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Simultaneous EEG and EDA measures in adolescent attention deficit hyperactivity disorder

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Abstract

Adolescent unmedicated ADHD males and age- and sex-matched normal control subjects were examined simultaneously using EEG and EDA measures in a resting eyes-open condition. ADHD adolescents showed increased absolute and relative Theta and Alpha1 activity, reduced relative Beta activity, reduced skin conductance level (SCL) and a reduced number of non-specific skin conductance responses (NS.SCRs) compared with the control subjects. Our findings indicate the continuation of increased slow wave activity in ADHD adolescents and the presence of a state of autonomic hypoarousal in this clinical group.

Keywords: ADHD; Adolescent; EEG; Theta; Beta; EDA; SCL

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Attention Deficit Hyperactivity Disorder (ADHD) is a behavioural syndrome of unknown aetiology, one of the most disruptive psychiatric disorders of childhood, with a prevalence that has been estimated to affect as much as 10% of school-age boys (Dulcan, 1997). The principal features of this disorder are lack of sustained attention, hyperactivity and impulsivity [American Psychiatric Association (APA, 1994)] associated with low self-esteem and poor academic performance. There are a number of features of this disorder that are age specific. Younger children tend to exhibit signs of gross hyperactivity and motor activity whereas in older children and adolescents, the hyperactivity has in most cases abated but may be experienced as inner feelings of restlessness (APA, 1994). The inattention and impulsivity, however, tend to endure.

Non-invasive measures of brain activity, such as electroencephalography (EEG) have been utilised as a means of elucidating underlying neural substrates associated with this disorder. Previous EEG studies in ADHD have examined mostly pre-adolescent children and have found increased slow wave activity (mostly Theta) (Satterfield et al., 1972; Lubar, 1991; Mann et al., 1992; Matsuura et al., 1993; Janzen et al., 1995; Chabot and Serfontein, 1996; Defrance et al., 1996; Bresnahan et al., 1997; Clarke et al., 1998) in ADHD children compared with normal control subjects. Mann et al. (1992) reported that ADHD pre-adolescents without hyperactivity or specific learning disabilities showed significantly increased Theta activity in the anterior-central regions compared with normal control subjects. Other studies employed a ratio of Theta to Beta that takes into account individual variability to examine regional activity in ADHD. Lubar (1991) found that this ratio was increased in the anterior region of their ADHD sample while Janzen et al. (1995) found an increase in the posterior region. Furthermore, Defrance et al. (1996) reported that children with ADHD showed significantly increased Theta activity over the entire scalp compared with control subjects under both resting and attend conditions.

Other studies have also reported a consistently reduced Beta activity in ADHD children (Callaway et al., 1983; Satterfield et al., 1984; Mann et al., 1992; Bresnahan et al., 1997; Clarke et al., 1998; Lazzaro et al., 1998). Satterfield et al. (1984) found an interaction between age and Beta activity. Younger ADHD children were found to show reduced Beta activity compared with control subjects.

Electrodermal activity (EDA) in ADHD has been investigated by a number of studies (for reviews see Rosenthal and Allen, 1978; Zahn, 1986). Most of these studies examined pre-adolescent ADHD children using electrodermal indices of arousal such as the skin conductance level (SCL), the skin conductance response (SCR) and the number of non-specific skin conductance responses (NS.SCRs) during resting, non-attend and attend conditions (Satterfield and Dawson, 1971; Satterfield et al., 1972, 1984; Cohen and Douglas, 1972; Spring et al., 1974; Montagu and Swarbrick, 1975; Montagu, 1975; Zahn et al., 1975, 1978, 1980; Rapoport et al., 1980; Pliszka et al., 1993; Shibagaki et al., 1993; Zahn and Kruesi, 1993). Some of these studies have reported reduced SCL (Satterfield and Dawson, 1971; Satterfield et al., 1972) and reduced task-related SCR amplitudes (Satterfield and Dawson, 1971; Cohen and Douglas, 1972; Spring et al., 1974; Zahn et al., 1975; Shibagaki et al., 1993) in unmedicated ADHD children compared with control subjects. The number of NS.SCRs was also found to be significantly lowered in ADHD children compared with control subjects (Satterfield and Dawson, 1971).

The behavioural disturbances characteristic of pre-adolescent ADHD children such as impulsivity and attentional deficits are known to continue into adolescence (Barkley, 1990). Only a paucity of studies have examined EEG and EDA measures in adolescent ADHD. Suffin and Hamlin Emory (1995) in an EEG study, employed an eyes-closed condition and neurometric EEG analysis to separate a subgroup of ADHD adolescents who showed both excessive frontal Theta activity and which were also responsive to stimulant medication, from a larger cohort of ADHD patients. Bresnahan et al. (1997) examined as part of a larger study, adolescents diagnosed with ADHD and found increased Theta activity in this group compared with control subjects. Our group (Laz-