Samatova K.S., Posnenkova O.M., Kiselev A.S.
Saratov State Medical University

Egorov E.N.
Saratov State University

Method of assessing the complexity in the brain spatial electrical activity

The Karunen-Loewe orthogonal decomposition method consists in solving the grading equation of the following form:

$$\int K(x, x^*)\Psi(x^*)dx^* = \lambda\Psi(x), \quad (1)$$

where K (x, x*) is the kernel of the equation, which is formed as follows:

$$K(x, x^*) = \langle \xi(x, t)\xi(x^*, t)\rangle_t. \quad (2)$$

Here $\langle ... \rangle_t$ means time averaging. As functions ξ (x, t) one can choose spatiotemporal distribution of physical quantities, on the basis of which supposed on analyzing the behavior of the system. In this case, before the formation of the matrix the kernel K (x, x*), it is necessary to reduce the value ξ (x, t) to zero mean.

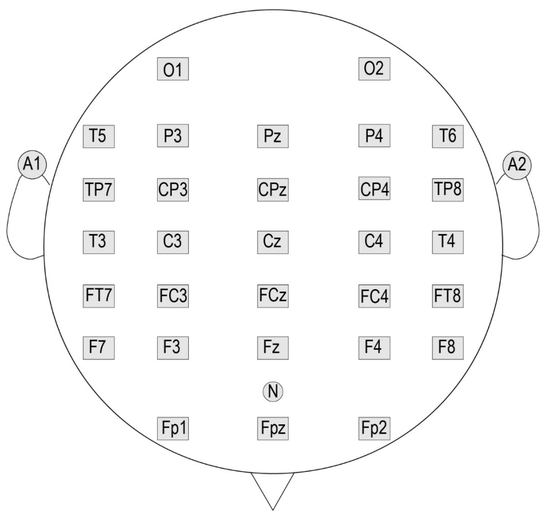
Note that the CL expansion is optimal in the sense that the proper problem (1) - (2) form the basis, so that the mean square error ε minimized: e = min <£ - £ of N > , where £ - exact solution, £ of N - the approximate solution, and of N -dimension of the basis

The solution of problem (1) - (2) is reduced to finding a set of eigenvalues {λ n } and eigenvalues natural vectors {Ψ n } . Each eigenvalue λ n corresponds to a certain vector Ψ n , which will determine the n-th CL mode of the oscillatory process. The value of λ n is proportional to the energy of the corresponding mode, which is conveniently distributed view in normalized form:

$$W_n = \frac{\lambda_n}{\sum \lambda_i} \times 100\%.$$

Electroencephalographrecorder Encephalan-EEGR-19/26 (Medicom MTD). This electroencephalography system in designing, development, manufacturing, realization and technical service of electronic medical equipment complies with the requirements of international standards ISO 9001 and ISO 13485

The quality of medical devices complies with the requirements of Council Directive 93/42/EEC. This system is produced under European standards EN 60601, EN ISO 14971, EN 62304 and certified by British Standards Institution (BSI).



Standard scheme 10-10 for EEG measurements
the frequency range 0.016 - 70 Hz
notch filter 50 Hz
the sampling frequency of the data of 250 Hz
additional channels: EOG, EKG, EMG
video signal for control

In this work , the time dependences of the EEG were chosen as the function ξ (x, t) , filmed in various areas of the cerebral cortex.

Problem (1) - (2) is a homogeneous Fredholm integral equation of the second of a. To numerically find the eigenvectors and eigenvectors numbers, it is necessary to represent equations (1) - (2) in matrix form, then the initial equations can be written in the form:

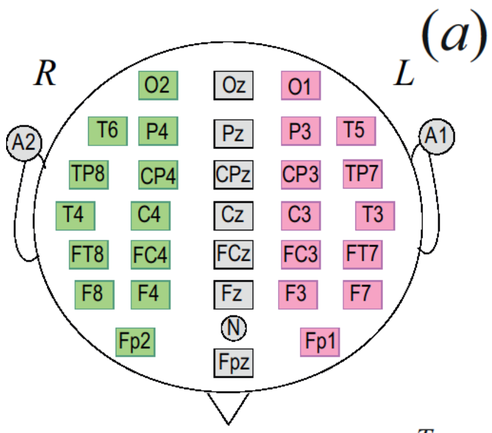
$$\sum_{p=1}^{n}\sum_{q=1}^{n} K(x_p, x_q)\Psi^k(x^q) = \sum_{p=1}^{n} \lambda_k \Psi^k(x^p), \quad k =$$

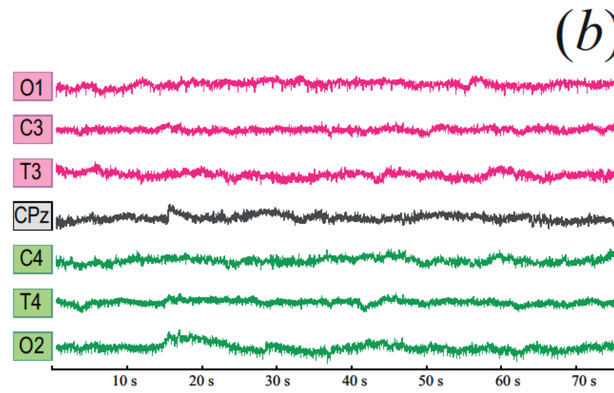
where

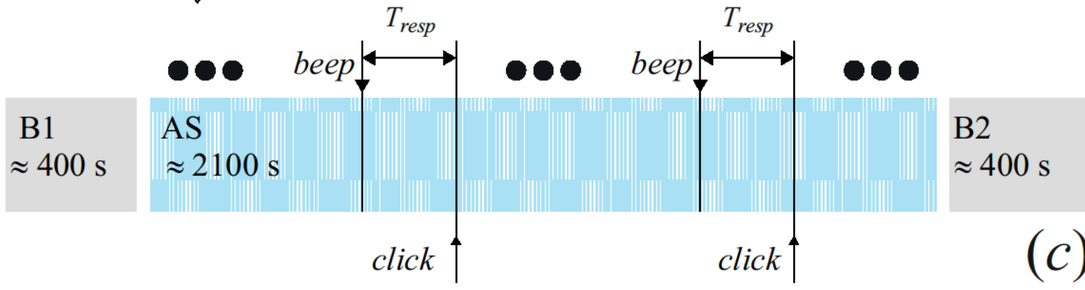
$$K(x_p, x_q) = \frac{1}{T}\sum_{m=0}^{T} (\xi(x^p, t_m)\xi(x^q, t_m))$$

Accordingly, interactions discrete in space and in time EEG dependencies taken during the experiment are recorded in the following form

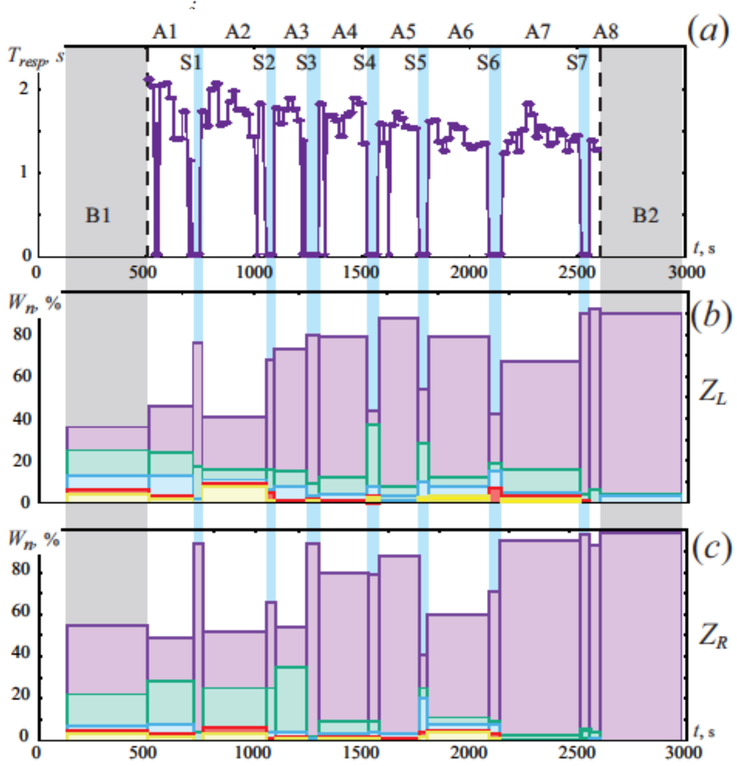
$$\xi(x^p, t_m) = \rho(x_p, t_m) = \rho(x, t)\,\big|_{x_p = p\Delta x,\, t_m = m\Delta t}$$



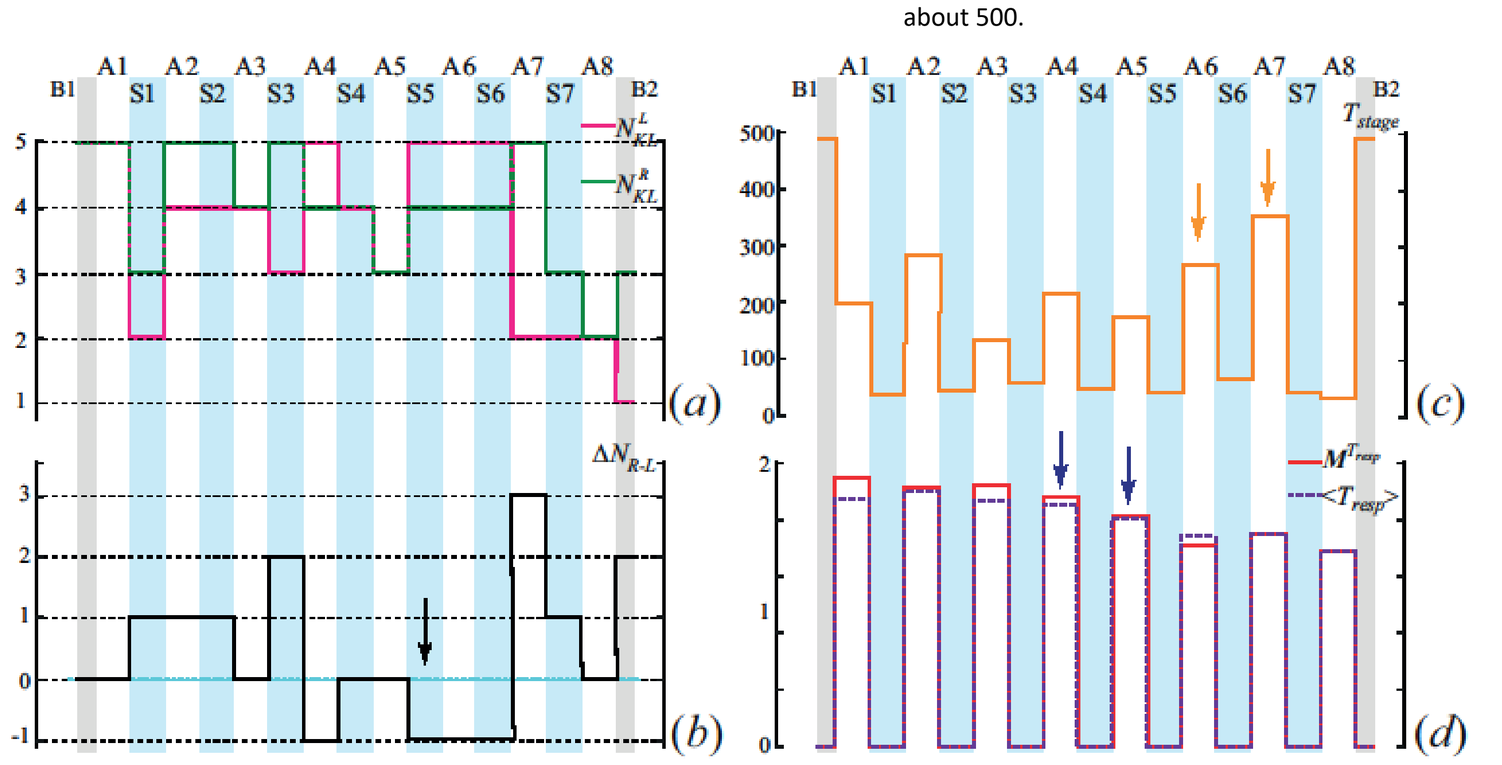




(a) The scheme of EEG electrodes placement, according to the standard _10_10_ arrangement. Di_erent colors, pink and green, correspond left and right scalp spatial zones, ZL and ZR, respectively. (b) Fragments of EEG signals recorded during the experimental active stage. The signals are shown in colors in accordance with the belonging to the ZL and ZR zones. (c) _ The scheme of experimental work: à light gray rectangle shows the _rst and last passive stages of the experiment (passive wakefulness with closed eyes), B1 and B2, respectively; a light blue rectangle with white patterns AS corresponds to the active stage; _beep_time moments of sound stimuli; _click_ _ time moments of remote button pressing; _Tresp _ the respond time duration of test subject for sound stimulus (_beep_). The total duration of active and passive stages is indicated on the respective rectangles. The _beeps_ number during the active stage is about 500.



Light gray rectangles indicate passive stages B1 and B2 with closed eyes of test subject. The active part of the experiment is divided into 15 stages. (a) The dependence Tresp(t) of the test subject's respond duration to the sound stimulus during the experimental current time t. Vertical dashed lines indicate the beginning and end of the active experimental stage AS. The stages at which the subject does not respond to sound stimuli are shown in blue rectangles (S1 _ S7). The experimental stages at which the test subject actively responded to sound stimuli are indicated as A1 _ A8. (b), (c) _ The distribution of normalized energy Wn of the _rst _ve KL-modes for experimental stages, for the left ZL and right ZR hemispheres, respectively. The height of the histogram column corresponds to the energy value of the certain KL-mode, the color _ to the mode number: 1 mode _ violet, 2 mode _ green, 3 mode _ blue, 4 mode - red, 5 mode - yellow.



Color and symbols denotations for the various experimental stages of the experiment (a) _ The number of N^{LR}_{KL} significant spatial KL-modes for the left and right hemispheres zones ZL (pink line) and ZR (green line), calculated for different stages of experimental work; (b) _ the difference ΔNR-L in the number of coherent spatial patterns for the zones ZL (pink line) and ZR (green line); (c) the time duration of the continuous stages B1, A1- A8, S1 - S7, B2; (d) is the median MTresp and the average left langleTresp right rangle of the subject's reaction time, estimated for each experimental stage.