical division of the optic analyzer after its extirpation at an early age. Author's abstract of candidate dissertation. Rostov-on-Don, 1957.
5. N. A. Moiseeva. In the book: Problems in the Comparative Physiology of Analyzers [in Russian], No. 1, p. 164. Leningrad, 1960.
6. O. E. Ponomareva. The effect of partial extirpation of the cerebral hemispheres at an early age on the optic and auditory conditioned reflexes in chicks. Author's abstract of candidate dissertation. Voronezh, 1961.
7. M. Tarabrina. Abstracts of Proceedings of the Ninth Conference of the S. E. RSFSR Branch of the All-Union Society of Physiologists, Pharmacologists, and Biochemists [in Russian], p. 89. Rostov-on-Don, 1949.
8. Ya. Myslivichek, L. Ilek, et al. In the book: Problems in the Physiology and Pathology of the Central Nervous System of Man and Animals in Ontogenesis [in Russian], p. 56. Moscow, 1961.
9. R. M. Benjamin and R. F. Thompson, Exp. Neurol., 1959, Vol. 1, p. 305.
10. M. A. Kennard, Am. J. Physiol., 1936, Vol. 115, p. 138.
11. M. A. Kennard, J. Neurophysiol., 1938, Vol. 1, p. 477.
12. K. S. Lashley. Brain and Intellect [Russian translation]. Moscow – Leningrad, 1933.
13. Idem. B in: Comparative Psychology Monographs. Baltimore 935, v. 11, No. 2, p. 5; The Neuropsychology of Lashley, New York 1960, p. 278.
14. Yü-Chüan-Tsang. J. Comp. Physiol. 34 (1937).

All abbreviations of periodicals in the above bibliography are letter-by-letter transliterations of the abbreviations as given in the original Russian journal. ***Some or all of this periodical literature may well be available in English translation.*** **A complete list of the cover-to-cover English translations appears at the back of this issue.**
