




Evaluation of Auditory Working Memory Abilities in Children with Self Limited Epilepsy with Centrottemporal Spikes (SECTS): A Pilot Study

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Abstract

Objectives Working memory abilities are essential in the perception of acoustic signals, especially in the presence of noise. This study aimed to measure the working memory and its associated factors in children with self-limited epilepsy with centrottemporal spikes (SECTS) and compare it with the typically developing children (TDC) without epilepsy.

Materials and Methods Twenty-two children with SECTS and 22 typically developing children participated in the study. The Digit span backward test was used for measuring working memory abilities.

Statistical Analysis and Results The working memory of children with SECTS, measured with backward digit span, was significantly poor compared with the TDC ($p < 0.001$). Factors such as the age of onset of seizures, duration of seizures, frequency of seizures and spike load did not influence the working memory.

Conclusion The children with SECTS demonstrated impairment in working memory abilities compared with normal children. The association between poor working memory and reported speech recognition impairment in children with SECTS needs to be studied.

Keywords

- ▶ self-limited epilepsy with centrottemporal spikes
- ▶ working memory
- ▶ digit span

Introduction

Self-limited epilepsy with centrottemporal spikes (SECTS) is a common focal epilepsy syndrome in childhood.¹ It usually begins at the age of 3 to 13 years and disappears after puberty.² The typical electroencephalography (EEG) findings include high voltage sharp centrottemporal spikes preceded by slow waves triggered by sleep and show a tendency to extend or change from one side to the other.³ Despite the improvements in the frequency of seizures and the remission

of seizures before puberty, many children with SECTS present with disturbances in neuropsychological evaluations.^{4–6} Recent studies reported that children with SECTS often exhibit difficulty processing verbal messages even though their peripheral hearing sensitivity was normal.⁷ Over the last decades, more attention has been given to studying the influence of working memory in processing verbal messages, especially in adverse listening situations. Working memory deals with the processing and storage when performing a

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task.^{8,9} The perception of spoken language requires a listener to extract, store, and integrate rapidly varying auditory stimuli. Working memory capacity is strongly linked to the auditory perception when the signal is distorted and contributes less when the acoustic signal is not distorted.¹⁰ Most studies recommended using working memory tests when evaluating the individual's listening abilities.^{11,12} The studies documenting the memory abilities in children with SECTS are inconclusive and vary from no memory deficit to severe impairment.¹³⁻¹⁶ Therefore, the present study aimed to measure the working memory abilities in children with SECTS.

Materials and Methods

Participants

This was a cross-sectional study. After the ethics committee approval, the participants were screened and recruited from the epilepsy clinic, Neurology Department, using a consecutive sampling technique. From the eligible cohort, we included children with typical clinical history and EEG findings of SECTS syndrome.² Children with clinical characteristics of attention deficit hyperactivity disorder, autism, etc., were excluded from the study. All the participants had undergone sleep and awake EEGs. However, MRI was not done for the participants. Age- and gender-matched typically developing children (TDC) without any otological or neurological illnesses were recruited from the pediatric OPD as controls. Intelligence tests and hearing assessments were performed before the memory tests. The intelligence was screened using the extension and validated version of the Gesell drawing test (a screening IQ test).¹⁷ In this test, all participants were presented with different geometrical shapes, with the complexity of the shapes progressing from easy to difficult. The participants had to copy the shapes on an A4 size paper. Each correct response was given one point, and the incorrect response received a zero mark. The total scores were compared with the normative data, and those who passed the test were only considered for the study. Pure tone audiometry was performed for all participants using the Inventis piano dual-channel audiometer. The air conduction thresholds were tested for the octave frequencies 250 Hz to 8000 Hz using TDH 39 headphones. The bone conduction thresholds were also obtained for frequencies 250 Hz to 4000 Hz. The participants with hearing sensitivity less than 15 dB HL were included in the study.

Procedure

We evaluated the working memory abilities using the backward digit span test by the auditory-verbal mode. The Digit span test is one of the most commonly employed tests for measuring verbal working memory. Smriti-Shravan software (version 1.0) was used for measuring the auditory digit span test.¹⁸ A laptop was used for the presentation of the stimulus. The stimuli were delivered to both ears at the most comfortable level via Sennheiser 202HD stereo headphones. In this procedure, the listeners were given sequences of numbers and asked to say the digits in the reverse order,

which is displayed on the screen. After each correct response, the software increased the number of digits at one level and decreased one level to an incorrect response. There was an interstimulus interval of 500 milliseconds and a response time of 5000 milliseconds. An adaptive staircase method was employed to estimate the digit span threshold. The maximum number of digits repeated correctly was recorded.

Statistical Analysis

The statistical analysis was completed using the Statistical Package for the Social Sciences (SPSS) software version 19 (IBM Corp.; Armonk, New York). The statistical analysis included the one-sample Kolmogorov-Smirnov test for checking the normality of the distribution. Mann-Whitney *U* test was used for comparing the digit span thresholds between children with SECTS and the TDC. The relationship between digit span thresholds and age of onset of seizures, duration of seizures, frequency of seizures and spike load were analyzed using Pearson's correlation.

Results

A total of 22 children with SECTS and 22 age- and gender-matched TDC were recruited for the study. The median (IQR) age of the children with SECTS was 10.55 (1.94) years, and of the TDC was 11.18 (1.73) years. The median age of onset of seizures was 8 years (minimum 5, maximum 12 years). Five children had a positive family history, but information about the type of epileptic seizures in the family was not available. The demographic profile of the children with SECTS is given in ►Table 1. Fifteen (68%) children reported nocturnal seizures, one (4.5%) had a pure daytime seizure, and the remaining six (27%) children had a combination of the two. The total number of seizures ranged from 1 to 12 events. All children had at least one EEG characteristic of SECTS. Left centrotemporal spikes were observed in 8 (36%) children, right centrotemporal spikes were seen for 4 (18%) children, and the remaining 10 (45%) children had bilateral discharges. Twenty participants were under anti-seizure medication, and only two of the children were not taking medications. Among the children under anti-seizure medications, most were treated with monotherapy, 19 (86%) and only 1 (4.5%) with multiple therapies. Sixteen (72%) children were on sodium valproate, two (9%) on phenytoin, and three (13%) on carbamazepine. There was a significant difference in the backward digit span thresholds of children with SECTS compared with TDC [2.50 (0.91) versus 3.50 (0.25) $p < 0.001$] (►Table 2). The correlation between age of onset, duration, frequency of seizures and spike load with the digit span thresholds were not found to be significant (►Table 3).

Discussion

The study aimed to examine the digit span as a measure of auditory working memory in children with SECTS. The study also evaluated the impact of factors such as the age of onset of seizures, duration of seizures, and the frequency of seizures on digit span thresholds. The mean digit span was

Table 1 Demographic profile of children with SECTS

Serial number (SECTS)	Age (y)	Gender	Family history	Age of onset of seizures (y)	Age of last attack of seizure (y)	Duration of seizure freedom (mon)	Seizure type	Laterality of spikes	Seizure frequency	Spike load (per min)	Antiseizure medication
1	12	Male	No	9	9	36	Nocturnal	Both	1	10	SVA
2	10	Male	Yes	8	10	6	Nocturnal	Both	2	8	SVA
3	11	Female	No	9	10	12	Nocturnal	Left	1	60	SVA
4	9	Male	No	9	9	6	Both	Left	2	3	SVA
5	11	Female	No	9	10	12	Nocturnal	Both	3	30	PHT
6	8	Male	Yes	7	7	12	Both	Right	2	36	SVA
7	8	Male	No	5	8	7	Nocturnal	Left	3	3	SVA
8	12	Male	No	12	12	5	Nocturnal	Left	4	2	SVA
9	8	Male	No	5	7	12	Nocturnal	Both	3	18	SVA
10	10	Female	No	7	10	6	Nocturnal	Both	2	4	SVA
11	12	Female	No	8	10	24	Nocturnal	Both	4	6	SVA
12	9	Female	Yes	9	9	3	Nocturnal	Both	2	5	No
13	11	Female	Yes	10	11	4	Nocturnal	Both	2	4	SVA
14	9	Male	No	7	8	12	Nocturnal	Right	6	6	SVA
15	15	Female	No	5	15	7	Both	Left	10	1	SVA
16	13	Male	No	8	11	24	Both	Left	5	12	SVA
17	8	Male	Yes	8	8	2	Nocturnal	Right	1	33	No
18	12	Male	No	10	11	12	Both	Both	2	4	SVA, CBZ
19	11	Male	No	7	10	12	diurnal	Right	12	4	SVA
20	10	Male	No	8	10	2	Nocturnal	Left	7	8	CBZ
21	12	Male	No	9	11	12	Both	Left	4	3	CBZ
22	13	Male	No	12	12	12	Nocturnal	Both	1	14	PHT

Abbreviations: CBZ, carbamazepine; PHT, phenytoin; SECTS, self limited epilepsy with centrotemporal spikes; SVA, sodium valproate.

Table 2 Comparison of digit span thresholds between SECTS and TDC

Group	Median (IQR)		p-Value
SECTS (N = 22)	2.50	0.91	
TDC (N = 22)	3.50	0.25	

Abbreviations: N, Number of participants; P, Statistical significance for two tailed tests.

Note: $p < 0.001$ is significant.

Table 3 Correlation coefficient between working memory and frequency of seizures, age of onset of seizures, duration of seizures, spike load and corresponding (p-Values)

	Frequency of seizures		Age of onset of seizures		Duration of seizures		Spike load	
	r	p-Value	r	p-Value	r	p-Value	r	p-Value
Working memory	0.06	0.77	0.08	0.70	0.001	0.99	-0.145	0.52

Note: p = Statistical significance for two tailed tests, significant ($p < 0.05$), r = correlation coefficient.

significantly lower for SECTS children than the TDC. However, the age of onset of the seizure, duration of seizures, frequency of seizures, and spike load did not influence the digit span thresholds.

The difficulties experienced by the children with SECTS in number recalling indicate a deficit in storing and manipulating the ongoing auditory input. According to the Ease of Language Understanding (ELU) model, working memory capacity is closely linked to language processing when speech is presented against background noise. The research focused on the connection between working memory and comprehending verbal messages has reported that limited working memory ability negatively affects the perception of spoken language, especially when the signal is distorted.^{19–21}

The poor digit span threshold observed in our study was in agreement with the previous studies.^{6,22,23} The functional imaging studies demonstrate that cortical areas such as the left ventral and dorsal prefrontal cortex are involved in auditory perception in the presence of noise and working memory activities.^{24,25} The epileptiform activity can alter the function of these cortical areas. In SECTS, the epileptiform activity spreads in the neurons of the rolandic cortex covering the central fissure on both sides.²⁶ One possibility is the spread of epileptic activity anteriorly from the rolandic cortex resulting in a functional deficit in working memory. Another explanation for this poor working memory ability is that epileptiform activities around Sylvian fissures can result in language dysfunction. This language dysfunction can affect the coding of verbal messages and leads to poor memory traces.^{27,28}

The present study demonstrated that children with SECTS have significant deficits in verbal working memory skills. Our findings emphasize the importance of early neuropsychological assessments, which include different measures of

working memory abilities. This will enable the clinicians to plan early intervention programs to reduce the adverse effects of memory deficit on scholastic performance. However, our study has certain limitations. The small sample size precludes the generalization of these findings. A formal IQ test was not done for the participants. Future studies may also evaluate the association between memory abilities and understanding spoken messages in the presence of noise in children with SECTS.

Conclusion

This study evaluated the working memory abilities of children with SECTS. The results indicate that children with SECTS had poor working memory abilities compared with the TDC.

Conflict of Interest

None declared.

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