A System for the Detection and Non-pharmacological Intervention in Attention Deficit/Attention Deficit Hyperactivity Disorder

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Abstract: ***A five channel electroencephalographic (EEG) system to observe evoked potentials and power spectral shifts, which may be indicative of Attention Deficit/Attention Deficit Hyperactivity Disorder (ADD/ADHD), is described. The system is intended for use by schools as a screening tool similar to the vision and hearing tests now routinely administered. In addition, the system can be used in a specific protocol for the non-pharmacological intervention in ADD/ADHD.***

Introduction

Learning disabilities, such as Attention Deficit Disorder, pose serious, long term obstacles to productive, integrated lives. The early detection and remediation of these disabilities is essential to help disadvantaged learners of any age or educational aspiration. Presently, most schools test incoming students for visual and hearing impairment. It is often not until much later that learning disabilities manifest as academic deficiencies, with frequently accompanying conduct problems.

There exists a body of data which describe age specific normative values for the electroencephalogram (EEG)[1]. In addition, there are other studies that relate certain electroencephalographic abnormalities to learning disabilities [2,3,4].

Researchers at the University of New Hampshire and the New England Neurobehavioral Institute (NE Neuro) EEG Laboratory have devised a system which amplifies the human EEG, filters and digitizes the analog signal, subjects the data stream to a statistical analysis of the power spectrum and compares the result with previously derived normative values to determine a given subject's inclusion in the category of learning disabled or normal.

Normally, EEG examination requires 16, 24 or up to 32 discrete channels of data from as many locations on the scalp of the subject, an arduous time consuming procedure. This study has chosen four scalp locations premised upon a survey of existing literature which suggests that the EEG data which we seek in order to show this specific learning disability may indeed be derived using only these four specific locations. This procedure would more easily lend itself to a large scale screening protocol than EEG examinations requiring many more channels of information.

Background

A review of the literature establishes the fact that the EEG power spectrum, sensory averaged evoked response and event related potential (ERP) can be used to assess the functional status, maturational development of the brain and to evaluate information processing related to sensory, perceptual and cognitive functioning. Recently published works have provided a substantive body of documented evidence relative to the use of the EEG as a diagnostic tool in the study of the brain function of both normal and learning disabled children [2,3,4,5,6].

The work of J. Lubar from 1973 to the present established the predominance of theta (4-7 Hz) EEG activity, with decreased beta -1(13-21.75 Hz) activity in children with ADD [7]. Subsequent to a diagnosis of ADD, Lubar showed that the administration of biofeedback to increase beta and decrease theta can lead to very significant changes in EEG and ERP measures, as well as improvements in psychometric test measures and school performance [8]. M. Tansey has recorded significant, long term beneficial results in SMR biofeedback in the treatment of ADD [9]. In another study by Tansey we find further confirmation of a theory that asserts that there are electroencephalographic "signatures" peculiar to learning disabled children[10].

The objectives of this ongoing research encompass three related phases of activity: the fabrication of instrumentation to detect and analyze

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the EEG; the establishment and implementation of neurometric methods whereby learning disabled children are diagnosed and identified; and the establishment and implementation of non-pharmacological intervention whereby ADD/ADHD can be remediated without drugs such as Ritalin. This paper represents the preliminary aspects of the first part of this three phase program.

System description

The instrumentation, the "CorTekScan," consists of a 5 channel EEG amplifier and computer interface. The unit is able to detect, amplify and filter 1 EOG channel and up to 4 EEG channels simultaneously. Scalp locations F3, F4, C3, and C4 in the International 10-20 System have been chosen as appropriate at this time but may change as research proceeds. Each channel amplifies the signal approximately 30,000 times and filters out signals above 32 Hz with an 8th order Bessel low-pass filter. Low frequencies are attenuated with a high pass filter with a 3 dB point of 0.4 Hz. After amplification and filtering, the signal is sampled and digitized with 12 bit resolution by a microprocessor sampling at 128 Hz. The digitized data is sent to the serial port of a PC at 19,200 baud.

The software portion of the system is responsible for all signal discrimination, processing and display of the sampled data. Along with EEG, electro-oculogaphic (EOG) information is collected so that when blink artifacts occur they can initiate data stream rejection. The system allows the EOG threshold to be set within a specific range and creates data files of up to 30 seconds of continuous EEG recording.

The Fast Fourier Transform (FFT) is used to derive the frequency spectrum with an additional calculation to obtain the power contained in each frequency of the spectrum. The FFT and power calculation perform a transformation of 256 data points in approximately 0.075 seconds. The 256 data points require 2 seconds to obtain, but the use of a circular buffer which allows the addition of a fixed number of new data points with the removal of a fixed number of old data points assures that 256 data points are always available with a lapse in time corresponding to the number of new points. A new power spectrum is calculated and displayed every 1/4 second, and all frequencies from 0-32 Hz are displayed with 1/2 Hz resolution.

The system can monitor and display the raw EEG (voltage vs. time), the power spectrum, a compressed spectral array (CSA) or a bar graph of the power spectrum from 0-32 Hz, divided into 8 discrete vertical components of 4Hz bandwidth each, currently being used in biofeedback training.

Discussion

The NE Neuro CorTekScan functions as designed to date and the use of a neural network to enhance the diagnostic capability of the system is presently being undertaken. The software and graphics program to administer the biofeedback is also in development. Upon further testing and refinement, in phases 2 and 3, it is proposed that a test protocol derived from this work will become part of a screening process for children entering the nation's school system or those deemed at risk.

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