中 國 醫 藥 大 學
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碩士學位論文

與年齡有關的動作準備皮質電位之分析

Age-associated Analysis of Movement-Related Cortical Potential

指 導 教 授 ： 蔡 崇 豪 教授

研 究 生： 林 義 宗

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本論文係 林義宗 於中國醫藥大學醫學研究所完成之碩士論文，經考試委員審查及口試合格，特此證明。

考試委員

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摘　要

動作準備皮質電位 (Movement-Related Cortical Potential, MRCP) 係吾人在運動起始之前腦波一連串的變化。一般認為該電位有三個構成的部份。第一個部份稱為 Bereitschaftspotential（BP），第二個部份稱為 Negative Slope（NS，負斜波），最後一個部份稱為 Motor Potential（MP，動作電位）。其中，第一個部份產生於動作起始前約 1.5 秒處。此部份除了被稱為 BP 之外，也被稱為 readiness potential；第二個部份（NS'）產生於動作起始前約 500 毫秒（500 ms），接著則是 MP。BP 最常被使用於運動障礙病態生理的研究。本實驗的實驗目標乃分析年齡(以 40 歲為分界)與動作準備皮質電位之關連性。在該實驗中，共有 26 位健康且慣用右手的受測者參與。吾人將其區分為 40 歲以上和 40 歲以下兩組，每組各有 13 位受測者。每位受測者皆被要求直視位於受測者位置約一公尺前的圓型紅色小點，左右手腕各以受測者個人的速度（self-paced rate，約每七秒鐘一下）作伸屈的動作，同時記錄其腦波（26 個位置，根據國際 10-20 系統）的變化。數據的統計方法係使用 student's t-test 來比較兩組之間左右手在 26 個位置 MRCP 的變化，並規定 P 值小於 0.05 為有意義的統計。從本實驗所得到的結果顯示，該兩組左右手的 MRCP 無明顯的變化（P>0.05），意即若以 40 歲為分界點，動作準備皮質電位不受年齡的影響。

關鍵字：動作準備皮質電位，動作準備電位（Bereitschaftspotential；BP），負斜波（Negative Slope；NS'），動作電位（Motor Potential；MP）。

Abstract

Movement-Related Cortical Potential（MRCP）is a series of changes of electroencephalographic（EEG）recordings before the onset of movement. In general, the MRCP is composed of three components: Bereitschaftspotential（BP, also called readiness potential）, Negative Slope（NS'）and Motor Potential（MP）. The first component（BP）begins approximately 1.5 seconds before movement onset, and the second component（NS'） initiates about 500 ms prior to the onset of movement; the third component follows NS' which is called Motor Potential（MP）.The MRCP is commonly used to study the pathophysiological aspects of human movement. As was acknowledged, the motion speed of the aged people usually become slow as compared with the young counterparts. It is uncertain whether the movement preparation or readiness would also perturbed along with the motion slowness.

The aims of the current study is to analyze the any different changes of MRCPs between two groups of people, the young and old groups, with the age of 40 as the watershed so as to understand whether motion preparation would be perturbed by the aging process.

Twenty-six right-handed normal volunteers,（17 men and 9 women, were recruited）to participate the study. The subjects were divided into two groups with 40 years as the cutting point, and each group consisted of 13 subjects. During the investigation, the subjects were asked to have their visual focus on the red spot about one meter in front of them, and performed left and right palm dorsiflexion movements in their own pacing（commonly around seven seconds）and recorded EEG in 28 locations（placement was according to international 10-20 system）. We used the student’s t-test as the statistical method to compare the changes of MRCPs, and when statistical significance was defined by p value below 0.05.

From our results, the current results revealed no statistical significant difference of the amplitudes on the changes of MRCPs of the left and right hands between the two groups of subjects. In other words, the movement preparation of the mankinds was not influenced by age when we used 40 years old as a cut-off point to evaluate MRCPs, then the MRCPs were not influenced by the age.

Keywords: Age-associated, Movement-Related Cortical Potential（MRCP）, Bereitschaftspotential（BP）, Negative Slope（NS’）, Motor Potential（MP）.

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Ⅰ. Introduction

1. Background

In 1950s, Bates[1] attempted to record the movement-related activity by photographic superimposition of multiple single-sweep electroencephalographic （EEG） tracts. Unfortunately, he only identified the post-movement activity because of the shortage of equipments and skills（no computer software for making on-line back averaging available at that time）. In 1960s, Kornhuber and Deecke[2] successfully made the first report of EEG activity prior to the voluntary movement onset. They stored all the data on magnetic tape, and then they made an off-line averaging of the EEG segments before the electromyogram（EMG）onset by backward of the tape. Later, by using this technique, they also successfully identified two components of MRCP, Bereitschaftspotential（also called readiness potential, RP）and reafferente Potentiale[2]. Furthermore, they found two more components prior to the movement onset, pre-motion positivity（PMP） and motor potential[3]（MP）. Before 1980s, although there were many studies on the MRCP, the physiological significance has not been fully clarified yet.

In 1980s, Libet et al.[4] reported that the intention to move occurred much later than the onset of BP, and their report has brought up a continuing question:“what is the physiological implication of the BP?" [5,6]. There have been many identifiable components of MRCP proposed by scientists（see Table. 1.）. In 1980s, Shibasaki et al.[7] identified eight components of MRCP. There were: BP, NS', P-50, and N-10（pre-movement）; N+50, P+90, N+160, and P+300 （post-movement）. Except BP and NS', each component was named according to the surface polarity and the mean time interval between the peak of each component and the peak of the averaged EMG. If the peak occurred before the EMG peak, the interval will be designated negative; on the contrary, if the peak occurred after the EMG peak, then the interval will be designated positive.

BP starts approximately 1.5 s prior to the onset of movement. It is symmetrically and widely distributed over the scalp. Besides, the maximal of BP is at the middle centro-parietal area. The onset of BP differs among different conditions of movement and among subjects. For example, BP commonly starts much earlier in the experimental condition as compared to the movement executed in more natural conditions. The reason may be that when the subject has much time to prepare for the movement in the experimental condition, the BP starts much earlier as compared to the movement executed in more natural conditions.

Shibasaki et al.[7] designated the late segment as Negative Slope（NS'）when the BP suddenly increases its gradient about 500 ms prior to the onset of movement. The NS' was distinguished from the early BP based on abrupt increase of the gradient at the central electrode corresponding to the movement for each individual subject. The term BP, however, can be indicated to three parts. The first part is the early segment "early BP" ; the second part is the late segment "late BP" and the last one is BP for the early BP and the late BP inclusive. The late BP is maximal over the contralateral central area for the hand movement and at the midline for the foot movement[8]. In order to study BP in individual subjects, it is necessary to record EEG via multiple electrodes, and then scientists may identify the abrupt increase of the gradient. Subsequently, the late steeper slope was called NS2 to contrast it with the earlier NS1[9], and BP2 to differentiate the earlier BP1 by the group of Deecke[10,11]. On the initiation of the process, the late BP was considered to be more specific for the site of movement; whereas the early BP was thought to represent the more general preparation for the next movement because of its diffuse distribution.

The early BP might be movement site-specific at least within the supplementary motor area（SMA）and the lateral pre-motor cortex. The midline maximal and symmetric distribution of early BP is most likely because of the summation of electrical fields generated from homologous areas of both hemispheres through volume conduction. The asymmetric distribution of the late BP associated with unilateral hand movement has been studied as the lateralized readiness potential[12]（LRP）. LRP was recorded between the electrodes over the two motor cortices. This montage would be expected to emphasize the asymmetrical components of the BP, particularly those arising from the underlying sensorimotor cortex[32].

The method of mentioned above is derived from the subtracting of the potentials recorded at C3 and C4（right-hand movement and left-hand movement）. In the field of behavioral psychology, LRP is commonly obtained in a choice reaction time task, and it is often used to investigate the time relationship between the stimulus evaluation system and the response activation system.

The component termed PMP or P-50 is predominant over the hemisphere ipsilaterally to the moving hand[3,7]. Since this component was not seen with bilateral simultaneous hand movement, Shibasaki and Kato[13] proposed that it might be related to the suppression of movement of the opposite hand in intended unilateral hand movement. However, this component might be just a trough formed between two successive negative potentials, and the peak of waveform might not have physiological significance. In fact, P-50 has not been identified by epicortical recording. As far as the MP or N-10 is concerned, this component is well localized to a small area of the contralateral central scalp. It is also precisely corresponding to the movement site, and it occurs immediately prior to the onset of movement. This component most likely represents the activity of pyramidal tract neurons in the primary motor cortex （M1）. The initial slope of MP [14] （isMP）corresponds to the early part of MP.

In 1980s, Shibasaki et al.[7] named the four post-movement of MRCP components according to the time interval measured from the peak of the averaged, rectified EMG to the peak of each identifiable peak. The component N+50 is a prominent negative peak localized to the frontal region and corresponds to the frontal peak of motor potential （fpMP）. The component P+90 is predominant over the parietal region, and it is larger over the contralateral hemisphere. The peaks of N+50 and P+90 showed similar scalp distribution to those of N70 and P65, respectively. From the observations, we assume that those peaks are related to kinesthetic feedback[15]. However, because of the different peak time after the movement onset between N+50 and P+90, it is still undetermined whether or not these two peaks are derived from a tangentially oriented dipole sitting in the post-central gyrus. The component N+160 is localized to the contralateral parietal area, thus forming a localized positive-negative complex with P+90. The component P+300 corresponds to reafferente Potentiale[2].

The magnitude and time course of BP recorded in the self-paced condition are influenced by various factors（see Table. 2.）. These factors include level of intention, preparatory state, movement selection as to freely selected versus fixed, learning and skill acquisition, pace of movement repetition, praxis movement, forced exerted, and so on[16].

As regards for the force exerted in isometric muscle contraction, Slobounov et al.[17] found that there is a larger amplitude of the last 100 ms segment of BP with greater perceived efforts rather than the force itself, while other segments were not influenced. Since the exertion of stronger force is commonly associated with the greater intention, motivation and effort of the subject, the effects of these psychological and physical factors cannot be clearly distinguished from each other. In 1990s, Masaki et al.[18] used a method to compare a target force production task with simple task. The results showed that the movement requiring precision in terms of force production was found to be preceded by a larger late BP than the simple task.

The speed of movement also affects the onset and magnitude of BP; the faster the movement is executed, the later the BP begins. As for the site of movement, Jankelowitz and Colebatch[19] found that larger late BP in self-paced movement of the proximal than the distal part of upper extremity.

In the case of hand movements, SMA and lateral pre-central gyrus, both bilaterally, were estimated to be the main generator sources for early BP. In 1990s, Praamstra et al.[20] estimated three dipole sources for explaining the early BP, one in the SMA and two others in bilateral M1. Furthermore, they showed that only the current source identified in the SMA was affected by the mode of movement selection; larger before freely selected than fixed movement. In 1990s, Cui and Deecke[11] used high-resolution DC-EEG analysis to find that BP occurred earliest in the medial wall motor areas （SMA and cingulated motor areas）, then in the contralateral M1, and lastly in the ipsilateral M1. The current consensus on the generator source of each MRCPs components is summarized in Table. 3.

2. The purpose of this study

Age is conventionally considered to be an important factor which may affect the motor speed of both mankind and animals. As it was acknowledged, the motion speed of the aged people usually become slowly as compared with the young counterparts. It is uncertain whether the movement preparation or readiness would perturb along with the motion slowness. The aim of the current study is to analyze the differences of MRCPs between two groups of people, the young and old groups, with the age of 40 as the cutting-off point, and to understand whether motion preparation would be perturbed by aging. In this study, 26 healthy and right-handed volunteers were recruited and divided into two groups based on their age.（the cutting-off point was set at 40 years of age）. In addition, we selected three segments（BP, NS' and fpMP）of MRCPs to investigate the age influence on MRCP.

Ⅱ. Methods

1. Subjects

In this study, 26 right-handed volunteers（19 men and 7 women）were recruited to participate this investigation. Every subject gave their inform consents prior to the investigation.

2. Experimental procedures

Initially, all subjects sat in an armchair comfortably and then they were asked to fixate their eyes on a small red spot approximately 1.5 meters in front of them. During the MRCP recording, the subjects performed hand movements at their self-paced rate (around 7 seconds per movement). The recording sessions were paused every 4 minutes for the subjects to refresh and to avoid artifacts. We selected the data of BP, NS' and fpMP. During the MRCP recording, the subjects performed hand movements （left hand and right hand） at their self-paced rate (around 7 seconds per movement). The recording sessions were paused every 4 minutes for the subjects to refresh and to avoid artifacts. We selected the data of BP, NS' and fpMP. Finally, the off-line analysis was performed.

3. Data acquisition

Twenty-six Ag/AgCl scalp electrodes were used for the electroencephalogram (EEG) recording. They comprised six midline sites and ten pairs of lateral sites. One electrode below the left outer canthus was used for the electro-oculogram (EOG) monitor. Electrode impedance was kept below 5 kΩ. All electrodes were referenced to the linked earlobes and the signals were filtered with a band pass ranging from 0.05 to 70 Hz (NeuroScan SynAmps, Neurosoft, Inc. Sterling, Va, USA). Surface electromyography (EMG) was recorded by a pair of electrodes taped over the right extensor digitorum communis (EDC) muscle; the signals were then rectified and filtered at a bandpass of 30-200 Hz. The EEG and EMG signals were sampled at a rate of 1 kHz for each channel. The subjects were seated in a comfortable chair with their hands resting on the chair arms. They were requested to perform self-paced, fast and brisk voluntary extensions of the right wrist at a rate of about one every 7 seconds. During recording, they had to fix their vision on a red target located 1.5 meters in front of them. Each subject accomplished four blocks of the four-minute continuous task with a three-minute break in between. EEG, EOG, and EMG data were gathered simultaneously and digitally for off-line analysis. The EEG recordings were conducted in accordance with the Declaration of Helsinki. The epoch period comprised 2000 milliseconds prior to the EMG onset (-2000 ms) and 1000 ms after the EMG onset (1000 ms). The baseline was corrected from the initial 250 ms (-2000 to -1750 ms). Artifact-free EEG sweeps were averaged after precise alignment with the rectified EMG burst onset.

4. Statistical method

The averaged MRCP waveforms from the 26 electrodes were used to compare the differences between the elder group and the young group. We calculated the mean amplitude arising from -1500 ms to -500 ms, which is known as the early BP; we also calculated the mean amplitude arising from -500 ms to the movement onset, which is regarded as the late BP. The peak amplitude of motor potential on FCz (also called fpMP, frontal peak of motor potential) was also measured for comparison. Data were analyzed by Student's t-test; a $P<0.05$ was considered significant.

Ⅲ. Results

In this study, 26 right-handed volunteers（19 men and 7 women, the average age was represented as MEAN±S.D., see Table. 5.）were recruited to participate this investigation. Twenty-six Ag/AgCl scalp electrodes were used for the electroencephalogram (EEG) recording.

We calculated the mean amplitude arising from -1500 ms to -500 ms, which is known as the early BP; we also calculated the mean amplitude arising from -500 ms to the movement onset, which is regarded as the late BP. The peak amplitude of motor potential and onset latencies at FCz was also measured for comparison. Data was analyzed by Student's t-test; a $P<0.05$ was considered significant.

The differences of MRCP in 26 locations（FP1,FP2, F3, FZ, F4, F7, F8, FC3, FCZ, FC4, C3, CZ, C4, T7, T8, CP3, CPZ, CP4, P7, P8, P3, PZ, P4, O1, OZ, O2; which were according to International 10-20 system）of electrodes（right and left hands; young: below 40 years of age; old: above 40 years of age）were shown in Table.4. The difference of the amplitude and latency of right hand and left hand（young: below 40 years of age ; old: above 40 years of age）on FCz was shown in Table. 6. The Grand average of MRCPs of left wrist brisk dorsiflexion was shown in Figure. 1. On this graph, the red color line represents the waveforms of the subjects with age above 40 years; the black color line represents the waveforms of the subjects with age below 40. Figure. 2 showed the Grand average of MRCPs of right wrist brisk dorsiflexion . On the graph, the red color line represents the waveforms of the subjects with age above 40 years and the black color line represents the waveforms of the subjects with age below 40.

Ⅳ. Discussion

MRCPs are the summed cortical activity occurring around the time of movement, and are usually recorded using surface electrodes placed over the scalp. However, the slow negative wave, the BP, preceding voluntary movement by one second or more was first reported forty years ago[3,23].

During recording, the subjects were requested to keep their eyes open, and to fixate on a single point. The former was to minimize alpha activity, and the later was to avoid eye movement. The onset of EMG and the onset of movement were used as triggers for data collection. Besides, the magnitude and time course of BP which were recorded in the self-paced rate and they were influenced by many factors.

In 1970s, Deecke et al.[22] proposed three types of BP depending upon the terminal part of the potential. Dick et al.[23] refer to "extreme inter-individual variability." Within subjects, the reproducibility is high, and there appears to be no systematic effect of practice on the BP. It appears that the BP may be absent in some subjects: such a finding may reflect differences in cortical anatomy rather than a more profound difference of how movement is generated. Age-related changes are minor.[30] Although the amplitude of the late component of the MRCP correlates with the force of contraction[26], Dick et al[23]. found little effect of movement amplitude or speed on the amplitude of the BP. In 2000s, Johnston et al.[24] reported that fatiguing contractions mainly affected the MP. Jankelowitz and Colebatch[25] found only mild changes of the BP in subjects with peripheral muscle paralysis; the onset is earlier and change in the waveform around the time of movement and afterward. Levodopa treatment increases the amplitude of the early BP in both animals and patients with Parkinson's disease, and dopamine antagonists tend to have the opposite effect.

In 1982, Libet et al.[27] found that impulsive spontaneous movements were preceded by a substantially shorter negativity than pre-planned ones. Benecke et al.[28]

found that the amplitude of the BP was increased when two movements were performed simultaneously. Touge et al.[29] showed that when subjects had to choose the direction of movement, the early BP became larger. As far as the current studies of MRCPs are concerned, they often use simple motor task such as finger extension, wrist extension, elbow movement and so on. In fact, these movements are quite different from practical movements which are under more natural condition. In 2000s, a study[31] was performed to investigate the recordings of MRCPs of daily life movements or the so-called praxis movements[30]. In the study mentioned above, the MRCPs were recorded from scalp electrodes in association with self-paced praxis movement of the right hand in right-handed normal subjects. The results of the study showed that BP started at the superior parietal region, predominantly on the left as early as 4 seconds before the movement onset, and then developed over the inferior parietal region. About 1 second before the movement onset, a sharp negative slope is seen over the midline frontal region and bilateral sensorimotor regions predominantly on the left. When the preparation of praxis movements performed in the right-handed subjects, the initial activation of the left parietal cortex is consistent with the ideomotor apraxia with lesion in the left parietal lobe.

The pre-movement slow negativity can be clearly divided into two components of MRCP. They are: early BP and late BP （also called NS'）. Both components are related to preparation or execution of voluntary movement. In addition, these two components are differentially influenced by many factors. Early BP is influenced by cognitive functions, while late BP is influenced by features of the movement itself. The cognitive functions include level of intention, preparatory state and movement selection; the features of movement itself include precision, discreteness and complexity.

In the pathological conditions, early BP is abnormal in PD, and the late BP is abnormal in hemiparesis and dystonia. Early BP and late BP are both abnormal in cerebellar lesions. From these observations, we know that the location of generators of the two components; the generators for early BP are: pre-SMA, SMA proper and bilateral pre-motor area （area 6）; and the generators for late BP are: contralateral precentral cortex including area 6 and area 4.

After conducting many experiments to interpret and to elucidate MRCPs, Kornhuber and Deecke gave a general explanation for the question "What the physiological implication of BP is". Firstly, there is a general decision to move periodically in the beginning of the whole experiment; secondly, it is possible that the decision for each individual movement is made subconsciously and the consciousness is switched on about 200 ms before movement onset. Thirdly, this 200 ms interval gives time for consciousness to veto the movement.

We proposed that age might be a conventional factor to influence the MRCP, because the changes of cognitive processes, decrease in nerve cells, and reductions of regional blood flow are associated with advancing age, and it is conceivable that MRCP components might also decline with aging. However, from our current results, when the cutting-off point of age was set at 40 years old, it did not affect the presentation of MRCP.

According to the experimental results of Jaswinder et al.[30] in 1990s, they examined aging effects on movement-related cortical potential in 26 right-handed, and neurologically normal subjects, and they found that motor programming as indexed by MRCP is unaffected by normal aging. The amplitudes, scalp distributions, the onset latencies of pre-movement and post-movement components of MRCP showed no significant difference between the young and old groups. The result of our current study is accordance with the results of Jaswinder et al.

Although it seems to be lack of aging effect on human brain potentials preceding voluntary movements, in 1990s, Isuhizuka, Tomi, and Sunohara [33] performed an experiment by similar methods, and they found the time required to prepare for voluntary movement and the period of preparation for movement are longer in aged subjects than in young subjects. In 2004, Labyta et al.[34] conducted an experiment to determine how cerebral aging influences the pattern of cortical oscillatory activity when a targeting movement with visual control is planned. Their results showed that the motor planning is less efficient in elderly subjects. As mentioned above, Isuhizuka H et al. defined young normal subjects as age below 40 years and aged normal subjects as age above or equivalent to 60 years old. We go back to the former part of this article, we know that there are many factors would affect the presentation of MRCP, and these factors include level of intention, preparatory state, movement selection as to freely selected versus fixed, learning and skill acquisition, pace of movement repetition, praxis movement, forced exerted, and so on. In general, the physical condition of the young is better than the aged, and then the differences of MRCP would appear. If we set more higher age as the cutting-off point, for example, 50 or 60 years, even 70 years of age, we may also evaluate the differences between each groups of people, and this investigation is worth further study. The limitation of this study is the recruitment of subjects. In addition, except selection of cutting-off point, we may study the MRCP of specific groups such as children, adolescents, young adults, the middle-aged, and the elderly, thus we may elucidate and clarify the presentation of MRCP.

V. Conclusion

From the current study, we can not detect statistically significant differences between the two groups of subjects. In other words, we know that when we used 40 years of age as the cutting-off point to test the MRCP between two groups of subjects （age above and below 40 years old）, we had a result that there was no significant change between the two groups of people.

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Ⅶ. *Appendixes*

Figure. 1.

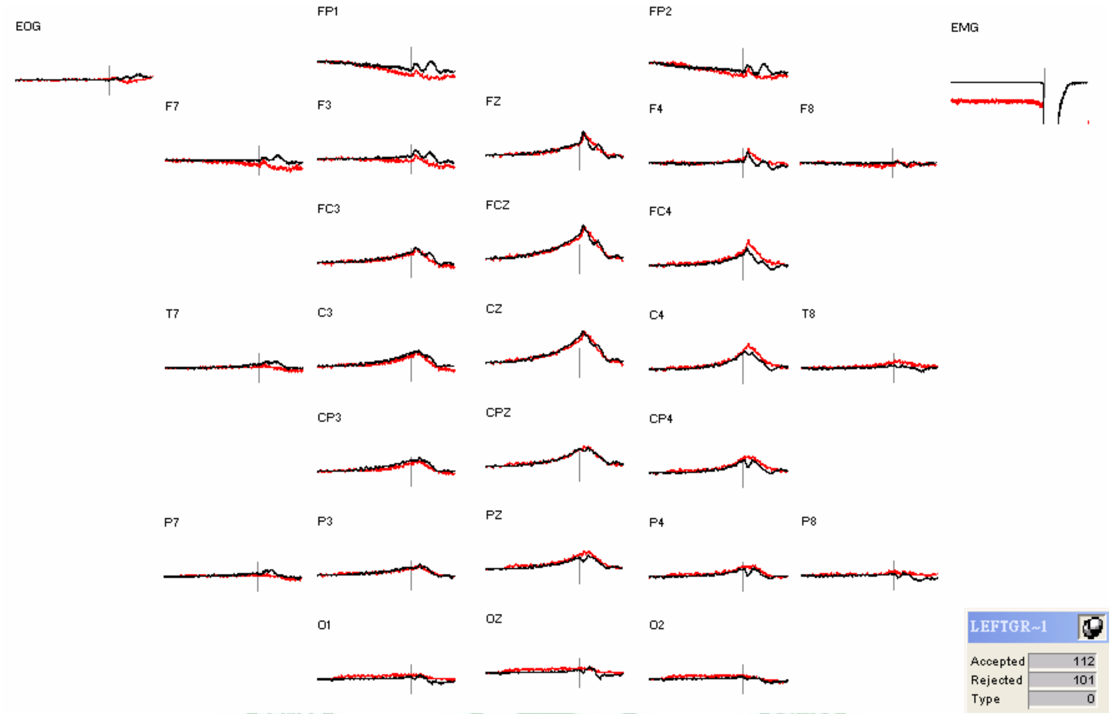

Fig. 1. Grand average of MRCPs of left wrist brisk dorsiflexion . The red color line represents the waveforms the subjects with age above 40 years; the black color line represents the waveforms of the subjects with age below 40.

Figure. 2.

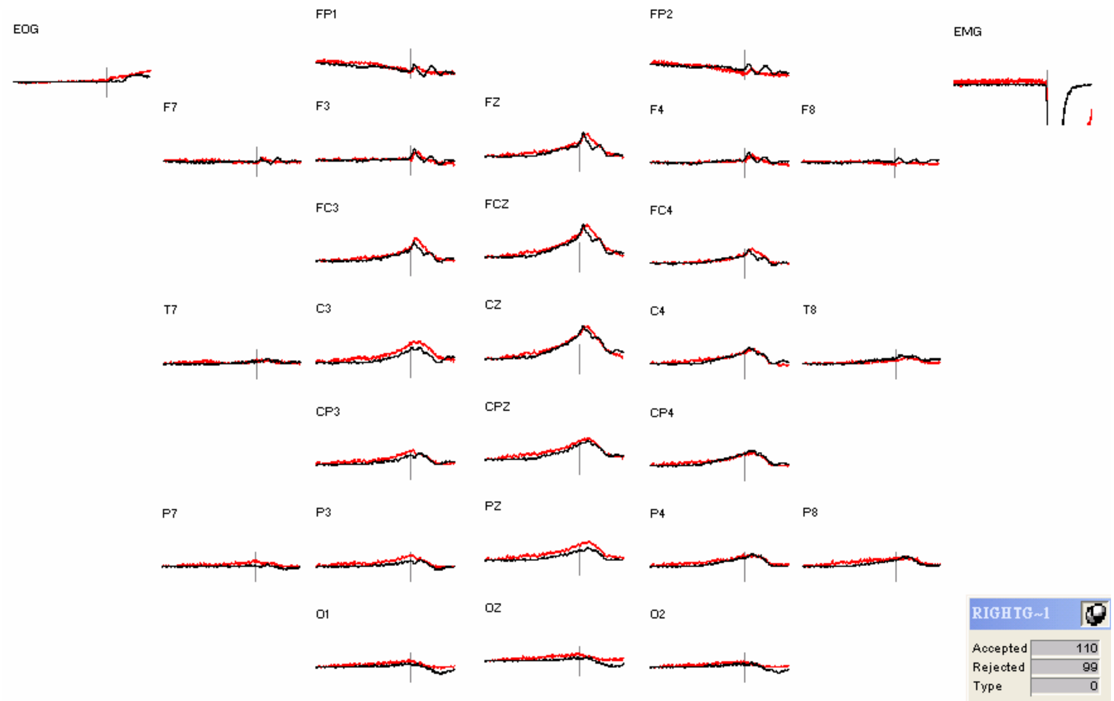

Fig. 2. Grand average of MRCPs of right wrist brisk dorsiflexion . The red color line represents the waveforms the subjects with age above 40 years; the black color line represents the waveforms of the subjects with age below 40.

Table. 1.

	Pre-movements components							Post-movements components					
Kornhuber & Deecke		BP		PMP		MP							RAP
Vaughan et al.		N1		P1		N2?		N2?					P2
Shibasaki et al.	BP		NS'	P-50		N-10		N+50	P+90		N+160		P+300
Dick et al.	NS1		NS2										
Lang et al.	BP1		BP2										
Tarkka & Hallett	BP		NS'	PMP		isMP		fpMP					
Kristeva et al.		RF				MF		MEFI	MEFII		MEFIII		PMF
Cui & Deecke	BP1		BP2			MP			PMPP		MEPI		MEPII

Table. 1. Terminologies of components of MRCP[32].

Table. 2.

Factors	Early BP	Late BP
Level of intention	Larger	
Preparatory state	Earlier onset	
Movement selection	larger	No effect
Learning	Larger during learning	
Praxis movement	Start parietally	
force	larger	
Speed	Later onset	
Precision	No effect	Larger
Complexity	No effect	Larger
Discretences	No effect	larger
Parkinsonism	small	No change
Cerebellar lesion	small	small
Dystonia	No change	small
Hemiparesis recovery	No change	involved
Mirror movement	No change	involved

Table.2. A list of factors influencing BP in normal and pathological conditions[32].

Table.3.

Generator sources of each component of movement-related cortical potentials	
Component	Generator sources
Early BP Earliest Next earliest	 Pre-SMA（bilateral） SMA proper（bilateral） Area 6（bilateral）
Late BP（NS'）	Area 6 （mainly contralateral） Area 4 （mainly contralateral）
MP（N-10）	Area 4（contralateral）
fpMP（N+90）	Area 3（contralateral）

Table.3. A list of generator sources of each component of movement-related cortical potentials[32].

Table. 4.

Locations of electrodes	P value: Y vs. O of left hand at -1500 to -500 ms	P value: Y vs. O of right hand at -1500 to -500 ms	P value: Y vs. O of left hand at -500 to 0 ms	P value: Y vs. O of right hand at -500 to 0 ms
FP1	**.81195**	**.31587**	**.63248**	**.80780**
FP2	**.75830**	**.51005**	**.43055**	**.78030**
F3	**.39434**	**.48137**	**.15931**	**.80174**
FZ	**.75313**	**.60294**	**.72923**	**.77202**
F4	**.93849**	**.17236**	**.10000**	**.94868**
F7	**.33872**	**.92236**	**.27797**	**.60159**
F8	**.42506**	**.96162**	**22427**	**.38474**
FC3	**.45757**	**.37322**	**.29972**	**.64975**
FCZ	**.88641**	**.32563**	**.40474**	**.98417**
FC4	**.93795**	**.80747**	**.99220**	**.84426**
C3	**.54677**	**.26105**	**.29250**	**.80724**
CZ	**.86352**	**.41618**	**.39752**	**.76553**
C4	**.80058**	**.51678**	**.66555**	**.61557**
T7	**.32016**	**.71813**	**.17518**	**.17962**
T8	**.80606**	**.57700**	**.25621**	**.29163**
CP3	**.39769**	**.79593**	**.22986**	**.92282**
CPZ	**.71833**	**.28760**	**.80699**	**.79575**
CP4	**.89499**	**.77948**	**.93592**	**.42773**
P7	**.77730**	**.40355**	**.55495**	**.60987**
P8	**.62426**	**.94180**	**.75709**	**.47710**
P3	**.98697**	**.26194**	**.63007**	**.38301**
PZ	**.63447**	**.22692**	**.99195**	**.54676**
P4	**.90252**	**.84078**	**.72125**	**.49442**
O1	**.27704**	**.05068**	**.10000**	**.17734**
OZ	**.11812**	**.16121**	**.87008**	**.35286**
O2	**.10030**	**.87369**	**.50969**	**.63827**

Table. 4. T-test of the MRCP between two groups of people. O presents subjects with age above 40 years old; Y presents subjects with age below 40 years old.
A ***P*<0.05** was considered significant.

Table. 5.

	Group 1 (40 y.o. >) n＝13	Group 2 (40 y.o.<) n＝13
MEAN±S.D. of Age	27.7692 ± 4.8846	58.2308 ± 11.9244

Table. 5. MEAN±S.D. of age of two groups of people.

Table 6.

	P VALUE
Y vs. O Latency Left hand	0.1518092273
Y vs. O Latency Right hand	0.9901707249
Y vs. O Amplitude Left hand	0.5386077535
Y vs. O Amplitude Right hand	0.7960595392

Table. 6. T-test of the amplitude and latency （on FCz） between two groups of subjects （left and right hands, P value <0.05：statistical significance）Y represents subjects with age below 40 years old; O represents subjects with age above 40 years old.