Children with attention-deficit/hyperactivity disorder and autistic features:
EEG evidence for comorbid disorders

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A B S T R A C T

Attention-deficit/hyperactivity disorder (AD/HD) is the most common psychiatric disorder of childhood, although AD/HD is rarely the only diagnosis given to these children. Within the literature there is some debate as to whether it is valid to diagnose AD/HD with autism as a comorbid disorder, since the present diagnostic systems exclude the diagnosis of both disorders in the same child. The aim of this study was to determine whether electroencephalography (EEG) differences exist between two groups of children diagnosed with AD/HD, one scoring high (AD/HD+) and one scoring low (AD/HD−) on a measure of autism. The EEG was recorded during an eyes-closed resting condition from 19 electrodes, and Fourier transformed to provide absolute and relative power estimates in delta, theta, alpha and beta bands. Compared to age- and sex-matched controls, the AD/HD− group had increased absolute power in all frequency bands, somewhat higher relative theta activity and decreased relative delta. In comparison to the AD/HD− group, patients with autistic features (AD/HD+) had a number of qualitative differences in the beta and theta bands. These results indicate the presence of two comorbid conditions in the AD/HD+ group, which suggests that AD/HD and autism can occur in the same individual.

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1. Introduction

Attention-deficit/hyperactivity disorder (AD/HD) is characterised by a persistent pattern of inattention and/or hyperactivity–impulsivity which is maladaptive and inconsistent with developmental level (Diagnostic and Statistical Manual of Mental Disorders, fourth edition (DSM-IV); APA, 1994). Symptoms of overactivity and inattention are also associated with pervasive developmental disorders (PDD), especially autism and Asperger’s syndrome (AS). Both the International Classification of Diseases (ICD)-10 (WHO, 1993) and DSM-IV adopt a strict hierarchical approach to these disorders, excluding a diagnosis of AD/HD if symptoms of inattention and hyperactivity occur during the course of a PDD. However, a substantial body of research has questioned the validity and clinical efficacy of excluding a comorbid diagnosis of AD/HD and PDD (Clark et al., 1999; Frazier et al., 2001; Gillberg and Billstedt, 2000; Goldstein and Schwebach, 2004; Lord, 2000; Yoshida and Uchiyama, 2004), with a growing number of studies reporting children who meet criteria for both disorders. Clinically, this is an important issue, as proper diagnosis is the first step towards effective treatment. To aid this, it is important for diagnostic criteria to accurately identify which disorders do/do not occur together, because forcing a clinician to choose between two diagnoses, when they should choose both, may mean that only one aspect of the patient’s problems is being treated.

Clinical studies examining comorbidity in children diagnosed with autism have consistently reported the presence of AD/HD symptoms, sufficient to meet the diagnostic threshold for the disorder, in between 50% (Gadow et al., 2004; Ghaziuddin et al., 1998; Sturm et al., 2004) and 83% (Frazier et al., 2001) of their children. Comorbidity rates of 60% (Goldstein and Schwebach, 2004), 68% (Yoshida and Uchiyama, 2004) and 73% (Wozniak et al., 1997) have also been reported. Those studies which have examined AD/HD symptom subtypes have found that symptoms of inattention are significantly more pronounced than symptoms of hyperactivity (Gadow et al., 2004; Goldstein and Schwebach, 2004; Sturm et al., 2004; Yoshida and Uchiyama, 2004), which is, perhaps, not surprising given that children with autism may be either hyperactive or hypoactive (or, more rarely, normally active). For example, in a retrospective chart study of 101 children diagnosed with ‘high functioning’ autism (primarily AS) with normal intellectual levels, Sturm et al. (2004) described attention deficits in 95% of the children (rating 67% as exhibiting ‘severe deficits’), while hyperactivity was noted in 56% of the children (36% exhibiting ‘severe deficits’) and 23% were rated with mild to severe hypoactivity. However, Gillberg and Billstedt (2000) have suggested that attention deficits may be universal in autism spectrum disorders.

There is no doubt that the issue of comorbidity of AD/HD and autism is contentious. As noted above, numerous studies have confirmed a significant overlap of symptoms, creating potential problems in clinical diagnosis and treatment (Perry, 1998). A crucial question is whether the inattention and hyperactivity seen in autism spectrum disorders differ qualitatively from the inattention and hyperactivity associated with AD/HD.

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HD. Lord (2000) suggests that there is a qualitative difference, in that, where these symptoms are not 'developmentally inappropriate', their occurrence in autism is a secondary effect of the triad of deficits intrinsic to autism. According to Rutter (2005), there is now an awareness that 'supposedly separate psychiatric conditions [do] co-occur' and what is needed, particularly in relation to the association between autism spectrum disorders and AD/HD, is the broadening of the scientific basis of research in this area.

Electroencephalography (EEG) studies of children with AD/HD have typically found increased theta activity (Satterfield et al., 1972; Mann et al., 1992; Janzen et al., 1995; Clarke et al., 1998, 2001a,b, 2007), occurring primarily in the frontal regions (Chabot and Serfontein, 1996; Lazzaro et al., 1998), increased posterior delta (Matousek et al., 1984; Clarke et al., 1998, 2001a) and decreased alpha and beta activity (Dykman et al., 1982), also most apparent in the posterior regions (Clarke et al., 1998, 2001a,b; Lazzaro et al., 1998); see Barry et al. (2003) for a review.

In comparison to the AD/HD literature, comparatively few studies of resting state EEG power have been conducted in children with autism. Dawson et al. (1995) examined EEG power at six sites, in a mixed group of low to higher-functioning autistic children and two control groups, a chronological-age-matched group and a language-age-matched group. During EEG recording, subjects viewed 'bubbles cascading from behind a black curtain' situated in front of the child. In comparison with both control groups, the autistic group showed significantly reduced EEG power in the delta, theta and alpha bands. Chabot et al. (2005) reported that autistic children tended to show a decrease in the hemispheric asymmetries of the EEG found in control subjects. Sutton et al. (2005) examined alpha activity in a group of high-functioning autistic children during a mixed eyes open/eyes closed trial. The autistic group exhibited significantly higher alpha power in the centro-parietal regions than controls, and significantly higher left-hemisphere asymmetry mid-frontally (F3/F4) and centrally (C3/C4). Orekhova et al. (2007) found that children with autism had an increase in high beta and gamma activity (24–44 Hz) recorded during a sustained visual attention task. These results were interpreted as indicating that high-frequency EEG activity may contribute to the abnormal development found in this disorder. Stroganova et al. (2007) found that autistic children had a generalised increase in left compared to right hemisphere EEG activity across all bands. This was seen as possibly indicating that autistic children have diminished capacity to generate EEG activity in the right temporal cortex. Coben et al. (2008) compared a group of children with autism to a normal control group. The autism group had global reductions in absolute and relative delta, an increase in both frontal and posterior relative theta, and a reduction in right hemisphere absolute beta activity.

The aim of this study was to determine whether quantitative or qualitative EEG differences exist between children with AD/HD who do or do not exhibit autistic features, in order to determine whether electrophysiological markers exist that support the comorbid diagnosis of both AD/HD and autism in the same child.

2. Methods

2.1. Subjects

Three groups of 60 children, aged between 8 and 13 years, participated in this study. Each group contained 50 boys and 10 girls. The groups consisted of an AD/HD group without autistic features (AD/HD−), an AD/HD group with autistic features (AD/HD+), and a control group. All groups were individually matched on age, using one-to-one matching. Each group contained 50 boys and 10 girls. The groups consisted of an AD/HD group without autistic features (AD/HD−), an AD/HD group with autistic features (AD/HD+), and a control group. All groups were individually matched on age, using one-to-one matching.

Table 1 Mean ages and psychometric test scores for the three groups.

<table>
<thead>
<tr>
<th></th>
<th>AD/HD + group</th>
<th>AD/HD− group</th>
<th>Control group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean age (years)</td>
<td>9.55</td>
<td>9.49</td>
<td>9.60</td>
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<td>Psychometric measures</td>
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<tr>
<td>Full scale IQ</td>
<td>96.7</td>
<td>96.7</td>
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<td>Spelling age (months)</td>
<td>110.3</td>
<td>112.6</td>
<td>105.4</td>
</tr>
<tr>
<td>Reading accuracy (months)</td>
<td>106.4</td>
<td>111.5</td>
<td>141.5</td>
</tr>
<tr>
<td>Reading comprehension (months)</td>
<td>104.0</td>
<td>105.4</td>
<td>135.6</td>
</tr>
<tr>
<td>DBC autism subscale (raw score)</td>
<td>28.5</td>
<td>6.6</td>
<td>4.2</td>
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<td>Conners’ DSM-IV Inattentive subscale (t-score)</td>
<td>74.0</td>
<td>70.6</td>
<td>54.1</td>
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<tr>
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<td>79.9</td>
<td>77.3</td>
<td>48.3</td>
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<tr>
<td>Conners’ DSM-IV Total subscale (t-score)</td>
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<td>51.2</td>
</tr>
<tr>
<td>CBCL Attention Problems (t-score)</td>
<td>74.7</td>
<td>73.8</td>
<td>51.2</td>
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