საქართველოს მეცნიერებათა ეროვნული აკადემიის მოამბე, ტ. 8, №1, 2014
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Human and Animal Physiology

On the Neurophysiological Mechanisms of "Preconscious"

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ABSTRACT. In the present paper different forms of electrophysiological activity of hippocampus are discussed from viewpoints of cognitive neuroscience. According to the well-known conceptions consciousness is a hippocamp-dependent process and unconscious hippocamp-independent. It means that electrophysiological correlate of hippocampal activation in alertness – theta rhythm – accompanies cognitive processing, while EEG desynchronization of hippocampal activity correlates with disfunction of the structure and unconscious (nonconscious) brain activity. In the paper the third form of hippocampal activity, low amplitude theta waves appearing during desynchronization of background activity is analysed. This intermediate form of hippocampal activation must be correlated with a lowered level of consciousness "preconscious", which after S. Freud appears during insufficient concentration of attention. Low amplitude theta waves indicate the appearance of weak memory traces. Different forms of hippocampal EEG activity are evoked due to the degrees of excitation of the midbrain reticular formation in humans and animals.

Key words: *hippocampus, theta rhythm, EEG desynchronization, intermediate activity, conscious, unconscious, preconscious.*

Cognitive neuroscience has been rapidly developing since the 60's of the 20th century. In the well-known behavioral experiments on rodents and primates it was established that cognitive functions are dependent on hippocampal formation, which is located in the medial temporal lobe. This structure is recognized as main substrate for cognitive functions: perception, orienting, learning and memory, attention, decision-making and voluntary movements [1-7]. According to Bennet, attention is a basic process determining all other cognitive functions [3]. In other words, Bennet has declared that effectiveness of conscious activity depends on concentration of attention, which in its turn is stimulated by the brain activating system, the brainstem reticular formation.

Materials and Methods

In chronic experiments the adult cats (2.5 -3kg) of both sexes were used. Under Nembutal anaesthesia (30 – 32 mg/kg i.m.), unipolar recording electrodes were implanted into the parietal cortex and posterior-ventral hippocampal areas CA1 and CA4. Reference electrode was placed on the occipital bone, ground electrode – on the frontal bone.The electrodes were

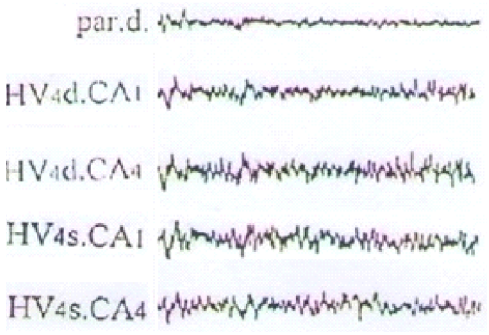

Fig. 1. Electrophysiological correlates of passive arousal in the hippocampus. Par.d. - parietal cortex, dexter; HV4d- s.- hippocampus posterior-ventralis, dexter-sinister; CA1-CA4 – hippocampal areas. Amplification – 100 microvolts; time - 1 sec.

made of constantane wire, 200 – 250 microns in diameter. For amplification and recording of EEG effects AC amplifiers (TC=0.1- 0.3 sec) and multichannel electroencephalograph (Hungary) were used.

Spectral distribution curves were built to characterize electrical effects. The power of discrete frequencies was derived from the power spectral density (PSD) calculated using fast Fourier transformation on the data array; sampling time – 5 sec, sampling frequency – 32 Hz.

Results and Discussion

During passive arousal desynchronization of hippocampal electrical activity is observed, correlated with hippocampal dysfunction and, as a result, with the absence of brain cognitive activity. In behavioral experiments it is observed during automatized conditioning in the course of nondeclarative procedural memory formation (Fig.1).

During active arousal the hippocampal activation correlates with generation of specific regular synchronized sinusoidal activity in the range of 4-7 waves/sec - theta rhythm. However frequency of these waves may change in different species [4, 7,8]. Theta waves appear during alertness, which is induced by more effective excitation of the midbrain reticular formation (RF) [6, 7]. Mainly it is connected with spatial tasks [8, 9]. During elaboration of discriminative spatial instrumental conditioned reflexes theta activity is registered in hippocampal areas bilaterally in the course of declarative episodic memory formation (Fig.2).

Amplitude of theta waves is defined by amount of hippocampal neuronal ensembles involved in theta activity. Rest of the hippocampal neurons remain desynchronized [6-7, 10].

Conscious activity of the brain (e.g. declarative, episodic memory) is considered as hippocampdependent versus to unconscious brain activity (nondeclarative, procedural memory) which belongs to hippocampindependent processes [1, 5, 8]. Evidently partial involvement of hippocampal neurons in theta activity correlates with lower level of cognition.

In our experiments proceeded on cats,

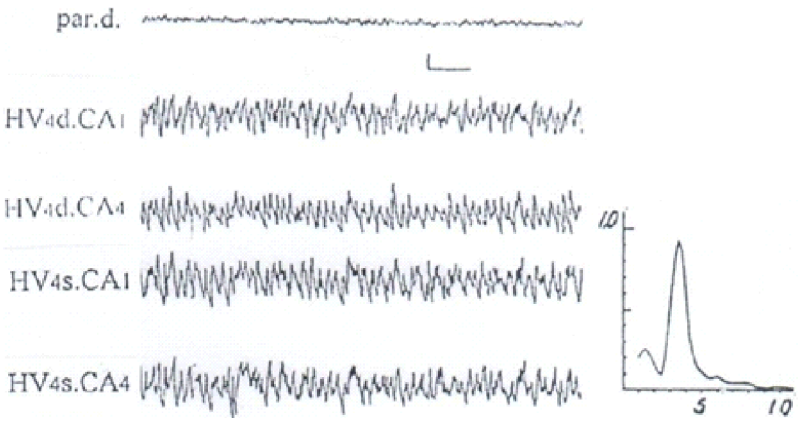

Fig. 2. Electrophysiological correlates of active arousal in the hippocampus. EEG records and power spectral analysis; abscissa – EEG frequencies; ordinate –spectral powers. Other designations are the same.

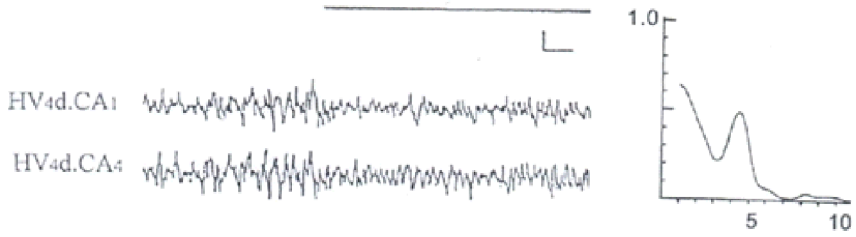

Fig. 3. Intermediate EEG activity in the hippocampus. EEG records and power spectral analysis. Other designations are the same.

electrophysiological events (EEG waves) registered in hippocampus in different paradigms of learning were following: 1. EEG desynchronisation recorded during automatized conditioned reflexes (1 signal – 1 feeder, Fig.1);

2. Theta activity recorded during spatial learning (2 signals – 2 feeders, Fig.2);

3. Low amplitude theta waves appearing during EEG desynchronisation, accompanying simple instrumental conditioned reflexes in the presence of differentiated (positive and negative) conditional signals (2 signals – 1 feeder, Fig.3). Evidently, low amplitude theta waves correlate with formation of weak memory traces.

In the experiments mentioned above, levels of hippocampal activation are different: passive arousal, active arousal and intermediate state.

The famous psychologist of the last century – Sigmund Freud determined four states of humans mind in wakefulness: conscious, unconscious (nonconscious), preconscious and subconscious [11]. It seems that at present S. Freud's views are not fully accepted by psychologists.

Summarizing all well-known neurophysiological data on hippocampal EEG reactions during wakefulness and modern conceptions of cognitive neuroscience, we may accept the following: 1. Hippocampal EEG desynchronization correlates with unconscious (nonconscious); 2. Hippocampal EEG synchronization (theta activity) correlates with conscious; 3. Hippocampal low-amplitude theta waves during EEG desynchronisation correlate with "preconscious" of Sigmund Freud, who announced that increasing concentration of attention evokes transformation of "preconscious" into "conscious". This last conception means for neurophysiology that during increased attention the amplitude of hippocampal theta activity also increases because more neuronal ensambles become involved into synchronization due to enhanced excitation of the reticular activating system [10]. This mechanism works in humans and mammals [12].

Animal Handling. All experiments reported in this paper were carried out according to Institute National de la Santé et de la Recherce Medicale and Paster Institute animal welfare quidelines.

ადამიანისა და ცხოველთა ფიზიოლოგია

„წინაცნობიერის“ ნეიროფიზიოლოგიური მექანიზმების შესახებ

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ცხოველებზე ჩატარებული ექსპერიმენტული გამოკვლევებისა და კოგნიტიური ნეირომეცნიერების კონცეფციების საფუძველზე განხილულია ჰიპოკამპის მოქმედების ელექტროფიზიოლოგიური კორელატები. ჰიპოკამპის ეეგ დესინქრონიზაცია კორელირებს სტრუქტურის დისფუნქციასთან პასიური ღვიძილის დროს, ხოლო თეტა რითმი - ჰიპოკამპის ეეგ აქტივაციასთან აქტიური სიფხიზლის დროს. გაანალიზებულია ჰიპოკამპის აქტივობის მესამე ფორმა - ეეგ დესინქრონიზაციის ფონზე დაბალი ამპლიტუდის თეტა რხევების წარმოქმნა, რაც მიუთითებს სუსტი მეხსიერების ფორმირებაზე დაქვეითებული ცნობიერების, „წინაცნობიერის“ დროს. ჰიპოკამპის სათანადო მექანიზმების ამოქმედება დამოკიდებულია შუა ტვინის გამააქტივებელი რეტიკულური ფორმაციის აგზნების ხარისხზე. ეს მექანიზმები მოქმედებს როგორც ადამიანებში, ისე ძუძუმწოვარა ცხოველებში.

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