Experimental VALidation of findings using BCI in Autistic kids- (EVAL BCI)

***Abstract*— Autism is a developmental disorder that impairs the ability of affected to communicate and interact. This disease impacts the nervous system, resulting in poor emotional, social, cognitive and physical health. Affected ones are however capable of excelling in some or other field of their interest. To identify their interest, they need to be exposed to wide range of activities on a daily basis. Manual interpretations can go wrong as a person can complete a task with interest, fear, etc. Brain Computer Interface (BCI), helps read and analyze the human brain activity using brain waves. Attention values and brain waves from samples are analyzed while performing activities as part of experiment. So in this study using BCI, manually interpreted sample's interest to a task is verified experimentally. It is learnt that, samples show an improved percentage attention during sessions of their favourite task.**

***Keywords*— BCI, autism, attention, experimental validation**

I. INTRODUCTION

Brain, the most complex part of nervous system in all vertebrates and most invertebrates is composed of more than 100 billion neurons. It controls all human activity and help to interpret data from outside world. In humans, brain is seated in head and controls body balancing, reflex actions, thinking, gait, etc. Using sensory information passed through neurons, brain commands to contract or extend the muscles, thereby controlling any motion.

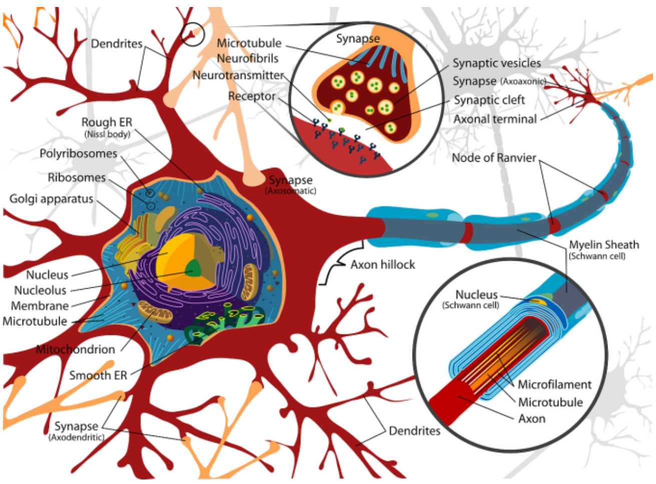

Fig. 1. A human neuron

Neurons communicate each other by creating a potential difference called 'action potentials' at their junction (synapse) followed by release of chemical neurotransmitters. Fig 1 shows structure of a neuron. During this neural activity, neural oscillations are induced, mainly in brain. These are collectively referred as brain waves or EEG (electroencephalogram) waves. Based on the activity performed, the strength of the EEG signal also varies. Different EEG signals, associated activity and frequency range are shown in Fig 2. These EEG signals become visible in prenatal stages, but all frequencies will be active in a person by 7-10yr. In most people sleep signal (delta waves) slowly degenerates after 80yr, resulting in reduced sleep. Earlier MRI and fMRI techniques were widely used, but being compact and easy to use BCI is more accepted. Using EEG sensors (wet /dry), BCI captures these EEG signals.

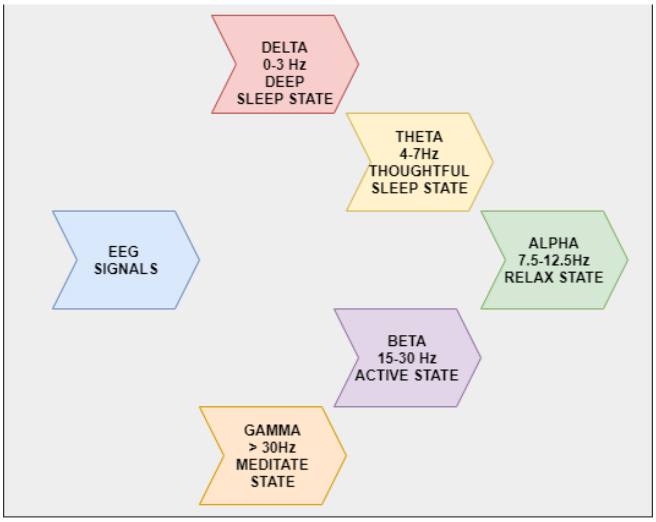

Fig. 2. Different EEG signals

Brain signal is considered as a composite data with enormous information about the entire body. In most wearable BCI headset captured signal is attenuated by noise and other electrical interferences, as it reaches the electrodes. So, captured signal is passed through noise filters before being used to compute the Attention and meditation levels. In a person with neural impairments, these signals shows variation compared to healthy ones. These variations can be used for detection of impairment if any, as early detection can help the child.

Over past few decade, active BCI based research has contributed lots to the society. Mostly they are aligned to automation of device functionality or aids in medical treatment. EEG signal generation, their frequency of operation are few primary research in this field [1]. Different applications of BCI research, like healthcare and future insights of BCI solutions are briefed in [2]. [3] and [4] deals with automation of a computer to enable users communicate with others. These were tested in bed ridden patients also for their rehabilitation. In research field, many works focus on neuro-feedback using EEG signals for post stroke rehabilitation [5]. Recently animated games [6] were developed for children to track their growth and then emerged immersive games with BCI feedback [7]. For autistic kids, BCI feedback based video games are developed in [8] to keep them engaged and track the improvements in them. In [9], neural training based autism therapy using BCI data is described. [10] Investigates usability of single electrode headset to study attention in users.

Autism is a disorder that results in poor neural development. Cause of autism is still not known but affected ones show a different brain structure compared to neuro-typical children. Development of autistic kids need more care and patience. Time to understand their interest to a task may take more than 6 months. Manual inspection of interest towards a task for an autistic kid can go wrong by careless handling of huge data. So in our approach we try to find the interest in autistic kids manually and validate them using BCI derived insights.

II. Methodology

Brain waves is composed of information regarding the physical state and thought process in a person. Currently a child's interested activities are identified manually by parents or supervisor. These predictions might go wrong and if they go wrong it can result child in compulsion state. To validate a person's interest to an activity, we rely on user's BCI recordings taken while performing the task. The methodology followed is shown in Fig 3 and explained briefly in the following subsections.

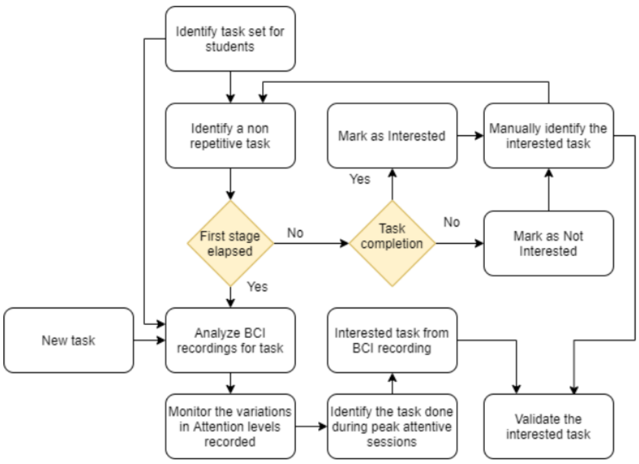

Fig. 3. Methodology followed to validate interest in a task.

A. BCI

Brain Computer Interface is an electro-mechanical device that help analyze brain waves using equipped EEG sensors. BCI devices are available in different models, like headband, auditory piece, bow, etc. In this study we have used a single electrode based BCI headset with a reference electrode clipped to ear. It can detect EEG waves and help us gather more insights about a person's brain activity. Data collection using EEG headset using task completion is shown in Fig 4.

B. Autism

Autism is a disorder, caused due to impairment in neural system. Affected ones have shown a reduced level of cognitive, emotional and physical activity. Continuous care and support from family and educational institutes in early stages can bring about much improvements in them. Their interested fields need to be explored by exposing them to different activities and guided properly to get the best in them.

Tata Consultancy Services and AASHA foundation has helped us in realizing and completing the study.

Fig. 4. BCI based data collection phase.

C. Experimental Procedure

In this study, we have selected 6 autistic student samples. Their profile is briefly described in Table I. This experimental study was performed in 2 phase, manual interpretation phase and BCI based validation phase. Activities set was identified prior to the study based on their age, patience, etc. Identified activities include curriculum related task like addition, writing passage, reading chapters and other activities like colouring, bounce ball, sorting, etc. In each phase expected task was explained for better understanding. Task execution may go wrong, but they are allowed complete the task without any compulsion.

TABLE I. Profile of Selected Samples

Sample count	Profile of selected samples		
	Read	***Write***	***Comprehension***
1	Good	Good	Medium
2	Poor	Medium	Poor
3	Medium	Good	Poor
4	Poor	Poor	Poor
5	Medium	Medium	Medium
6	Poor	Good	Poor

a. Manually interpreted profile.

In manual interpretation phase, they were made to perform different task in six months of time. All samples were made to undergo wide variety of task sessions. In this time, their favourite task is identified manually through the completion rate and level of interest shown to perform a task repeatedly.

In BCI based validation phase, all variety of task were made to be performed again by all six samples in each sessions. Even new task were given to some samples with a person to help, like puzzle solving. Nine sessions were recorded in a month time with BCI headset. In this phase, task is not repeated, to ensure more variant activities are covered. During each sessions, captured EEG data is saved to a file to analyze and deduce conclusions later. Obtained brain signals and attention levels are analyzed using different statistical tools. Throughout data analysis phase, attention parameter (key parameter) is given prior importance.

III. Experimental Results

In this study, recordings from 2 phases are collected and processed to validate manual interpretations from former with the latter. From the former phase, interest to activities exposed were obtained manually. This is shown in Table II, for further reference.

TABLE II. MANUALLY IDENTIFIED FAVOURITE TASK

Sample count	Descriptors
	Favourite activity
1	Subtraction
2	Puzzle
3	Puzzle
4	Stringing beads
5	Bounce ball
6	Puzzle

b. Identified through continuous manual monitoring

From the second phase of experiment, we get 9 EEG recordings each of 6 samples. Activity done during each session is noted for final comparison. For each data comprises of EEG waves like delta, theta, alpha, beta and gamma and other parameters measured like attention and meditation. For the study as a reference, threshold attention level is set to be 50 in scale of 0-100.

TABLE III. ACTIVITY DESCRIPTION OF 9 SESSIONS

Session	Activities of 6 samples					
	Sample 1	***Sample 2***	***Sample 3***	***Sample 4***	***Sample 5***	***Sample 6***
1	Subtract	Puzzle	Colour	Bead	Read	Puzzle
2	Subtract	Puzzle	Colour	Bead	Read	Puzzle
3	Teach	Draw	Write	Match	Copy	Add
4	Read	Copy	Read	Match	Read	Add
5	Read	Copy	Read	Match	Read	Add
6	Write	Sort	Puzzle	Match	Write	Math
7	Puzzle	Maths	Write	Sort	Colour	Math
8	Oral	Colour	Yoga	Trace	Describe	Sort
9	Treasure	Fix nuts	Immitate	Match	Bounce	Craft

c. Task given to samples in phase 2.

For each session, percentage attention recorded and the duration for which attention more than threshold level is recorded are computed. Activity performed by the samples is listed in Table III. Percentage attention period recorded for each session for each sample is shown in Fig 5. Each sample is represented in different coloured bars (red, orange, green, yellow, blue and gray), their percentage attention level is plotted in Y axis.

By comparing Fig 5 and Table III, activity for which the maximum attention is recorded can be obtained. Then comparing it with Table II, we can validate the results from phase 1 and phase 2 as same. For example, sample 4 records maximum on session 2 where task was to perform 'Bead task', which is recorded as sample's favourite task. Sometimes for same activity attention is lower, this can happen as brain signals are affected by many factors. But for all samples it is noted that the session with highest attention level recorded matches sessions with their favourite task identified manually in phase 1 of the study.

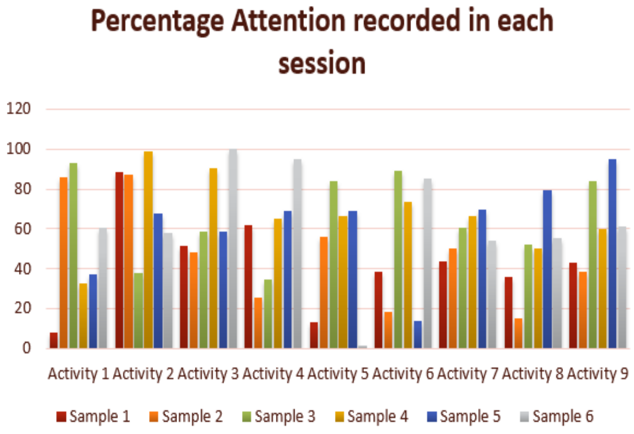

Fig. 5. Plot of percentage attention recorded in each session of phase 2.

IV. Conclusions

Communicating with autistic kids is a tedious task and it need much patience. Finding their area of interest and promoting them in that direction needs utmost care. Today, this done manually but this decision might go wrong due to manual errors while handling large amount of data. In this study we try to validate a person's manually predicted interested activity with one derived from BCI recordings. Results shows that both results are same in our case. As children grow, their interest also varies over time and it becomes difficult to keep track of it, proposed method can help in that scenario. BCI results over a period can be used to analyze a sample's interest to a task. This can even be used even for neuro-typical kids to identify their real interest. Through this study we try to open a new window for knowledge transmission with autistic kids using BCI.

Acknowledgment

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