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The Effect of the Age in using the Brain-Machine Interface

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ABSTRACT

Brain Machine Interface (BMI) especially used for disabled people and military services. However, in the literature review, no study was detected on the relationship between the age of the person using the device and the performance of it. The aim of this study is to detect whether age is important in controlling a robot using BMI or in which age range this control is more efficient. The study was carried out with 45 healthy male subjects (age range: 7-60). The focusing and activating time of each subject was recorded and analysed. The analysis results showed that this time was the shortest in children and the longest in adults. The study results indicated that the time to focus and activate the device increased in parallel with the age, and hence, the children and the young were much better at controlling or activating an external device through BMI.

Keywords: Brain Machine Interface, Electroencephalography, Neurosky Mindwave, Robot

Beyin Makine Arayüzü kullanımında Yaşın Etkisi

ÖZ

Beyin Makine Arayüzü (BMI), özellikle engelli insanlar ve askeri hizmetler için kullanılmaktadır. Fakat yapılan literatür taramasında cihazı kullanan kişinin yaşı ile cihazdan alınan verim arasında herhangi bir çalışmaya rastlanmamıştır. Bu araştırmanın amacı, BMI kullanılarak bir robot kontrol edilirken cihazı kullanan kişinin yaşının önemi ve hangi yaş grubunda bu kontrolün daha verimli yapılabildiğini belirlemektir. Çalışma, 45 (7-60 yaş aralığı) sağlıklı erkek denek ile yapıldı. Her deneğin odaklanma ve aracı harekete geçirme süreleri kayıt altına alınarak analiz edildi. Analiz sonuçları, bu sürenin çocuklarda en kısa, yetişkinlerde ise en uzun olduğunu göstermiştir. Çalışmamızın sonuçları, yaşla birlikte odaklanıp aracı harekete geçirme süresinin arttığını ve bundan dolayı yetişkinlere göre çocuklar ve gençler BMI ile harici cihazları ve robotları kontrol etmede veya çalıştırmada daha başarılı olabileceklerini göstermektedir.

Anahtar Kelimeler: Beyin Makine Arabirimi, Elektroensefalografi, Neurosky Mindwave, Robot

INTRODUCTION

Brain Machine Interfaces (BMIs) are systems that enable people to use a machine, an electromechanical arm, or a variety of neuroprosthesis without using their muscles [1-3]. The purpose is to control the devices by interpreting the brain wave frequencies with these systems [4-5]. BMI technology, which is considered to be very important, especially for paralyzed patients [6-9]. It has been investigated to using in military in recent years such as in unmanned aerial vehicles, military trainings and operations [10, 11]. The brain, spinal cord and peripheral ganglia had the main components of the central nervous system, and the brain consists of more than 100 billion neurons [12]. Neurons stimulated electrically process and transmit data with electrical and chemical signals [13, 14]. Different thinking activities result in different brain signal patterns. Brain Computer Interfaces (BCIs) were controlled by direct use of brain signals [15]. Electroencephalography (EEG), near infrared spectroscopy, magnetoencephalography, functional magnetic resonance imaging, local field potentials and similar techniques have used in BCI applications. However, EEG is often preferred because of its simplicity, inexpensiveness, high temporal resolution and being practical in recording, processing and application [16, 17]. In this method, neural interactions are detected with the help of electrodes and transferred to the electronic systems by using special programs [18]. EEG signals vary based on brain activity

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status (Figure 1), and collected, processed and interpreted by algorithms. The most commonly used method is the Fast Fourier Transform (FFT). Since FFT converts a signal from temporal quantity into frequency quantity, brain frequency distributions can be examined [19].

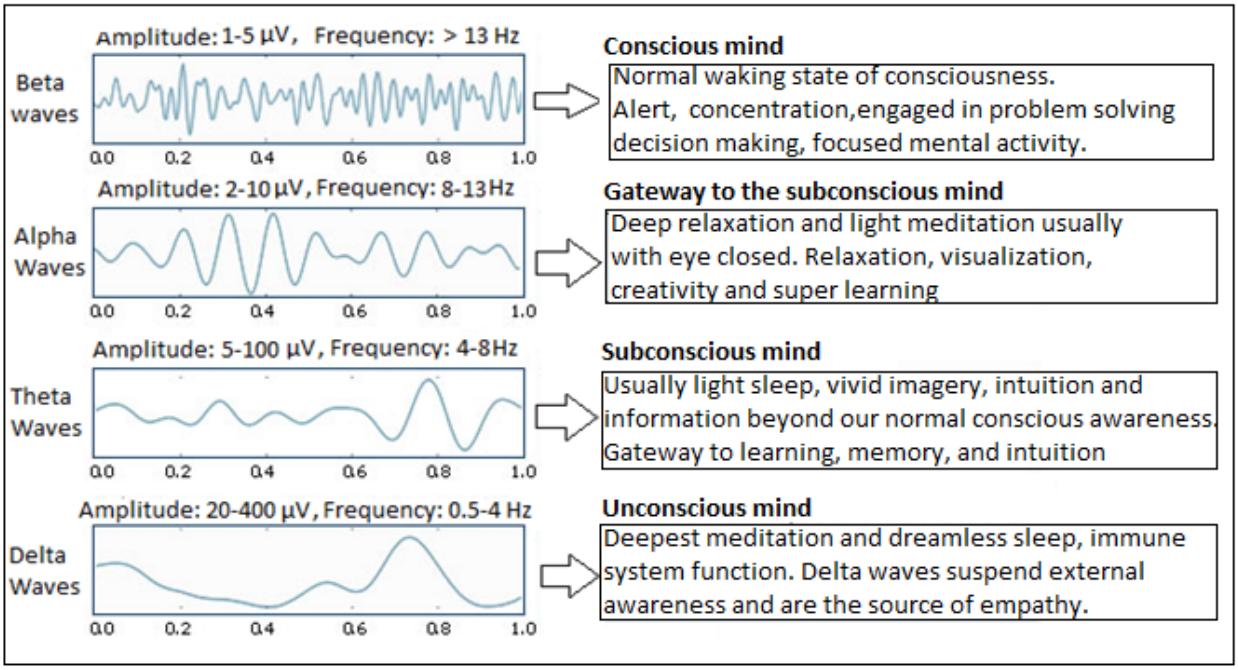

Figure 1. Four EEG brain waves and the states of consciousness

With EEG signals, patient treatment methods are developed and communication is established with electronic devices [17, 20]. General BMI process steps (signal collection, pre-processing, attribute extraction, classification and application) are shown in Figure 2 [1].

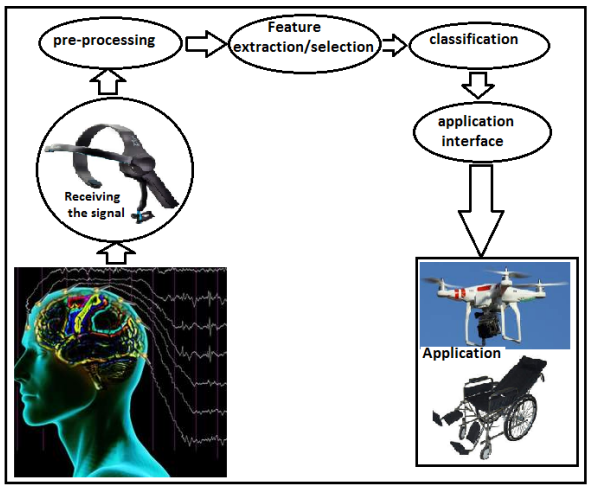

Figure 2. Basic process steps of BMI

EEG recording in children, young people and adults differs depending on brain, cerebellum, skull, scalp, head size and subject's behaviour and ability [21]. Some changes with age occur in the body and the brain [22, 23]. One of these changes was related with cognitive performance [24]. Therefore, the age and development of the person are important in the recording, processing and application of EEG signals. In the literature research, no study was detected examining the relationship between the age of the user and the performance obtained from the vehicle, robot or machine that works with the EEG signals. Furthermore, BMI is a rapidly growing multidisciplinary (biophysics, neuroscience, computer science, engineering and clinical rehabilitation) research and development technology. In our study, the purpose was to determine whether the age of the person was important when controlling a robot/machine by using BMI. The study is important since it is one of the initial studies in this field.

MATERIAL and METHOD

In the study, Neurosky mobile brain wave receptor device, which can measure real time EEG signals in the brain, was used. This device includes a ThinkGear chip which constitutes the interface between the user's brain and the robot systems. The sensor, which touches the contact and reference points in the forehead and ear, processes all the measured data and transfers these data to the software and applications in digital form. Processing raw brain waves, the attention and meditation values, which are cognitive activities, are calculated in the ThinkGear chip [21]. The technical specifications of this system are accessible from ref. [24] and [25]. Subjects who had brain and nerve disease or underwent any neurological surgery were excluded from the study. However, maximum attention was paid to standardizing parameters such as high temperature, cell phone, chemical exposure, radiation, drugs, and age

of individuals in the groups. The study was performed on 45 healthy male subjects, including 15 children (age range: 7-14), 15 teenagers (age range: 15-24) and 15 adults (age range: 25-60). The mini device that was designed by using Neurosky Mindwave BMI (Figure 3) was introduced to the groups, and the instruction on how to use it was explained.

Figure 3. The vehicle and neurosky mobile brain waves sensor that was used in the study.

Then, in a laboratory medium, the subjects were told to do linear movements to take the device to the point determined by using Neurosky Mindwave BMI, and bring it back. The distance between the subjects and the vehicle was about 60 cm. They were looking and focusing at the test vehicle and trying to move the vehicle with their powers of thought. The stopwatch was used to calculate vehicle activation times. Each subject's focusing and activating time was recorded. These recorded parameters were analyzed, and the success rates of the groups were compared with each other.

Data Analysis

For statistical analysis of the research data, the SPSS (Statistical Package for Social Sciences) was used. To define whether the data fit the normal distribution, the Kolmogorov Smirnov test was applied and the normal distribution of the data was determined. Then, the One-Way Analysis of Variance (ANOVA) was used to determine the significant difference between the groups. A difference at $p<0.05$ was accepted to be statistically significant.

RESULT and DISCUSSION

The results of the duration of moving the vehicle by focusing (mean ± standard deviation) and the average age of the participants are given in Table 1.

As seen in Figure 4, the difference between groups was significant at a statistical level ($p<0.05$). The time to move the vehicle by focusing increased significantly with age. These results show that young people can be more successful in a machine/robot control that works with thought.

BMI, also known as BCI, is a system that enables people to interact with their environment by using control signals generated from EEG activity, without utilizing the muscular and the motor neural systems [27-29]. EEG is a measurement of electrical stimuli of neurons. Therefore, it can be used to examine the cognitive activities of human [20, 30]. In recent years, EEG waves have been used in a variety of applications such as remote robot control, wheelchair control and computer interface control for people with paralysis [15, 31-34].

Table 1. Summary of age and time to move the vehicle by focusing.

Subject	Group 1 (Age 7-14)		Group 2 (Age 15-24)		Group 3 (Age 25-60)	
	Age	Time to move the vehicle by focusing (Second)	Age	Time to move the vehicle by focusing (Second)	Age	Time to move the vehicle by focusing (Second)
1	7	1,53	15	5,58	25	9,17
2	8	2,01	16	6,62	25	10,15
3	8	2,88	16	12,14	26	10,75
4	9	2,05	19	6,89	27	11,53
5	9	2,62	20	7,92	29	11,06
6	10	2,91	20	8,25	30	12,81
7	10	2,58	21	8,01	31	5,68
8	10	2,41	21	9,23	32	13,02
9	11	2,68	21	8,52	36	6,28
10	11	2,48	22	6,11	38	8,38
11	11	2,13	22	14,05	39	10,86
12	13	2,68	23	9,59	45	14,56
13	13	4,25	23	9,65	48	16,18
14	14	5,38	24	5,50	52	17,15
15	14	7,29	24	12,36	59	18,83

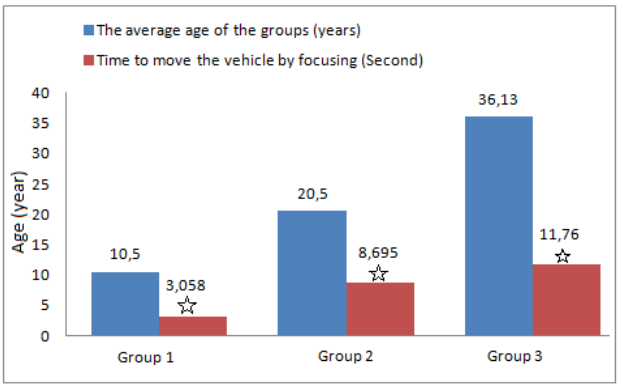

Figure 4. The average age of the groups and time to move the vehicle by focusing. Significant difference was observed between groups ($p < 0.05$). Values were given as Avg. ± SD. * Show intergroup difference ($p < 0.05$).

In addition, research on BCI technology for therapeutic applications to cure functions in injury at war, and on BCI devices in military and improving performance has been increasing rapidly [10]. Recent developments in EEG technology and BCI offer commercial BCI headset equipment ready for use in many new applications with an acceptable quality-cost ratio. We used BCI headset in the present research and focuses on the importance of the age of the user in controlling a robot that works with brain waves. Especially in unmanned aerial vehicles and robotic applications working with brain-thinking power, the efficiency of the device is vital. Therefore, it is important to understand machine and robots to be used in unmanned aerial vehicles, electronic devices, wheelchairs that can be operated more efficiently, and to determine the age group which may be more effective.

In this study, it was observed that the time to move the vehicle by focusing increased with age. And this increase between groups was statistically significant ($p<0.05$). The significant increases in time to move the vehicle by focusing may be due to the EEG waves and changes in cognitive functions. Because it is known that changes occur in brain EEG waves with age [21]. And also, normal aging is associated with significant changes in cognitive functions parallel to changes in brain function. Dias et al. [24] reported that the alpha peak frequency decreased with age on the left hemisphere, and was correlated directly to working memory capacity and attention [35]. Our results are in parallel with Dias et al. [24] findings. According to our findings, it is suggested that young pilots should be employed in operations where unmanned aerial vehicles and robot are used.

CONCLUSION

In conclusion, the results of our study show that the time to focus and activate the device increased in parallel with the age, and hence, children and young people may be more successful than adults in controlling or activating an external device through BMI. According to the present study, the age of the person is important in the communication system between the human brain and an output device. The ages of users should be considered when designing and manufacturing the BMI. The study is expected to be a useful resource for researchers in this field.

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