

THE EYE MOVEMENTS AND PARKINSON'S DISEASE

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Abstract : The presented study was conducted to analyse the electrooculography signal. We have computed the smooth pursuit eye movements gain before and after subcutaneous apomorphine administration. The results showed significant differences between groups of patients and healthy volunteers.

Keywords: ocular pursuit, electrooculography, Parkinson's disease.

1 INTRODUCTION

The aim of the study is to create the diagnostic unit for eye movement measurement and parameters of smooth pursuit eye movements (SPEM) computation. This non-invasive, simple and fast measurement can bring very useful information. We used the obtained results (SPEM gain) for actual nervous system state examination [1,2] and medicaments effect. In this article we will describe the application of the measurement method, data processing and results application on parkinsonian patients.

2 METHODS

2.1 Technical aspects

Each patient was requested and trained to keep watching on the horizontally oscillating white point on the black screen (17" colour monitor). The point diameter was 0.5 cm. The point track was positioned at the eye level 70 cm in front of the subject. The total visual angle was 21°. The point movement was linear with the oscillation period of 2 seconds (frequency 0.5Hz).

At the start of each measurement the point persists two seconds in the left and right outside positions to get information about the maximum eye movement amplitude. This information is used for calibration.

The electrooculography (EOG) signal was recorded by Brain-Quick system (Micromed, Mogliano, Italy). The bipolar registration of corneoretinal potential was performed under standard conditions – two disc electrodes were placed in the lateral parts of the left or right canthus. Simultaneously with the EOG signal the actual target position has been recorded – fig.1.

The EOG stimulation program was created by one of the co-authors (P.D.).

2.2 Measurement conditions

The patients were sitting in a comfortable chair in a quiet and semi-darkened room. There was no head fixation. Each patient was instructed not to move his or her head during the measurement. The total recording time varied between 90-270 seconds.

2.3 Medical aspects

We examined 21 patients (13 men, 8 women) and 21 healthy subjects as a nonpatient control group. Each EOG measurement of smooth pursuit eye movements (SPEM) on patients was executed both before and after administration of subcutaneous apomorphine (ASA). Apomorphine was administrated subcutaneously, the dose varied between 0.5/1.0 ml (0.1ml/10kg) during the diagnostics apomorphine test. The investigated control group consisted of age-matched healthy subjects that underwent only the SPEM recording without ASA procedure. The subjects in the control group had no previous history of central nervous system disorder.

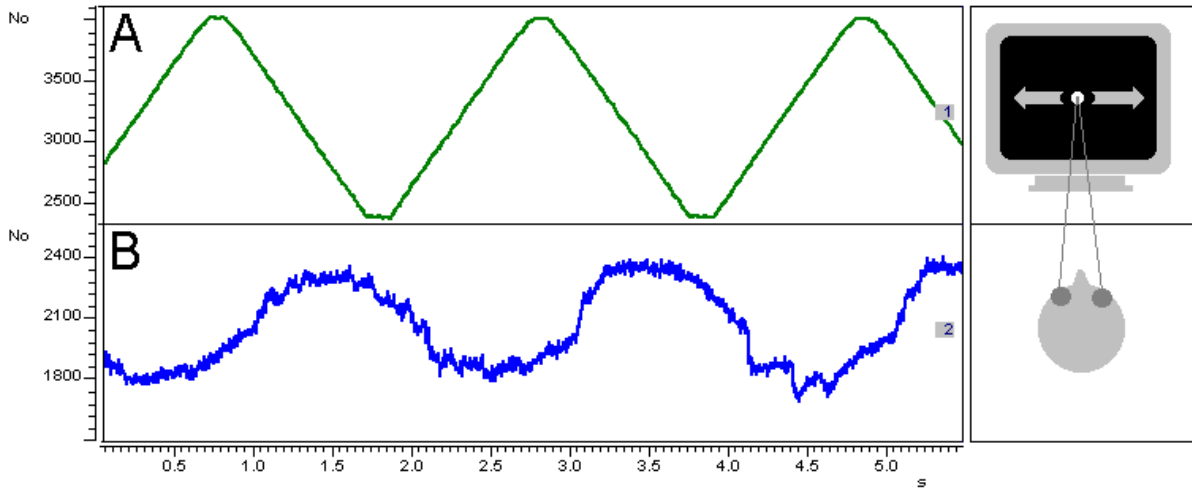


Figure 1. A – point track. B – EOG signal. The point movement period is 2 seconds.

2.4 Processing

All records were analysed off-line by the computer using an interactive graphics and ScopeWin EEG processing program (the program was created by two of the co-authors P.J. and J.H.).

The recorded EOG signal was filtered in the following frequency bands : 0.02-12 Hz, 0.8-12Hz and 0.02-0.8Hz. From the power spectrum (PWS) of the EOG signal the SPEM gain G was computed using $G=I1/I2$, where $I1$ represents the integral of the PWS in the 0.02-12.0Hz band and $I2$ represents the integral of PWS in the range 0.02-0.8 Hz. The maximal value of the SPEM gain (sinusoidal point track) can be potentially 1. This holds in the case of the same values of $I1$ and $I2$ integrals. It means that the integral between 0.8-12.0 Hz is zero. This hypothetical value cannot be achieved in real measurement.

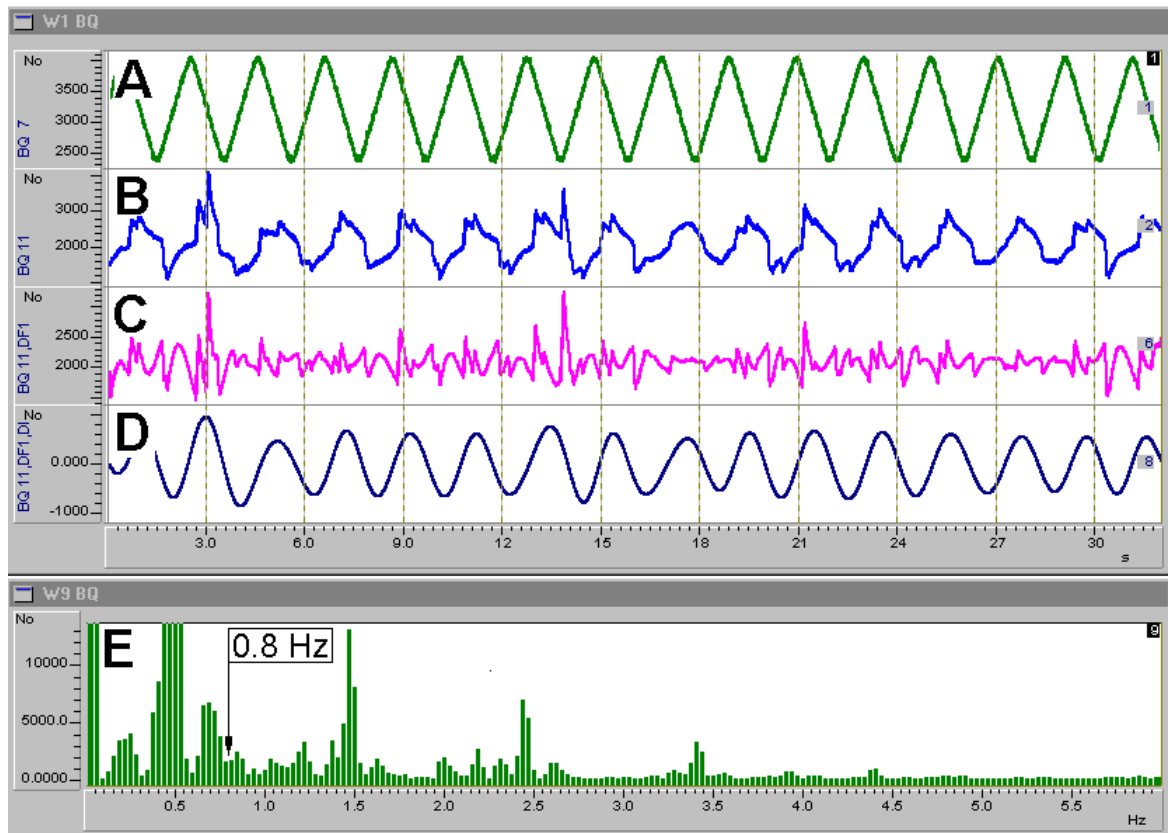


Figure 2. SPEM Gain=0.85, discontinuously target tracking. Parkinson's disease.

A - target movement, measured signal, B – EOG, measured signal, C – EOG in the range 0.8-12.0Hz, D – EOG in the range 0.02-0.8 Hz, E – power spectrum of EOG signal

If we use linear left-right point movement, the spectrum of the point track includes a higher harmonic. It is also incorporated in the measured EOG signals. The third, fifth and seventh harmonic can be seen in the EOG spectrum in Fig.2, E and Fig.3, E .

In the control group of healthy volunteers the mean SPEM gain value was near 0.94. Generally it holds that the higher SPEM gain value represents the better (smooth and fluent) point movement sighting.

The results were analysed in both the numerical (gain) and graphical forms (time course of the filtered EOG signal). Interactive graphical analysis-verification was used for removing incorrect records. The incorrect record is the one, which includes artefacts (head movement, disorderly eye tracking).

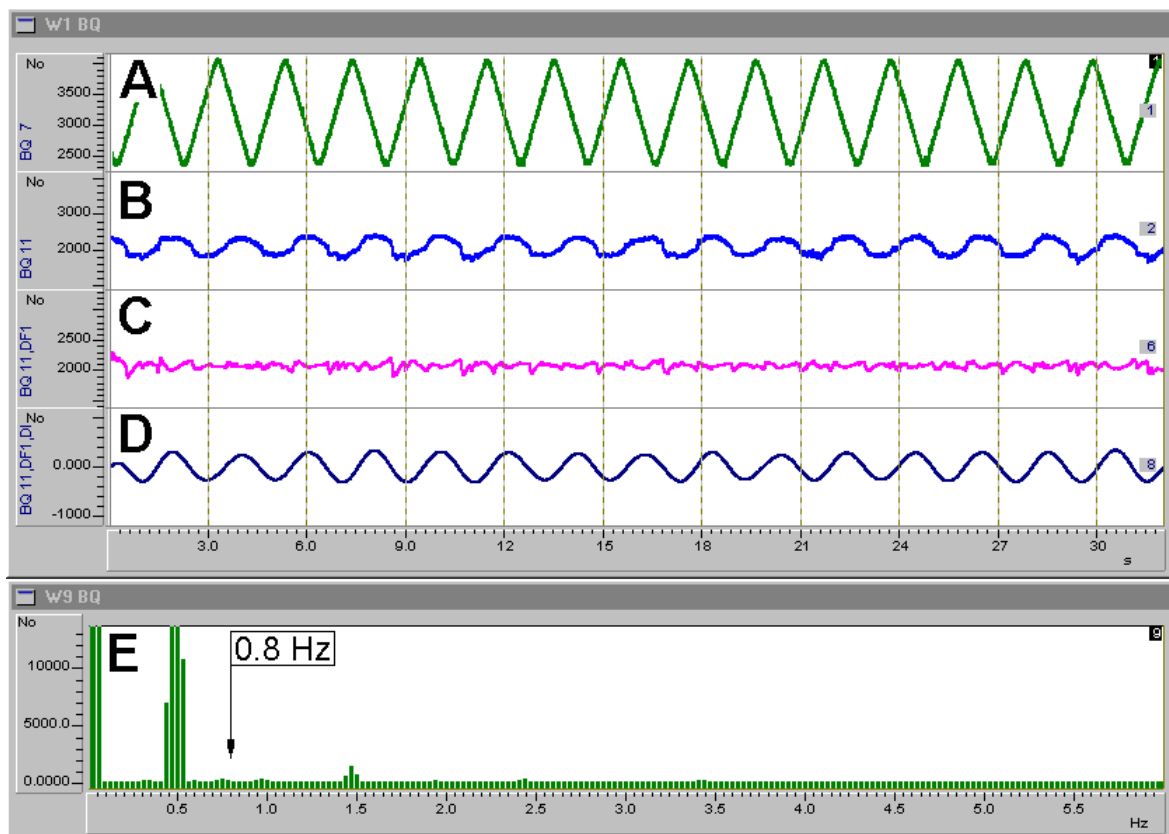


Figure 3. SPEM Gain=0.95, smooth eye movement. Healthy volunteer.

A - target movement, measured signal, B – EOG, measured signal, C – EOG in the range 0.8-12.0Hz, D – EOG in the range 0.02-0.8 Hz, E – power spectrum of EOG signal.

3 RESULTS

SPEM before and after ASA administration were recorded for 21 patients who suffered from the idiopathic Parkinson's disease. All patients were L-Dopa-naive. EOG periods of 30 seconds duration were successively mathematically evaluated. The statistical comparison of the SPEM gain for parkinsonian patients (p-pts) before and after ASA and for the age-matched study group was made, and it showed significant differences in the SPEM gain between the groups, and before and after the injection of apomorfine into the patients.

The mean pursuit gain of p-pts before ASA was 0.83 ± 0.10 and after ASA administration it was 0.87 ± 0.09 . It is evident that ASA has an influence on the eye tracking and significantly improve ability to follow the moving point.

In the control group we have got the following results : in the first part of examination the pursuit gain is 0.94 ± 0.03 and in the second part is 0.93 ± 0.04 . Two examinations of the control group create comparable conditions of p-pts measurement before and after ASA administration. To compare this result it is essential to exclude other influences, such as tiredness or routine in the second measurement. In the control group the mean gain value of the second measurement is slightly

less than the first measurement. In the p-pts group the gain of the second measurement after ASA is greater. This improvement is unequivocally due to ASA administration.

4 DISCUSSION

Our results confirmed the following presumptions : (a) pendulum-tracking patterns in the p-pts group was poorer than in the control group, (b) the ASA demonstration in the p-pts group has verifiable and positive influence on the tracking, (c) the repeated measurements in the control groups have shown no significant differences. These obtained outcomes are important for subsequent clinical utilisation.

The presented results of measurement come out from relatively simple pursuit gain computation. This value gives information about the ability of patients concentration on the moving point and its monitoring. On the other hand it brings no information about (for example) the response ability and reaction quickness. There exist other possibilities for cerebral eye movement control measurement and processing. This was already discussed in literature [2,3].

We expect that phase computation may bring significant information benefit. The phase is defined as time delay between the target track and eye monitoring track and its time course during measurement. We have experience with phase analysis in cardiovascular diagnostics [4,5] where the phase contains important information about time stability of the regulatory loop between blood pressure and heart rate.

Even though the SPEM gain computation is simple, the results of the presented study have proved to be clear diagnostic contribution.

This study was supported by a grant of GA ÈR 102/00/1262 and (in part) supported by a grant GA ÈR 309/98/0490. All measurements and data processing have been done at the clinical workplace of the 1th Department of Neurology, St. Anna Hospital, Masaryk University of Brno.

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