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Children with attention-deficit/hyperactivity disorder and comorbid oppositional defiant disorder: an EEG analysis

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Abstract

This study investigated EEG differences between two groups of children with attention-deficit/hyperactivity disorder combined type (ADHD), with or without comorbid oppositional defiant disorder (ODD), and normal control subjects. Each group consisted of 20 males. All subjects were between the ages of 8 and 12 years, and groups were matched on age. EEG was recorded during an eyes-closed resting condition from 21 monopolar derivations, which were clustered into nine regions for analysis. The EEGs were Fourier transformed to provide absolute and relative power estimates for the delta, theta, alpha and beta bands. Values were also calculated for the theta/alpha and theta/beta ratios. The ADHD groups had more absolute and relative theta than the control group. Regionally, the ADHD groups had less relative alpha and more relative delta in posterior regions, and less relative beta in the frontal regions, than the control group. These differences were also apparent in both ratio measures. Only two significant topographic differences were found between the ADHD groups, with both of these being less deviant from normality in the ADHD+ODD group than the ADHD group. These results indicate that EEG correlates of ADHD are not clouded by the presence of comorbid ODD, which suggests possible applications in clinical practice.

Keywords: Attention deficit/hyperactivity disorder; Oppositional defiant disorder: Children; EEG; Diagnosis

1. Introduction

EEG studies have found fairly consistent group differences between children with or without attention-deficit/hyperactivity disorder combined type (ADHD). These include increased theta activity (Satterfield et al., 1972; Janzen et al., 1995; Clarke et al., 1998, 2001a,b), which occurs primarily in the frontal regions (Mann et al., 1992; Chabot and Serfontein, 1996; Lazzaro et al., 1998); increased posterior delta (Matousek et al., 1984; Clarke et al., 1998, 2001b,c); and decreased alpha and beta activity (Dykman et al., 1982; Callaway et al., 1983), also most apparent in the posterior regions (Mann et al., 1992; Clarke et al., 1998, 2001b,c; Lazzaro et al., 1998). Ratios between frequency

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bands have also been used to assess differences in the EEGs of normal children and children with ADHD. An increase in both the theta/alpha (Matousek et al., 1984; Ucles and Lorente, 1996; Clarke et al., 1998, 2001b,c) and theta/beta ratios (Lubar, 1991; Janzen et al., 1995; Clarke et al., 1998, 2001b,c) have been found in children with ADHD.

While EEG studies have found consistent differences between children with and without ADHD, ADHD is often a highly comorbid disorder, being found in conjunction with anxiety and depressive disorders (Cohen et al., 1989; Velez et al., 1989), learning disabilities (Pliszka 1998; Biederman et al., 1995), and conduct disorder (CD) or oppositional defiant disorder (ODD) (Jensen et al., 1997). However, few studies have investigated the impact of these comorbid disorders on the EEG of ADHD children. Clarke et al. (2002) investigated EEG differences between two groups of children with ADHD of the combined type, with or without reading disabilities (RD). That study found EEG differences between children with ADHD and ADHD + RD. The ADHD + RD group had greater relative theta, less relative alpha, and a higher theta/alpha ratio across all regions, as well as increased posterior relative delta. These results suggested that RD has some components which are distinct from those found in children with ADHD, although the two disorders commonly occur together. The results also suggested that ADHD and RD have independent EEG correlates, and that when these are combined, each component contributes an additional level of abnormality in the EEG.

The most common comorbid disorders in ADHD are ODD or CD, with studies reporting that between 42% and 93% of children with ADHD have CD or ODD (Anderson et al., 1987; Offord et al., 1989; Bird et al., 1993).

EEG studies of behaviourally disordered children have been conducted using a number of different categories. These have included delinquency (Wiener et al., 1966; Swinton et al., 1977; Hsu et al., 1985) and CD (Phillips et al., 1993). All of these studies failed to find significant differences between their behaviourally disordered groups and non-delinquent control subjects. Only one study has found EEG differences, between children with ODD and control subjects (Baving et al., 2000). That study reported that the normal alpha asymmetry in the frontal regions was not present in boys with ODD.

In contrast to these studies, which used passive EEG measures, a number of event-related potential (ERP) studies have found differences between children, adolescents and young adults, with or without CD. From these studies, the most common differences have been a reduction in amplitude of the P300 component of the ERP (Bauer and Hesselbrock, 1999a,b; Overtoom et al., 1998) and a longer P300 latency (Kim et al., 2001) in the CD groups.

Few studies have compared EEG differences in ADHD children with or without comorbid CD or ODD. Satterfield and Schell (1984) investigated EEGs of hyperactive adolescents, both with and without signs of delinquent behaviour. The non-delinquent hyperactive group had higher total power and absolute alpha and beta, higher relative alpha and beta, and less relative theta compared with normal control subjects. The EEGs of the delinquent hyperactive group were similar to those of the control group. From these results it was concluded that hyperactive children with abnormal EEGs have a childhood disorder that is secondary to an underlying brain dysfunction. In comparison to this, the delinquent group, with normal EEGs, has a childhood disorder secondary to an underlying environmental-social factor. However, this model is not supported by the ERP literature.

The aim of this study was to investigate whether EEG differences can be found between children with ADHD with comorbid ODD, and ADHD without ODD, and to quantify the nature of these differences. It is hypothesised that both ADHD groups will have increased theta activity, with reduced levels of alpha and beta activity, compared with control subjects. However, no EEG differences are anticipated between the two clinical groups.

2. Methods

2.1. Subjects

Three groups of 20 boys participated in this study. All children were between the ages of 8 and