UNIVERSITI TEKNOLOGI MARA

IDENTIFICATION OF EEG SIGNAL FEATURES OF NORMAL AND DYSLEXIC CHILDREN USING WAVELET TRANSFORM AND PREDICTIVE ANALYSIS

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ABSTRACT

This study looks into the differences in electroencephalograph (EEG) signal features of normal children, poor and capable dyslexic by investigating the alternate pathway created during writing-related tasks. Previous researches have only concentrated on functional magnetic resonance imaging (fMRI) and positron emission tomography (PET) that are not practical to be applied in a real working scenario. Unique signal features that are extracted from an optimum wavelet transform found between normal children, poor and capable dyslexic enables the design of a diagnosis technique to complement the available time-consuming and labour-intensive manual assessment of dyslexia. The current assessment method requires a skilled diagnostician to be on hand, coupled with the fact that early symptoms are very diverse and too subtle to be recognized. With a total of 33 subjects between the age of 7 to 12 years old, EEG was acquired during writing tasks of words and non-words through a minimal eight electrode locations of C3, C4, P3, P4, T7, T8, FC5, and FC6. Brain activation areas were studied through 2D topography mapping of the EEG subjects and identification of active frequency components were found through power spectrum density (PSD). Results revealed that right brain activation of electrode location FC6, C4, P4, and T8 in a person with dyslexia could be applied as a marker to indicate their ability to overcome learning disability of reading and writing. This gives an indication of the learning pathway within the brain for normal children and establishing the existence of a compensatory alternate activation in capable dyslexic. Features of band power, approximate entropy (ApEN), and variance were extracted, and its suitability was tested through analysis of variance (ANOVA) and observation of hemisphere dominance. Band power was found to agree with the hypothesized activation for all three groups of normal children, poor and capable dyslexic but requires an additional within electrode measurement in the form of theta/beta ratio to differentiate similar activation areas observed in normal children and poor dyslexic. The addition of the theta/beta ratio has also improved on the overall classification results. The optimization of mother wavelet function and order was performed by analyzing the area under the curve (AUC) of receiver operating characteristics curve (ROC) measurements of support vector machine (SVM) classifier of both linear and radial basis function (RBF) kernel. 10-fold cross-validation was performed on all classification to ensure result validity. Extraction of features through Daubechies wavelet transform of order 8 produced the highest AUC of ROC average measurement of 0.9996 and became the mother wavelet function and order of choice. In learning task simplification, subjects were observed to see words and non-words as a geometric shape based on their EEG readings. Classifier performance based on the identification of the three groups under study, i.e., normal children, poor and capable dyslexic, stands at 89% for accuracy and sensitivity. In a one against all evaluation, classification of normal children achieved an accuracy of 91%, poor dyslexic with an accuracy of 93% and capable dyslexic at 94% accuracy. The overall findings of the dyslexic's EEG enable an objective assessment to be made of the child's progress and effectiveness of an intervention program. It also allows for the design of a neurofeedback protocol that utilizes the capable dyslexic brain activation areas as the benchmark.

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CHAPTER ONE
INTRODUCTION

1.1 Background of Study

A learning disorder is thought to have a prevalence rate of nearly 10% of the general population [1] that would amount to at least 267,396 Malaysian public primary school going students in 2017 [2]. From that figure alone, 80% is believed to suffers from dyslexia, the highest percentage if compared to attention-deficit/hyperactivity disorder and autism [3]. In a population of school-going children with an age range from 7 to 12 years old, 25% have a learning difficulty in both reading and mathematics [4], which indicate that the struggle is not only specific to reading-related tasks but across multiple topics within the curriculum. With a number that substantial, early identification and intervention of dyslexia is of great importance in providing appropriate support for these children to navigate through the education system.

Dyslexia is a neurological disorder that causes a child to lag behind their peers in acquiring the necessary skills in reading that could also affect writing, verbal communication, and spelling even though the child have an average or even higher intelligent quotient (IQ) than the norm. Common behavioral indications of dyslexia are difficulty in reading age-appropriate material, unreadable or slow writings or copying, bad spelling, and letter reversals. These signs are mostly subjective and can be due to other various reason. It has been revealed that a dyslexic brain processes information differently and their struggle in a learning-related task is not a direct consequence of having low-level vision, hearing impairment or even inadequate education, which is in contrast to earlier beliefs [5]. Areas of the brain normally responsible for learning-related activities are not functioning effectively, showed deficient synchronization and evidence of delayed firing of neurons [6]. These neurological differences manifest itself in the child having issues with phonics awareness and their ability in rapid automatized naming, two key components in acquiring reading and writing skills [7].

As signs of dyslexia is commonly associated with reading and writing, its assessment is only made at an age where the child is already in school, which is akin to waiting for the child to fail [8]. In early schooling, dyslexic tend to mask their inefficiencies and seems to be normal by memorizing texts and passages. As and when