

## Research Article

# System Design and Development of a Novel Unique Neuro-Physical Medical Treatment Method for SMA - Spinal Muscular Atrophy Disease and for Similar Neurological Muscle Diseases

## Abstract

This article introduces a project entitled as “System Design And Development of a Novel Unique Neuro-Physical Medical Treatment Method for SMA-SPINAL MUSCULAR ATROPHIA-Disease and for Similar Neurological Muscle Diseases” which is completely original and unique to the author of this article [1-40].

The project contains the theory of a method tried to be developed that can treat SMA (Spinal Muscular Atrophy) disease and other similar neurological diseases. In the study, brain data will be examined with a 14-channel EEG device. With this device, the signals in the brain will be examined and these signals will be transmitted to the patients’ muscles. Many physical and sensory functions cannot be performed in SMA patients. Coughing, swallowing, breathing, chewing, walking, hand, arm and other muscle movements cannot occur. With this EEG device, the signals in the brain will be able to be seen as waves. By means of the special software of EEG device it is possible to manipulate the cube on the computer screen just by brain thinking and it is possible to simulate facial movements and facial expressions on the computer screen, as well [1-40].

This article explains a project which aims to develop a treatment method integrated with electrical-electronic and computer systems based on neuro-engineering, which is much more economical and accessible to all patients regarding the treatment of the disease. That is, by the realization of the method to be developed, it may be possible to treat individuals with other neurological diseases without applying expensive treatment methods. BCI – Brain Computer Interface applications will also be used for the project [1-40].

With the implementation of this methodology introduced by this study, it is also possible to treat individuals who are suffering from other neurological diseases without applying expensive treatment methods. This Braingate-based technology which is planned to develop by this article, can also be used especially for paralyzed patients, ALS patients, MPS, SSPE and DMD patients as well as SMA patients [1-40].

By use of Braingate technology it is aimed to detect signals belonging to muscles and related functions from the brain motor cortex and transmit them as electrical signals to the muscles where these signals cannot be transmitted. This treatment is based on the principle of activating muscles that cannot work or weakly work with the implementation of electrical current. The project described in this article aims to improve the quality of life and treat SMA patients by artificially stimulating muscles using internal or external devices and systems. Energy will be given to inactive points with brain power, or rather brain energy. SMA patients will only need to think about this to move any limb they want. When neurons become active, movement will occur spontaneously. For example, if the patient manages to raise his/her arm, it becomes obvious that muscles such as the breathing muscle, eating muscle, etc. can also be stimulated. The thought energy taken from the brain will be used for this work [1-40].

At the beginning stage of the project, the brain wave signals of two people who are not sick and two people who are sick will be examined and compared. These brain waves are actually electrical signals with voltage, current intensity, wavelength and frequency, and they carry a certain amount of energy. This energy will be evaluated as electrical energy and will first operate a mechanism containing a small electric motor, and the theory described in this article will be confirmed. As the ultimate goal, a limb of an SMA patient will be moved with this electrical energy. This energy will be sent to the motor cortex or to each muscle separately, depending on the requirement. Special “Nerve Cables” will be used as the signal and energy transmission tool here. Nerve Cable is the electrical cable drawn from the brain to any part of the body [1-40].

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**Keywords:** SMA, Spinal Muscular Atrophy, Atrophy, Muscle Disease, Neuro-engineering, Neural-engineering, Scoliosis, Motor Neuron, BCI, Brain-Computer Interface, Baringate, EEG–Electroencephalography, EMG-Electromyography, Neural Conduction, Pediatric Disease, Energy Transfer

## Introduction

This article introduces a project titled as “System Design And Development of a Novel Unique Neuro-Physical Medical Treatment Method for SMA-SPINAL MUSCULAR ATROPHIA-Disease and for Similar Neurological Muscle Diseases” which is completely original and unique to the author of this article [1-40].

The project contains the theory of a method tried to be developed that can treat SMA (Spinal Muscular Atrophy) disease and other similar neurological diseases. In the study, brain data will be examined with a 14-channel EEG-Electroencephalography device. With this device, the signals in the brain will be examined and these signals will be transmitted to the patients’ muscles. Many physical and sensory functions cannot be performed in SMA patients. Coughing, swallowing, breathing, chewing, walking, hand, arm, leg and other muscle movements cannot occur. With this EEG device, the signals in the brain will be able to be seen as waves. By means of the special software of EEG device it is possible to manipulate the cube on the computer screen just by brain thinking and it is possible to simulate facial movements and facial expressions on the computer screen, as well [1-40].

SMA (Spinal Muscular Atrophy) is a muscle disease that affects the anterior horn motor nerve cells (neurons) in the spinal cord, restricting mobility and preventing the signals from the brain from being transmitted to the muscles. While the incidence is 1/10000 in the world, this rate is 1/6000 in Turkey. Due to the mutation in the SMN gene, not enough SMN protein can be produced. In these patients, brain functions work, but since the production of SMN protein is not sufficient, the signals produced in the brain cannot be transmitted to the muscles. SMA is inherited. The occurrence of the disease in children depends on both parents carrying the mutation gene. When parents carry the mutated gene, there is a possibility that ¼ of the children will have SMA. The symptoms of the disease vary depending on the type of disease. In general, these symptoms are as follows: symptoms include weak muscles, weakness, difficulty in moving, poor head control, poor sucking and swallowing difficulties, hoarse voice and twitching of the tongue, unusually frequent falls after starting to walk, and decreased ability to walk. Type 0, symptoms appear before birth, it is the rarest and severe form of SMA. Type 1 is the most common and most severe type of SMA patients. In Type 1 patients, symptoms are observed before 6 months. In Type 2 patients, symptoms appear after the 6<sup>th</sup> month, previously, baby development was normal. Type 3 patients are normal at birth, symptoms begin after the 18th month. Type 4 occurs in adulthood, the onset and progression of the disease is slow. As a result of SMA symptoms, people consult a neurologist and the disease is diagnosed. EMG (electromyography) is performed to measure the person’s nerves and muscles. If the findings are normal, a blood test is performed and suspicious gene structures are examined. In the light of the findings, the person is diagnosed with SMA disease. There are other neurological diseases that have similar characteristics to this disease. For example, in paralyzed patients, in cases where there is no damage to the brain, brain signals cannot be transmitted to the muscles due to the damage to the spinal cord. In this article, the main purpose of the study within the scope of current project to treat SMA and similar neurological diseases, to help make the living conditions of these patients easier, to prevent children from being at risk of death due to their inability to access expensive treatment methods, and to relieve the sadness of families. Since there are not enough studies in this context, this project study will also help enrich the literature on such topics [1-40].

SMA has become a disease heard about frequently in recent years. It is estimated that there are approximately three thousand SMA patients in Turkey. This disease progresses as a very difficult process for both the patient and his/her family. Especially babies with Type 1 suffer from the disease very severely. They live connected to approximately 6 - 7 devices, and most of them live until the age of two. Treatment with the use of conventional drugs is provided for a price of approximately 2.5 million dollars. It is not possible for everyone to afford such a high fee. Financial aid is provided by the state - government provided that certain criteria are met. Patients who do not meet these conditions and cannot afford treatment costs are left to die. Unfortunately, there are very little and restricted medical and technical information on this subject [1-40].

This article explains a project which aims to develop a treatment method integrated with electrical-electronic and computer systems based on neuro-engineering, which is much more economical and accessible to all patients regarding the treatment of the disease. That is, by the realization and implementation of the methodology to be developed, it may be possible to treat individuals who are suffering from with other neurological diseases without applying expensive treatment methods. BCI – Brain Computer Interface applications will also be used for the project [1-40].

This Braingate-based technology which is planned to develop by this article can also be used especially for paralyzed patients, ALS patients, MPS, SSPE and DMD patients as well as SMA patients [1-40].

There is no previous study related this methodology to be developed for the treatment of SMA disease within

the scope of the current project introduced here. Thus, the project entitled as “System Design And Development of a Novel Unique Neuro-Physical Medical Treatment Method for SMA-SPINAL MUSCULAR ATROPHIA-Disease and for Similar Neurological Muscle Diseases” is completely original and unique to the author of this article [1-40].

**Method, Findings and Discussion**

The implementation method of the project shall be realized by using Braingate technology, the signals in the brain will be detected, the signals will be amplified to certain values, classified them by extracting attributes, and then these electromagnetic wave signals will be converted into digital signals. Later, these digital signals will be converted into electrical energy. This electrical energy will be produced in the form of electrical signals and it is predicted that the signals will have the characteristics of AC-alternating current. Then it is aimed to transmit the produced electrical energy to the muscles. Braingate technology enables detecting brain signals through a sensor placed in the brain. Evaluations are made after these signals are transmitted to the computer. In the light of these evaluations, it is aimed to control the muscles only with the ability to think. The produced signals will be detected and to be transmitted at the required value to the muscles for muscle stimulation. Through these stimulations, the muscles will be able to perform their functions. The muscles mentioned here are the muscles that enable the body’s hand, arm, leg, head, neck and skeletal movements, the muscles that affect the respiratory system, the muscles that perform swallowing, sucking, eating and drinking functions, and the muscles that concern other body functions [1-40].

A kind of EEG–Electroencephalography equipment with 14 channels named as EMOTIV / EPOC<sup>x</sup> and also an oscilloscope device were already provided and they are ready for the development stages of current study. The serial number of existing Emotiv /Epoc <sup>x</sup> EEG device is E2020730. Figure 1 and Figure 2 shows the EMOTIV/ EPOC<sup>x</sup> EEG equipment with 14-channel. Figure 3 shows the official serial number of existing EMOTIV / EPOC<sup>x</sup> EEG equipment. Figure 4 shows the USB oscilloscope device. The EEG equipment will allow to examine the brain data. This device will allow examining the signals in the brain and these brain signals will be transmitted to the patients’ muscles. Many physical and sensory functions cannot be performed in SMA patients. SMA Disease is a hereditary muscle disease caused by a gene disorder. Patients are unable to cough, swallow, chew, and unable to perform hand, arm, leg, neck and other muscle movements. With this EEG device, it is possible to see the signals in the brain as waves [1-40].

For example, it is possible to simulate the same facial movements on the computer screen. The oscilloscope device will provide to process the signals in the brain as waves [1-40].





Figure 3: The official serial number of existing EMOTIV / EPOC<sup>X</sup> EEG equipment.



Figure 4: The USB oscilloscope device.

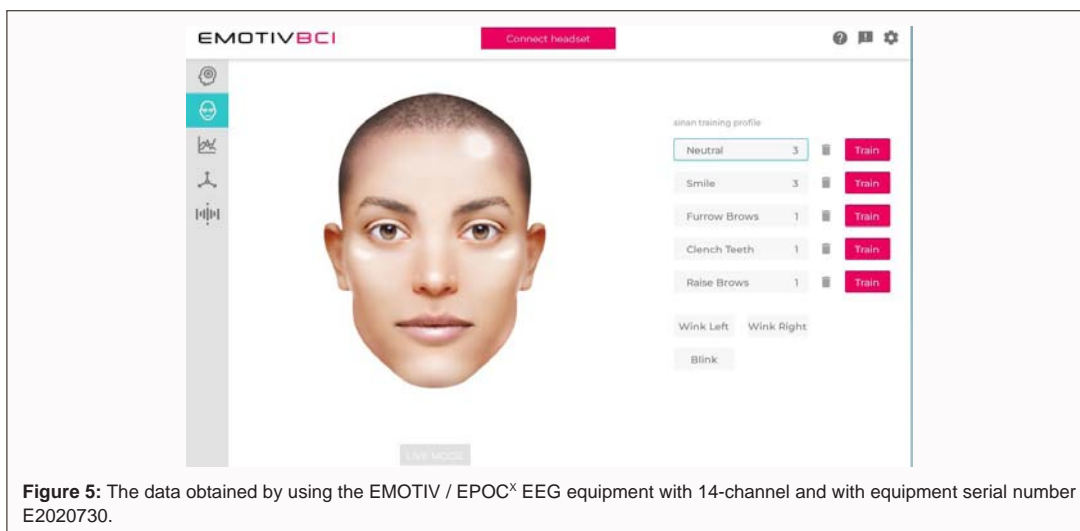


Figure 5: The data obtained by using the EMOTIV / EPOC<sup>X</sup> EEG equipment with 14-channel and with equipment serial number E2020730.

By use of Braingate technology it is aimed to detect signals belonging to muscles and related functions from the brain motor cortex and transmit them as electrical signals to the muscles where these signals cannot be transmitted. If the muscles are stimulated with the right signals, the desired action can be performed. As a matter of fact, Electrical Muscle Stimulation treatment is already used in physical therapy. This treatment is based on the principle of activating muscles that cannot work or weakly work with the implementation of electrical current. The project described in this article aims to improve the quality of life and treat SMA patients by artificially stimulating muscles using internal or external devices and systems. Energy will be given to inactive points with brain power, or rather brain energy. SMA patients will only need to think about this to move any limb they want. When neurons become active, movement will occur spontaneously. For example, if the patient manages to

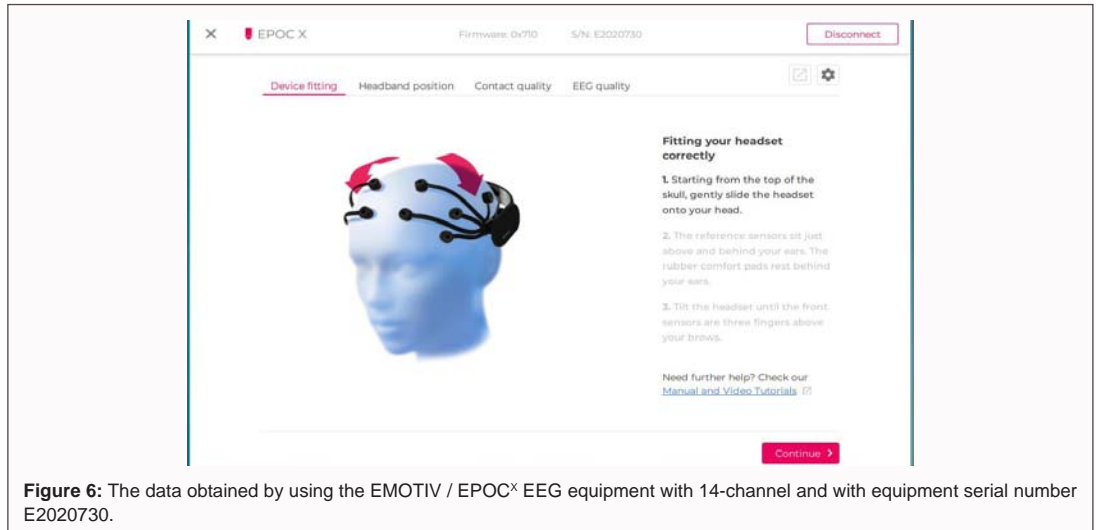


Figure 6: The data obtained by using the EMOTIV / EPOC<sup>x</sup> EEG equipment with 14-channel and with equipment serial number E2020730.

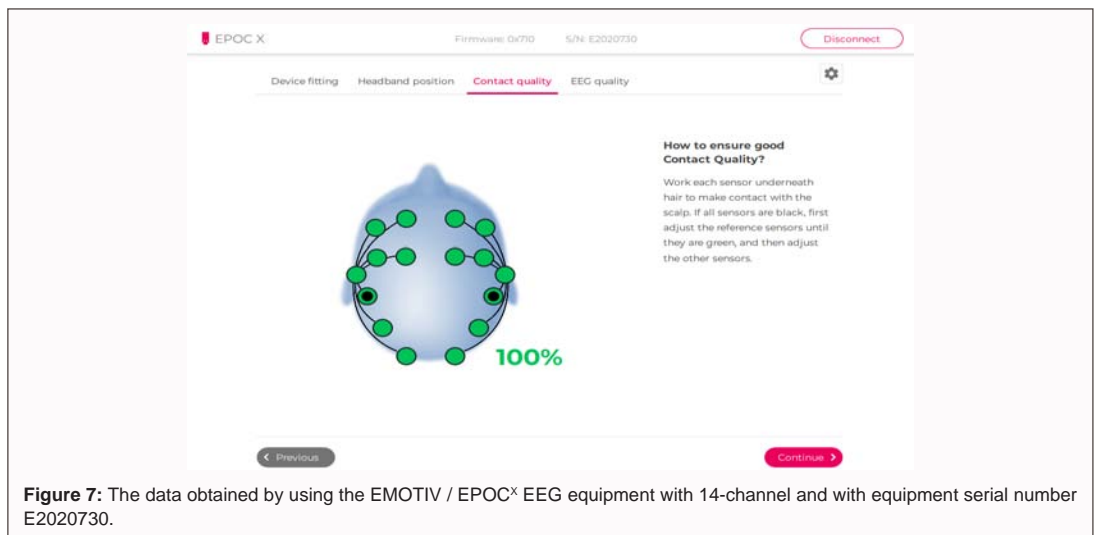


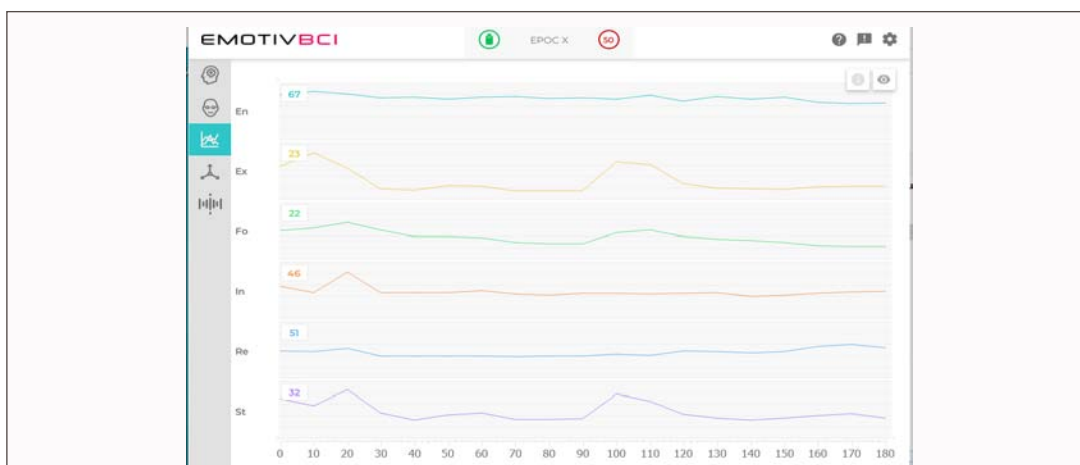
Figure 7: The data obtained by using the EMOTIV / EPOC<sup>x</sup> EEG equipment with 14-channel and with equipment serial number E2020730.

raise his/her arm, it becomes obvious that muscles such as the breathing muscle, eating muscle, etc. can also be stimulated. The thought energy taken from the brain will be used for this work. This energy can be sent to a special computer and processed with an oscilloscope, the computer in question can be mounted on the SMA patient, and the brain wave energies (delta waves ( $\delta$ ), theta waves ( $\theta$ ), alpha waves ( $\alpha$ ), beta waves ( $\beta$ ), gamma waves ( $\gamma$ )) taken from the brain can be processed and converted into electricity in this computer, and this electrical energy can be transmitted to the movement centers by placing a nerve cable through surgical intervention. To prove that the system is working, a small movement mechanism, arm, etc. can be operated first, and a small electric motor that drives this mechanism can be started. In this way, even the spine can be moved. Signals detected with EEG will be obtained as digital signals. Then, these digital signals will be converted to analog signals via a digital-to-analog converter. Sensed analog signals will also be transmitted to the nerve connections. [1-40].

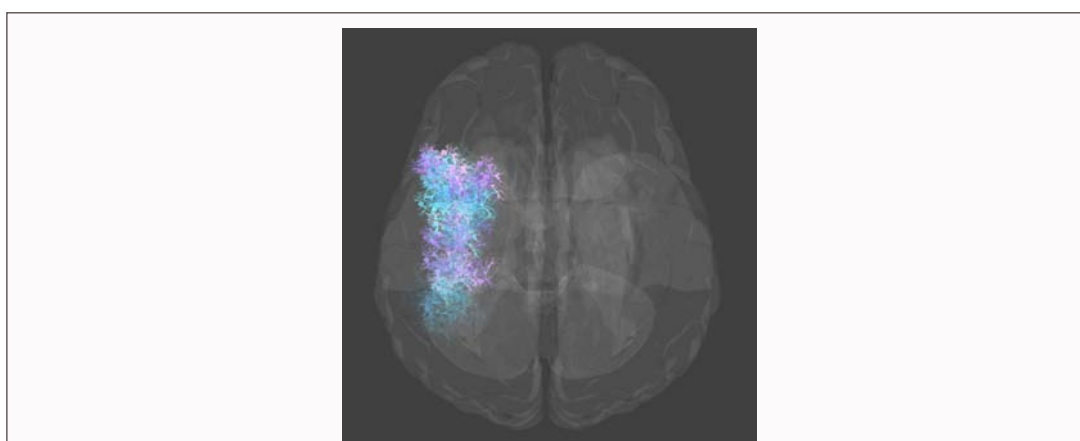
At the beginning stage of the project, the brain wave signals of two people who are not sick and two people who are sick will be examined and compared. These brain waves are actually electrical signals with voltage, current intensity, wavelength and frequency, and they carry a certain amount of energy. This energy will be evaluated as electrical energy and will first operate a mechanism containing a small electric motor, and the theory described in this article will be confirmed. As the ultimate goal, a limb of an SMA patient will be moved with this electrical energy. The signals and data obtained with the EEG device will be connected to Arduino, a code will be written and a transformation will be created on the computer. By taking advantage of this energy coming from the brain signals, the electric motor will be operated through thought. The signals here will be taken from both the brains of healthy people and the brains of SMA patients, and the results will be compared. If the electric motor can be started with the energy resulting from the brain signals of the patient with SMA, the limbs of the patient with SMA can also be moved with this energy. The brain energy obtained will be stored in an energy storage system such as a capacitor or battery and will be added to the electric motor from there [1-40].



**Figure 8:** The data obtained by using the EMOTIV / EPOC<sup>x</sup> EEG equipment with 14-channel and with equipment serial number E2020730. Note: By means of the special software of EEG device it is possible to manipulate the cube on the computer screen just by brain thinking and it is possible to simulate facial movements and facial expressions on the computer screen, as well.

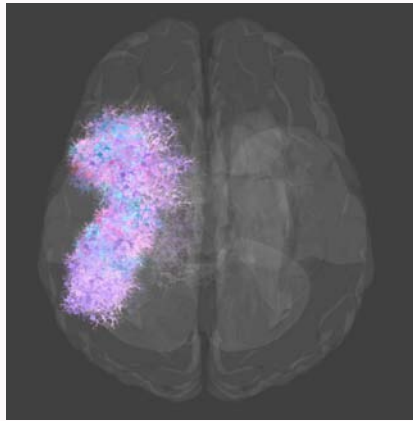


**Figure 9:** The data obtained by using the EMOTIV / EPOC<sup>x</sup> EEG equipment with 14-channel and with equipment serial number E2020730.



**Figure 10:** The data obtained by using the EMOTIV / EPOC<sup>x</sup> EEG equipment with 14-channel and with equipment serial number E2020730.

If the electric motor can be operated with the energy of the signals received from the brain, the muscles of the hands, arms, legs, neck, swallowing, chewing and breathing can also be energized and these muscles can be moved. This energy will be sent to the motor cortex or to each muscle separately, depending on the requirement. Special “Nerve Cables” will be used as the signal and energy transmission tool here. Nerve Cable is the electrical cable drawn from the brain to any part of the body [1-40].



**Figure 11:** The data obtained by using the EMOTIV / EPOC<sup>x</sup> EEG equipment with 14-channel and with equipment serial number E2020730.

### Conclusion

Therefore, as a basic principle, these muscles and their connected systems, which cannot perform their movement functions because they cannot receive the necessary electrical stimulation from the brain, will gain movement ability thanks to the neurophysiological treatment to be designed.

Ultimately, SMA patients who lack these features will regain their health thanks to the medical treatment method developed within the scope of project which is introduced by this article. The project entitled as “System Design And Development of a Novel Unique Neuro-Physical Medical Treatment Method for SMA-SPINAL MUSCULAR ATROPHIA-Disease and for Similar Neurological Muscle Diseases” is completely original and unique to the author of this article.

The physical parameters to be studied and determined during the development process of the current treatment method can be stated as follows; It is predicted that there will be current intensity, potential difference, voltage, frequency, period, wavelength, band width, amplitude, duration, time, action potential and related physical parameters [1-40].

Measurements have been realized successfully and the data obtained by using the EMOTIV/EPOC<sup>x</sup> EEG equipment with 14-channel are shown by Figure 5, Figure 6, Figure 7, Figure 8, Figure 9, Figure 10 and Figure 11 [1-40].

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