ADHD: Linguistic abilities and EEG findings compared to specific language impairment

Fatma-Alzahraa Kaddah,a* Mervat Abdel-Raoufb

a Unit of Phoniatrics, Department of Otorhinolaryngology, Ain Shams University, Cairo, Egypt
b Neurology Department, Alexandria University, Alexandria, Egypt

Received 6 December 2010; accepted 17 January 2011
Available online 23 June 2011

Abstract Background: Attention deficit hyperactivity disorder (ADHD) is often associated with language impairment (LI). Additionally, it may be associated with abnormal electroencephalographic (EEG) findings.
Aim: To assess language abilities and EEG findings in children with ADHD presented with LI in comparison to children with specific Language Impairment (SLI).
Patients and methods: A comparative study was conducted on the different linguistic abilities and electroencephalographic findings of 30 Arabic speaking ADHD children with LI and 30 age and gender matched children with SLI. Abnormal EEG findings were classified according to anatomical distribution.
Results: The group of ADHD children with LI had significant delay in the acquisition of first word and two word sentence utterance in comparison to the group of SLI children. The ADHD children...
Attention deficit hyperactivity disorder (ADHD) is the most common neuro-developmental disorder of childhood, affecting about 3–5% of children globally with symptoms starting before seven years of age. ADHD is increasingly diagnosed in the preschool years, with prevalence rates ranging from 2% to 6%. ADHD is diagnosed two–four times as frequently in boys as in girls, with 30–50% of those individuals diagnosed in childhood continuing to have symptoms into adulthood. ADHD is the most frequently reported psychiatric diagnosis for children with a language disorder. Previous research reported that about 30% of children with speech or language impairments had ADHD. In one report, 45% of children with ADHD had at least one element of language impairment. Language impairment in ADHD has been considered by some to reflect a common underlying prefrontal executive function deficit. Electroencephalographic (EEG) research over the last 30 years has found fairly consistent group differences between children with or without ADHD. More recently, EEG has been used both in research to describe and quantify the underlying neurophysiology of ADHD, but also clinically in the assessment, diagnosis, and treatment of ADHD. Although various electroencephalographic alterations have been described in these patients, their pathological significance has not been determined. Some researchers supported a re-conceptualization of ADHD based on the EEG finding rather than the behavioral profile. Others were interested to assess the association between cognitive and behavioral disorders and EEG in ADHD children. There have also been reports of ADHD children with language disorders and neuropsychological changes as epileptiform anomalies in the EEG recording.

Children with ADHD have been compared to normal controls, to children with reading disabilities without psychiatric disorder, to children with other psychiatric diagnoses than ADHD who have normal language, and to children with other psychiatric disorders who have language impairment (LI). To our knowledge, up till now, no previous research compared both the linguistic abilities and the EEG findings in ADHD children with LI versus children with SLI.

Understanding the relationship between ADHD and language impairment may lead to better assessment and more effective treatment strategies of both disorders. Also the understanding of the neurophysiologic background of ADHD may help better understanding of the behavioral abnormalities and the different comorbidities of it, including the language and learning disorders.

The objective of this study is to assess the language abilities and EEG findings in ADHD children with language impairment compared with children with SLI in order to provide a better understanding of the nature of the language disorder in this group of children. This may also provide better plans of treatment for ADHD children with LI.

2. Patients and methods

2.1. Subjects

This comparative cross-sectional study was done on two groups of children. Group I included 30 native Arabic speaking children with ADHD associated with language impairment that presented or were referred to the Clinic of Phoniatrics. They were 20 males and 10 females. Their age ranged from 4 to 7 years. Any child with a history of previous afebrile seizures, absence periods, documented language regression, motor developmental delay or hearing loss was not included in the study. Moreover, children who demonstrated coexisting autistic features, gross neurological abnormalities, or IQ scale < 90 were not included. Group II consisted of 30 age and gender matched native Arabic speaking children with SLI (with mental IQ ≥ 90), who when presented to the Phoniatrics clinic, were included as a comparative group (SLI group). They were 22 males and 8 females. Their age ranged from 3 years and 6 months to 6 years.

2.2. Procedures and clinical tools

All the children were subjected to the following protocol of assessment:

1. Thorough history taking according to the protocol of language assessment of Kothy et al. to confirm language disorder with special consideration to developmental milestones of language and exclusion of fits or periods of absence.
2. Vocal tract examination to exclude any organic disorder.
3. Audiological evaluation was done to ensure normal hearing sensitivity as tested by pure tone audiometry or auditory brainstem response (ABR).
4. The social and mental ages were obtained using Vineland Social Maturity Scale and Stanford-Binet Intelligence Scale, respectively. IQ scores were determined.
5. Neuropsychiatric assessment was done by full neurological examination and the application of the Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition (DSM-IV).

Conclusion: The ADHD children with LI had worse language parameters and more frequent abnormal EEG findings than children with SLI.
3. Results

There were no significant differences ($p > 0.05$) between the two groups regarding age or IQ scores (Table 1). There were significant differences ($p < 0.05$) between the two groups regarding the age of acquisition of both first word and two-word sentence. The ADHD group had significantly ($p < 0.05$) less mean scores of the total language, semantics, receptive syntax, phonological and pragmatics language parameters in comparison to the SLI group. Meanwhile, no significant difference was detected between the two groups regarding expressive syntax scores (Table 2).

The frequency of abnormal EEG findings was significantly ($p < 0.05$) higher in ADHD group than SLI group (Table 3). Considering the types of the different EEG abnormalities, no significant difference ($p > 0.05$) was detected between the two groups regarding abnormal background activity, while the ADHD group had significantly ($p < 0.001$) higher frequency of abnormal epileptiform activity than the SLI group (Table 3).

Regarding the anatomical distribution of abnormal EEG findings, out of the 30 ADHD children, 2 (6.7%) patients had abnormal background activity, 8 (26.7%) patients had generalized abnormal epileptiform activity [diffuse distribution in 5 (16.7%) patients, and subcortical distribution in 3 (10%) patients] and 7 (23.3%) patients had focal distribution of epileptic activity [bilateral in 6 (20%) patients and unilateral in 1 (3.3%) patients] (Chart 1).

The site of abnormal focal discharge was bilateral frontal in 1 (3.3%) patient, bilateral frontotemporal in 4 (13.4%) patients.

<table>
<thead>
<tr>
<th>Table 1</th>
<th>Comparison between the two groups regarding the chronological age and intelligence quotient.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Variables</td>
<td>Group I Mean (±SD)</td>
</tr>
<tr>
<td>Chronological age (months)</td>
<td>59.3 ± 10.6</td>
</tr>
<tr>
<td>Intelligence quotient</td>
<td>92.9 ± 2.2</td>
</tr>
</tbody>
</table>

Group I = Children with attention deficit hyperactivity disorder and language impairment, Group II = Children with specific language impairment, SD = Standard deviation.

<table>
<thead>
<tr>
<th>Table 2</th>
<th>Comparison between the two groups regarding the age of milestones of language development and the different language parameters findings.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Variables</td>
<td>Group I Mean (±SD)</td>
</tr>
<tr>
<td>Age of acquisition of first word</td>
<td>20.4 ± 6.1</td>
</tr>
<tr>
<td>Age of acquisition of two-word sentence</td>
<td>35.7 ± 7.8</td>
</tr>
<tr>
<td>Total language</td>
<td>58.3 ± 16.2</td>
</tr>
<tr>
<td>Semantics abilities</td>
<td>63.3 ± 16.7</td>
</tr>
<tr>
<td>Receptive syntax</td>
<td>59.8 ± 18.5</td>
</tr>
<tr>
<td>Expressive syntax</td>
<td>60.1 ± 15.4</td>
</tr>
<tr>
<td>Phonological quotient</td>
<td>58.7 ± 15.5</td>
</tr>
<tr>
<td>Pragmatics quotient</td>
<td>52.3 ± 19.7</td>
</tr>
</tbody>
</table>

Group I = Children with attention deficit hyperactivity disorder and language impairment, Group II = Children with specific language impairment, SD = Standard deviation.

* Significant.
patients, left temporal in 1 (3.3%) patients and bilateral temporo-parietal in 1 (3.3%) patient. Meanwhile, out of the 30 SLI children, 3 patients (10%) had abnormal background activity and 2 (6.7%) patients had diffuse generalized abnormal epileptiform activity (Chart 1). No significant difference ($p > 0.05$) was detected between the two groups regarding the diffuse generalized abnormal epileptiform activity.

### 4. Discussion

Increasingly, there is agreement that early childhood is a critical period for brain development and that early intervention is crucial for addressing cognitive and developmental delays and disorders. In the last 10 years, the number of children being diagnosed with ADHD has risen to four times the original prevalence rate. 27

Although ADHD groups generally tend to manifest with mental ages lower than chronological ages,28 only children with ADHD who presented by language impairment, and had IQ scores greater than 90 were included in this study. This selection criterion was to exclude the mental subnormality as a predisposing factor for LI in this group. In this way, these children would be matching the SLI children in mentality (thus explaining the non-significant difference between the IQ of ADHD group and the SLI group). Brown29 reported that the onset of language development may be delayed in ADHD. In this study, children with ADHD showed delayed language development in the form of delayed onset of utterance of first word and delayed onset of two-word sentence.

**Language characteristics of ADHD children with language impairment in comparison to SLI children:** This study investigated language parameters in a selected group of relatively younger ADHD children (age range 4-7 years) who presented with language impairment, in comparison to children with SLI not associated with ADHD. Most previous studies compared language parameters in ADHD children with normal control group. Raslan and Refaie,28 found statistically significant differences between a group of ADHD children and a normal control group on all scales of Arabic Language Test (ALT) except for the expressive scale. On the other hand, Leonard,30 revealed that children with ADHD demonstrated significantly lower expressive language and pragmatic domain deficiencies. Oram et al.31 suggested that language tasks requiring high levels of sustained attention, inhibition, working memory, or planning/organization would be particularly difficult for children with ADHD.

In this study, the ADHD children had lower mean scores of the total language and all language parameters than SLI group except for the expressive syntax score. Raslan and Refaie,28 reported that the most frequently affected linguistic ability in ADHD group was the receptive speech (100% of patients), followed by pragmatics (75% of patients) and the least affected was expressive speech (33% of patients). Meanwhile, other researchers mentioned that problems in both receptive and expressive language abilities have been reported in children with ADHD.31,32 The ADHD group in the current study had impairment also of their expressive language abilities, as they had lower expressive syntax score and significantly lower phonological and pragmatics scores than the SLI group and all of these criteria indicated problems in expressive language abilities. Furthermore, the suggestion of pragmatic difficulties was reported by several studies of expressive language functioning among children with ADHD.33

Our findings of significant lower language abilities in children with ADHD associated with LI in comparison to SLI group were reasonable, because those children with ADHD had either behavioral abnormalities or defective level and span of attention, which will interfere with their language acquisition. Previous studies have suggested a relationship between language and behavior based on the frequent comorbidity of LI and behavioral and psychological problems.34,35 Behavioral problems may impact the amount, type, and quality of communication between parent and child. This may limit a child’s opportunities for language exposure and acquisition or alter the type of language models provided by the parents.36 Moreover, motivational deficits characterize some children with

---

Table 3: Comparison between the two groups regarding the abnormal electroencephalographic findings.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Group I</th>
<th>Group II</th>
<th>$p$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abnormal EEG</td>
<td>17 (56.7%)</td>
<td>5 (16.7%)</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>Types:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Abnormal background activity</td>
<td>2 (6.7%)</td>
<td>3 (10%)</td>
<td>&gt;0.05</td>
</tr>
<tr>
<td>Abnormal EA</td>
<td>15 (50%)</td>
<td>2 (6.7%)</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

Group I = Children with attention deficit hyperactivity disorder and language impairment, Group II = Children with specific language impairment. EEG = Electroencephalogram, EA = Epileptiform activity.

* Significant.
** Highly significant.

Chart 1: Frequency of the abnormal epileptiform activity according to the different anatomical distribution in the two groups: Group I = Children with attention deficit hyperactivity disorder and language impairment, Group II = Children with specific language impairment, EA = Epileptiform activity.
ADHD with qualitative differences in encoding of reward information, and these variations may further interfere with their sensitivity to environmental reinforcement and subsequently limit their chance to benefit from such reinforcement which is highly indicated for language acquisition.

Pragmatic skills are the most important component of social communication. Out of the various aspects of language, perhaps the most likely to be related to behavior is pragmatics. Our study demonstrated significantly impaired pragmatics language abilities in ADHD group, and this finding may suggest a strong relationship between pragmatics abilities and behavioral abnormalities in ADHD as supported by Ketelaars et al. where they considered that the early assessment of pragmatic competence may provide an early marker for the detection of ADHD. Moreover, the association between pragmatics impairment and ADHD may be explained as children with ADHD do not interpret emotions as accurately as non disabled individuals. They are also less adept than others at identifying emotions.

EEG findings in ADHD children with language impairment and in children with SLI: In this study, abnormal EEG findings were significantly higher in ADHD group than in SLI group. Abnormal epileptiform activity had significantly higher frequency in children with ADHD than SLI group. Silvestri et al. stated that ADHD is a condition often associated with EEG epileptiform abnormalities. Abnormalities of the visually inspected clinical EEG (e.g., increased epileptiform activity or slow waves) were repeatedly observed and range in prevalence from 15%–30%. ADHD children typically have an excess of slow wave activity, primarily in the delta and theta bands, and deficiencies of alpha and beta activities. These results have been interpreted as indicating that children with ADHD have a central nervous system (CNS) dysfunction, which has been characterized primarily as either a maturational lag or cortical underarousal.

Focal EEG abnormalities either frontal or frontotemporal were detected in 16.7% of the ADHD children of this current study. This might correspond with the abnormalities of frontostriatal circuits that have been found by brain imaging studies in patients with ADHD. The literature appears to support the hypothesis that children with ADHD suffer from frontal lobe dysfunction. Research on children with ADHD has shown a general reduction of brain volume, but with a proportionally greater reduction in the volume of the left-sided prefrontal cortex. These findings suggest that the core ADHD features of inattention, hyperactivity, and impulsivity may reflect frontal lobe dysfunction but other brain regions particularly the cerebellum have also been implicated.

This study revealed that 16.7% of the SLI group has abnormal EEG findings either abnormal background activity (10%) or abnormal diffuse epileptiform activity (6.7%) and none of them had focal EEG abnormalities. Previous EEG study in various populations of children with SLI and other developmental language impairments have been conducted by Nasr et al. and invited comparison with our study. An initial description of focal and generalized epileptiform abnormalities was given in a case series of seven patients who had developmental language impairment, more receptive than expressive. Our results are comparable to the results of Tuchman et al. where 20% of delayed language non-autistic children had an abnormal EEG result, with 8% having seizures and epileptiform activity. Also, Venkateswaran and Shevell, reported abnormal electroencephalography results in 31.5% of children with SLI, including a percentage of 6.3% with epileptiform activity. Their finding was higher than the prevalence rate of epileptiform activity in (3.5%) out of a historical cohort of 3726 children in the study done by Cavazzuti and colleagues. Finally, it was concluded that epileptiform activity in SLI is rare and without apparent impact on clinical care. These findings may draw attention to the possible need of anti-epileptic treatment in some cases with ADHD.

Although structural language and communication problems have been observed in children with ADHD, few studies have separated the effects of ADHD and LI. The findings of our study presumed that the underlying nature of each of the ADHD criterion and the LI criterion could be primarily of different origin. This suggestion could be supported by the variable electrophysiological findings detected among the two groups of this study, where the abnormal EEG findings, in general were more related to the ADHD criterion than the LI one, being significantly less in our group with LI alone. However, the two studied groups; group with ADHD and LI, and group with SLI alone, could share the same underlying nature for having the LI criterion. Children with developmental language delay had significant abnormal findings on functional neuroradiological studies such as positron emission tomography (PET) in comparison to ADHD children without LI that were more frequent in the subcortical area and most frequent in the thalamus. Research within the last decade indicate a weakened asymmetry in Broca’s area of SLI children, abnormal right to left symmetry of cerebral blood flow in SLI children, and decreased cerebral blood flow in the right parietal lobe and subcortical areas of SLI as compared to ADHD children.

Although each of the two disorders might have its own underlying nature, yet having the ADHD criterion in association with the LI one would predispose to an excess impairment of language abilities and such impairment might exceed that for children with LI only. Children with a comorbid diagnosis generally have more severe problems generally. This could be due to interference between these additive inattention/hyperactivity factors and the acquisition of language skills.

In conclusion, children with ADHD associated with language impairment had worse language parameters and more frequent abnormal EEG findings than children with SLI. Early recognition and treatment of children with ADHD associated with LI are recommended to identify foci of disorders aiming at early intervention. Children with ADHD should be subjected to detailed language assessment protocol including full assessment of pragmatic abilities. Language intervention may be structured according to systematic evaluation of the language parameters. Treatment strategies, designed for these children should address attention disorders underlying the language impairment. It is notable that early detection and intervention can reduce the severity of symptoms, decrease the interference of behavioral symptoms on school functioning, enhance the child’s normal growth and development, and improve the quality of life experienced by children with ADHD. Further neurophysiologic studies are recommended to better explain the nature of this association and the pathophysiological background of these EEG abnormalities.
photon emissions computed tomography (SPECT), electroencephalogram (EEG), behaviour symptoms, cognitive and neurological soft signs in children with attention-deficit hyperactivity disorder (ADHD). *Acta Paediatr.* 2000;89:830–835.


