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EEG activity in children with Asperger's Syndrome

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HIGHLIGHTS

- The results indicated the role of frontal lobe abnormalities as one of the dysfunctions present in Asperger's Syndrome, consistent with the Theory of Mind model of the disorder.
- EEG abnormalities in these children suggest the presence of some degree of maturational lag in CNS development.
- Results lend support for the further investigation of Asperger's Syndrome as a disorder separate from Autism.

ABSTRACT

Objective: This study investigated differences in the EEG power and coherence of children with Asperger's Syndrome.
Method: Twenty boys with Asperger's Syndrome, aged 7–12 years, and an age and sex matched control group, participated in this study. The EEG was recorded during an eyes-closed resting condition from 19 electrode sites, which were clustered into nine regions prior to analysis. One minute of trace was analysed using Fourier transformations to obtain both absolute and relative power estimates in the delta, theta, alpha and beta frequency bands. Wave-shape coherence was calculated for 8 intrahemispheric and 8 interhemispheric electrode pairs.
Results: The Asperger's group had a global increase in absolute delta and an anterior increase in relative delta. Both absolute and relative theta were globally increased and relative alpha was globally decreased. Subjects with Asperger's Syndrome exhibited a broad pattern of reduced hemispheric asymmetry in intrahemispheric coherence. Reduced anterior interhemispheric coherence in the alpha and beta bands was also found in the Asperger's Syndrome group.
Conclusions: These results suggest the existence of frontal lobe abnormalities in children with Asperger's Syndrome, and possible abnormalities in normal CNS maturational processes.
Significance: This is the first major study to investigate EEG power and coherence anomalies in children with Asperger's Syndrome.

1. Introduction

Asperger's Syndrome is one of five disorders listed under the category of Pervasive Developmental Disorders in the DSM-IV (APA, 1994), with the most common and robust of these disorders being Autism (Volkmar et al., 1994). Within the literature, Asperger's Syndrome has been studied under the label of "high functioning Autism" and "Autism Spectrum Disorder" (Tanguay, 2000), and the debate continues over whether Autism and Asperger's Syndrome are qualitatively distinct disorders (Sanders, 2009), and what the exact criteria for the disorder should be (Church et al., 2000). In recent changes to the DSM, the broad category of Pervasive Developmental Disorders in the DSM-IV has been re-categorised into a single catch-all disorder in the DSM-5

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(2013) titled Autism Spectrum Disorder. This has been a controversial move and a number of professional societies in the United States have criticised the change on the grounds that there will be a lack of continuity of research into the disorder, with some of the individuals diagnosed under DSM-IV criteria not meeting criteria under the DSM-5.

In contrast to the DSM, the International Classification of Diseases 10th edition (ICD-10; WHO, 1993) is currently undergoing a revision. The ICD-11 was due for release in 2015 but this has been pushed back, with a new release date proposed for 2017. Currently the ICD-10 has a category of Asperger Syndrome and this category is still in the beta draft of the ICD-11 (WHO, accessed 27/4/2015). Due to the controversies surrounding the removal of Asperger's Syndrome as a distinct disorder from the DSM-5, and the proposed retention moving forward in the ICD-11, there is an increased need for research into this disorder, especially if it can help determine the validity of the disorder as a category in its own right.

As the subjects in this study were assessed using DSM-IV criteria and prior to the release of the DSM-5, the DSM-IV criteria will be further discussed. According to the DSM-IV (APA, 1994), Asperger's Syndrome is characterised by chronic, severe and persistent impairments in social interactions, and the presence of restricted repetitive patterns of behaviour, interests and activities (APA, 1994). The DSM-IV sets this disorder apart from Autistic disorder, as children with Asperger's Syndrome do not experience significant language delays (APA, 1994). Although prevalence rates of Asperger's Syndrome vary with the selected diagnostic criteria, Attwood (2006) suggested that rates can vary from one in 1100 children to one in 33,000 children, with Fombonne (2009) placing the rate at approximately 6 in 10,000. Asperger's Syndrome has also been found to be more common in males than females (APA, 1994).

Asperger's Syndrome is a neurodevelopmental disorder (APA, 1994), and as such, investigations of brain function are warranted in this population. Electroencephalography (EEG) is a non-invasive method of assessing electrical activity in the brain. EEG specifically measures the changes in voltage over time produced by currents in the neurons (Niedermeyer, 2004). Electrical activity is recorded using electrodes placed over the various parts of the scalp, which correspond to regions of the cortex directly below. Spectral EEG simplifies the raw signal into standard frequency bands: delta, theta, alpha, beta, and sometimes gamma, which reflect different levels of brain functioning (Knyazev, 2007). EEG assessment has proven a valuable tool for detecting brain dysfunction in a wide range of clinical and research applications. Due to its high temporal resolution, non-invasive nature, portability and relatively low cost, EEG has been extensively utilised in psychophysiological research. Two of the most common analyses of resting state EEG are power and coherence analysis. Both can be performed on the same trace but provide different information about brain function, with power providing a degree of functional information while coherence informs about connectivity. To date the EEG literature for the various disorders listed under the DSM-IV category of Pervasive Developmental Disorders is relatively small, and utilises few common paradigms. Part of the reason for this is that Autistic children are often non-compliant with the requirements for EEG recording, making reliable data difficult to obtain.

In the broad area of Autism there have been a few power studies. Dawson et al. (1995) found that their Autistic group had significantly reduced EEG power in the delta, theta and alpha bands. Chabot et al. (2005) found Autistic children had a decrease in the normal EEG hemispheric asymmetries found in control subjects. Sutton et al. (2005) found Autistic children to have significantly higher alpha power in the centro-parietal regions than controls. 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. Stroganova et al. (2007) found that Autistic children had a generalised increase in left compared to right hemisphere EEG activity across all bands. 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 anterior and posterior relative theta, and a reduction in right hemisphere absolute beta activity. Sheikhani et al. (2012) found left frontal and left temporal reductions in alpha activity during an eyes-closed resting condition, in a group of children with Autism Spectrum Disorder.

Coherence studies of Autistic children have also found differences compared to a normal control group. Cantor et al. (1986) found in a group of children with Autism Spectrum Disorder, increased interhemispheric and intrahemispheric coherence in delta and alpha bands, during an eyes-open rest condition. Additionally, less asymmetry between the left and right hemisphere was found. Furthermore, children with Autism Spectrum Disorder exhibited similar activation patterns to typically developing toddlers, suggesting a maturational lag in brain functioning. More recently Murias et al. (2007) studied coherence during an eyes-closed resting condition and found adults with Autism Spectrum Disorder had increased short-range theta coherence, particularly in the left frontal and temporal cortex, suggesting localised hyperconnectivity in these areas. The researchers also found reduced long-range fronto-parietal and fronto-occipital coherence in the alpha band, indicative of weak functional connectivity between the frontal lobe and posterior regions. These findings support the theory of local overconnectivity and global underconnectivity (Courchesne and Pierce, 2005). Coben et al. (2008), using an eyes-closed resting condition, found differences in coherence between Autistic children and normal controls including reductions in delta and theta intrahemispheric coherence for both short-medium and long distances, and global reductions in interhemispheric coherence. In addition, they found reduced alpha coherence temporally and reduced beta coherence in posterior regions. Sheikhani et al. (2012) found extensive increases in gamma coherence across the scalp and differences between their Autistic and control groups in the alpha band in frontal, temporal and parietal electrode pairs, although the direction of this difference is not specified.

To date, almost no peer-reviewed journal articles have been published on the EEG of children with Asperger's Syndrome. Scolnick (2005) conducted a pilot study of Neurofeedback training in five children with Asperger's Syndrome. A pre-treatment EEG found an increase in the theta/beta ratio of all children, with the increase being greatest in the fronto-central midline sites. Lázár et al. (2010) compared coherence of individuals with Asperger's Syndrome and controls during non-rapid eye movement sleep. The researchers found decreased intrahemispheric coherence in frontal regions and the right hemisphere. Fronto-central coherence was lower in the Asperger's group. The results provided evidence for frontal under connectivity and increased asymmetry in Asperger's Syndrome, which is similarly speculated in Autism.

Duffy et al. (2013) provided preliminary evidence for the distinction of Asperger's Syndrome from the umbrella of Autism Spectrum Disorders. Discriminant function analysis was used to successfully distinguish 92.3% of a group of children with Asperger's Syndrome from a group of children with Autism Spectrum Disorder, suggesting children with Autism and Asperger's Syndrome exhibit distinct coherence patterns. Compared to children with Autism Spectrum Disorder, the Asperger's group exhibited left hemisphere reductions in coherence between fronto-temporal and temporo-parietal regions. Additionally, increased left hemisphere coherence between mid-temporal to more posterior regions was found. In the right