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Case report
Olgu sunumu

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Neurofeedback improves EEG complexity and social interaction in a boy with autism: A case report

Otizmli bir çocukta, nörogeribildirim EEG karmaşıklığı ve sosyal etkileşimi artırdı: Olgu raporu

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Abstract
Autism is an interhemispheric connectivity disorder, and intracortical circuits are also likely to be disturbed. Autism is characterized by impairments in communication with restricted interest and repetitive behaviors. Auto Train Brain is a neurofeedback-enabled mobile phone software application designed in Sabancı University laboratory for improving the cognitive functions of dyslexic children. Applying Auto Train Brain for 14 channels to an autistic boy created complexity improvements at lower temporal scales. After neurofeedback therapy, the patient began to use eight different single words, and his social responsiveness became significantly better. As a result of these, his CARS score improved from 39 to 34. He demonstrated an increased ability to follow instructions, and his attention span increased. Therefore, his FACT score increased from 21 to 30.
Keywords: Autism, Auto Train Brain, Neurofeedback

Öz
Otizm her iki hemisfer arasında oluşan bağlantısızlık sendromudur, aynı hemisferdeki kısa bağlantıların da etkilenmesi muhtemeldir. Otizmde dar ilgi alanı ile iletişimde bozukluk ve tekrarlayıcı davranışlar bulunur. Auto Train Brain, Sabancı Üniversitesi laboratuvarlarında tasarlanmış, nörogeribildirime dayalı ve disleksik çocukların bilişsel performanslarını artıran bir cep telefonu uygulamasıdır. Otistik bir çocukta, AutoTrain Brain 14 kanaldan uygulanmış ve düşük geçici ölçekte EEG karmaşıklığının arttığı gözlenmiştir. Nörogeribildirim terapisinden sonra çocuk, 8 farklı kelime kullanmış, sosyal tepkileri önemli ölçüde düzelmiştir. CARS puanı 39'dan 34'e ilerleme kaydetmiştir. Komutları yerine getirme becerisi artmış, dikkat süresi uzamıştır. FACT puanı 21'den 30'a yükselmiştir.
Anahtar kelimeler: Otizm, Auto Train Brain, Nörogeribildirim

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Introduction

Impairments in communication with restricted interest and repetitive behaviors characterize the autism spectrum disorders (ASDs), which may affect up to 1% of children. Autism is a polygenetic developmental neurobiological disorder with multiorgan system involvement (neocortical and cerebellar system, immune system, and gastrointestinal system), though it predominantly involves central nervous system dysfunction. It is an interhemispheric connectivity disorder, and intracortical circuits are also likely to be disturbed [1,2].

Auto Train Brain is a neurofeedback-enabled mobile phone software application designed in Sabancı University laboratory for improving the cognitive functions of dyslexic children. The software reads electroencephalography (EEG) signals from 14 channels of eMotiv EPOC+ and processes these signals to provide neurofeedback to a person to improve the brain signals with visual and auditory cues in real-time [3]. With its patented novel approach, Auto Train Brain improves the intracortical circuits and improves functional connectivity for people with dyslexia.

In this report, we have examined the positive outcomes of applying Auto Train Brain to a boy with autism.

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Case presentation

The patient was thirty months old when he was diagnosed with autism spectrum disorder according to DSM V criteria. He was six years and ten months old at our initial evaluation. He was non- verbal but could sustain brief eye contact and could follow simple commands.

The childhood autism rating scale score (CARS) and Frankfurt Adaptive Concentration Test (FACT) was used to determine autism severity and attention performance, respectively. His CARS score was 39 (The cutoff score for the diagnosis of autism is 30), and FACT score was 21 (the average score is 32). Visual analysis of sleep electroencephalography (EEG) did not reveal any epileptic discharge. The quantitative analysis of EEG data showed lower complexity in the lower temporal scales and higher complexity in the higher temporal scales.

The treatment plan was to apply Auto Train Brain at home, 3 times a week, at least 100 times with the provision and help of his parents. The main goal of the experiment was to reduce the slow brain waves if the recorded ones were above the TD norm age group's average slow waves, and improve the fast brain waves if the recorded ones were below the TD norm group's average fast waves. Visual and auditory feedback was provided online in real-time via the Android Java program after processing the EEG data gathered from the subject's head. For all analyses in this report, Theta (4-8 Hz), Alpha (8-12 Hz), Beta-1 (12-16 Hz), Beta-2(16-25 Hz), and Gamma (25-45 Hz) band data were recorded for 14 channels. Throughout the experiments, an eMotiv EPOC+ headset was used. The internal sampling rate in the headset is 2048 Hz per channel. The EEG data were filtered to remove artifacts and alias frequencies, then downsampled to 128 Hz per channel. There were 14 EEG channels plus two references. Electrodes were placed according to the 10-20 system. Before training with MyEmotiv mobile application, the calibration of the eMotiv headset on the subject's scalp was achieved, ensuring that each electrode transfers EEG data with high quality.

To measure the success of this training, at the start and end of the training, the "sleep" state raw EEG data was measured with eMotiv PRO software and eMotiv EPOC+ headset, and multiscale entropy was calculated [3]. The sampling rate of the EEG data was 128 Hz. The raw data were filtered by using a bandPass FIR filter (1-50Hz). The artifacts were removed manually by using EEGLAB's data rejection options. The independent component analysis was performed. MSE was calculated for one continuous 60-s epoch for each experimental and control EEG reading. The number of samples(N) is set to N= 128*60 (7680). Sample entropy parameters were set to (m=2, r=0.25*standard deviation of EEG signal), which have proven to be effective in other studies [4]. We have created 40 temporal scales to analyze the complexity. The expected outcome of the experiment was to increase in the EEG complexity and increase in social responsiveness.

After neurofeedback therapy, the patient began to use eight different single words, and his social responsiveness became significantly better. As a result of these, his CARS score improved to 34. He demonstrated an increased ability to follow instructions, and his attention span increased. Therefore, his FACT score increased to 30.

Applying Auto Train Brain for 14 channels created complexity improvements at lower temporal scales. The results show that low complexity at lower temporal scales has improved after 120 sessions of Auto Train Brain training (Figure 1) in all channel locations. The power band values pre- and post-treatment were also included for the sake of completeness of analysis (Figure 2 and Figure 3). These figures demonstrate that the slow brain waves were reduced, and the left-brain dominance was increased.

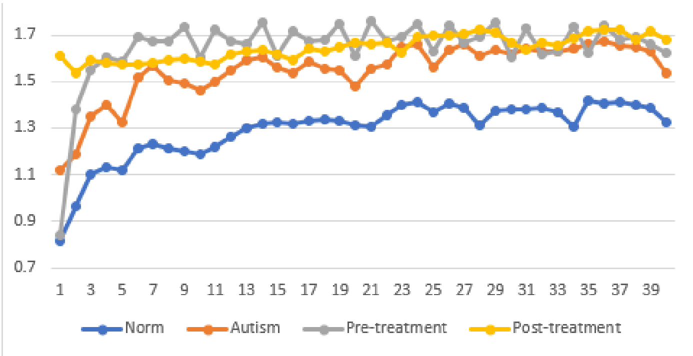

Figure 1: MSE

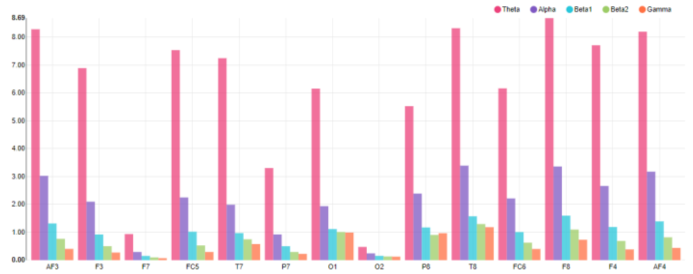

Figure 2: Frequency band values pre- treatment

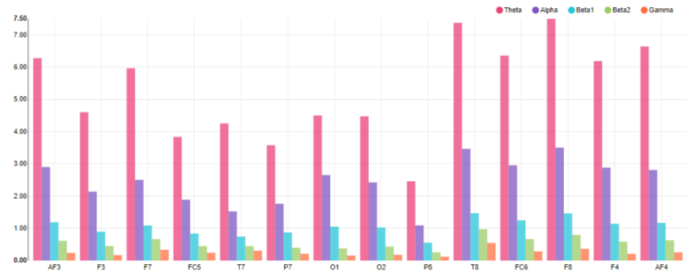

Figure 3: Frequency band values post- treatment

Discussion

This report was the first attempt to apply Auto Train Brain to ASD, as the neurofeedback protocols in Auto Train Brain were initially designed to improve the cognitive abilities of people with dyslexia. In dyslexia, the interhemispheric connections are usually developed, whereas there is “disconnection syndrome” in intracortical circuits (mainly between Broca and Wernicke area). From this perspective, autism and dyslexia seem to be reverse conditions [5,6]. However, they share similarities in gamma band abnormalities (gamma bands are too low or too high in both conditions).

In the literature, neurofeedback has previously been applied to autism with success (at C4 reward 10-13 Hz, at F7 reward 15-18 Hz, at T3-T4 reward 9-12 Hz, at F3-F4 reward 7-10 Hz and 14.5-17.5 Hz, inhibit 2-7 Hz, 22-30 Hz) [7]. Auto Train Brain provides a novel neurofeedback method such that the process is personalized according to each individual's needs, and the algorithm is bound by age-grouped norm data. These features make it easy to apply at home without any side effects.

Auto Train Brain successfully improves the intracortical circuits and improves the EEG complexity in people with dyslexia with its particular neurofeedback protocols. Applying the same protocols to a boy with autism indeed solved the problems at short cortical connections, whereas the long-distance temporal connections were not affected much. This remaining problem creates the necessity to adapt the neurofeedback protocols of Auto Train Brain for ASD to improve the long temporal connections as well. The new protocol to improve interhemispheric connections was added to Auto Train Brain, but not tested on ASD yet.

The patient was able to wear the headset during the training sessions. In most cases of ASD, the subjects cannot wear the headset for 20 minutes because many ASD subjects find the headset irritating. Although the neurofeedback protocol was useful for solving the functional connectivity issues, a specialized headband for ASD subjects to read EEG signals more comfortably should be developed.

Conclusion

Auto Train Brain, which was initially developed to improve the cognitive abilities of dyslexics, was applied to a boy with autism successfully. According to the multiscale entropy measures pre- and post-experiment, improvements in the intracortical circuits have been determined. There is a need to address the interhemispheric connections at Auto Train Brain protocols which will be enhanced shortly.

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