A pathway to the basal ganglia including the posterior thalamus and superior colliculus. Electrophysiological and anatomical studies

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Our project was to study parallel processing of sensory information. First of all we attempted to prove the hypothesis that the sensory information that reaches the basal ganglia basically of tectal origin. Besides this, other forms of parallel information processing was studied, too. The range of our experiments was rather wide it extended to four species: human, cat, rhesus monkey and rat were either our experimental subjects. During the time of the grant we published 29 full-paper, English language publications. During this time seven PhD diplomas were earned by our students.

During the past years the project was modified in several aspects. Monkey experiments were interrupted by technical reasons and morphological experiments were discontinued because of retirement of our collaborator (prof. Masao Norita). To counterweigh these conditions (with the permission of OTKA) we started to elaborate one experimental trial, a novel schizophrenia model in rats.

We detail our results according to the publications reached.

Physiological and anatomical investigation of the tectofugal ascending system in awake and in anaesthetized cats.

In the first part of our experiments we studied the co-operation between the posterior thalamus (that included first of all the suprageniculate nucleus) and the caudate nucleus in anaesthetized, artificially ventilated cats. We tried to record simultaneously one neuron in both structure and looked at the common of the activities. Significant cross-correlation was sought for between the spiking of the simultaneously recorded neurons. Of the recorded 288 Sg-CN neuron pairs, 26 (9.2%) showed significantly correlated spontaneous activity. Nineteen pairs (6.7%) showed correlated activity during stationary visual stimulation, while 21 (7.4%) pairs during stimulus movement (19).

In the second series of our experiments visually evoked local field potentials (LFPs) were recorded simultaneously in the CN and the SG in order to investigate the coupling between these structures at a population level. The effect of static and dynamic visual stimulation was analyzed in 55 SG-CN LFP pairs in the frequency range 5-57 Hz. Statistical analysis revealed significant correlation of the relative powers of each investigated frequency band (5-8 Hz, 8-12 Hz, 12-35 Hz and 35-57 Hz) during both static and dynamic visual stimulation. Through these experiments we provided evidence on the co-oscillation and synchronization of the CN and the SG at a population level upon visual stimulation, which suggests a significant cooperation between these structures in visual information processing (27).

In separate experiments we investigated the effect of sine-wave luminance-contrast-modulated drifting gratings that can elicit oscillation of the activity of visual neurons at the temporal frequency of the stimulus. We demonstrated that the spatiotemporal stimulus parameters that elicit maximal oscillations often differ from those that elicit a maximal discharge rate (12, 28).

Experiments in behaving, awake head-fixed feline model

Through our five year work we developed a awake, behaving, eye-controlled feline model, which is suitable for chronic visual electrophysiological recordings. Two trained cats were suspended in a canvas harness in a specially designed stand. The animals had been trained to fixate the center of a monitor during static and dynamic visual stimulation. Eye movements were monitored with implanted scleral coil in a magnetic field. Our two trained cats could maintain accurate fixation, even during optic flow stimulation, in an acceptance window of ±2.5°. The model has yielded accurate recordings for over two years.

Extracellular multielectrode recordings were made from the CN of two cats in a visual fixation paradigm applying static and dynamic stimuli. The recorded neurons were classified in three groups according to their electrophysiological properties: phasically active, tonically active and high-firing neurons. Comparing awake and anaesthetized cats, we found significantly more visually active neuron sin the awake preparate. Further our results demonstrate that both the static and the dynamic components of the visual information are represented in the CN (5, 17).

Human investigations

Visual evoked potentials to study the magnocellular/dorsal visual system

Our studies performed in humans are mainly for the elucidation of the magnocellular/dorsal visual system.

a. The comparison of global form and motion perception during flickering light stimulation.

Global form and motion perception thresholds were assessed with static Glass pattern stimuli and random dot kinematograms, with and without 12 Hz flickering light stimulation. Global motion thresholds were almost unaltered by flickering stimulation, while a significant threshold elevation was caused in the global form perception task. The strongest conclusion allowed by our data is that simultaneous flickering photostimulation elevates global form perception thresholds but not global motion perception thresholds. This could point to different visual processing of motion perception (11).

b. Migraine studies

Impairment of visual contrast sensitivity is a well-known phenomenon in adult migraineurs. Little is known, however, about whether contrast sensitivity deficits are already present in children with migraine. Our studies showed that visual contrast sensitivity is present in migraine, particularly in the lower visual frequencies, which finding supports the involvement of magnocellular system (18, 23).

Patients with migraine showed a significantly poorer performance in both main phases of the Rutgers acquired equivalence (fish and face) test, which demonstrates the alteration in visual associative learning in migraineurs. Although the deficit in the trial to error learning, which is connected to the basal ganglia, is already significant the generalization phase, which considered to be dependent on the hippocampi, was especially marked. These results can be interpreted as behavioural support for findings that have suggested the involvement of the basal ganglia and the hippocampi in migraine (2).

c. Colour blindness and the magnocellular system

Our third theme was the colour blindness, in relation to this it, we detected that the contrast sensitivity increases, presumably compensatory. The investigation of the alteration showed that the increase is better on the high-frequency side. That shows a predominance of the parvocellular system in the colour blind (16, 29).

Similarly, evoked potential study was performed in diabetics to show whether retinal or vascular changes are primarily in diabetic retinopathy (14, 6).

Characterization of a complex schizophrenia model in different in vivo tests.

This part of the study revealed that a new rat substrain, developed by selective breeding after juvenile social isolation and ketamine treatment, showed several alterations related to schizophrenia. It has been demonstrated that, similarly as can be observed in schizophrenic patients, these animals show impairments in acute pain sensitivity, sensory gating, locomotor activity, thermoregulation and cognitive functions together with electrophysiological alterations. Besides this model, our pain studies revealed that several peptide and lipid endogenous ligands can induce antinociception at spinal level in a chronic, inflammatory pain model. Furthermore, a new model for testing the actions different ligands at fast voltage gated sodium channels was developed, and our results revealed limited effects of capsaicin and the endogenous cannabinoid, anandamide on these channels (3, 4, 9, 10, 15, 20, 24, 26).

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