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Analysis of physiological signal variation between autism and control group in south indian population.

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Abstract

Autism is a neurological and developmental disorder caused due to malfunction in brain development. It is an emerging field in child psychiatry in the world. Moreover in developing countries like India there is a need for awareness regarding autism among the medical professionals. The proposed research was to investigate variation in the physiological parameters between autism and normal children. Eighty Indian Children subjects (40 Normal and 40 Autism) from a special school participated voluntarily in this study with age group ranging from 8–13 years. Photoplethysmograph (PPG) and galvanic skin response (GSR) signal were recorded during mental task through clue cards with visual like alphabets, numbers, fruits, colors, and animals. The experiment was performed during the forenoon session for both normal and autism children. The task performance is measured by calculating the error of commission and omission. PPG and GSR signal are pre-processed, and dicrotic notch, heart rate (HR) and GSR feature are extracted from the acquired signal. The nonparametric Mann-Whitney-U tests were performed. The heart rate, dicrotic notch, and GSR were significantly ($p<0.05$) high for the autism group when compared to control children. The current study result implies that PPG and GSR signals recorded for the autistic children are high in comparison with normal children.

Keywords: Autism, Heart rate (HR), Photoplethysmography (PPG), Galvanic Skin Response (GSR), Mental task

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Introduction

Autism is a complex developmental disorder with a disability that occurs in the first three years of the life, which will obviously lead to the neurological disorders [1]. This affects children communication and social interaction skills. Autistic children usually will have issues with non-verbal communication, social interactions, lack of social awareness, and activities that include an element of play and/or banter. This makes the child break the bond with peers (in part, due to an inability to express their feeling and emotions). The survey conducted by CDC and data released in April 2012, states that approximately 1 in 88 children faces the problem of autism in U.S. [2]. This is an attractive emerging field in child psychiatry in India with only limited awareness and diagnosis in autism. In other countries like United States, Europe, Asia, Korea there has been a constant record and awareness of the development and diagnosis of this disorder. One of the major difficulties for the parents with the autistic children in India is to get the accurate diagnosis in the initial stage.

Information and awareness about Autism Spectrum Disorders (ASD) have changed significantly in recent years. Due to the numbers of children being diagnosed with an ASD, it is important for clinicians and other health professionals to be familiar with current information on ASDs. Early identification of children with ASD and referral to appropriate intervention can impact the long-term outcome. It is now widely acknowledged, the forms of treatment enjoying the broadest empirical validation of individual's autism effectiveness treatment is based upon a behavioral model. All the treatments have their foundation related to psychological principles of learning the human behavior. This form of treatment is derived from the experimental study of behavior, which is a field of science dedicated to understanding the laws by which environmental events determine behavior. By understanding these laws, we can

develop applications to change behavior. The science where these principles are applied to the improvement of socially relevant behavior is known as applied behavior study, and the development of the behavioral treatment of autism is mostly the result of this field of science.

Autism is a severe developmental disability that develops in early three years of life. This type of disorder seem to be normal, but their brain development is impaired [1]. Such a situation can only be diagnosed at a later stage. Thus, it is late for any treatment for autistic children who are unique in nature makes predicting treatment be difficult and also often critical [3]. Previous research done by the autism centers characterized that autistic people will have three main criteria, such as social interaction impairment, communication impairment, repetitive and restrictive behavior. Survey conducted in 2008 by CDC prevalence rate of 1 in 88 American children have autism [2, 4]. The parent report says the prevalence of diagnosed ASD in U.S. 2011-12 was estimated to be 2.00% children age between at 6-17 year. This prevalence estimate 1 in 50 is significantly higher than the estimate of 1.16% or 1 in 86 for children in that age group in 2007 [5]. In India, the prevalence rate is almost 1 in 250 children with autism [6].

Many scientists have reported that autism is caused by a malfunction in the development of the brain, which encompasses many regions. In the autistic brain, the cerebellum is larger, and the corpus callosum is smaller [7]. Another study showed that the amygdala and the hippocampus are different in an autistic brain [8]. In an autistic, these structures have densely packed neurons that are smaller than those in a healthy brain. Also, in the cerebellum there is a noticeable reduction in the number of Purkinje cells [9]. Courchesne linked the cerebellum with attention shifting, and the autistic takes a longer time to change the focus of his attention.

The exact reason behind the development of Autism during pregnancy remains unclear, but occurrence may be due to genetic defects. The diagnosis of the disorder is very much important because early detecting will help parents or caretakers better handle their children. Using the physiological signals such as the heart rate, skin conduction, muscle contractions and blink rates can be used to predict the mental and physical health of a person. Also, it is a known fact that these physiological signals may be induced or altered in particular environments [10]. The Autonomic nervous system (ANS) response like heart rate and skin temperature was monitored significant changes observed between typically developing children and ASD children [11]. The stress detection system based on physiological signals like heart rate (HR) and galvanic skin response (GSR) using fuzzy expert systems was used to determine the individual stress level. Stress detection system provides fast decision and individual state of mind and act as a suitable application for measuring the stress level [12].

It has been noted that the physiological signals of individuals with and without autism are almost same in conditions where social stimulus is not introduced, e. g., in a closed room or at times when no one is trying to talk to him/her. However, in an environment with social context, these childrens may show many variations that can be used as an indicator of the autism spectrum disorder. Monitoring physiological signal is useful to analyze the emotional state, but it may not be apparent. ASD children often react very superficially in ways, contrasting developmentally typical children, so design and evaluation of physiological signals to children with autism are necessary.

Photoplethysmography is a noninvasive method to measure the arterial and venous blood volume changes at a peripheral site where the blood vessels are close to the skin such as the finger and the earlobe. The physiological signal checked for children based on the level that the pediatrician has a guided the parents or caretakers for further investigation. The extracted features are systolic and diastolic values and the pulse amplitudes of the waveform. The normalized low-frequency components in the systolic and the diastolic values of the PPG waveform showed a significant difference between before and after postural change [13]. The benefits of PPG include easiness to set up, simple use and low cost. The PPG can take a measure without having direct contact with the skin surface.

The wavelet transform technique is ideally suited to study a particular event or short-duration changes in signal [14]. An important application is the ability to compute and manipulate data in compressed parameters that are often called features. The biomedical signals are time variant, considering the many data points; the signal will be compressed using wavelet transform to get useful parameters. In the present study, the mental task is given through clue cards that provide visual images like alphabets, numbers, fruits, colors and animals (Table 1). Then we attempted to analyze the physiological (PPG and GSR) signal variation between autism and control group. The feature was extracted from the physiological signals using wavelet packet decompositions to compare between the groups.

Material and Methods

Eighty subjects, 40 normal and 40 autistic children's from a particular school in South region of India participated voluntarily. Age group chosen for our study is between 8–13 years. All the experiments were conducted in the

morning session in a classroom, and the participant was made to sit in a comfortable chair with caretakers. The experiment was carried out as per the guidelines of the Institutional Ethics Committee of the Institute (VIT University, Vellore). Parents and Caretakers read and signed an informed consent before participating.

The experiment was conducted for 180 seconds in the morning time. During the experimental phase, subjects were accompanied by the caretaker to increase the comfort level of the participants. While conducting the mental task study, 13 autistic children dropped out with various reasons, and the remaining 27 childrens cooperated for the total duration of 180 seconds and normal children cooperated well throughout the total duration of study.

The PPG and GSR were recorded simultaneously during the mental task, and digital data was plotted in MATLAB software. Wavelet decomposition algorithm is applied to obtain a signal with the proposed output. The noise removal and amplification were performed by the pulse oximeter itself. The wavelet transform is the solution to multi-resolution analysis method and could give a more accurate temporal localization. The main advantage is to provide simultaneous information on the frequency and time location of signal characteristics at multiple resolutions corresponding to different time scales. Recently, wavelet packets have appeared to be a powerful tool to match the time-varying characteristics of some engineering signals. The importance of wavelet decomposition is to remove the motion artifact and to plot the signal with the same baseline. We conducted a wavelet packet analysis of 180 seconds, level 10 in (db4) family was adopted as the mother wavelet.

Results

The feature extraction of the PPG signal for autistic and normal children is done using time domain analysis, in which a single waveform is taken into consideration, and down-sampled. This method will give continuous change in the signal during a particular period of time and feature extraction will help in analyzing even a small change in the waveform and digital values of the pulse that may helpful in the diagnosis of the subject. The mental task performance study showed the error of the commission ($P < 0.001$) which was a significant difference between autistic children and normal children. The error of commission for autistic children was 75% and 100% for normal children. An error of omission is 10% for autistic children and 0% for healthy children. It was noticed that autistic children have more failure to respond to the response (answer identified) compared to healthy children.

The comparison between autistic and normal children was found that the dicrotic notch and heart rate (for first 90 sec and last 90 sec) during the mental task performance was significantly ($p < 0.001$) high for autistic children as compared to control group as shown in Table 2. The heart rate of the subject was found using the summary report of the subject. Using the digital values obtained from the signal, the average heart rate is determined for 180 seconds. The skin conductance (GSR) of the autistic group is more than the controlled group because of the process that the child is undergoing when he/she is being questioned (Table 2).

Table 1. *List of characters used in Clue cards for mental task assessment*

Alphabets	Colors	Fruits	Animals	Numbers
B	Red	Pineaple	Dog	1
C	Orange	Orange	Cat	3
D	Blue	Apple	Lion	5
E	Yellow	Grapes	Tiger	4
A	Green	Bannana	Elephant	2

Table 2. *Shows Feature extracted Parameters between Autistic and Healthy Children*

Sl. No	Parameters	Autistic Children (Mean±Standard Error)	Normal Children (Mean±Standard error)	Significant Value (p)
1.	Average of dicrotic notch	89.64 ± 1.31	79.96 ± 1.75	P < 0.001
2.	Pulse rate for first 90sec	88.30 ± 1.23	80.42 ± 1.63	P < 0.001
3.	Pulse rate for last 90sec	88.68 ± 1.22	81.57 ± 1.70	P < 0.001
4.	GSR average	133.06 ± 7.59	73.93 ± 6.73	P < 0.001

Discussion

Children with ASD have problems to know and understand the emotions of people around them and also have difficulty in trying to put across their feelings and emotions to people [2]. The physiological changes give several results related to the stress response that can be measured by invasive method [11]. One of the biggest challenges is distinguishing children with other developmental concerns from children with ASD. When children screen positive for possible ASD, or there is a high level of concern about ASD on the part of the clinician or the family, referral for further evaluation should be made. The diagnosis depends on the abilities of

experienced clinicians to identify features of ASD through detailed history taking, direct observation and assessment instruments specific to ASD.

Current best practice in the diagnosis of ASD is determined by a multidisciplinary team of clinicians, minimally including a physician (developmental pediatrician, child neurologist or psychiatrist), psychologist, and speech-language pathologist. Other disciplines such as occupational therapy, physical therapy, and/or audiology may be included as appropriate. The physician also orders appropriate medical testing to confirm or rule out other conditions suggested by history and physical examination.

The Heart rate (HR) and Galvanic skin response (GSR) can give information about the state of mind of ASD individual during the cognitive evaluations [12]. Finally, the psychological evaluation should also measure the individual's current adaptive functioning. The measure of adaptive functioning is necessary for diagnostic clarification, intervention planning, and response to intervention. Another component of a comprehensive assessment of autism spectrum disorders is a speech-language- communication evaluation, completed by a speech pathologist with experience in assessing children with possible ASD. Given that communication deficits are a core feature of ASD, all individuals presenting for differential diagnosis of ASD should be administered through speech-language evaluations.

Monitoring physiological signals is a way to measure the emotional information that may not be apparent. This works exceptionally well in case of children with autism because they are socially inert. For example, children with ASD might smile when they are in pain. They might show no expression or a neutral expression when they are enjoying an activity [10]. Autonomic nervous system (ANS) plays a significant role to control all activities of physiological, sympathetic and parasympathetic branches, adaptively respond to the situation [15]. The Autonomic nervous systems (ANS) is a typical response to anxiety and associated with ASD consistently with over arousal [11]. This analysis leads to identifying the content of PPG signal that is different for autistic children and normal children. The pulse is not constant, it keeps on changing, depending on the activity that one is doing. The pulse of a normal human being is around 65 to 75 bpm [12]. This study showed that the heart rate of the autism group is higher than the controlled group due to the higher stress levels.

The GSR of autistic children is such that the signal is unpredictable, i.e., unable to predict when a child is stressed and when the child is relaxed. This is due to the failure of the child to understand what others are telling them, and the confused state of mind of the child leads to instability of the signal. The stress faced by the autistic children is due to the failure to respond, understand and communicate with others of their peers and also makes them more stressed to express their emotion and needs to give higher rates of pulse. When a mental ability task is given to autistic children, due to the abnormality in the brain, they tend to drift from the task given to them and unable to concentrate at one thing at a time. They tend to get tensed and stressed out as compared to normal children, which shows the increase in the ANS activity more predominantly, the Sympathetic Nervous System and hence the heart rate increases. Based on the results observed from our study, we conclude that heart rate and stress level of autistic children is more compared to normal children.

Conclusion

The current study deals with the variation of physiological signals in autistic and normal group. Physiological signals are easier for analyzing the problems faced by autistic children and can be used for better diagnosis. The main advantage of the present study is that it can be done by any non-professional people at home or clinics quickly and safely. The clinics can do at low cost due to the availability of all the components. The physiological signals will not only help the autistic children, but also people around them to know for sure what they are going through or feeling at the point of time.

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