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Autistic Disorder Analysis Among Children and Adult

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ABSTRACT

Introduction: Monitoring neurophysiological signals and neuroimaging helps the researchers to identify the relations between the major disorders in neurodevelopmental and behavioural changes. Specifically, the brain typical pattern that leads to Autism Spectrum Disorders (ASD) can be analyzed in children with the signals effectively.

Objectives: Early identification of Autism Spectrum Disorders syndrome helps the parents to decide about the therapies and treatments required for improving their day to day activities.

Materials and Methods: Different analyses performed by various researchers using machine learning algorithms using the EEG and ECG signals have been presented. Different techniques and devices used for acquiring the data through various experiments are also presented.

Results: This paper presented a few techniques followed by various researchers; accuracy, sensitivity, recall achieved by the methodologies have been presented.

Conclusion: Data collection plays a major role in analyzing the Autism Spectrum Disorders where most of the researches find it very difficult and early diagnosis also plays a major role in the improvement the Autism Spectrum Disorders children.

Key Words: Autism Spectrum Disorders, EEG Signals, ECG Signals, Behavior Disorders

INTRODUCTION

Autism is one of the psychological and heterogeneous developmental disorders due to the abnormal wiring between the different brain regions.¹ It is a neuropsychiatric syndrome, derived from the Greek term autos, where an individual keeps himself/herself isolated from nearby interactions. CDC estimates that the incidence rate of autism was 1 in 110 kids in 2006 and that the rate was 1 in 88 births by 2012.¹

The CDC estimates its present prevailing frequency to be 1 out of 68 births or 14.7 per 1000 kids.² In India 1 out of 68 children is being diagnosed with ASD. At least 70 million people have autism worldwide in which 10 million are Indians. Due to the X-chromosome patching related mutations (PTCHD1) genes, five times boys are more vulnerable to this disease than compared with girls. In kids over 1.5–2 years of age, clinical symptoms are noted owing to an abnormality in neuronal connections both in computational and physical. It

may occur as troubled sleep, depression, reduced length of sleep, anxiety, and enhanced delay in the start of sleep (Belmonte et al., 2004). Researchers describe aggression, hyperactivity and behaviours of stereotypes as prevalent in autistic men, while autistic women demonstrate anxiety, depression, and increased intellectual deficiency.³ Other characteristics include macrocephalus, where head circumference development accelerates in the first 2 years followed by slowing down in subsequent adolescence, repetitive behaviour, delay in development, behavioural impairment, and absence of interaction and interactivity. Infant early behavioural traits are delayed in babbling and inappropriate sleep and eating practices.

TYPES OF AUTISM SPECTRUM DISORDER

Autism spectrum Disorders can be classified into various types and are specified in table 1.⁴

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Table 1: Autism Spectrum Disorders Types

Types	Features and Affected Rate
Classic autism - Autistic disorder	This has resulted in 20% of the population that leads to unusual behaviour and self-injurious with a deficiency in interactive communication skills.
High functioning Autism - Asperger's syndrome	Majority of the children with social impairment, unusual behaviour with normal language and communication with cognitive ability.
Atypical autism - Pervasive developmental Disorder	Very less population with 5% to 7% with having difficulties for social communication and interaction.

Autism can be categorized into four different categories where the individual can be persistently severe, Persistently Moderate, Improving and Worsening.⁴ The persistently severe category of autistic patients finds it very difficult to manage their day to day life. This kind of people always tends to perform some self-injuries because they have a severe cognitive disability. Similarly, the other category where persistently moderate finds difficult to interact with others. This group of individuals finds it difficult to cope up in communication skills. This category of people can be improved through therapies especially behavioural therapies. The next category of autistic patients is referred to as Worsening where their behaviours worsen day by day.

FACTORS INSTIGATING AUTISM

Different trials and experiment have been performed and analyzed to provide likely causes of autism. Autism is a neurobiological abnormality that affects the nerve fibres of the corpus callosum, which connects the two hemispheres (left and right) of the brain and plays a major role in sensory, motor and cognitive information transmission. A brain region's inherent wiring potential is consistent with reduced wiring expenses connected with small geodesic distances. The brain's complex surface is studied by computing the geodesic distance. It was noted that the inherent connection of the brain differs from ordinary topics in ASD topics. The functional connectivity of the ASD brain with other brain regions within frontal and temporal regions decreases for ASD. Over connectivity or under connectivity occurs due to less specialized autistic brain resulting in language impairment and reduced learning rate.

DIAGNOSIS

Behavioural therapies can be given to the people if diagnosed at early stages. Children with autism are more focused

on the face's region particularly mouth relative to the region of the eye and have the weak judgmental capacity. Gaze and position detection can assist in autism diagnosis using a virtual-reality-based intervention expression system that tracks eye gaze and physiological signals with Autism Spectrum Disorders typically develop in emotion identification tasks. The variations between the ASD and normally developing characters can be calculated with eye monitoring indices and output information. Quantitative differences between autistic and normal using facial discrimination since autistic people have impaired recognition concerning facial identification eye discrimination is also suggested.⁵ Functional magnetic resonance imaging technique helps to identify the neurons correlation during motion processing is tracked by Takarae et al. (2014).⁶ To improve the ASD people, passive views of visual movement and monitoring are identified. This study also suggested high abnormalities towards visual processing in autism. Chromosomal microarray analysis, exome sequencing and genetic testing are suitable tools in the identification of de novo mutations and ASD risk genes. Dyslexia is a learning disorder in which the children finds difficult to reading and learning because of their problem in identifying the sounds and matching with letters and words. This disorder affects the brain area that process language. These children can be successful if they have special attention from family members with active participation in various activities. The general cure is not available but Early Intervention and specialized assessment result in the best outcome.

AUTISM INFORMATION GATHERING UNIT

This includes four modules the biosignal sensor unit, the video processing unit, Central Processing Unit (CU), Assessment unit. The main function of the biosignal sensor unit is the acquisition of EEG and ECG signals using wearable and wireless devices from the child. Child behaviour is recorded using the video processing unit both in still and mobility conditions. All the collected data are processed using a central processing unit to evaluate the physiological and behavioural parameters linked with the behaviours of the ASD child.

Biosignal Sensor Unit

Electroencephalogram (EEG) signal Recording and Analysis

Acquiring electroencephalogram signal, digitizing and transmitting the signal with reduced environmental noise is done using Enobio wireless device (STARLAB, Barcelona, Spain). This device continuously records EEG signals over 32 channels which have to be placed according to the 10/10 standards and two references at 500 Hz with a 32-bit accuracy.⁶ This Enobio can be used either with gel or dry electrodes. Gel electrodes provide good contact but it might

be uncomfortable for the children, whereas dry electrodes can be chosen for easier setup and give good comfort for ASD children than normal child resulting in a good performance. EEGLAB Toolbox can be used to pre-process the EEG Signals resulting in the removal of noise and artefacts. After-pre-processing, QEEG analysis can be done using the Matlab toolbox. Power Spectral Density (PSD) is computed for the EEG signal in the frequency domain, so a conversion from time-domain has to be processed. For each electrode, absolute power as well as and the relative power of each band has to be identified. Relative powers are more reliable than absolute because they are less affected by artefacts. The BSI (Brain Symmetry Index) is computed within each EEG band considering the total energy in both left and right hemisphere region. Coherence value estimates correlation among the collected signals from scalp points and is computed for each frequency band.

ECG Recording and Processing

ECG recording is performed using a wearable device called Shimmer R which is a wireless base module powered by a 3.6 V rechargeable battery, that allows up to 7h of continuous monitoring per charge. This is tailored with cardio-fitness Polar™ or Adidas™ chest straps a lightweight, long term monitoring to gain in ergonomics. These signals are processed using different filtering techniques that aim at the removal of ECG artefacts and interferences. Significant features that identify the engagement of the child can be identified from the signal. The Heart Rate (i.e the number of poundings of the heart in a specific time expressed in beats per minute - HR), the Root Mean Square of the Successive Differences (an indicator of vagal activity - RMSSD), and the Respiratory Sinus Arrhythmia (periodic fluctuations in HR - RSA) are the measures to be identified.

Video Mobile Unit

The video mobile unit has to be set up with two environmental cameras with a frame rate of 60fps and is the solution of 640×480 for recording. The video cameras are synchronized to contextualize the neurophysiological parameters with the behaviour of the child. An expensive camera has to be used to capture video in-order to exactly identify the eye, mouth expression and their gait. The video analysis toolbox has to be developed to label the children behaviour from the recorded session. Some features like gesture, gait, mouth and eye variations that are instantaneous have to be annotated which represents the state of the ASD child. Manual annotation by the referring therapist has to be performed to identify the behaviour and the state of the autistic child. Behaviour always corresponds to action with start and end time, where state refers to the behavioural states i.e. engaged or disengaged. This video analysis tool generates an XML file with information's about the annotated events. This annotation file on every session will help to identify significant behav-

iour for exploratory analysis with EEG and ECG signal.

Central Unit

Central Unit is used to monitor the neurophysiological signals and the expressions of the child. The data recorded from the sensors and the video recorder is sent to this unit using Bluetooth data transmission. This unit notifies the session start to all the recording units to initialize each new session. The data collected can be processed offline and can be uploaded in the cloud for further research users.

Similarly, wearable's can also be used for data acquisition of the neurophysiological parameters for the treatment. Lucia et al⁷ acquired the signals from the autistic children during their therapy classes. EEG features were fetched from the EEG signals and identified the heart rate variability. This study helps to monitor the treatment effects for which naturalistic paradigms can be also used. Juan et al⁸ identified the behavioural changes and issues of the ASD people using some smartwatch. These authors performed nine-day experiments with two individual to show their behavioural changes during different emotions. Sucksmith et al. studied⁹ the empathy and emotions of the parents of the child affected by ASC. The study shows that the fathers have lesser empathy quotient than the mothers. Similarly, the anxiety level of the autistic children is analyzed to understand the physiological changes¹⁰. Many supervised algorithms were proposed to analyze the physiological signals. This paper proposed a Kalman filtering theory for identifying the physiological factors to evaluate the heart rate variability. This scheme achieved 99% of sensitivity and 92% specificity. Robust machine learning algorithm^{11,12} was proposed by Yuan¹³ using semi-structured and structures digital forms. The data are preprocessed and classified and achieved an accuracy of 83.4% and 91.1% of recall. Mohd et al.¹⁴ studied the EMG signals of the ASD children by acquiring the signal from the lower limb muscles during the walking process. These signals are studied for the typical development children also and the difference between them is studied for considering for habitation problem.

CONCLUSION

Monitoring neurophysiological signals and neuroimaging helps the researchers to identify the relations between the major disorders in neurodevelopmental and behavioural changes. Specifically, the brain typical pattern that leads to Autism Spectrum Disorders (ASD) can be analyzed in children with the signals effectively. Early identification of Autism Spectrum Disorders syndrome helps the parents to decide about the therapies and treatments required for improving their day to day activities. Different analyses performed by various researchers using machine learning algorithms using the EEG

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Conflict of Interest:

The Author(s) declare(s) that there is no conflict of interest.

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