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APPLICATION OF BIO FEEDBACK INSTRUMENTATION IN CURING AUTISM

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Abstract: Complexly organized structure in the universe is the human brain. It is made up of one hundred billion nerve cells or neurons, which form the basic structural and functional units of nervous system. Each neuron makes nearly one to ten thousand contacts with other neurons where exchange of information occurs. Even this universal master has some disorders, where cure is a question mark. One of such disorders is autism. Autism can be defined as a disorder where social communication and interaction is lost or improper. For example, if the patient is talking to a person and sharpening a pencil at the same time, he suddenly drops a pencil and the sharpener or turns his head opposite to the normal direction. The main gland responsible for the summation of all the inputs, known as "AMYGDALA", which is either called as the gateway to limbic gland may have some problem in connection to the various lobes such as frontal lobe, temporal lobe, occipital lobe. The reports of the autistic patient seem to be bulged in shape. Medication leads to some side effects, even then it is not a complete cure. So, a smart proposal of a non invasive treatment is prepared in this paper. This equipment is designed with a feedback control system which takes EEG readings and records the amplitude and whenever an abnormal condition is observed in the signal immediately a measurement device gives the required potential pressure which makes the patient set to the normal condition. Acupressure is the phenomenon used for associating various body parts and several nerves connecting main functional glands in the brain, so that the principle application can effectively show better impact on the treatment for the autistic patient. This paper completely explains about how the disorder can be treated properly and in a noninvasive mode. The pain stimulator helps us to give the feedback and thus gaining the required result. A recorded EEG is taken in order to check the position of the patient after the feedback is done to the patient. This proposal admits the procedure of electronic stimulation for the neural disorders and preventing the side effects caused by the medication suggested to the patient.

1. INTRODUCTION

Autism, also called autistic disorder, appears in early childhood, usually before age 3 (National Institutes of Health, 2001). Autism prevents children and adolescents from interacting normally with other people and affects almost every aspect of their social and psychological development.

Autism has a wide variety of characteristics ranging in intensity from mild to severe. One child with autism does not behave like another child with the same diagnosis. Children and adolescents with autism typically:

- Have difficulty communicating with others.
- Exhibit repetitious behaviors, such as rocking back and forth, head banging, or touching or twirling objects.
- Have a limited range of interests and activities.
- May become upset by a small change in their environment or daily routine.

In addition to these characteristics, some children with autism experience hypersensitivity to hearing, touch, smell, or taste. Symptoms of autism can be seen in early infancy, but the condition also may appear after months of normal development. In most cases, however, it is not possible to identify a specific event that triggers the disorder.

Possible Indicators of Autism Spectrum Disorders

Does not babble, point, or make meaningful gestures by

- 1 year of age
- Does not speak one word by 16 months
- Does not combine two words by 2 years.
- Does not respond to name
- Loses language or social skills
- Some Other Indicators
- Poor eye contact
- Doesn't seem to know how to play with toys
- Excessively lines up toys or other objects
- Is attached to one particular toy or object
- Doesn't smile
- At times seems to be hearing impaired.

Autism is part of a cluster of conditions called **autism spectrum disorders (ASDs)**, or known by the broader term, **pervasive developmental disorders (PDDs)**. All of these conditions share similar symptoms. Although autism can affect children of any race and ethnicity, it is four times

more common in boys than in girls. Autism can range from mild to severe, but most children with the condition have difficulty in these three areas:

Communication - Children with autism have trouble with both verbal and nonverbal communication. They may avoid making eye contact or smiling, and may not understand the meaning of a smile, wink or wave. About 40 percent of children with autism don't speak at all. Another 25 percent start talking at between 12 and 18 months, but then rapidly lose their language ability. Some children with autism have difficulty forming words into sentences, or repeat exactly what they hear -- a condition called echolalia. Because they can't communicate what they want, sometimes autistic children scream or cry out of frustration.

Social interaction - Children with autism have difficulty relating to other people, in part because they can't understand other people's feelings and social cues. As a result, they can appear distant or aloof. They may shy away from physical or emotional contact, avoiding hugs and eye contact. Because autism affects the senses, some everyday sounds or smells may be unbearable to autistic children. They may cover their ears and scream when the phone rings, or gag from the smell of a peach. Or they may be less sensitive to pain than other children, and not feel a thing when they get a cut or bruise.

Repetitive behaviors - Autistic children often repeat the same behaviors (called stereotyped behaviors, or stereotypy) over and over, including waving their arms, banging their head against a wall, repeating the same words, or obsessively lining up toys, books or other objects. Repetition is a theme throughout an autistic child's life. Any change to their daily routine -- even something as simple as cutting a sandwich straight across rather than on a diagonal -- can lead to a meltdown.

The symptoms of autism can vary dramatically from child to child. While one child may be entirely unable to communicate, another may be able to recite entire Shakespearian plays. One child may be unable to add 3 + 4; another may be able to perform advanced calculus functions.

In addition to autism, four other conditions fall under the header of ASDs:

Asperger syndrome - Children with this condition have some symptoms of autism, including poor social skills and a lack of empathy, but they have age-appropriate language skills and a normal or high IQ.

Rett syndrome - This condition affects only 1 out of every 10,000 to 15,000 children, the vast majority of them girls. Those with Rett syndrome shy away from social contact. They may wring their hands and be unable to control the movement of their feet.

Childhood Disintegrative Disorder (CDD) - This rare disorder affects only about two out of every 100,000 children with ASDs, most of them male. Children with CDD will develop normally until about age 3 or 4, then will suddenly and dramatically lose their motor, language and social skills.

Pervasive Developmental Disorder - Not Otherwise Specified (PDD-NOS) - This condition shares some of the same symptoms with autism (communication and social delays), but does not meet the full criteria for diagnosis.

Autism is much more common in people with certain genetic, chromosomal, and metabolic disorders, such as fragile X syndrome (an inherited form of mental retardation whose name refers to a damaged and fragile-looking X chromosome), phenylketonuria (an inherited condition in which the body lacks the enzyme needed to process the amino acid phenylalanin**e**, leading to mental retardation) and tuberous sclerosis (a rare genetic disorder that causes benign tumors to grow throughout the body and brain). Epileptic seizures, mental retardation and vision and/or hearing loss are also common in children who have autism.

Causes of Autism

Scientists believe that autism stems from a combination of genetic and environmental factors. Research done with twins reveals a strong family connection. If one identical twin has autism, the other twin has a 60 to 90 percent chance of also having the condition (in non-identical twins, the rate is about 3 percent). In families with one autistic child, the chance of having a second child with the condition is about 2 to 8 percent -- 75 times greater than among the general population. Also, members of families with autistic children are more likely to have language delays and social difficulties, as well as mental disorders.

Scientists believe that not just one, but a combination of as many as a dozen genes is to blame for autism. Mutations in these genes can make a child more susceptible to autism, or can lead to specific symptoms of the condition. Some of the genes scientists have isolated are HOXA1 (involved in brain structures and nerves), RELN (involved in connections between nerve cells), and GABA pathway genes (involved in helping nerve cells communicate with one another). These genes likely set the stage for autism, but it's possible that environmental factors actually trigger the condition.

A number of environmental factors have been linked to autism, from viral infections to exposure to chemicals such as mercury, lead or polychlorinated biphenyls (PCBs -- a group of

chemicals that were once used as lubricants and coolants). Some research has suggested that prenatal exposure to substances such as thalidomide (a drug used in the 1950s and 60s to treat morning sickness, used to treat cancer) or valproic acid (a drug used to treat epileptic seizures) can cause a child to develop autism. In 1998, a British study by Dr. Andrew Wakefield cast international attention on one potential environmental culprit: childhood vaccines. His small study suggested that the measles-mumps-rubella (MMR) vaccine caused an infection in the intestines, which led to the developmental and gastrointestinal disorders seen in autism. Because children are vaccinated at around the same age as autism is diagnosed, the theory that vaccinations were to blame gained popularity. Adding to the questions surrounding vaccines was other research indicating that exposure to thimerosal, a mercury-based substance that was once used as a vaccine preservative (specifically in the diphtheria, tetanus, pertussis; Haemophilus influenzae type b (Hib); and Hepatitis B vaccines), could affect brain development and trigger autism. In 2004, the Institute of Medicine completed a thorough review of all the evidence related to vaccines and autism, and concluded that there was no apparent link between thimerosal or the MMR vaccine and autism. Several other large studies have echoed those conclusions. However, the debate about vaccines and autism continues, and research is ongoing.

2. METHODOLOGY

Diagnosis for Autism: Although there is no cure for autism, studies show that early diagnosis and intervention (before the age of three) results in better outcomes for children. The last decade has seen major advances in the standardization of diagnostic tools for autism and in the refinement and expansion of applied behavioral analysis, a one-on-one teaching approach that relies on reinforced practice of various skills and desirable behaviors. Although there are many concerns about labeling a young child with an ASD, the earlier the diagnosis of ASD is made, the earlier needed interventions can begin. Evidence over the last 15 years indicates that intensive early intervention in optimal educational settings for at least 2 years during the preschool years results in improved outcomes in most young children with ASD. In evaluating a child, clinicians rely on behavioral characteristics to make a diagnosis. Some of the characteristic behaviors of ASD may be apparent in the first few months of a child's life, or they may appear at any time during the early years. For the diagnosis, problems in at least one of the areas of communication, socialization, or restricted behavior must be present before the age of 3. The diagnosis requires a two-stage process. The first stage involves developmental screening during 'well child" check-ups; the second stage entails a comprehensive evaluation by a multidisciplinary team. Screening A "well child" check-up should include a developmental screening test. If your child's pediatrician does not routinely check your child with such a test, ask that it be done. Your own observations and concerns about your child's development will be essential in helping to screen your child. Reviewing family videotapes, photos, and baby albums can help parents remember when each behavior was first noticed and when the child reached certain developmental milestones. Several screening instruments have been developed to quickly gather information about a child's social and communicative development within medical settings. Among them are the Checklist of Autism in Toddlers (CHAT), the modified Checklist for Autism in 8 Toddlers (M-CHAT), the Screening Tool for Autism in Two-Year-Olds (STAT), and the Social Communication Questionnaire (SCQ) (for 1011 children 4 years of age and older). Some screening instruments rely solely on parent responses to a questionnaire, and some rely on a combination of parent report and observation. Key items on these instruments that appear to13 differentiate children with autism from other groups before the age of 2 include pointing and pretend play. Screening instruments do not provide individual diagnosis but serve to assess the need for referral for possible diagnosis of ASD. These screening methods may not identify children with mild ASD, such as those with high-functioning autism or Asperger syndrome. During the last few years, screening instruments have been devised to screen for Asperger syndrome and higher functioning autism. The Autism Spectrum Screening Questionnaire (ASSQ), the Australian Scale for Asperger's Syndrome, and the most recent, the Childhood Asperger Syndrome Test (CAST), are some of the instruments that are reliable for identification of school-age children with Asperger syndrome or higher functioning autism. These tools concentrate on social and behavioral impairments in children without significant language delay. If, following the screening process or during a routine "well child" check-up, your child's doctor sees any of the possible indicators of ASD, further evaluation is indicated. Comprehensive Diagnostic Evaluation The second stage of diagnosis must be comprehensive in order to accurately rule in or rule out an ASD or other developmental problem. This evaluation may be done by a multidisciplinary team that includes a psychologist, a neurologist, a psychiatrist, a speech therapist, or other professionals

who diagnose children with ASD. Because ASD's are complex disorders and may involve other neurological or genetic problems, a comprehensive evaluation should entail neurologic and genetic assessment, along with in-depth cognitive and language testing. In addition, measures developed specifically for diagnosing autism are often used. These14 include the Autism Diagnosis Interview-Revised (ADI-R) and the Autism Diagnostic Observation Schedule (ADOS-G). tThe ADI-R is a 16 structured interview that contains over 100 items and is conducted with a caregiver. It consists of four main factors—the child's communication, social interaction, repetitive behaviors, and age-of-onset symptoms. The ADOS-G is an observational measure used to "press" for socio-communicative behaviors that are often delayed, abnormal, or absent in children with ASD. Still another instrument often used by professionals is the Childhood Autism Rating Scale (CARS). It aids in evaluating the child's body movements, adaptation to change, listening response, verbal communication, and relationship to people. It is suitable for use with children over 2 years of age. The examiner observes the child and also obtains relevant information from the parents. The child's behavior is rated on a scale based on deviation from the typical behavior of children of the same age. Two other tests that should be used to assess any child with a developmental delay are a formal audiologic hearing evaluation and a lead screening. Although some hearing loss can co-occur with ASD, some children with ASD may be incorrectly thought to have such a loss. In addition, if the child has suffered from an ear infection, transient hearing loss can occur. Lead screening is essential for children who remain for a long period of time in the oral-motor stage in which they put any and everything into their mouths. Children with an autistic disorder usually have elevated blood lead levels. Customarily, an expert diagnostic team has the responsibility of thoroughly evaluating the child, assessing the child's unique strengths and weaknesses, and determining a formal diagnosis.

Study of EEG in an Autistic patient: An electroencephalogram (EEG) is a test to detect problems in the electrical activity of the brain. Brain cells communicate by producing tiny electrical impulses. In an EEG, electrodes are placed on the scalp over multiple areas of the brain to detect and record patterns of electrical activity and check for abnormalities. The test is performed by an EEG technician in a specially designed room that may be in your health care provider's office or at a hospital. You will be asked to lie on your back on a table or in a reclining chair. The technician will apply between 16 and 25 flat metal discs (electrodes) in different positions on your scalp. The discs are held in place with a sticky paste. The electrodes are connected by wires to an amplifier and a recording machine. The recording machine converts the electrical signals into a series of wavy lines that are drawn onto a moving piece of graph paper. You will need to lie still with your eyes closed because any movement can alter the results.

Brain Functions in the Autistic patient: Over the past few years, a number of studies have been published linking differences in brain structure and function to autism spectrum disorders.

- At a certain point in post-natal development, autistic brains are larger.
- Certain portions of the brain, such as the amygdala, may be enlarged in autistic brains.
- Certain parts of the brain may function differently in autistic people.
- "Mini columns" in the brain may be formed differently and be more numerous in autistic brains.
- The entire brain may function differently in autistic people.
- In many autistic people, the brain develops too quickly beginning at about 12 months.

By age ten, their brains are at a normal size, but "wired" atypically. The brain is most complex thing on the planet. So its wiring has to be very complex and intricate. With autism there's accelerated growth at the wrong time, and that creates havoc. The consequences, in terms of disturbing early development, include problems within the cortex and from the cortex to other regions of the cortex in ways that compromise language and reasoning abilities." Mini columns, which are small structures within the cortex, are also different among autistic people. Autistic people have more mini columns which include a greater number of smaller brain cells. In addition, the "insulation" between these mini columns is not as effective as it is among typically developing people. The result may be that autistic people think and perceive differently and have less of an ability to block sensory input.

3. CALCULATIONS

Detection of Abnormal changes: The behavior of Autistic brain is completely different from the normal human's brain. This change of activities can be detected with the help of EEG signal processing using wavelet based information processing done in MATLAB. *Wavelet analysis* is a time-frequency method for signal processing, relies on an appropriate basis constituted with a series of wavelets and wavelet coefficients. The wavelet is a

smooth and quickly vanishing oscillating function with good localization in both frequency and time. A wavelet family is the set of elementary functions generated by dilations and translations of a unique admissible mother wavelet $\psi(t)$

$$\psi_{j,k}(t)=2^{j/2}\psi(2^j t-k)$$

Where j, are the scale and translations parameters, respectively and t is time. This family constitutes an ortho normal basis of the Hilbert space L2 (R) consisting of finite-energy signals. The correlated decimated discrete wavelet transform (DWT) provides a non redundant representation of the signal and its values constitute the coefficients Cj(k) in a wavelet series. If the discrete signals are assumed to be given by the sampled values S= {s0 (n), n=1… M}, with ts=1. Then, for decomposition over N resolutions levels, the wavelet expansion will be

$$S(t)=\sum^{-1}_{j=-N}\sum_k Cj(k)\psi_{j,k}(t)=\sum_{j=-N}^{-1} r_j(t)$$

Here wavelet coefficients Cj(k) can be interpreted as the local residual errors between successive signal approximations at scales j and j+1, and rj(t) is the residual signal at scales j. It contains the information of the signal S(t) corresponding to the frequencies $2^{j-1}\omega\le|\omega|\le 2^{j-1}\omega$. Since the family $\{\psi_{j,k}(t)\}$ is an orthonormal basis for L^2 (R), the concept of energy is linked with the usual notions derived from the Fourier theory. Then, wavelet energy at each resolution levels j=-1, -2… -N, will be the energy of the detail signal

$$E_j=\|rj\|^2=\sum|C_j(k)|^2$$

and the energy at each sampled time k will be

$$E_k=\sum_{j=-N}^{-1}|C_j(k)|^2$$

In consequence, the total energy can be obtained by

$$Etot=\|S\|^2=\sum_{j<0}\sum_k|C_j(k)|^2=\sum_{j<0}E_j.$$

Then, the normalized values, which represent the relative wavelet energy

$$p_j=E_j/E_{tot}$$

for the resolution levels j=-1, -2… -N, define by scales the probability distribution of the energy. Clearly, $\sum p_j=1$ and the distribution $\{p_j\}$ can be considered as time-scale density. This gives a suitable tool for detecting and characterizing specific phenomena in time and frequency planes. According to the Shannon entropy concept which provides a measure of the information of any distribution, the total wavelet entropy is defined as

$$S_{WT}=S_{WT}(p)=-\sum_{j<0}p_j\cdot\ln[p_j]$$

The total WT appears as a measure of the degree of order/disorder of the signal, so it can provide useful information about the underlying dynamical process associated with the signal. For a very ordered process like periodic mono-frequency signal, the total WE will be near zero or a very low value. And for a totally random process which represents a very disordered behavior, the WE will take the maximum value. If the number of wavelet resolution levels included in such an evaluation is called j N , then the maximum possible entropy value is Smax =lnNj, and the total WE can be normalized as S/Smax.

Practical Implementation: The theoretical part is discussed but the practical work should be done in order to get real time variations in the patients. For this paper total three cases are reviewed where only one case is discussed here completely.

Case I: A three year old child has a difficulty to talk, to express his inconvenience and other typical moments like hunger, urination, etc right from his 8th month(as per the doctor records) of age. This patient is treated as an epilepsy patient and medicated respectively but the patient did not turn up but apparent changes are seen such as movement eye brows indicating his hunger, anxiety, etc. After repeated oral exercises, the child is now able to react properly but progress of this type exercises is very slow and also not satisfactory. But the child is seen so intellect that he can identify the book color and shelf in which the required book is stored. His social communication is improving slowly with respect to the changes in the medication and also in food habits.

Case II: An eight year old boy who is totally normal up to his seventh year but turned in to an abnormal child which is later known as neural disorder and finally prosecuted as Autism. No medicine helped him and change of food habits helped him accordingly his regular activities are completely numb. After one year, he was out of this danger without any precautions. His EEG showed continuous distortions with very small normal waveforms. This case is an example that autism has no medicine or a prescribed treatment.

Case III: This is a case of 21 year old girl who has this ASD (Autistic Spectrum Disorder) from the age of sixteen and got interrupted at irregular times. When the patient is subjected to mental stress then immediately she used to go numb. After undergoing guided medication she was affected by other problems like temporary paralysis. But in this case whenever the patient is found abnormal she was made to smell the stringent odor like red chilly smell or sliced onion etc. After this treatment she used to get relaxed and come to normal state. The EEG report of this patient is interpreted and analyzed in terms of frequencies.

The proposal of Biofeedback instrumentation has been initiated with the help of this type of response. Considering the approximate values of the recorded EEG pulses for the normal and the autistic patient then the difference could be easily traced out. The Autism affected patients has a reported record of having high frequency ranges of EEG compared to

the normal human's EEG frequency values. So the undesired frequency can be cancelled out with this feedback instrumentation.

Practice of Acupressure: While conducting biofeedback instrumentation, there can be a confusion of points on which feedback has to be applied. While we just give the response to the EEG points, it is indefinite that the reaction could probably take place or not. So here the principle of Acupressure is adopted and proposed for the betterment of the treatment. Let us discuss the details and points of application on the human body with the help of this Acupressure. Acupressure and acupuncture share the same active points (also called trigger points, acupoints, acupressure points, or acupuncture points). The ancient Chinese developed system of active point's stimulation over 5,000 years ago. The active points are located on imaginary lines called meridians. Accordingly, the points are referred to by the meridian they are located on and consecutive number of point on that meridian. The ancient Chinese believed that life energy chi (pronounced *chee*) flows through these meridians. In a healthy person the energy flow trough meridians is unobstructed. The blockade of chi flow results in an illness. The Chinese believed that active points stimulation clears the meridians and improves the flow of energy. The western medical science only begins to understand the mechanisms responsible for positive effects of active points stimulation. Stimulation of active points is thought to lead to increased release of endorphins. Endorphin is a natural body painkiller. Endorphin and morphine are chemically different molecules but, by coincidence, they have very similar 3-dimensional shape. This similarity in shape allows morphine to bind the endorphin receptor, reduce pain, and induce feeling of happiness. Thus endorphin released by acupressure stimulation may lead to relaxation and normalization of body functions. The points of application are taken in nervous system such that all the main points are covered and the key points are not left out. So let us see the point of application on the nervous systems.

Acupoint 1: Two thumb widths from the largest crease on the inside wrist; the point is between the tendons in the middle of the wrist, the electrode should be placed on the same point.

Acupoint 2: On the largest crease of the inner wrist, which is exactly on line with the little finger.

Acupoint 3: On the middle finger, just above the nail, on the side closest to the thumb.

Acupoint 4: In middle of sole of the foot, behind the ball.

Acupoint 5: Below the brow ridge at the corner of the eye nearest the bridge of the nose, just below a notch in skull.

Acupoint 6: Just below or inside the eyebrow, near the middle; feel for a notch in the eyebrow ridge.

Acupoint 7: On the back of the jawbone, below the ear.

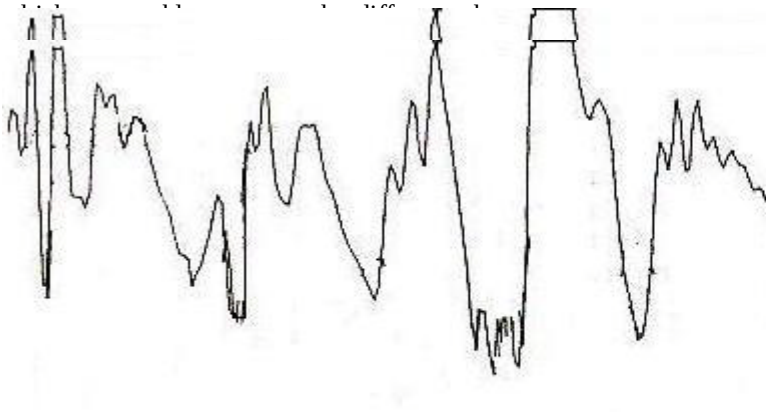
Acupoint 8**:** Two palm widths plus one thumb width above the outer ankle bone, just behind an imaginary vertical line from the tip of the ankle bone.

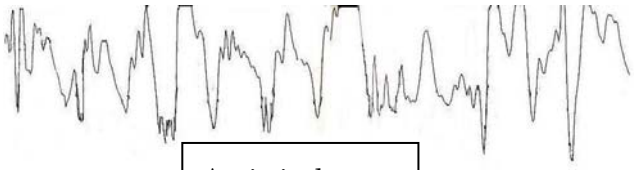
Along with these points other few points are considered which influences the main affecting region and those include the EEG points.

The patient is made lies on the bed and he is connected with the EEG electrodes and at the same time the patient is given the feedback connections at the prescribed points. Here the technician should take care such that no mutual interference is caused between the EEG electrodes and feedback electrodes. The major points described here for the treatment do not interfere with the EEG electrodes but the feedback electrodes which are connected at the frontal, occipital and parietal regions needs safety precautions. The feedback circuit is nothing but a pain stimulator which is controlled by the micro controller or micro processor. The EEG waveforms are recorded and programmed with the help of MATLAB and then those frequencies are received by the micro controller and the frequency range is compared and then the required frequency signal is converted into voltage signal is given to the patient at the prescribed points of treatment.

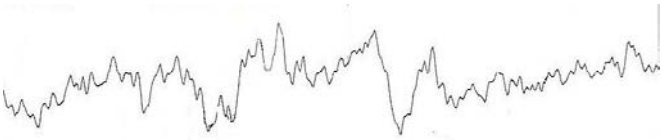
4. RESULT

From the given EEG record it can be clearly noticed that the feedback given to the patient could give adequate relief from the disturbances and distortions in the neural circuitry. The patient's EEG is recorded in parallel with the feedback treatment





Autistic data



Normal data

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