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Neurofeedback Training to Improve Comprehension and Expression of ASD Child: A Case Study

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Abstract

Autism spectrum disorder (ASD) is a neurodevelopmental-related disorder that pertains until adulthood. Children with autism show difficulty in functioning such as in social interaction, communication and behaviour. Thus this preliminary case study addresses the effect of neurofeedback training to improve autistic spectrum disorder behaviour. Neurofeedback is a form of training using the operant conditioning paradigm to regulate the brainwave activities voluntarily using a real-time feedback (audio or visual). The neurofeedback training aimed to enhance beta wave (15 to 20 Hz) and inhibit theta wave (4-8 Hz) at T5 and P3. A 12 years old boy diagnosed with ASD undergone 15 sessions of neurofeedback training to improve his language comprehension and expression. The participant showed observable improvement in speech/ language or communication and sociability subscale of the Autism Treatment Evaluation Checklist (ATEC). Improvement could be observed in term of Matts comprehension and expression based on parents and teachers report on both ATEC scores and interview. The study presents feasible evidence of neurofeedback training to improve ASD symptoms.

***Key Words*:**Neurofeedback; EEG Training; Neuropsychology; Cognitive Psychology; ASD

1 Introduction

Historical records can be traced back at least 5000 years ago from the Middle East that suggested the brain as a control centre of behaviour, which at present known as the brain hypothesis (Stirling, 2002). Later, the studies related to brain and behaviour from physiological psychology field evolve, thus one of it is known as neuropsychology, which seek to understand the relationship between the brain and behaviour and attempts to explain which observable behaviour is expressed by the brain activity (Beaumont, 2008). Beaumont (2008) stated that neuropsychology consisted of clinical neuropsychology and experimental neuropsychology. Clinical neuropsychology is related to behavioural neurology and dealing with patients with cerebral lesions. As for the experimental neuropsychology, it deals with normal subjects in the laboratory using a variety of techniques which includes dichotic listening, divided visual field, lateralized tactile presentation and more specialized physiological techniques. The early development of neuropsychology shows many techniques used to measure brain structure and functions which include examining brain tissue, lesion and ablation, electrical stimulation and electrical recording (Stirling, 2002). Electric recording enabling researchers or health practitioner to learn about the brain function and it is the basis of neurofeedback. Computer screen or chart recorder display the brain electrical activity detected by the electrodes attached to the scalp.

The potency of surface recording is due to electrochemical activity of the brain that is conducted passively through the meninges and the skull to the scalp. The activity of millions of neurons in the brain area closer to the recording electrodes is summarized in the form of recorded voltages. Therefore, in order to obtain the spatial distribution of brain activity, different electrode placement is used to enable simultaneous recording. This procedure has proven invaluable to diagnose different disorder such as epilepsy and identification of sleep-related disorders (Stirling, 2002) is also known as neurofeedback protocol.

Neurofeedback training had been widely used wide range of field such as cognitive and memory enhancement, especially aiming to counter the effects of aging. Neurofeedback is also used as peak or optimal performance training in musical performance, ballroom dance performance, sports and surgical skills. Apart from that, neurofeedback training also used as an intervention in other disorder such as learning and developmental disabilities, substance abuse, antisocial personality, autism spectrum disorder (ASD), attention deficit/hyperactive disorder (ADHD) anxiety and depression (Hammond, 2011).

2 Literature Review

2.1 Neurofeedback and ASD

Over the years neurofeedback has gained attention as an alternative and effective treatment for some early childhood disorders as such attention-deficit/hyperactive disorder (ADHD), Aspergerss disorder, learning disability, obsessive-compulsive disorder (OCD) and ASD (Demos, 2005; Evans, 2002). A number of randomized clinical studies on the usage of neurofeedback training for ADHD have proven the efficacy of neurofeedback training for ADHD (Bakhshayesh, Hnsch, Wyschkon, Rezai, & Esser, 2011; Gevensleben et al., 2010; Liechti et al., 2012). The American Psychiatric Association (Association, 2015) defined ADHD as a developmental disorder characterized by inattention, hyperactivity and impulsivity. The findings has lead studies of neurofeedback as an alternative treatment for autism since generally autistic children show symptoms of attention-deficit and hyperactivity (Wang et al., 2013). Autism is a neurodevelopmental disorder and associated with impairment in interaction and communication (Brentani et al., 2013; Coben & Padolsky, 2016). According to Evans (2002), almost all autistic spectrum children and adults have impaired socialization and vocalization and they have their own learning method. Their unique learning method often landed them in difficulty in learning situation as school may attempt to force them to learn a certain way instead of invidualized their own learning method (Evans, 2002). Neurofeedback in ASD was first reported in 1994 by Cowan and Markham (Coben, Linden, & Myers, 2010). Cowan and Markham (1994) conducted a case study for autistic child and found out that after undergoing 21 sessions, the child show improvement in focus, attention and more relaxed. Improvement in autistic behaviour, social and academic functioning was also noted. A study by Sichel, Fehmi, & Goldstein (1995), was also one of the first published study employing neurofeedback on a diagnosed mildly autistic child. Their case study reported positive results and showed improvement in the autism DSM-III- dimensions after 31 neurofeedback sessions. Another study by Jarusiewicz (2002) was done to test the efficacy of neurofeedback training on 12 children diagnosed clinically with ASD as reported by their parents. The children undergone at least 20 sessions (M=36 sessions) and a maximum of 69 sessions. The study proved significant evidence that neurofeedback is efficacious for autistic spectrum individuals. All 12 children showed positive changes in their conditions based on parent interview and the Autism Treatment Evaluation Checklist (ATEC).

Coben and Padolsky (2016) then extended the study done by Jarusiewicz (2002) with more sample, various assessments (neuropsychological tests, ratings of behavior and executive function), and guided measures of brain functioning using quantitative EEG (QEEG) analysis and Infrared (IR) imaging. The experimental group involved 37 children diagnosed with Autistic Spectrum Disorder (ASD) and another 12 ASD children was put in the wait-list control group. Both groups were matched for demographic (age, gender and race), handedness, other treatments and severity of ASD. The experimental group undergone 20 sessions of guided neurofeedback with individualized treatment protocol. The protocol of each participants were based on QEEG analysis and Infrared imaging to accurately target the specific regions. The findings showed that the experimental group improved significantly in their ASD symptoms as compared to the wait list group. The study proved that neurofeedback is an efficacious treatment for ASD. These findings provide promising evidence that neurofeedback training can be used as a treatment modality to improve ASD symptoms. Diagnosis for autism showed several abnormalities in brain functioning which include high-beta activity related to anxiety, high delta/theta activity related to lack of attention, impulsivity and hyperactivity and abnormal EEG or seizure activity (Marzbani, Marateb &Mansourian, 2016). In addition, one of the most common abnormalities in brain among ASD children is high beta type. Thus, neurofeedback training for ASD children usually focus on enhancing beta wave while inhibiting theta-alpha ratio. In this study, neurofeedback training is used to help improving autistic behaviour especially in social interaction and communication.

2.2 The 10-20 System

Specific symptoms relates to specific regions of the brain (Demos, 2005). Sensors placement is guided by matching specific brain functions with specific symptoms. For instance, the frontal lobes are responsible for immediate and sustained attention, social skills, emotions, empathy, time management, working memory, moral fiber or character, executive planning, and initiative (Demos, 2005). The standardized system for electrode placement is known as the international 10-20 system. The system provides a method of describing where the electrodes are placed (Soutar & Longo, 2011). It is a method of reference for neurofeedback protocol in standardizing areas of the skull and comparing data. The term 10-20 refers to the placement of electrodes over 10% or 20% of the total distance between specified skull location which named using letters and numbers. Typically, there are two types of montage applied in neurofeedback training (i) unipolar (active electrode placed on the skull is compared with reference electrode) and (ii) bipolar (two active electrode placed separately on the skull is compared with one reference electrode). The brain activities at the active electrode are the sum from activity of active electrode minus activity of reference electrode (Marzbani, Marateb, & Mansourian, 2016). The letter represents the lobe and the number is to identify the location of the hemisphere (Trans Cranial Technologies Ltd., 2012). In other words the letter F referring to frontal lobe, T for temporal lobe, P for parietal lobe, O for occipital lobe and C for central. Even numbers referring to sensors positions on the right hemisphere and odd numbers referring to sensors position on the left hemisphere. Thus, the T5 electrode is placed over the left hemisphere at the temporal region, and the P4 electrode is found over the right parietal region.

3 Methodology/Materials

3.1 Sample

Matt (not his real name), was born in November 2003. He was diagnosed with Autism Spectrum Disorder by doctor since he was four years old. He is attending special developmental centre and was referred by his teacher as a suitable candidate to undergo neurofeedback training as he fall under the category of high functioning ASD (as diagnosed by medical doctor). The researchers, teacher and Matts parents meet up in March 2016 for discussion and observation regarding his medical history and neurofeedback training.

3.2 Measure

Autism Treatment Evaluation Checklist (ATEC) is a 77 items scale developed by Rimland and Edelson, (1999) to provide general condition of a childs current behaviours and skills (communication, sociability, sensory and cognitive awareness, and health and physical behaviour). ATEC is easy to administer designed to be completed by parents and teachers of ASD children. The scale was administered before and after the training. Matts parents and teachers rating of ATEC showed that Matt scored high (indicating higher symptoms) rating in speech/language/communication subscale and in sociability scale. Apart from using ATEC to assess the efficacy of the training, interview with the parents and teacher were done at the end of the preliminary training.

3.3 Training

Matt undergone 15 sessions of neurofeedback training using the Brain Trainer System for five weeks. The training was performed twice a week (30 minutes per session) beginning March 2016. A neurofeedback expert was consulted to design a suitable protocol for Matt. The training was then aimed to enhance beta wave (15 to 20 Hz) and at the same time inhibiting theta wave (4-8 Hz) at T5 and P3. This protocol was recommended to improve Matts language comprehension and expression. Active electrodes were attached to T5 and P3 based on 10-20 International System. The reference electrode was placed on the right ear with the ground on the opposite ear. The electrodes were cleaned using NuPrep gel and Ten20 conductive paste was used to attach the electrodes to the skin.

A three minute baselines were taken in the beginning of each session and thresholds were set. The brainwave responses to stimuli shown on the researchers screen are observed in real time for artefact characteristic, amplitude and frequency. The feedback information in the form of video games provided visual and audio feedback displayed on the trainees computer screen showing the performance of the trainee. The audio and visual feedback will indicate the trainee if he is able/not able to obtained scores.

4 Results and Findings

Prior to the first session Matt was introduced to the electrodes and a mock training was done to get him familiarized with the equipment involved especially the pacing of electrodes on his scalp and ears. Initially he was uncomfortable when electrodes were attached to his ear and scalp. To help Matt familiar and get used to the electrodes, he was allowed to touch and placed the ear clip on his ears himself a few time by the teacher before the actual session begin the following week. On the first session Matt was calm and the researcher him the Bugz Raider game that he will play on the first session. The game required him to shoot several types of bugs to gain marks, while dodging few object or the bugs itself to avoid losing marks.

During the first session, he anxiously presses the joysticks button aimlessly trying to produce a bubble. After some minimal guidance by informing him that the bubble will only appear when he focused on the screen. He then gradually able to enjoy the game and showed excitement every time he earned higher score from the game. He would stop during the resting period and give a high-five to the trainer if his score increase. However, as the level of the game increase and he had to face more challenge, he dodged the bug rather than trying to shoot it because of fear of losing more marks. In the fifth to seventh session, Matt showed disappointment every time he hits the bugs by saying No, no, no because he lost marks causing him to get low score. This indicates that he is able to express his feelings. At certain time he also seemed to be more relaxed, as he only pressed one button that function to shoot the bubble. Several times during the sessions (8th to 10th session), Matt, suddenly become fidgety and scratched his eyes especially during the last period (8-10th period) showing disinterested and less excited. This could be due to lack of sleep or has gotten bored of the game. The trainer had to give minimum encouragement to keep him motivated. As shown in Figure 1 and Figure 2, Matts ATEC scores reported by both parent and teacher on speech, sociability subscales improved after neurofeedback training. Sensory/cognitive awareness and health/physical/behaviour did not show much change. Total scores for ATEC showed improvement for both parent and teacher.4.1 Sub Heading (if any).

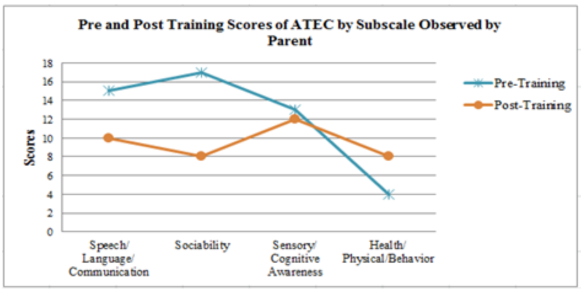

Figure 1. Pre and Post Traning Scores of ATEC by Subcsale Observed by Parent

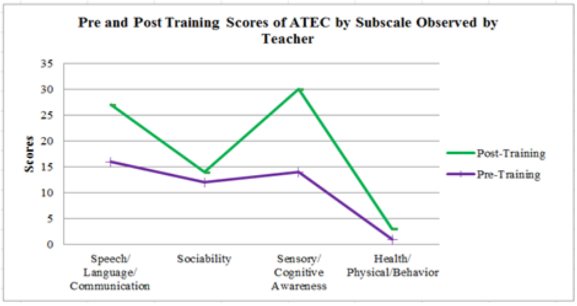

Figure 2. Pre and Post Traning Scores of ATEC by Subcsale Observed by Teacher

Figure 3 display the average readings of the T5 and P3 Beta protocol throughout the 15 sessions. Apart from that, parents and teacher also reported that Matt showed modest improvement in speech, language and communication. His parents also reported that upon receiving the training, Matt interacted more with his younger sister through play and shown improvement in his verbal communication. This also supported by the improvement in his sociability through the observational by the parents and teachers. He also showed better eye contact with family at home and teacher at school.

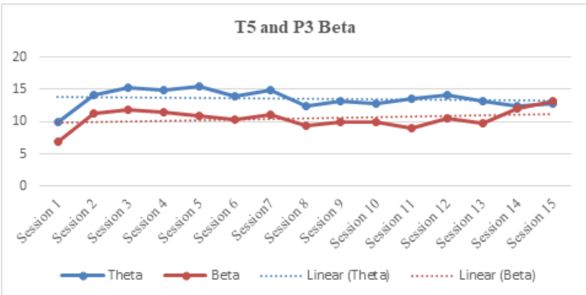

Figure 3. The Average Readings of the T5 and P3 Protocol (Reward Beta; Inhibit Theta)

5 Conclusion

The aim of the neurofeedback training was to improve Matts language comprehension and expression. Due to low number of sessions, not surprisingly the training did not provide remarkable improvement in all four sub scales. However, positive feedback from the parents and teachers on his expression and social interaction showed that more neurofeedback training session can be considered. Findings on the data across sessions revealed modest improvement in the theta and beta wave. Plotted graph on Beta showed positive (increase) trend line. Whereas the theta (inhibited wave) showed expected trend (increased). Improvement could be observed in term of Matts comprehension and expression based on parents and teachers report on both ATEC scores and interview. Trainers also noticed that Matt was more interactive with the trainer and would give gestures such as a high-five to the trainer when he scored well during the training. Teacher and trainer noticed Matts improved in term of eye contact after the 9th sessions. Given the preliminary nature of this training, the data obtained are limited to a high functioning ASD child and involve one subject. Therefore a case study limited the generalization of the result. Base on the current result, neurofeedback training is a promising treatment for neurodevelopmental disorder such as ASD. Since this is a case study, the absence of a proper controlled design and enough sample size limit the generalization of the efficacy of the result. More training sessions might contribute to better improvement of ASD symptoms. The result might also differ for other spectrum. However, this case study presents feasible evidence of neurofeedback training to improve ASD symptoms.

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