1

Movement related evoked potentials in Parkinson's disease patients and healthy controls

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**controls**

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*Abstract***—The aim of this study was to demonstrate the role**

**of movement related evoked cortical potentials (MREP) in**

**Parkinson’s disease (PD) diagnostics. The experiment consisted**

**of repeated spontaneous thumb movements in a time**

**interval of 5-10 s. There were two groups of subjects, PD patients**

**and healthy controls. We observed shift in the latency of**

**the beginning of MREP, the Bereitschaftpotential (BP), in**

**patients with PD. The BP started earlier for healthy controls**

**than for the PD patients when the PD patient’s affected hand**

**movement was observed. The BP latency shift was observed**

**for the affected hand, but the beginning of the BP was not**

**influenced for the healthy hand. The later components of**

**MREP were not significantly influenced. The PD patients**

**group was diverse and in accordance with that the standard**

**deviations of MREP components’ amplitudes for this group**

**was much greater that for the controls group.**

*Keywords***—movement related evoked potentials (MREP),**

**Bereitschaftpotential (BP), Parkinson’s disease (PD) patients,**

**control group**

I. INTRODUCTION

The Bereitschaftpotential (BP) is a slow negative cortical

potential that develops around 1.5 to 1 s prior to the onset of

a self-paced movement. It was first described by Kornhuber

and Deecke in 1964 and ever since it has been a powerful

tool for studying voluntary movements. The BP is the electrophysiological

sign of planning, preparation and initiation

of volitional acts [1]. Its amplitude, slope and latency have

been shown to be impaired in neurological disorders such as

Parkinson’s disease, Huntington’s disease, dystonia and

cerebellar disease, psychiatric disorders such as schizophrenia

and depression and in patients with focal lesions of the

thalamus, basal ganglia, cerebellum and prefrontal and

parietal cortices. Apart from scalp electroencephalography

(EEG) many different electrophysiological methods have

been used to quantify the BP: magneto-encephalography

(MEG), intracranial EEG recordings, combined EEG and

positron emission tomography (PET), combined EEG and

functional magnetic resonance imaging (fMRI), combined

EEG and MEG or combined MEG and PET. [2]

In order to locate cortical structures activated during

movement preparatory and executive phases, a method of

movement related evoked potentials (MREP) is often used.

The method consists of EEG segmentation and averaging

relative to movement onsets. The result of this method is a

movement synchronous electrical activity. Evoked potentials

obtained during spontaneous movements show a specific

spatiotemporal distribution. A movement planning

phase correlates with the BP, followed by a movement

preparation phase which manifests as a steeper-sloped potential,

the negative slope (NS), and finally a movement

execution phase associated with a sharp negative peak, the

motor potential (MP). Spatiotemporal maps indicate that the

brain electrical activity generated during self-initiated

movements arises from the frontocentral regions of the

brain, more particularly from the supplementary motor area

(SMA). Further, the activity spreads to the contralateral

primary motor cortex (M1).

Variations in the BP have been the most frequently investigated

in Parkinson’s disease (PD) patients. PD belongs

to a group of conditions called motor system disorders,

which are the result of the loss of dopamine-producing brain

cells. Four primary symptoms of PD are tremor, or trembling

in hands, arms, legs, jaw and face; rigidity, or stiffness

of the limbs and trunk; bradykinesia, or slowness of movement;

and postural instability, or impaired balance and

coordination. As these symptoms become more pronounced,

patients may have difficulty walking, talking, or completing

other simple tasks. [3] A slowness of movement execution

and a difficulty of movement preparation and initiation in

PD patients do not affect all kinds of movements to the

same extent. PD patients confront difficulties while performing

self-initiated movements, but there seems to be no

differences between PD patients and healthy subjects in

preparation and execution of externally triggered movements.

[4] The BP amplitude reduction has been observed in

PD patients repeatedly. However, the BP has not been consistently

found to be abnormal in PD patients. This can be

due to differences in disease severity and a medication state

between subjects in different studies.

2

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II.MATERIALS AND METHODS

The goal of this experiment was to examine differences

in the cerebral dynamics between the control group and the

group of subjects with the diagnosis of the Parkinson’s

disease (PD) and to demonstrate its clinical usability. The

experiment consisted of self-paced voluntary movements.

The control group consisted of 11 healthy, right-handed

males. Control group subjects did not suffer from any

known neurological or other diseases. They ranged in age

from 23-25 years (mean 23.45+/-0.68). The group of subjects

with the diagnosis of the Parkinson’s disease consisted

of 16 subjects, 7 of them were patients with left onset PD

(the right brain hemisphere) and 8 of them were patients

with right onset PD (the left brain hemisphere). There were

6 female and 9 male subjects and they ranged in age from

41-73 years (59.4+/-9.8). Mean duration of the disease was

4.5 years (range from 0.5-10 years). Subjects of both groups

were informed in detail about the experiment and signed a

consent form. The experiment was approved by the local

ethic committee.

During the experiment subjects sat in a comfortable

chair. They were told to close their eyes and to relax. They

had to minimize body movements, ocular movements and

blinking as much as possible in order to decrease contamination

of the recorded signal. Some of the subjects from the

group with the PD diagnose had tremor and their recoded

signals were contaminated with the muscle artifacts.

Subjects were instructed to perform repetitive trials in

which they had to push the button every 5-10 seconds.

There were 100 artifact-free trials in each experiment.

Movement related evoked potentials (MREP) were recorded

using an EEG amplifier, the Brain Products Gmbh

QuickAmp 136 and an electrode cap consisting of 32 active

electrodes, the actiCAP. For data acquisition and analysis

software programs Brain Vision Recorder and Brain Vision

Analyzer were used.

At the beginning of the experiment was necessary to prepare

the subject for the measurement. The actiCAP with

32 electrodes was placed on the subjects head. Electrodes

were placed according to the International 10/10 system.

Monopolar recording was performed toward an average

activity obtained from all electrodes. ActiCAP enables low

electrode-skin impedances and a short subject preparation

time. The electrode impedance was adjusted to be below

5 kOhm using an electrically high conductive gel. Vertical

(VEOG) and horizontal (HEOG) eye movements were monitored

to avoid contamination of the recorded signal with

ocular artifacts. Muscular activity was recorded from right

and left abductor policis brevis (APB). The closure of the

pushbutton contact was applied as a trigger signal. The

EEG, EMG, VEOG, HEOG and the trigger signal were

recorded during the whole experiment.

EEG signals were filtered with a pass band filter with a

low-cutoff frequency set to 0.1 Hz and a high-cutoff frequency

set to 70 Hz both with a slope of 48 dB/oct. EMG

signal were filtered with a pass band filter with a low-cutoff

frequency set to 0.1 Hz and a high-cutoff frequency set to

300 Hz. All signals were digitalized by a sample rate frequency

of 1000 Hz.

The analysis of the recorded EEG signal was performed

off-line after each experiment. Obtained MREP were analyzed

in the intervals of 2000 ms before and 1000 ms after a

trigger onset. The MREP baseline was determined as the

average of all samples from the first 300 ms period. Before

each signal averaging, the computerized semiautomatic

ocular correction and artifact rejection were made in order

to reject trials in which blinks, artifacts or deviations in the

eye position occurred. From the individual MREP the grand

average was calculated. After that trails were filtered by a

low pass filter with a cutoff frequency of 8 Hz in order to

eliminate the residual alpha activity.

III. RESULTS

Obtained grand averages of MREP from PD patients and

controls were compared and the result is shown on Figure 2

(right thumb movement) and Figure 3 (left thumb movement).

Figures show MREP above the motor cortex (electrodes

on the side of the head that is contralateral to the

hand performing the movement). It can be seen in Figure 1

that onset points of characteristic components are assigned

with the same names as the corresponding components: BP,

NS and MP. MREP are shown in a time interval beginning

2000 ms before the trigger onset and ending 1000 ms after

the trigger onset. The trigger onset is shown in the figure by

a vertical line placed on a time axis at 0 ms. It can be seen

that the BP starts earlier for healthy controls than for PD

patients.

Fig. 1 Characteristic components of MREP

3

Movement related evoked potentials in Parkinson's disease patients and healthy controls

From figures average values for BP, NS and MP can be

obtained. The BP starts for the right thumb movement

at -1290 ms for patients with right onset PD (0+/-0.89 μV),

at -946 ms for patients with left onset PD (0+/-0.99 μV) and

at -1651 ms for healthy controls (0+/-0.50 μV). It can be

concluded that the standard deviation of the BP amplitude is

much greater for PD patients, which is probably due to

differences in a disease severity and a medication state. A

slope and an amplitude of the later component, the NS, are

not influenced, yet it starts earlier for the PD patients. The

NS starts for the right thumb movement at -525 ms for patients

with right onset PD (-1.36+/-1.69 μV), at -423 ms for

patients with left onset PD (1.50+/-1.30 μV) and at -275 ms

for healthy controls (-1.06+/-1.09 μV). The MP starts for

the right thumb movement at -134 ms for patients with right

onset PD (-2.15+/-1.81 μV), at 39 ms for patients with left

onset PD (3.84+/-3.37 μV) and at -7 ms for healthy controls

(-3.45+/-1.52 μV).

C3FC1

-2000 -1500 -1000 -500 0 500

-3

-2

-1

0

1

Fig. 2 MREP during spontaneous right thumb movement; controls (blue)

and patients with right onset PD (red)

C4FC2

-2000 -1500 -1000 -500 0 500

-3

-2

-1

0

1

Fig. 3 MREP during spontaneous left thumb movement; controls (blue)

and patients with left onset PD (red)

-1.50 μV 0.00 μV 1.50 μV

-2000 ms - -1880 ms -1880 ms - -1760 ms -1760 ms - -1640 ms -1640 ms - -1520 ms -1520 ms - -1400 ms

-1400 ms - -1280 ms -1280 ms - -1160 ms -1160 ms - -1040 ms -1040 ms - -920 ms -920 ms - -800 ms

-800 ms - -680 ms -680 ms - -560 ms -560 ms - -440 ms -440 ms - -320 ms -320 ms - -200 ms

-200 ms - -80 ms -80 ms - 40 ms 40 ms - 160 ms 160 ms - 280 ms 280 ms - 400 ms

400 ms - 520 ms 520 ms - 640 ms 640 ms - 760 ms 760 ms - 880 ms 880 ms - 1000 ms

Fig. 4 Spatiotemporal distribution of MREP during spontaneous left thumb

movement in patients with right onset PD

-1.50 μV 0.00 μV 1.50 μV

-2000 ms - -1880 ms -1880 ms - -1760 ms -1760 ms - -1640 ms -1640 ms - -1520 ms -1520 ms - -1400 ms

-1400 ms - -1280 ms -1280 ms - -1160 ms -1160 ms - -1040 ms -1040 ms - -920 ms -920 ms - -800 ms

-800 ms - -680 ms -680 ms - -560 ms -560 ms - -440 ms -440 ms - -320 ms -320 ms - -200 ms

-200 ms - -80 ms -80 ms - 40 ms 40 ms - 160 ms 160 ms - 280 ms 280 ms - 400 ms

400 ms - 520 ms 520 ms - 640 ms 640 ms - 760 ms 760 ms - 880 ms 880 ms - 1000 ms

Fig. 5 Spatiotemporal distribution of MREP during spontaneous right

thumb movement in patients with right onset PD

The BP starts for the left thumb movement at -927 ms for

patients with left onset PD (0+/-0.99 μV), at -1893 ms for

patients with right onset PD (0+/-0.66 μV) and at -1561 ms

for healthy controls (0+/-0.60 μV). The NS starts for the left

thumb movement at -421 ms for patients with left onset PD

(-0.97+/-1.71 μV), at -378 ms for patients with right onset

PD (0.89 +/-2.26 μV) and at -328 ms for healthy controls

(-1.06+/-1.09 μV). The MP starts for the left thumb movement

at -88 ms for patients with left onset PD

(-2.77+/-2.08 μV), at -47 ms for patients with right onset

4

Movement related evoked potentials in Parkinson's disease patients and healthy controls

PD (1.70+/-1.72 μV) and at -37 ms for healthy controls

(-3.24+/-1.32 μV).

It is interesting to compare movements of healthy and affected

side of the body. Figure 4 and Figure 5 show a spatiotemporal

distribution of MREP in patients with right onset

PD. Maps show the spatiotemporal distribution in a period

2000 ms before and 1000 ms after the trigger onset. An

amplitude scale range is from -1.5 μV (blue) to 1.5 μV

(red). Each map represents an average activity in a period of

120 ms. Figure 4 refers to a condition where a subject is

performing the movement with his/her healthy hand, and

Figure 5 refers to a condition where the movement is performed

with the affected hand. It can be clearly seen that the

negative activity that occurs prior to the movement onset

starts earlier when the movement is performed by means of

a healthy hand.

IV. DISCUSSION

In order to explore the influence of Parkinson’s disease

on movement related potentials we performed a simple

spontaneous thumb-pacing experiment with PD patients and

healthy controls. We observed shift in the latency of the

beginning of the BP in patients with PD. The BP latency

shift was observed for the affected hand. The beginning of

the BP was not influenced for the healthy hand. The later

components of MREP were not significantly influenced.

From the numerical representation it can be concluded that

the standard deviation for PD patients is greater than for the

controls. This group of subjects is much more versatile than

the control group. They vary in age, gender, illness duration

and severity and medication dosage. Yet we can conclude

that the BP is indeed influenced by the PD because both for

individuals and for the whole group we were able to come

up with a conclusion which side of the body was affected by

comparing related MREP.

V. CONCLUSION

MREP that occur during spontaneous thumb movement

are influenced by the Parkinson’s disease in their initial

part, the BP. The influence occurs as a latency shift and

amplitude reduction of the BP. It is important for future

studies to perform the experiment with more homogenous

groups and to match the control group by age and gender.

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