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Attention deficits in children with epilepsy: Preliminary findings

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ABSTRACT

Objective: Attention difficulties are a common clinical complaint among children with epilepsy. We aimed to compare a range of attentional abilities between groups of children with two common epilepsy syndromes, Temporal Lobe Epilepsy (TLE) and Idiopathic Generalized Epilepsy (IGE), and to healthy controls. We also investigated whether epilepsy factors (laterality of seizure focus, epilepsy onset, duration, and severity) were related to attentional abilities.
Methods: Multiple dimensions of attention (selective, sustained, and divided attention and attentional control) were assessed directly with standardized neuropsychological measures in 101 children aged 6–16 years (23 children with TLE, 20 with IGE and 58 healthy controls). Attention was also assessed indirectly, via a parent-report measure.
Results: Children with TLE performed worse than children with IGE ($p = 0.013$) and healthy controls ($p < 0.001$) on a test of attentional control, but no between-group differences were apparent on tests of other attentional abilities. Compared to healthy controls, greater attention problems were reported by parents of children with TLE ($p = 0.006$) and IGE ($p = 0.012$). Left-hemisphere seizure focus and greater epilepsy severity were associated with poorer attentional control and sustained-divided attention, respectively, but no other epilepsy factors were associated with attentional abilities.
Significance: These findings suggest that children with localization-related epilepsy, but not generalized epilepsy, may be at risk of deficits in attentional control. Interventions aimed at improving attentional control may be targeted at children with localization-related epilepsy, particularly those with a left-hemisphere seizure focus, who appear to be particularly susceptible to this type of attentional deficit.
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1. Introduction

Problems with attention are a common clinical complaint among children with epilepsy. Attention problems can occur to the exclusion of other neurocognitive deficits in children with epilepsy [1] and, according to parental reports, are more prevalent relative to healthy controls [2]. Attention Deficit Hyperactivity Disorder (ADHD) is also over-represented among children with epilepsy, relative to the general population, where these patients usually meet criteria for inattentive-type, rather than combined-type, ADHD [3]. Moreover, attentional deficits have been found to have significant clinical implications in children with epilepsy, with inattention being specifically implicated in academic underachievement [4] and attention being the only variable (among memory, self-esteem, and socioeconomic status) to predict academic performance in children with epilepsy, after controlling for intelligence [5].

Neuropsychological research and models have shown that attention is a complex ability which involves several different components. A principal component analysis conducted by Mirsky and colleagues [6] found four primary attentional factors (focused, sustained, shifting, and encode) which are each supported by different neural structures and networks. Thus it is possible that the pattern of impaired and preserved attentional skills may be determined by certain epilepsy variables (such as the side and site of seizure focus, or type of seizure).

Previous studies have shown that children with focal epilepsy appear to exhibit difficulties in a range of attentional abilities [7,8].

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Furthermore, the presence of these deficits has been established in children with epilepsy irrespective of the presence of an intellectual impairment [9] or ADHD diagnosis [8]. Attention deficits have also been observed in children who experience generalized seizures, such as children with idiopathic generalized epilepsy (IGE) [10], when compared to healthy controls. However, few studies to date have examined a range of disparate attentional abilities between children with common types of epilepsy, such as Temporal Lobe Epilepsy (TLE) and IGE. Establishing a pattern of attentional deficits could contribute to clinical management, as children who are at risk of deficits in attention could be referred for assessment and subjected to early intervention.

The impact of other epilepsy factors on attentional abilities in children also remains unclear. One study failed to find an association between laterality of seizure focus and attentional abilities [11] while others found poorer sustained and selective attention were associated with left [7] and right [12] hemisphere seizure foci, respectively. In patients with complex partial seizures, older age of seizure onset has been associated with better performance on tests of visual attention, ability to switch attention between tasks [2], and faster motor speed [11]. Antiepileptic drug (AED) therapy has been linked to attention problems [13], while seizure frequency has also correlated with parent-reported attention problems [2] and increased hyperactivity [11]. However, the absence of an association between these epilepsy-related factors and attention problems in adult patients with epilepsy has also been documented [14].

The primary aim of this study was to compare and characterize a range of attention abilities in children with IGE, TLE, and healthy controls. The secondary aim was to examine the impact of other epilepsy variables, including hemisphere of seizure focus (for the TLE group), age of seizure onset, and epilepsy duration and severity. We hypothesized that both children with IGE and TLE would exhibit greater attention problems than healthy controls on standardized tests of attention and parent-report measures. It was also hypothesized that children with TLE would exhibit greater attention problems than those with IGE. Finally, it was hypothesized that older age of seizure onset and longer epilepsy duration would be associated with poorer sustained attention.

2. Material and methods

2.1. Participants

Twenty children with IGE, 23 children with TLE, and 58 healthy children (the control group) participated. Inclusion criteria were (i) English fluency, (ii) aged six to 16 years, and (iii) a Full Scale Intelligence Quotient (FSIQ) ≥ 80. Exclusion criteria were the presence of: (i) a major sensory deficit; (ii) significant neurodevelopmental disorder, or (iii) another neurological disorder. All patients with epilepsy were recruited from The Children's Hospital at Westmead, The Hospital for Sick Children or McMaster Children's Hospital.

Patients with either IGE or TLE (pre-surgical, post-surgical or non-surgical) who had experienced at least one seizure in the two-year period prior to assessment were identified via patient file review. Treating pediatric neurologists reviewed medical history, electroencephalography records, and available imaging data to ensure patients met criteria for a diagnosis of either IGE or TLE.

A total of 26 patients with IGE (87%) and 25 patients with TLE (81%) initially consented to participate. However, six patients with presumed IGE were excluded (subsequent findings disqualified their IGE diagnosis) while two patients with TLE were excluded (one obtained a FSIQ score < 80 and the other refused to take further part in the study).

Within the IGE sample ($n = 20$), patients met criteria for Childhood Absence Epilepsy ($n = 10$), Febrile Seizures Plus ($n = 3$), Juvenile Absence Epilepsy ($n = 2$), Epilepsy with Myoclonic Absences ($n = 2$) and Epilepsy with Generalized Tonic-Clonic Seizures alone ($n = 1$). Two patients could not be classified into an IGE syndrome. Seventeen patients with IGE were on monotherapy while three were on polytherapy, with sodium valproate being the most commonly prescribed AED. No patient with IGE had a diagnosed learning disability.

Within the TLE sample ($n = 23$), 15 patients had a left-hemisphere seizure focus (including six postoperative patients), six had a right-hemisphere seizure focus (including one postoperative patient). The laterality of seizure focus could not be determined in two patients. A total of 12 patients with TLE had evidence of a hippocampal abnormality, six of whom had not undergone surgery but nevertheless had MRI evidence of hippocampal sclerosis ($n = 2$), dysplasia ($n = 2$), tumor ($n = 1$) or gliosis ($n = 1$). Of the seven post-surgical patients with TLE, six had undergone hippocampal resection, as a result of mesial temporal gliosis ($n = 3$), sclerosis ($n = 1$), microcortical dysgenesis ($n = 1$) or dysplasia ($n = 1$). One patient with TLE underwent a left anterior lateral temporal lobectomy which spared the hippocampus. Fourteen patients with TLE were on monotherapy, seven on polytherapy, and two were not taking AEDs. Six different AEDs were represented within the TLE group, with carbamazepine ($n = 8$) and levetiracetam ($n = 8$) being the most common. One patient with TLE had a diagnosed learning disability (dyslexia).

Fifty-eight participants were recruited into the control group via word-of-mouth recruitment, through the peer networks of patients with either IGE or TLE and other healthy participants. All control participants were free of a history of epilepsy. No control participant was diagnosed with a comorbid developmental disorder or learning disability.

2.2. Materials

2.2.1. Neuropsychological measures

2.2.1.1. Intelligence. FSIQ ($M = 100, SD = 15$) was derived from two subtests (Vocabulary and Matrix Reasoning) of the Wechsler Abbreviated Scale of Intelligence [15].

2.2.1.2. Attention skills. A selection of subtests was administered from the Test of Everyday Attention for Children [16], a neuropsychological battery designed to assess attentional capacity in children. Four attentional

Table 1
Description of select subtests from the Test of Everyday Attention for Children [16].

Subtest	Description
Sky Search (selective attention)	A pen-and-paper based timed visual search task. In the first part, children are required to find and circle as many target stimuli as possible (spaceships), which are located amidst very similar distractor stimuli. Distractor stimuli do not feature in the second part of the task; participants must simply circle each target stimuli as quickly as possible. The difference in performance between the first and second parts gives an indication of selective attention that is free from the influence of motor slowness (Attention Score). Both accuracy (Targets Found) and efficiency (Time per Target) are assessed.
Score! (sustained attention)	A task that requires children to keep a mental tally of the number of sounds they hear on an audio recording, over ten separate trials. At the end of each trial the child reports the total number of sounds heard. A scaled score is calculated, based on accuracy.
Sky Search DT (sustained-divided attention)	A task that requires simultaneous completion of the aforementioned tests of selective and sustained attention. Children are required to locate target stimuli on a sheet, situated amidst distractor stimuli, while also mentally tallying a series of audible sounds. A Decrement Score is calculated, which represents the change in their Sky Search Time per Target score.
Creature Counting (attentional control/switching)	A timed task that requires repeated switching between counting upwards and downwards. Children are required to count visual stimuli (aliens in a burrow) and to either change or maintain their counting direction whenever they encounter an arrow. A scaled score is calculated which accounts for both accuracy and efficiency.

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