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EEG analysis in Attention-Deficit/Hyperactivity Disorder: a comparative study of two subtypes

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Abstract

This study investigated differences in the EEG between children with Attention-Deficit/Hyperactivity Disorder of the Combined Type, Attention-Deficit/Hyperactivity Disorder of the Predominantly Inattentive Type and control subjects. All subjects were between the ages of 8 and 12 years, and groups were matched on age and gender. The EEG was recorded during an eyes-closed resting condition from 21 monopolar derivations and these were clustered into nine regions prior to analysis. One minute of trace was analysed using Fourier transformation to obtain both absolute and relative power estimates in the delta, theta, alpha and beta frequency bands. The patient groups were found to have greater levels of theta and deficiencies of alpha and beta in comparison to the control group. Children with Attention-Deficit/Hyperactivity Disorder of the Predominantly Inattentive type were found to be significantly different from those of the Combined type in the same measures, appearing to be closer to the normal profiles. The general results support a maturational lag model of the central nervous system in Attention Deficit/Hyperactivity Disorder. The differences between the subtypes suggest a difference in the severity of the disorder rather than a different neurological dysfunction.

Keywords: Attention Deficit/Hyperactivity Disorder subtypes; Children; EEG; Maturation; Diagnosis

1. Introduction

Over the course of this century the disorder that has become known as Attention Deficit/Hyperactivity Disorder (ADHD) has undergone clarification in its aetiology. Initially ADHD was believed to result from brain damage, but this explanation lost favour as children without brain damage were diagnosed with ADHD. Subsequently, researchers in the 1950s and 1960s changed the name of this disorder from 'minimal brain damage' to 'minimal brain dysfunction'

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(Green and Chee, 1994). In 1968 the DSM-II first listed diagnostic criteria for ADHD under the title 'hyperkinetic reaction of childhood', characterised by overactivity, restlessness, distractibility and short attention span (APA, 1968). Much of the literature from the 1960s and 1970s used both 'minimal brain disfunction' (MBD) and 'hyperactive' to describe the same disorder. In DSM-III (APA, 1980), the title was changed to 'Attention Deficit Disorder' and two groups were identified, children with and without hyperactivity. In the DSM-IV (APA, 1994), the diagnostic criteria have changed again, with three main groups being identified: ADHD of the Predominantly Hyperactive-Impulsive Type, ADHD of the Predominantly Inattentive Type (ADHDin) and ADHD of the Combined Type (ADHDcom). This disorder is primarily found in boys (James and Taylor, 1990), with the ratio of boys to girls being approx. 4:1 for all three DSM-IV groups (De Quiros et al., 1994).

With normal maturation, EEG frequencies increase as a function of age, with slow wave activity apparently being replaced by faster waveforms (Matousek and Petersen, 1973; Matthis and Scheffner, 1980). John et al. (1980) developed 32 linear regression equations predicting the frequency composition of the EEG as a function of age. The results indicated that development of the normal EEG was linear in nature. Benninger et al. (1984), in a longitudinal study of 96 boys and girls, found that theta activity decreased as alpha increased and that the speed of change in occipital areas was almost twice that of central areas. Gasser et al. (1988a) found that certain regions of the brain matured before other regions. Absolute power in delta, theta and alpha 1 frequency bands was found to decrease and amplitudes to become similar with age. The decline was found to be greatest in posterior regions. Frontally, delta and theta were found to develop in parallel, whereas theta dominated delta in all other areas. Alpha activity showed a strong posterior increase. At frontal and central regions, the increase started later and remained small. All beta activity showed a decline with age. Except for alpha 2 activity, all frequency bands and total power showed a continuous decrease in power with age. For relative power, a strong complementary replacement of theta by alpha 2 activity was found up to the age of 14. Delta, theta and alpha 1 frequencies decreased with age and higher frequencies increased. All of these studies found a decrease in slow wave activity and an increase in faster frequency bands with age, with this change being linear in nature.

Topographic studies of maturation have found changes to take place from posterior to anterior regions. Gasser et al. (1988b) found that delta, theta and alpha waves were developed earliest occipitally followed by parietal, central and frontal regions. Beta waves developed earliest in central regions followed by parietal, occipital and then frontal regions. In the central area, the midline was found to have a lower frequency power than the two hemispheres, whereas high frequency power was found more evenly distributed between the three regions.

Electrophysiological studies of children with learning and behavioural problems have found that these children have differences in the EEG when compared to normal control subjects (John et al., 1988). Studies of mentally retarded children (Gasser et al., 1983a), learning disabled children (Lubar et al., 1985) and hyperactive children (Capute et al., 1968; Wikler et al., 1970) have found an increase in slow wave activity in the EEG.

Satterfield et al. (1973a), with a group of good responders to stimulant medication, found an increase in slow wave activity and greater power in the lower frequency bands between 0 and 8 Hz, prior to medication being prescribed. Matousek et al. (1984) found the highest correlates of MBD in the relative delta band for parieto–occipital derivations. Mann et al. (1992), in a study of children with ADHD, found an increase in absolute amplitude in the theta band during a resting condition, predominantly in the frontal regions. During cognitive tasks, ADHD children showed a greater increase in theta activity in frontal and central regions, and a decrease in beta activity in posterior and temporal regions, with tasks requiring sustained attention. The ADHD children were found to have EEG frequency distributions that resembled profiles typical of younger children. Mann et al. (1992) concluded that this finding