RECENT DEVELOPMENTS OF NEUROBIOLOGY IN HUNGARY II.

RESULTS IN NEUROPHYSIOLOGY NEUROENDOCRINOLOGY NEUROPHARMACOLOGY AND BEHAVIOUR

Edited by Kálmán Lissák

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K. LISSÁK

AKADÉMIAI KIADÓ, BUDAPEST 1969

MANUSCRIPT SUPERVISED

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G. ÁDÁM, E. ENDRŐCZI, I. HUSZÁK, B. STARK

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FOREWORD

In November 1967 the Hungarian Academy of Sciences and the Ministry of Health appointed the Committee of Neurobiological Research with K. Lissák as President and G. Ádám as Secretary to take over and continue the work of the Co-ordinating Committee organized in 1959. Members of the Committee are E. Grastyán, B. Horányi, I. Huszák, P. Juhász, J. Knoll, I. Környey, P. Popper and J. Szentágothai.

It is one of the responsibilities of the Committee to compile and edit the series "Recent Developments of Neurobiology in Hungary", Volume I of which was published in 1967. The present, second, volume carries eight papers from various fields of neurobiology, produced in different departments of the University Medical School of Pécs. With this the authors also wish to contribute to the commemoration of the 600 years anniversary of the foundation of the first Hungarian university in Pécs, celebrated in 1967.

K. Lissák

Pécs, March 1968

RECENT NEUROPHYSIOLOGICAL OBSERVATIONS ON THE ORGANIZATION OF BEHAVIOURAL PROCESSES

by

K. LISSÁK

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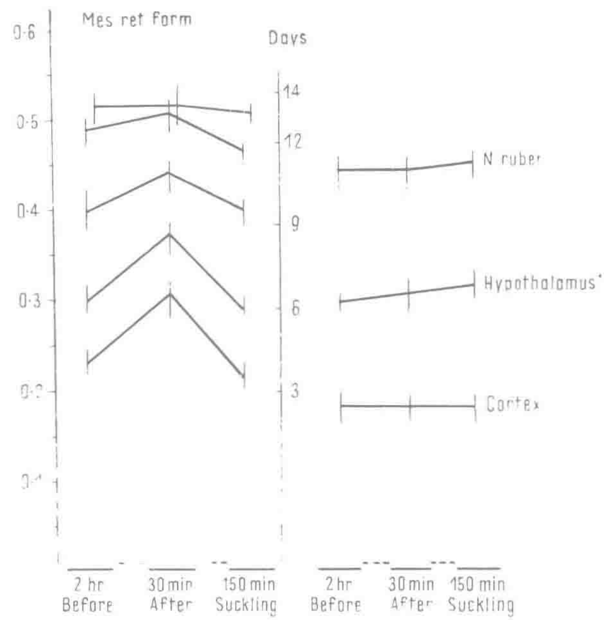
Evolutional studies have shown that progressive development in higher mammals is characterized by an increasing transfer of the priority of cortical representation over other parts of the brain. Morphological, electrophysiological and behavioural investigations demonstrated that the development of brain functions during ontogeny and phylogeny is a process corresponding to perfection and increasing plasticity of behaviour although the integration of motivated behaviour seems to be remaining more dependent on brain stem and diencephalic activities rather than on neopallial functions. There are some questions which are permanently in the focus of neurobiological interest especially those bearing relation to elementary processes like sleep and wakeful state, orienting response, evolvement of temporary linkages, integration of motivated behavioural reactions, etc. In a wider sense, the main tasks of neurobiological as well as physiological investigations are directed to the study of the homeostatic control of living organism. Neurophysiological research has to clarify the relations between brain and behaviour as well as the morphological and neurophysiological background of these problems.

There is no doubt that for such a study multidisciplinary methods are required involving neuromorphology, electrophysiology, neurochemistry and experimental psychology. The present paper summarizes the results of our investigations concerning the integrative function of the central nervous system in relation to elementary behavioural processes.

ONTOGENETICAL STUDIES

Differences in the maturation of the behavioural reactions approaching versus avoiding in the course of ontogeny have been observed in both children and higher mammals. A number of investigators (Sarkisov 1964, Schneirla 1956) have reported a relatively late establishment of avoiding conditioned reflex behaviour as compared with the acquisition of an approaching reaction. Employing air-blows as conditional stimuli and electric shocks for eliciting unconditioned reactions, during the experiments conducted in our laboratory, the presentation of several hundred associations failed to create temporary linkages which would have been manifested in the form of a motor restlessness during the first 10 postnatal days.



*The dissection of hypothalamus was made macroscopically

Fig. 1. Fluctuation of the "free" acetylcholine content in the mesencephalic reticular formation with the suckling time. Centrally placed ordinate shows the postnatal life in days. Ordinate on the left side corresponds to the concentration of acetylcholine in μg pro DNA-P micromole. Values of nucleus ruber, hypothalamus and neocortex were estimated at 6–9 days of age

In contrast, an approaching searching behaviour of litters towards the mother might be observed in the first postnatal days (Endrőczi and Hartmann 1967).

Investigations concerning the maturation of brain stem and diencephalic functions in newborn rats revealed that the mesencephalic reticular formation shows a fluctuation depending on the suckling time in its "free" acetylcholine concentration during the first 10 postnatal days. A gradual decrease in the acetylcholine content of the brain stem reticular formation was found in the second and third hours after suckling, which was markedly elevated following suckling for at least one hour. There was no fluctuation in the concentration of this chemical transmitter in other parts of the brain (Endrőczi et al. 1968). A correlation was also found between the fluctuation of the acetylcholine content and the general motor activity in young rats: increasing motor restlessness was consistent at the presuckling period when, in fact, the acetylcholine concentration showed its lowest values

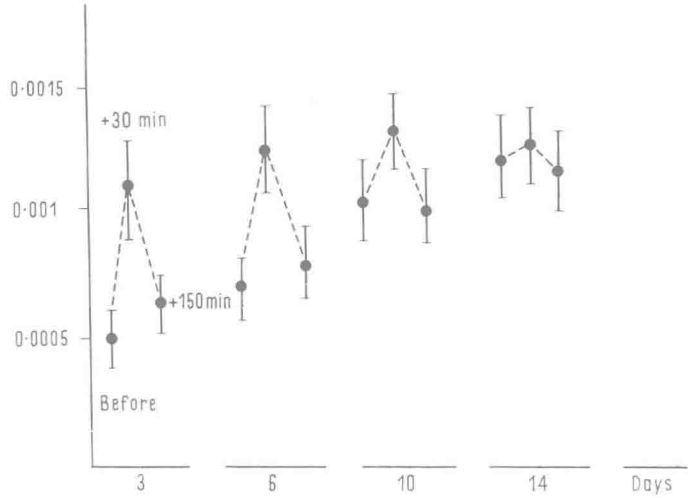


Fig. 2. Fluctuation of the "free" acetylcholine content in the mesencephalic reticular formation with suckling in the early postnatal life

in the brain stem reticular core. Obviously, the periodical changes both in the concentration of the chemical transmitter and the motor activity have reflected alterations occurring in the brain stem reticular network and these changes are closely related to the feeding behaviour of the young rats (Figs 1 and 2).

Bilateral electrolytic destruction of the lateral hypothalamic "drinking and feeding" centres did not impair the suckling behaviour of newborn rats until the second postnatal week. Similarly, there was no remarkable change in the gross behaviour until this age following bilateral lesions in the posterior hypothalamus at supramammillary level. These observations indicated that the influence of forebrain structures on brain stem functions and their involvement in basic behavioural reactions is immature in the early postnatal life (Endrőczi et al. 1968).

A fatal hypermotility after bilateral destruction of the preoptic region in adult rats is well known from literature (Hassler 1964, Korányi et al. 1963, Lissák and Endrőczi 1965*b*, etc.). Similar lesions in the first 10 postnatal days resulted in a temporary, compensated motor restlessness in the rat. The hypermotility can be attributed to disinhibition of brain stem ascending activation after cessation of descending inhibitory pathways. This descending inhibition plays a basic role in the organization of motivated behavioural reactions and in the learning processes which we discussed in earlier publications (Endrőczi and Lissák 1962, Lissák and Endrőczi 1965, Endrőczi 1967, etc.). The bilateral lesions in the medial forebrain bundle region led to a compensated impairment of motor behaviour and the learning capability of the rats was markedly inferior to their litter-mates in an avoiding conditioned reflex situation at 40–60-day-old age (Figs 3 and 4).

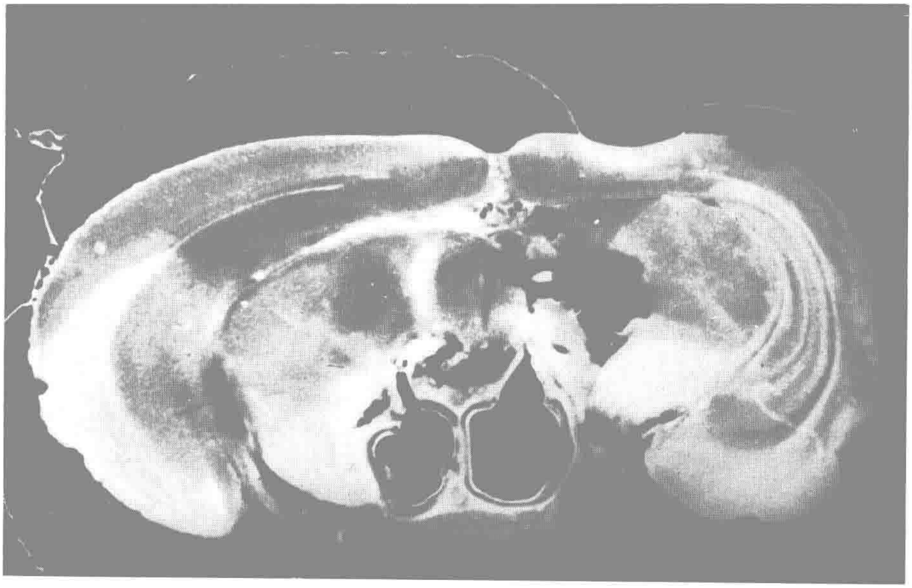


Fig. 3. Large bilateral lesions on the junction of mesencephalon andposterior hypothalamus which failed to influence suckling activity in the first postnatal week

By electrical stimulation of the mesencephalic reticular formation in the rat, maturation of brain stem and forebrain connections was studied electrophysiologically. Mesencephalic-evoked potentials in the basal septal region of the 8–10-day-old, dl-tubocurarine immobized rats showed a 24–28 msec latency, then they appeared in the form of negative waves lasting for 45–60 msec. Recovery period of this response was several hundred msec which was reduced to 40–100 msec, characteristic of the adult only in the third and fourth postnatal weeks. Mesencephalic-evoked response in the ipsilateral hippocampus could be recorded at the end of the first postnatal week but it did not show a full development before the third week after birth. The small amplitude and high stimulation threshold of

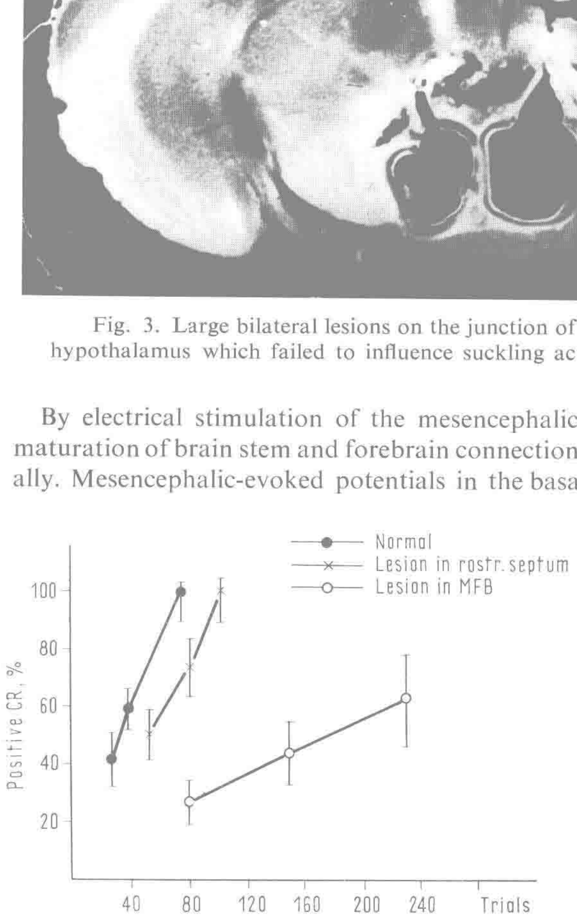


Fig. 4. Avoidance conditioned learning of 40-day-old rats. Lesions were performed bilaterally in the rostral-septum and the medial forebrain bundle region at 3-day-old age. Ordinate shows the performance of conditioned response in percentage in the course of training

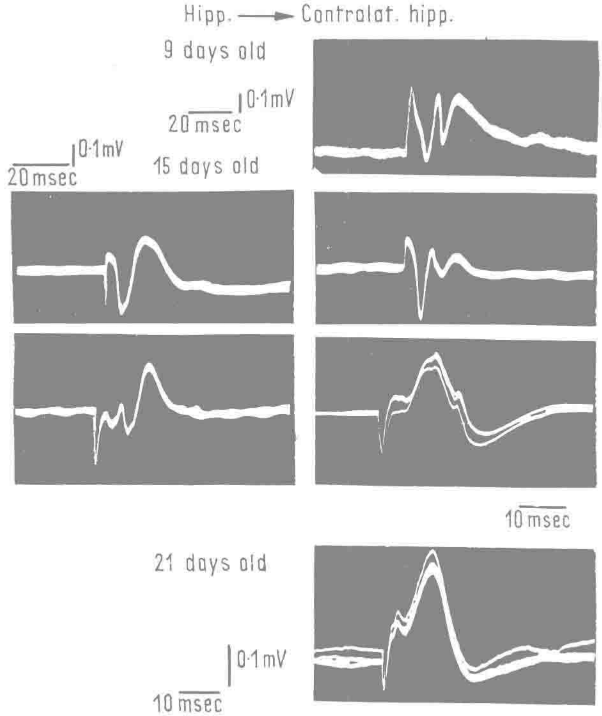


Fig. 5. Contralateral hippocampal-evoked potentials in 9, 15 and 21-day-old rats. The records of 15-day-old rats were taken from different depths of the hippocampal pyramidal layer. All records were taken by bipolar electrodes on dl-tubocurarine immobilized animals

the hippocampal response recorded in sectors CA_1 and CA_2 cannot be attributed solely to the immature state of the pyramidal layer, because the commissural volley by stimulation of the contralateral hippocampus led to a relatively well-developed response on the 10th–12th days after birth. Propagating spikes produced by stimulation of the contralateral hippocampus might be observed already in the first week after birth, although spontaneous firing following stimulation with 10 cps was found only from the second postnatal week. This electrophysiological observation indicates the stepwise maturation of the apical dendrites, which show a gradual lengthening until the third postnatal week (Figs 5 and 6).

A relatively early maturation of the brain stem and striopallidal connections was observed by using evoked potential technique, and there was a late development of functional connections between brain stem and basomedial hypothalamus. Although the functional maturation of different ascending connections