ON THE POSSIBILITY OF USING EDR FOR ESTIMATION THE VIGILANCE CHANGES

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AIM OF THE WORK

Recently the way of estimation of drowsiness by means of EDR registration was discussed. It was interesting to look for the similar way of objective estimation of operator's vigilance (with open eyes). For this purpose, electrodermal activity during visual perception test was registered.

EXPERIMENTAL

Three independent measures of skin resistance with external voltage source (0.9 v). Dry electrodes; two pairs of rings on fingers and the bracelet on wrist with area 1 cm^2.

EDR recognition using appropriate software developed by us.

Additional parameters:

- 2 monopolar EOG (horizontal and vertical) using left mastoid reference,
- monopolar EEG (Cz) using right mastoid reference,
- ECG (nonstandard – left arm - left mastoid).

Measurements: Polygraph MACLAB 8.1, with Macintosh computer.

Sampling rate 100 Hz, with 12 bit ADC. The amplifier bandwidths for EOG, ECG and one of EDA channels from 0.7 (time constant 1.5 s.) to 20 Hz, for EEG - 0.7-50 Hz., for two EDA channels – high frequency filters (upper limit 20 Hz).

Vigilance monitoring - monotonous visual detection test. The subjects watched the regular monotonous movements of the dot of light around the Pentium Computer's monitor and pressed the joystick button when noticing the dot's jump past one position. The jump occurred at irregular intervals approximately 8 times a minute. The reaction time was measured; when it exceeded 6 s, the error was registered (by memorizing -1 at the time of error).

42 experiments on 11 volunteers aged 21-61 were carried on.

Experiment's duration 30 min.

RESULTS

The time of experiment was enough for most subjects to begin making errors.

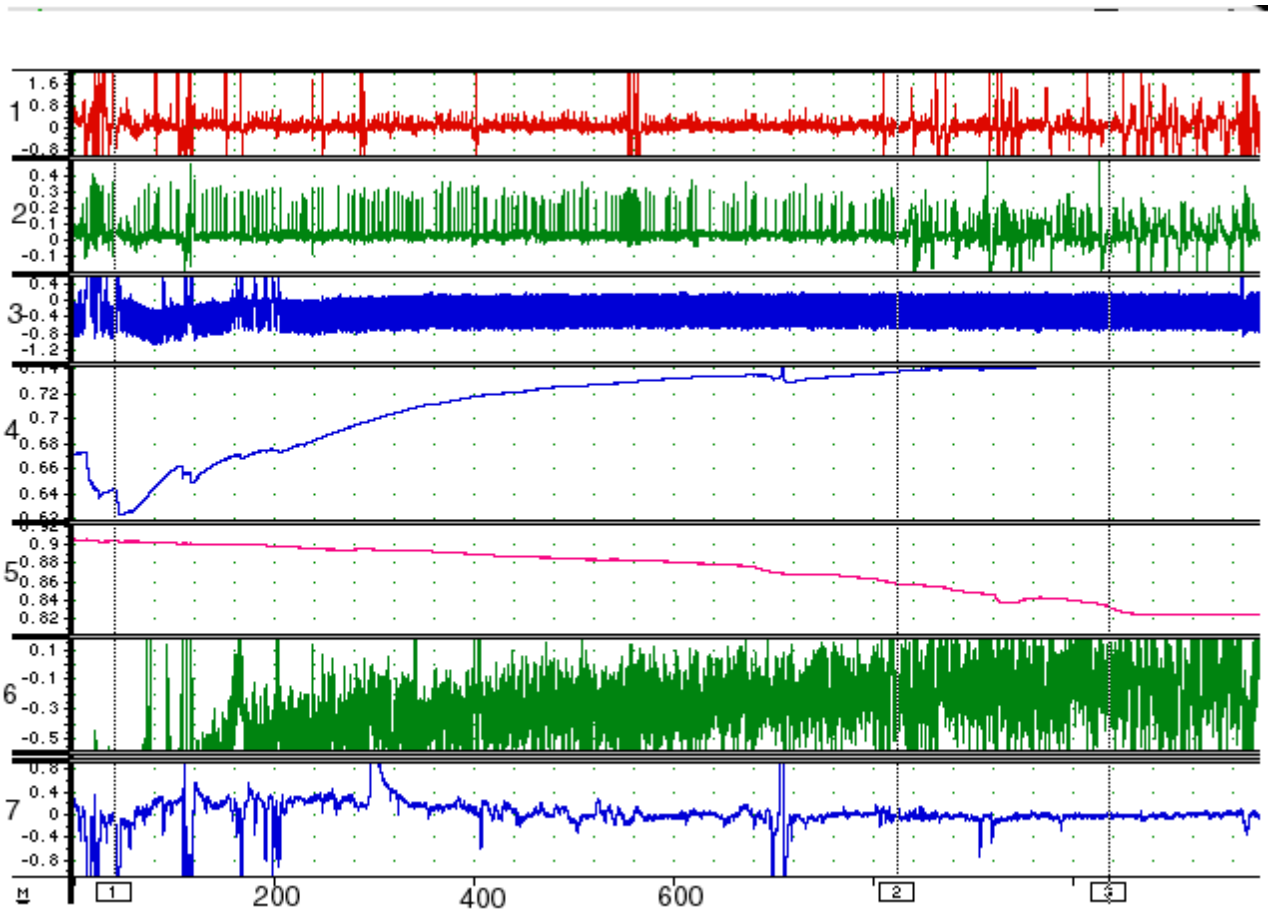
Errors classification:

- accidental - other physiological parameters are not changed. Frequently accompanies movements. Occurs mostly at the beginning (first 5 minutes).
- reversible - ECG, horizontal EOG and for some persons - EEG changes, but after one missing of the pressing proper performance is observed, and physiological parameters reverse;
- irreversible - followed by the sequence of errors with accidental proper reactions . Physiological parameters stay changed.

On Fig. 1,2 are the examples of polygraphic registration with errors of different kinds.

Fig. 1

Example of polygraphic registration.



Channels: 1-EOG horizontal, 2-EOG vertical, 3-ECG, 4-EDA, fingers, 5-same, wrist, 6-EEG, 7-EDR, phasic (filtered).

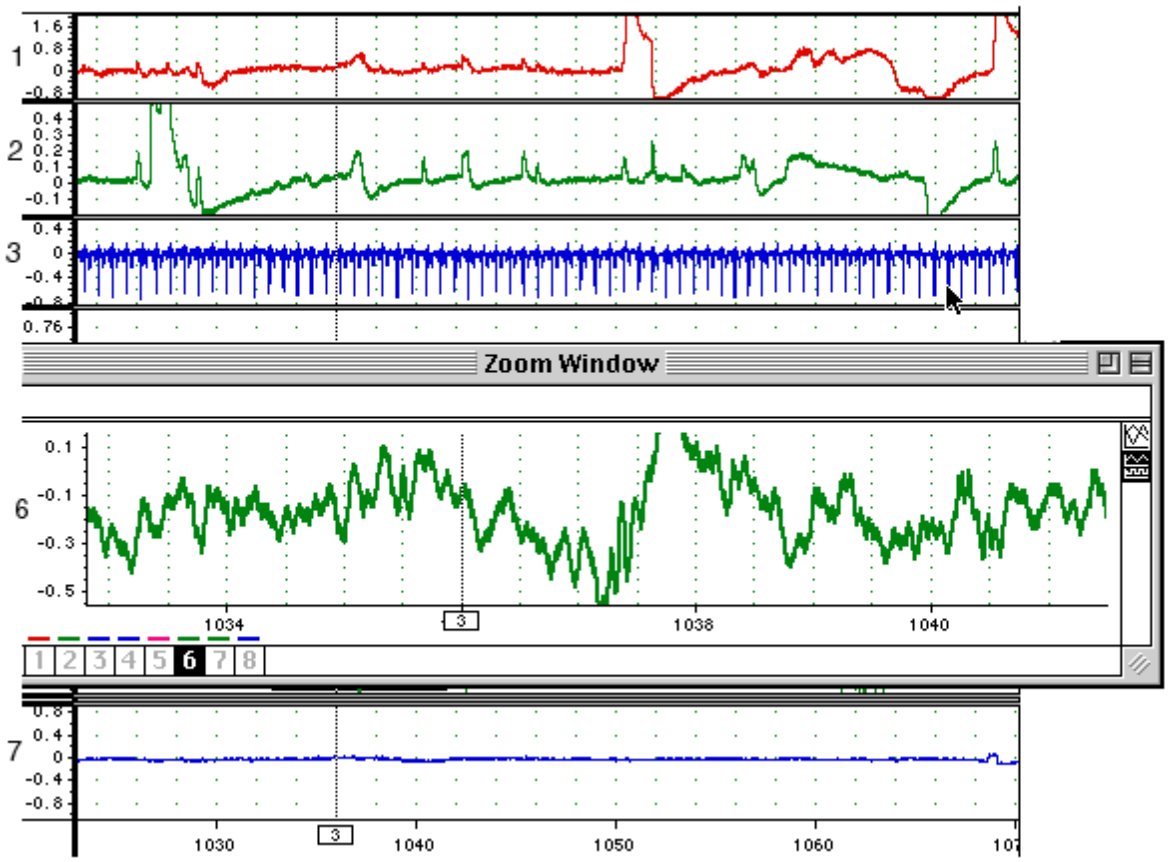
Horizontal axis –time (seconds), vertical – 4,5 – v, others – mv.

Mark 1- beginning of the test, marks 2,3 – time of first and second errors.

Both errors occur during long intervals between EDR.

Fig. 1b

Example of polygraphic registration, extended in time, near the second error (mark 3).



Channels as in Fig.1. (4 and 5 not shown).

Slow forms in EEG are seen.

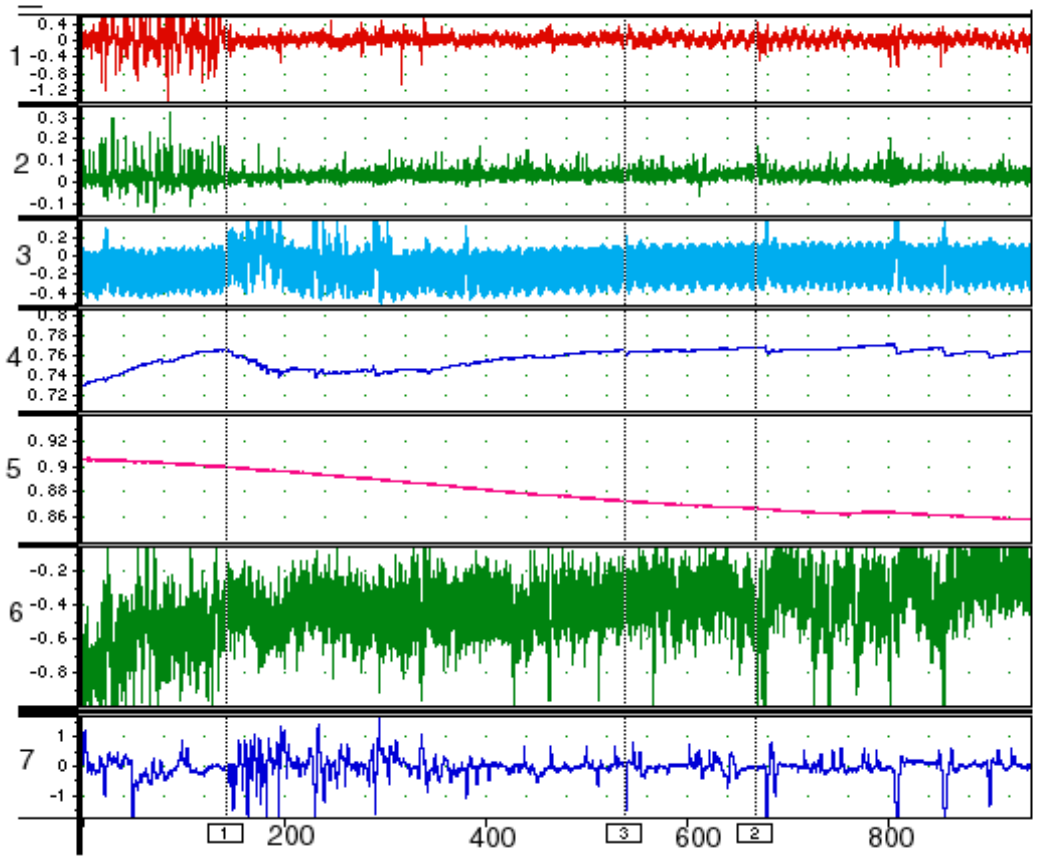
Near the errors, signs of drowsiness could be seen (eyes movements, see also EEG on Fig. 1b).

The subject is "stable" and calm, so there are few EDR and movements.

The resistance increased, and EDR frequency decreased, see Fig. 1. The reaction time increased, then errors appeared. To the time of the first error, EDR were absent for about 3 minutes. First error is reversible, the second one - nonreversible, and the subject was drowsy.

Fig.2

Another example of polygraphic registration.

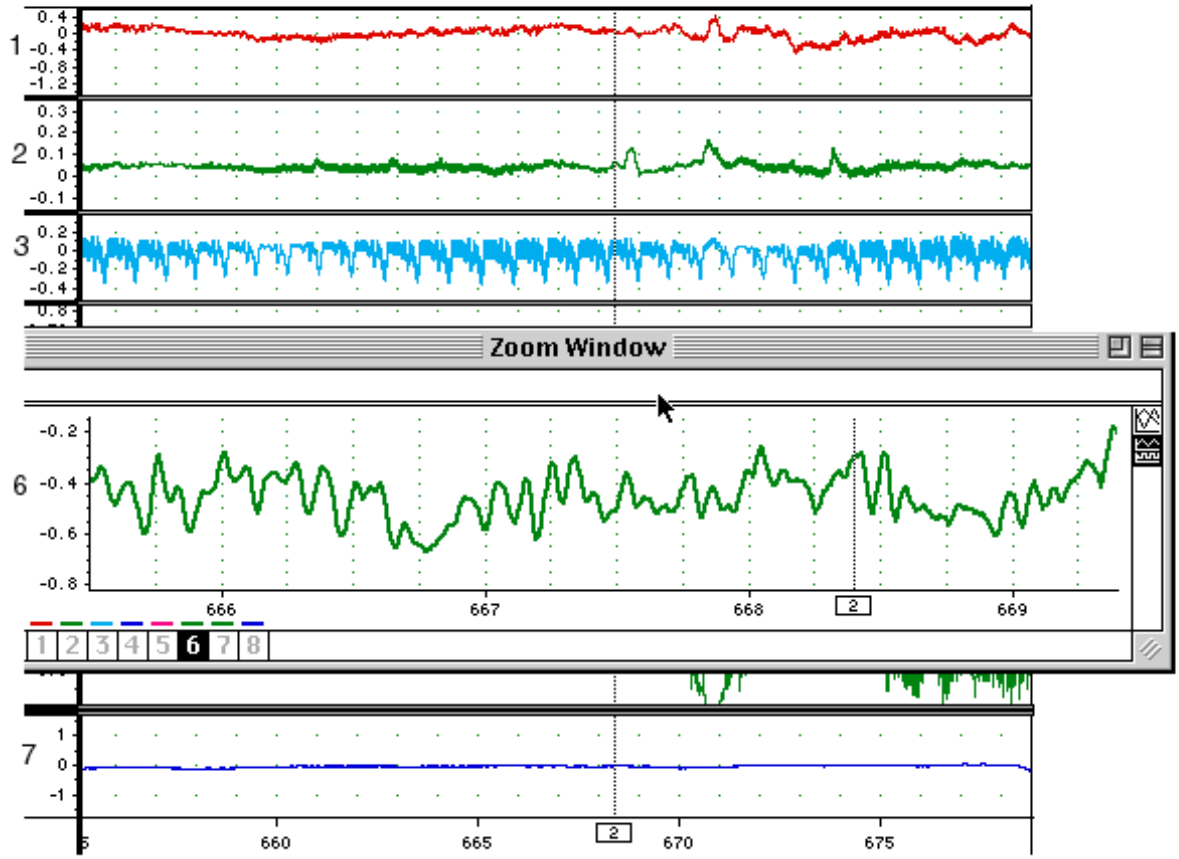


Channels are the same as in Fig.1. Mark1- beginning of the test, mark 2- first error, 3- last EDR before error.

The subject is "labile" and quick, so EDR and movements are multiple. Here, multiple EDR and many artefacts due to movements are seen in Chan. 8.

Error appears in large interval between EDR (more than 2 minutes).

Fig.2b

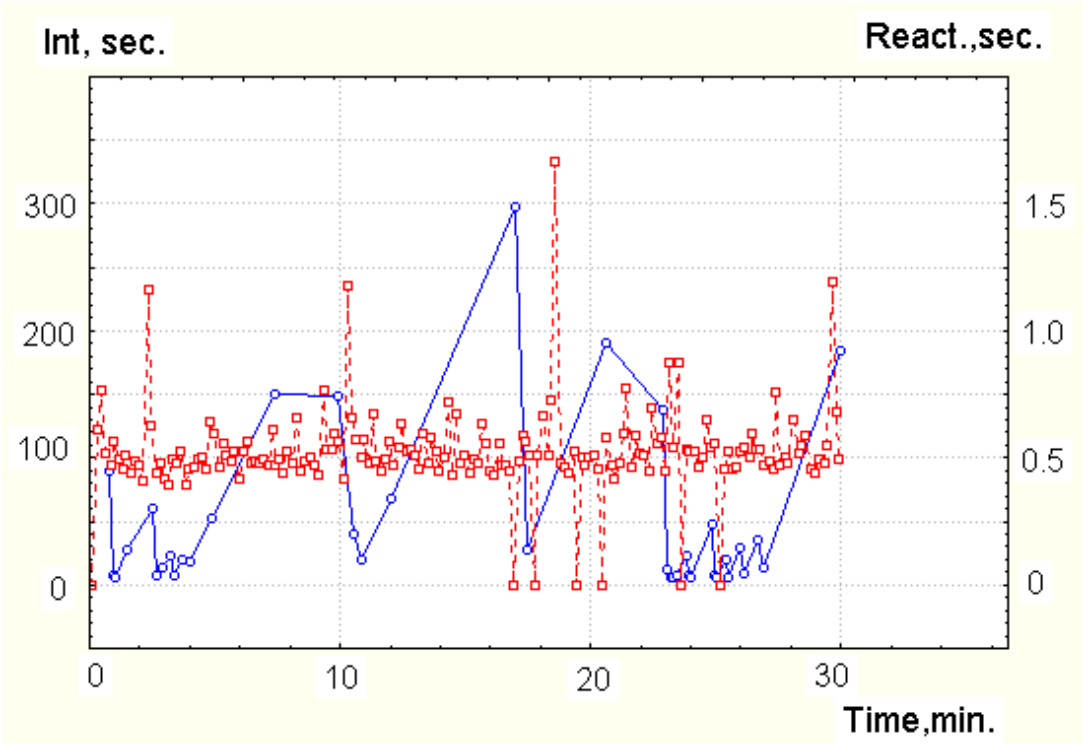


Polygraphic registration, same as in Fig.2, extended in time, near the first error (mark 2). Channels as in Fig.1. (4 and 5 not shown). There are no slow forms in EEG (no drowsiness).

Before errors, the interval between EDRs increase. The subject is not drowsy, and the error seen on the Fig.2 is reversible. So are other errors in this experiment. Nevertheless, all errors appear during long intervals between EDR.

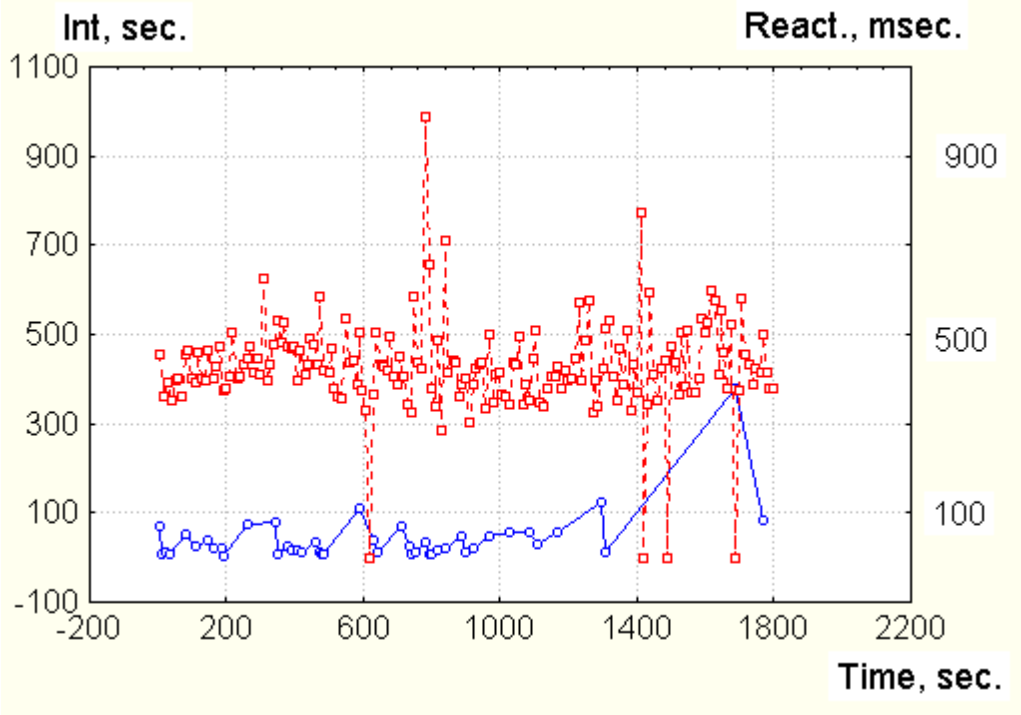
Most of the errors in all experiments occur during long intervals between EDR. The examples are on Fig. 3-5.

Fig. 3



The reaction times (squares, right axis, red) are put against the time (horizontal axis) when the dot of light moved across the monitor; when the button is not pressed (error), -1 is shown. So, the squares above average line belong to the cases of reaction time increase, while those below 0 show the errors. Interval duration (dots, left axis, blue) are shown at the time when next EDR is registered.

Fig.4

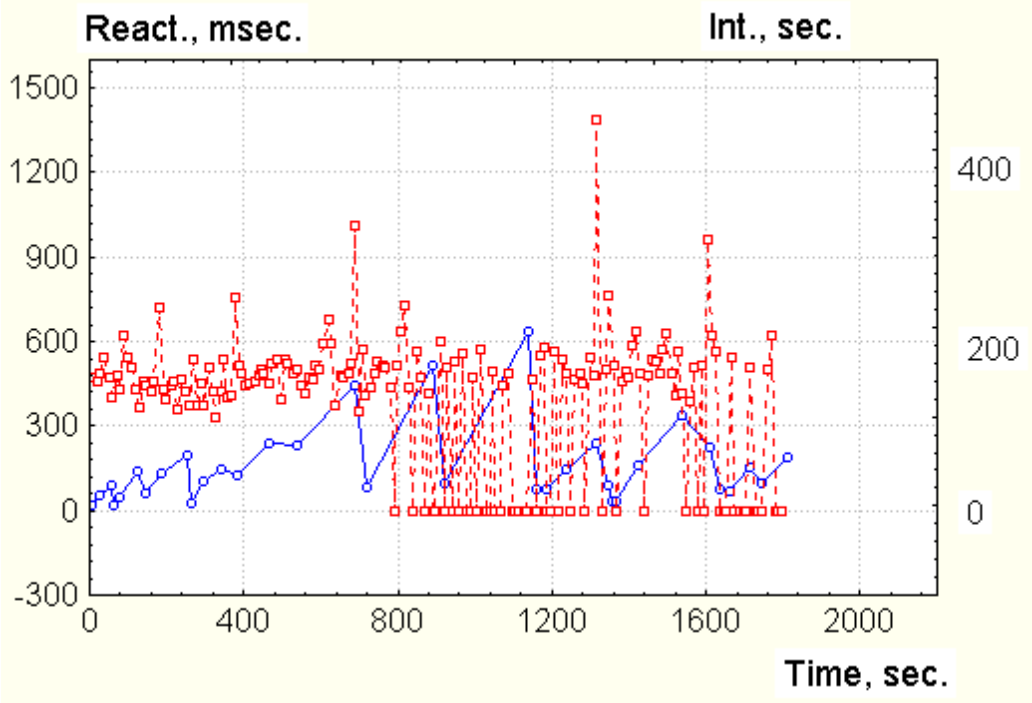


Notations as in Fig. 3.

"Labile" person, with only three intervals more than 100 sec. and very few errors occurring in increased intervals.

Fig. 5

Same as previous, except that the first error is irreversible.



During first large interval, the reaction time increased; the first error appears during the second large interval.

As could be seen, almost all errors (except possible accidental ones at the beginning) occur inside the long intervals between EDR.

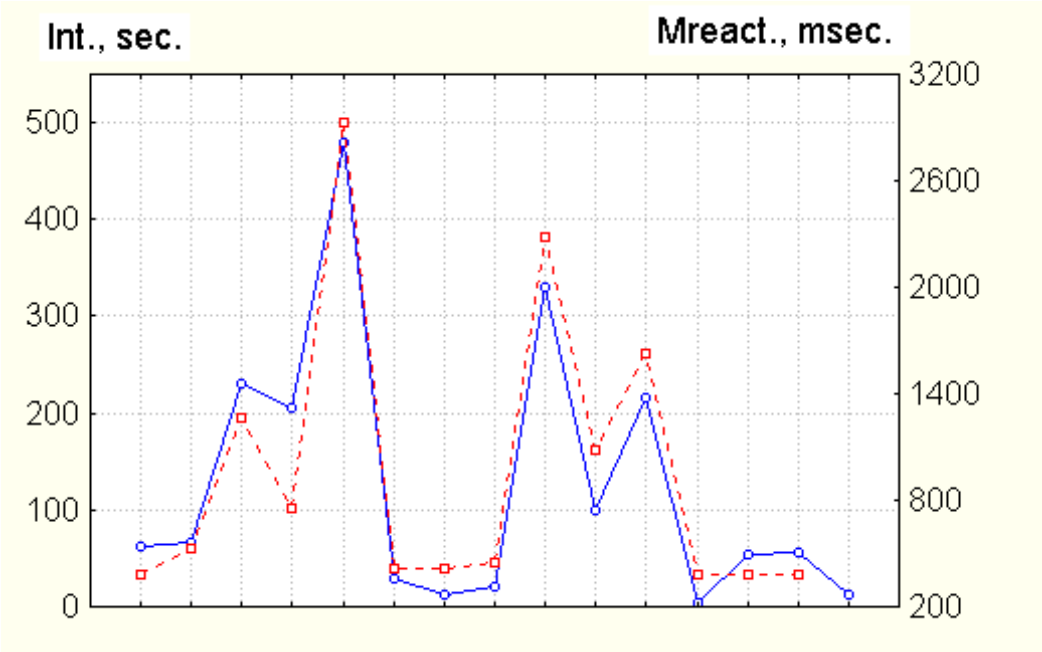
Minimal interval registered before the first non-accidental error was 65 s., whereas mean interval for wakefulness is about 20 s.

The intervals between EDR signals including reversible errors significantly exceeded the mean ones (154 s against 39 s).

To obtain quantitative information about the connection of intervals between EDR and vigilance, the correlation of the interval and reaction time averaged for the interval was looked for. To do it, the reaction time corresponding to the error was taken as the time before next pressing of the button. Correlation coefficients (Pearson's) were found to be between 0.4 and 0.9.

Examples of correlations - Fig.,6 - 8.

Fig. 6



Example of almost perfect correlation of intervals between EDR (left scale, dots, blue) and Mean reaction times (averaged through the interval) (squares, right axis, red). Horizontal axis – case numbers. Correlation coefficient in the case is 0.94.

Fig.7

The example of worse correlation (r=0.6). Corresponds to the case shown on Fig. 3. Designations as before.

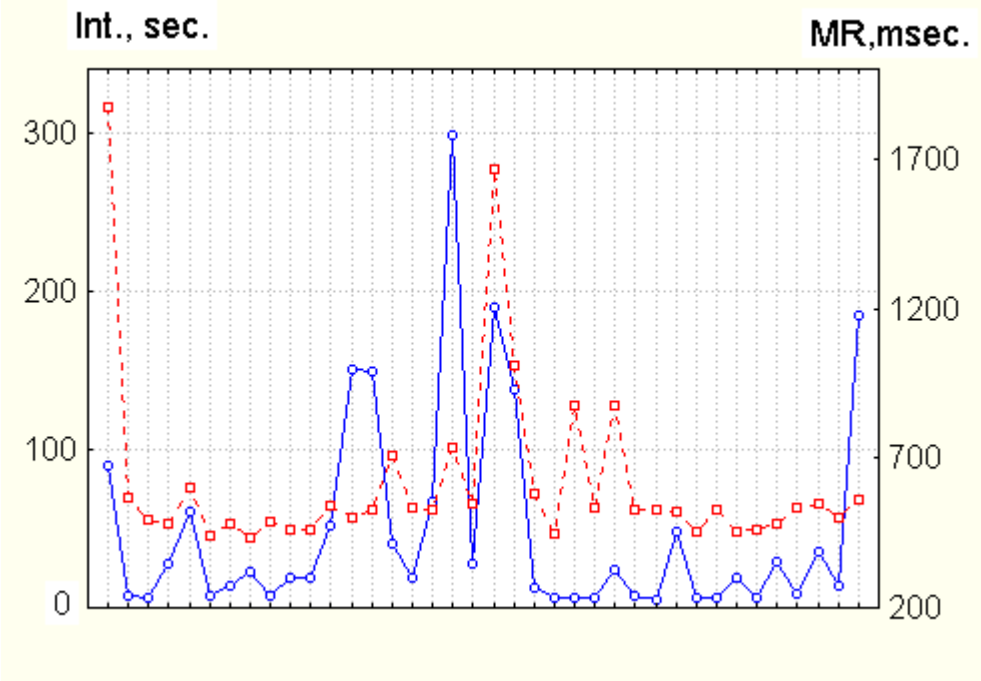
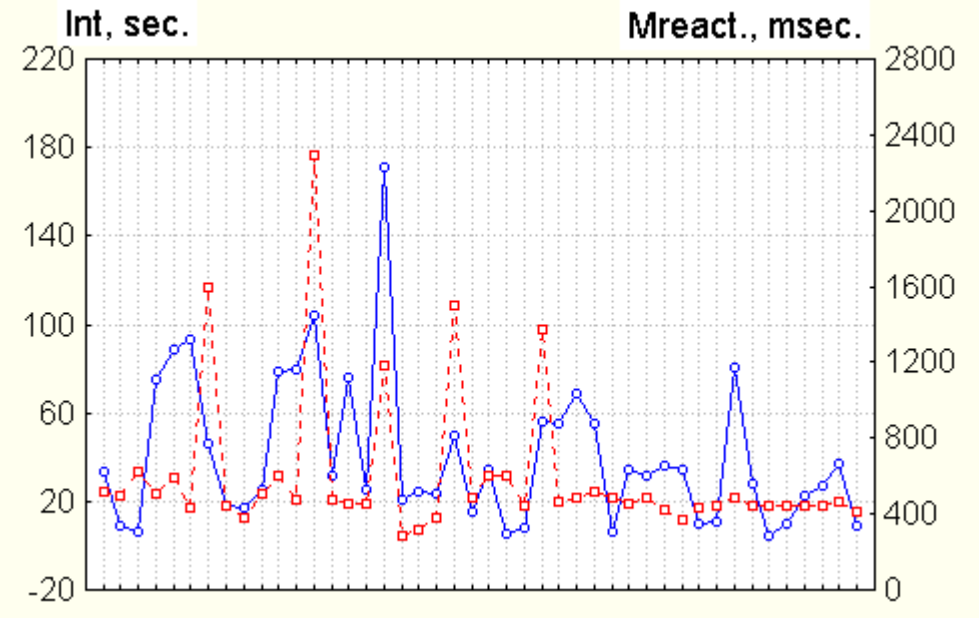


Fig. 8

Another example of said correlation



The best correlations are obtained in cases when there were observed only few EDR and multiple errors, see also Fig. 6 – 8. Therefore, long intervals between EDR correspond mostly to errors, and not to reaction time increase. That fact is connected to drawbacks in detection test used.

CONCLUSION

Intervals between EDR correlate with reaction times during visual recognition test. EDA is easily monitored and its measurement doesn't depend on the subject's condition. Our software allows to register EDR and not the artefacts due to movements. So, resistance monitoring along with EDR recognition by proper software, could possibly be used to estimate vigilance changes.