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Software tools for EEG complex group analysis

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SUMMARY

The paper considers the possibilities and procedure for working with a freely distributed program Conan-EEG for Windows 7-10 that provides automatic group analysis of EEG recordings based on the most informative indicators of EEG amplitude and synchronity with the removal of blinks and similar distortions.

Keywords: EEG synchronity; EEG amplitude; Blink artifacts; Frequency domains; Individual and group differences; Depression; Sleep stages; Schizophrenia; Factor analysis; Cluster analysis; Discriminant analysis

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INTRODUCTION

The Conan-EEG program performs automatic group analysis of EEG recordings using indicators that are most effective for identifying intergroup and individual differences. It was created at Moscow State University and is a modification of the CONAN complex electrophysiological laboratory [1] which has been used in hundreds of Russian scientific and educational organizations since the early 90s. The program implements the analysis of EEG correlation synchronity, analysis of EEG amplitudes by derivations, removal of blink artifacts and similar distortions. The program is distributed under the free license of The Free Software Definition and can be downloaded from the MSU website by direct link. At the beginning of the work, it is necessary to create the Blinks folder on disk C, into which to rewrite the EEG recordings files of examinees/patients intended for analysis in EDF format, which must meet the requirements of the EDF+ standard and be accurately tested by EDFChecker and Polyman. All the results of working with the program will be placed in this folder.

The analysis of EEG correlation synchronity:

This method, created in 2010, has shown its high sensitivity in recognizing inter-individual and group differences (norm and schizophrenia, depressive disorders, sleep stages, etc. [2-5] surpassing in this respect all known EEG indicators and ensuring the reliability of differentiation of the compared groups approaching 100%.

After starting the program, press the "2" key. After the message about the completion of the procedure, the AKS-Alpha.txt file will appear in the Blinks folder which includes the table "columns – file names, rows - pairs of derivations" with correlation synchronity coefficients (values in % of 1) calculated for alpha or other current frequency range (AKS-Delta.txt, AKS-Teta.txt etc.).

The correct analysis of EEG amplitude:

After starting the program, press the "4" key. After the message about the completion of the procedure, the DiapFiles.txt file will appear in the Blinks folder containing a matrix of results: rows – subjects, columns – EEG amplitudes by derivations. Recall that amplitude estimates are devoid of many errors inherent in frequently used EEG power estimates [6].

The correct removal of blinks and similar distortions:

Attention! There must be Fp1 or F3 derivation in the records. After starting the program, press the "0" key. After the message about the completion of the procedure, take the corrected files from the Blinks folder.

Before restarting the analysis, the text files of the results should be deleted from the Blinks folder [7] **Fig. 1.**

Selection of the frequency domains of the analysis. Press the "1" key and in the EEG analysis menu, set the required domain according to the flip list Диап= Alpha, then cancel the menu. After that, the calculated synchronities will be written to a file with the name of this range. The set range will be valid until the next change.

Changing frequency domains. Press the "1" key and in the EEG analysis menu that appears, press the A=Диапазоны button. In the table that appears, change the number, names, and boundaries of the frequency domains. Using the write and read buttons, these settings can be archived and then read, if necessary, without manual adjustments. The set domains will be valid until the next change.

- Analysis of a single record. Press the "F3" key and read the desired EEG recording file from the list. Press the "1" key to open the EEG analysis form, in which two continuations are possible **Fig. 2.**

1. Press 8=Синхронность button. and in synchrony analysis

Fig. 1. EEG analysis menu.

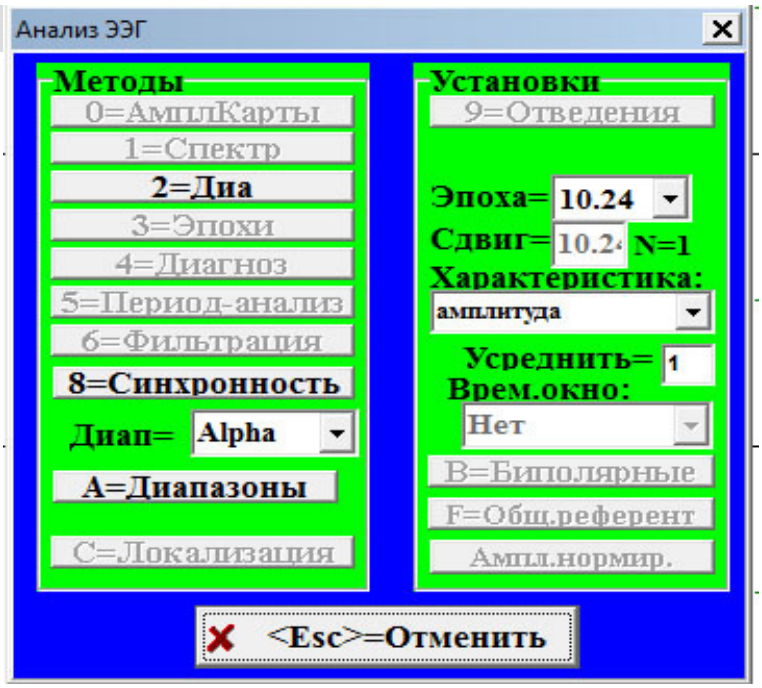


Fig. 2. Forest plot of the differences in accuracy between training and testing of the different algorithms.

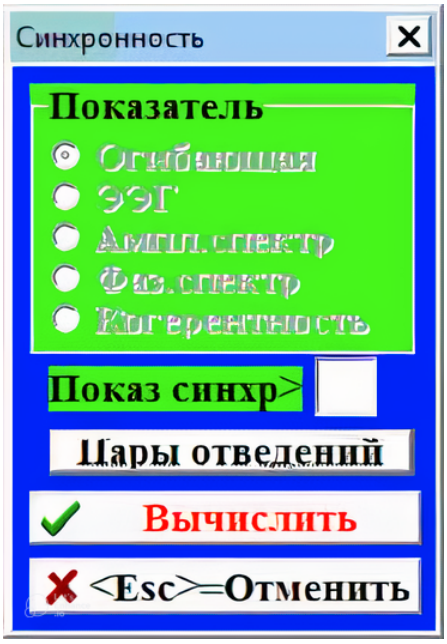


Fig. 3. Results of synchronity analysis.

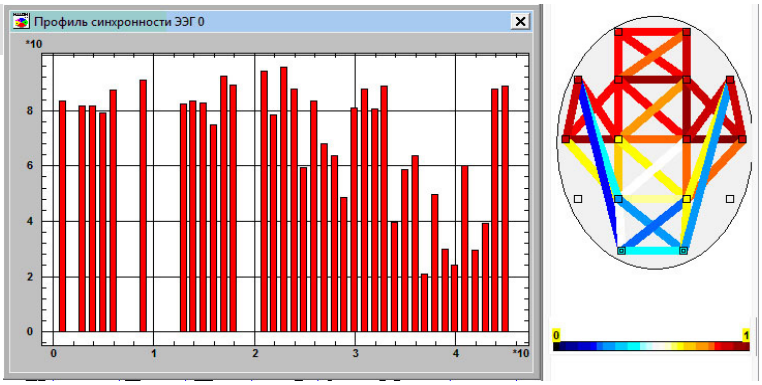
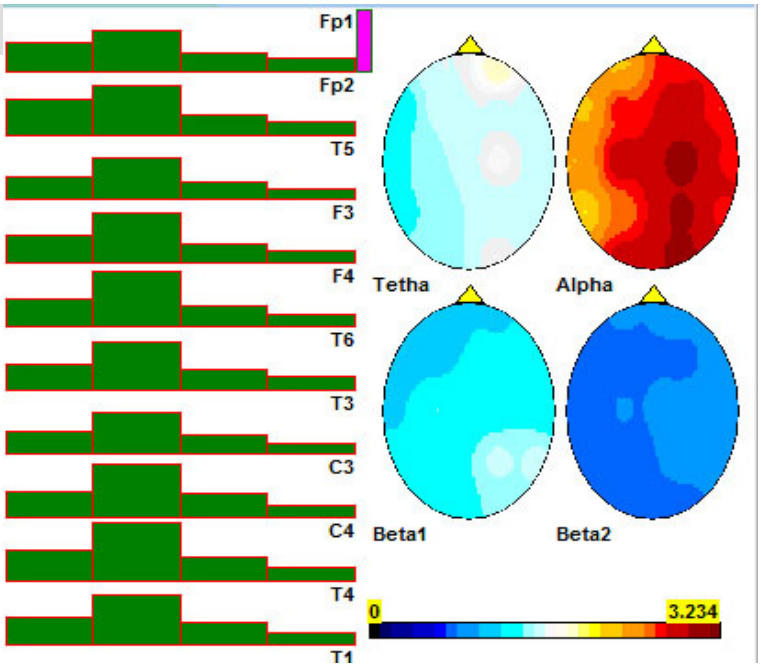
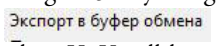
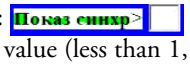


Fig. 4. Results of synchronity analysis.

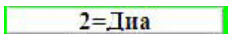


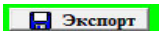
menu press 

,button then the diagram of synchronities in the order of derivation pairs and the color map of the distribution of synchronities on the scalp will be displayed in figure 3. If you right-click on this diagram and select the 

item from the following list then the values X, Y will be transferred to the clipboard). If in the right input field: 

of synchronity menu set some threshold value (less than 1, e.g. 0.5), then only over-threshold synchronity estimates will be present on the diagram and map. To re-analyze the same record, you need to read its file again **Fig. 3.**

2. Press the 

button and in the right half-window you will see the diagram of average EEG amplitudes in frequency domains in the order of derivations and the color topographic maps of their distribution on the scalp. When you right-click in this half-window, a context menu appears in which, by clicking the 

button, the values of the column diagrams can be saved in a text file under the name of the read EEG record **Fig. 4.**

Statistical analysis of the results:

So, as a result of the program, the matrices of the results of the examinees/patients-indicators are obtained. Researchers are usually interested in identifying differences (social, age, gender, ethnic, functional, clinical, etc.) between two groups of subjects. The first step may be to identify paired differences between columns or rows according to known statistical criteria. Further, each file can be individually subjected to factor analysis, to study the main factors and the initial variables, mainly projected on them. On this basis, you can try to choose a meaningful interpretation of the main factors. It is also possible to visually study the projections of objects (subjects) on the plane of the main factors for the uniformity of their changes or the presence of some separate groupings. In the latter case, using a divisive cluster analysis strategy, you can try to divide objects into an estimated number of classes and verify this separation using discriminant analysis. The total matrix with two groups of subjects can also be subjected to a discriminant analysis to verify its division into two groups. If such a classification turns out to be reliable and the number of incorrectly classified subjects is small, then this will be a convincing argument that the EEG synchrony in the two groups as a whole differs significantly. In addition, the calculated discriminating function can be used to assign new indeterminate subjects to a particular group.

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