Cognitive and behavioral profiles of pediatric surgical candidates with frontal and temporal lobe epilepsy

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Abstract

Background

We aim to prospectively analyze memory and executive and social cognitive functioning in patients with drug-resistant frontal lobe (FLE) and temporal lobe epilepsy (TLE) with focal lesions and isolate the impact of intellectual ability on specific deficits.

Methods

A neuropsychological evaluation was performed in 23 children with FLE, 22 children with TLE, and 36 healthy pediatric controls (HCs). Patients in the epilepsy groups had a range of lesions, including low-grade epilepsy-associated tumors, focal cortical dysplasia type II, and mesial temporal sclerosis.

Results

There were no significant differences between children with FLE and TLE regarding memory, executive, or social cognitive functioning. General Ability Index was a predictor of memory, executive function, and social cognition scores and was influenced by the age at onset and duration of epilepsy and the number of antiepileptic drugs prescribed at the time of assessment. FLE patients' Working Memory Index scores, which measure verbal mnesic processing, were significantly lower than those of HCs and TLE patients. The greatest differences in both clinical groups compared to HCs were recorded in cognitive executive functions, and FLE patients had lower scores in this domain. Regarding behavioral executive functions, TLE patients presented impaired emotional control and impulse inhibition and FLE patients exhibited decreased flexibility.

Conclusion

Consistent with previous research, our findings provide further detailed evidence of small differences in cognitive performance among children with FLE and TLE. These differences emerge on analysis of the factors with which deficits are associated.

Keywords: Neuropsychology, Pediatric focal epilepsy, Executive function, Memory, Social cognition.

1. Introduction

Research into the cognitive and behavioral phenotypes that characterize epilepsy stems from the consideration that epilepsy is a disease that affects neural networks, in which cognitive or behavioral disturbances are not only a side effect of seizures and the underlying pathology, but also a comorbidity of epilepsy as a brain disease [1]. Behavioral, neurophysiological, and neuroimaging studies suggest that neural distribution in focal epilepsy is not restricted to the epileptogenic zone, but rather can affect widely distributed networks in the brain. In children, epileptic activity can interfere with the development of neural networks, causing weaker segregation and integration of these networks, which makes it difficult to move from local to distributed networks, which are more effective in processing information [2]. Therefore, widespread cognitive impairments are more common than specific deficits in children with focal epilepsy, especially among patients with a very early age of seizure onset [3].

Recent has evidenced presence of alterations in connectivity throughout the brain in cases of focal epilepsy; such findings may explain, at least partially, the difficulties facing researchers when distinguishing the cognitive impairments that characterize frontal and temporal epilepsy in childhood [4]. The lack of consistency in prior investigations may be due to the modalities of study and methods of analysis used [5], but also to the difficulties inherent to the study of a disease as heterogeneous as epilepsy as well as the varying drug treatments used for seizure control.

Frontal lobe epilepsy (FLE) is the most common type of epilepsy in children [6, 7], though confirmed structural etiology is found in only 25%, including focal cortical dysplasia (FCD) and low-grade epilepsy-associated tumors (LEAT) [8]. As in FLE, FCD and LEAT are a common etiology in childhood temporal lobe epilepsy (TLE) [9, 10]. In

contrast to adults, mesial temporal sclerosis (MS) is less common in childhood and is usually associated with dual pathology involving ipsilateral neocortical lesions [10, 11].

Most pediatric patients with TLE are of average intelligence, although some studies show that 19-21% of children have impaired intellectual functioning [12, 13], and intellectual dysfunction rises to 57% of patients when onset of seizures occurs during the first year of life [14]. Among FLE patients, intelligence scores tend toward the lower limit of the normal range [15, 16] and the age at onset of seizures correlates with poorer intellectual performance [17]. Some studies that have analyzed specific intellectual aspects in pediatric FLE patients have reported lower performance on intellectual tasks that require working memory [18], as well as significantly lower scores on working memory and processing speed indices compared to Verbal Comprehension Index scores [19]. Rzezak, Guimarães, Guerreiro and Valente [20] found that intelligence is a confounding factor due to the significant impact that intellectual capacity has on memory and executive functioning of children and adolescents with TLE without intellectual disability. However, Dennis, Francis, Cirino, Schachar, Barnes and Fletcher [21] argue that using FSIQ as a covariate may produce overcorrected, anomalous, and counterintuitive findings on neurocognitive function. Nonetheless, these authors recommend separating cognitive aptitude from performance. Intelligence in epileptic children is influenced by age at disease onset, as earlier appearance of seizures is associated with more impaired intellectual function [14, 22].

Alterations in memory processes have been classically associated with TLE [23]; however, evidence of this relationship in child TLE patients has proven more elusive. Recent work has failed to establish a link between verbal and nonverbal memory deficits and the affected hemisphere or underlying pathology [24]. The same is true in children

with FLE, as various studies have suggested that alterations in memory are not a characteristic of the deficits presented by these patients and that their lower performance on memory tasks may be secondary to attentional or executive difficulties that impact coding and recovery processes [25, 26].

Executive functioning is another aspect that has been the focus of previous research. Various neuropsychological studies have associated deficits in executive functions with FLE, reporting difficulties in attentional control, verbal fluency[4], cognitive flexibility, working memory [27], and inhibition control [16]. However, alterations in executive functions are not exclusive to FLE and have also been reported in TLE [28]. Comparisons of the two groups have revealed certain differences between them [27, 29, 30], one such difference being worse performance in FLE patients [31, 32].

Unlike research on intellectual ability, executive functioning, and memory, there are no studies comparing the social cognition function of children with FLE and TLE, although alterations in facial recognition of emotions and social cognition have been described in adults with TLE [33]. Furthermore, onset of epilepsy before age 5 years is associated with increased involvement in such functions [34].

The main objective of this study is to analyze the neuropsychological functions involving frontal and temporal networks in child patients with TLE or FLE. Using a homogeneous sample of pediatric patients with structural epilepsy of either type that was refractory to antiepileptic drug (AED) treatment, we evaluated patients for memory, executive functioning, and social cognition, isolating the impact of intellectual ability on specific epilepsy-related deficits.

2. Methods

2.1. Participants

For this descriptive and comparative study, we evaluated 81 children treated in the same center, with ages ranging from 3 to 18 years; in this regard the study population is similar to that of other pediatric focal epilepsy studies [4]. Patients receiving care in the epilepsy surgery program with a diagnosis of drug-resistant structural epilepsy (n=45) were selected and assigned to one of two clinical groups: frontal lobe (FLE, n=23) and temporal lobe epilepsies (TLE, n=22). Additionally, a healthy control group made up of children without neurological disease or neurodevelopmental disorders and with normal academic achievement was included (HC, n=36).

Inclusion in the epilepsy group was based on presence of a structural lesion in one cerebral hemisphere limited to a single brain lobe, as identified using 3T magnetic resonance imaging (MRI) scans. The lesions studied were low-grade epilepsy-associated tumors (LEAT), including dysembryoplastic neuroepithelial tumor (DNT), ganglioglioma (GG), and other LEATs; focal cortical dysplasia (FCD) type II; and MS. Diagnosis of the type of lesion was confirmed histopathologically after surgery. Patients with bilateral conditions (bilateral MS), FCD type I, or a history of epileptic status were excluded to avoid an additional cognitive impairment caused by bilateral or diffuse disease or another condition.

This study was performed according to the Helsinki Declaration of 1975, and parents or legal guardians of patients and controls signed written informed consent.

2.2. Materials

This research employed measures appearing in the neuropsychological protocol of the epilepsy surgery program of Hospital Universitario Infantil Niño Jesús, which follows international recommendations [35, 36] and has been used and validated in previous investigations [37, 38]. The cognitive variables included in this research were full scale intelligence quotient, general ability, perceptual reasoning, working memory, processing speed indices, as well as memory, cognitive and behavioral executive functioning, and social cognition domains. Emotional recognition of faces and immediate and delayed memory of faces were included as part of the social cognition assessment. Immediate and delayed memory of faces is defined as "the ability to encode, remember, and recognize faces", an essential process for perception and social communication [39]. For further details, Table 2 shows the correspondence between variables for each domain.

The tests included were Wechsler Preschool and Primary Scale of Intelligence, Fourth Edition (WPPSI-IV) [40], Wechsler Intelligence Scale for Children, Fourth (WISC-IV) [41] and Fifth Edition (WISC-V) [42], Wechsler Adult Intelligence Scale, Fifth Edition (WAIS-V) [43], the NEPSY-II (a developmental neuropsychological assessment, Second Edition) emotional recognition of faces, immediate facial memory, delayed facial memory, inhibitory control, and non-verbal fluency subtests [44], Children's Auditory Verbal Learning Test, Second Edition (CAVLT-2) [45], the Reynolds Intellectual Assessment Scales non-verbal memory subtest [46], Children's Color Trails Test (CCTT) [47], and Behavior Rating Inventory of Executive Function (BRIEF-2) [48]. We used Spanish versions of all tests, which contained a Spanish normative sample, with the exception of CCTT, which was a Spanish translation using the original normative sample. All tests were carried out in the patients' native language

(Spanish). Table 2 indicates the neuropsychological functions evaluated and the tests with which these functions were measured.

2.3. Procedure

Participants were prospectively recruited from January 2015 to February 2020. Each candidate was studied to determine their suitability for surgery in accordance with a multimodal pre-surgical evaluation protocol [49], which includes a neurophysiological study performed with the use of video-electroencephalogram (Video-EEG) monitoring, a structural neuroimaging study with high-definition MRI, a co-registered fluorodeoxyglucose positron emission tomography (FDG-PET), and an extensive neuropsychological study.

2.4. Statistical analysis

The scores obtained from the protocol tests were transformed into Z scores [mean (M) = 0; standard deviation (SD) = 1] from each norm test values to homogenize them and enable comparisons between tests obtained using different types of measurement. The frequency, percentage, marginal means, and 95% confidence interval were used to describe the characteristics of the sample.

Chi-square test was performed to analyze the distribution of clinical variables among the patient groups and the distribution of nonverbal fluency and Wechsler test scores across the clinical and control groups.

The predictive value of GAI for memory and behavioral and cognitive executive functions and social cognition was assessed by simple regression analysis. This index was

used to estimate general intellectual ability from verbal and nonverbal subtests and reduce the impact of working memory and speed processing indices. Patients' and controls' scores on memory and behavioral and cognitive executive functions and social cognition tests were compared by means of multivariate analysis of covariance (MANCOVA) using the General Ability Index (GAI) as a confounding factor. Differences in intellectual functioning between participant groups were analyzed by MANOVA. Spearman's correlation coefficient was used to analyze the relationship between numerical variables. Finally, linear regression models were used to study the association between GAI and clinical variables (age at seizure onset, number of antiepileptic drugs, and duration of epilepsy). SPSS version 25.0 (IBM Corp, Armonk, NY) was used for data analysis. P values <0.05 were considered statistically significant.

3. Results

Table 1 shows the relevant demographic characteristics and clinical variables of all participants. The average age of the participants at the time of evaluation was 9 years and 9 months (SD = 51.85 months). The sample comprised 42 males (51.85%) and 41 females (48.15%). Regarding the underlying lesion, 20 patients presented FCD type II, 17 patients had LEAT (4 with DNT, 11 with GG, 2 with pleomorphic xanthoastrocytomas), and 8 patients had MS with associated FCD type IIIa. The average age at onset of seizures was 5 years and 3 months (M = 63.55 months; SD = 6.81 months) and the mean duration of epilepsy was 4 years and 1 month (M = 49.02 months; SD = 40.7 months). The lesion involved the left hemisphere in 24 patients, 12 located in the frontal and 12 in the temporal lobe; and the right hemisphere in 21 patients, 11 in the frontal and 10 in the temporal lobe. At the time of evaluation, all patients were undergoing

treatment with AEDs: 10 with a single drug (22.22%), 21 were receiving dual therapy (46.67%), and 14 were on polytherapy consisting of three or more AEDs (31.11%). The duration of epilepsy (r=-0.501; p=0.000) and the number of AEDs at the time of neuropsychological evaluation (r=-0.451; p=0.001) correlated inversely with age at onset of seizures.

There were no differences between FLE and TLE patients in the distribution of age of onset (χ^2=3.376; p=0.185), gender (χ^2=0.573; p=0.449), duration of epilepsy (χ^2=0.044; p=0.978), number of antiepileptic drugs (χ^2=2.769; p=0.25), or age during neuropsychological evaluation (χ^2=0.5547; p=0.758). Regarding the lesion, FCD was more frequent in the FLE group (n=17), while TLE was more common among participants with LEAT (n=11); only 8 patients had HS (χ^2=19.257; p=0.000).

No difference in distribution was found for full scale intelligence quotient (χ^2=17.27; p=0.037), verbal comprehension (χ^2=16.437; p=0.044), working memory (χ^2=15.994; p=0.048), or processing speed (χ^2=16.577; p=0.043) indices or nonverbal fluency (χ^2=18.395; p=0.025) scores. However, the score distribution for general ability (χ^2=10.064; p=0.435) and perceptual reasoning (χ^2=7.395; p=0.688) was different among the sample of the study.

[INSERT TABLE 1 ABOUT HERE]

Comparing all study variables, only one significant difference was found between the clinical groups: FLE patients had lower Working Memory Index (WMI) scores than

patients with TLE (F=6.84; p=0.012). Table 2 and Figure 1 contain the scores for each epilepsy group and comparisons between each group of patients relative to the HC group.

Mean scores for variables of intellectual functioning in all groups were near the average, except for the Working Memory Index (WMI) in FLE patients, which were below average (Z=-1.13). Also, the lowest group scores were recorded among FLE patients. FLE patients had significantly worse FSIQ scores (F=25.04; p=0.000), though no significant differences were obtained for the General Ability Score. Also, the FLE group had worse cognitive performance, working memory (F=17.40; p=0.000), and processing speed (F=9.74; p=0.000) indices than the HC group, reaching statistical significance.

[INSERT TABLE 2 ABOUT HERE]

Simple linear regression models revealed (Table 3) that patients' GAI was influenced by the age at onset of seizures [β: 0.01 (0.00 – 0.01)], duration of epilepsy [β: -0.01 (-0.02 – 0.01)], and the number of prescribed AEDs at the time of evaluation [β: -0.68 (-1.07 – -0.29)]. Coefficient values for epilepsy duration and AED number were maintained in the multiple regression model, where age at seizure onset does not appear due to the high correlation between variables.

[INSERT TABLE 3 ABOUT HERE]

Table 2 shows that General Ability Index (GAI) was a predictive factor in memory, cognitive executive functions (except planning), and social cognition. However, the prediction was weak, although significant, in behavioral executive functions.

For the memory domain, all scores in the epilepsy and control groups approximated average values, except for FLE group scores in nonverbal memory (z=-1). No significant differences were found between epilepsy groups in verbal memory scores with GAI as a covariate. However, nonverbal memory scores in the FLE group were significantly lower compared to HCs (t=-2.41; p=0.022). Taking this into account, WMI scores predicted scores for narrative memory (r=0.511; p=0.015), verbal serial learning (r=0.602; p=0.011), and delayed verbal recall (r=0.547; p=0.023) in the FLE group.

Cognitive executive functioning is the domain with the lowest Z-scores among patient groups. Lower performance in planning (z=-1.6) and flexibility (z=-1.06) were found in the FLE group, and TLE patients also showed alterations in planning tasks (z=-1.01). FLE group scores were significantly lower for planning (t=-4.57; p=0.000), inhibitory control (t=-3.26; p=0.002), nonverbal fluency (t=-3.79; p=0.000), and flexibility (t=-3.52; p=0.001) compared to the HC group with GAI as a covariate. In this group, inhibitory control (r=0.539; p=0.014) and nonverbal fluency (r=0.536; p=0.018) were associated with WMI scores. The same is true for TLE patients, though this group did not differ from HCs in terms of inhibitory control. Patients with TLE had lower performance in planning (t=-3.03; p=0.004), nonverbal fluency (t=-4.43; p=0.000), and flexibility (t=-2.83; p=0.007). Even WMI was not impaired in the TLE group and was associated with planning (r=0.556; p=0.048) and flexibility scores (r=0.621; p=0.023).

Regarding social cognition, scores for the epilepsy groups were near the average in all variables. Immediate facial memory scores were significantly lower in the FLE (t=-

3.88; p=0.000) and TLE (t=-2.22; p=0.03) groups. Nonverbal memory determined the execution of tasks that require facial recognition of emotions in the FLE (r= 0.801; p=0.005) and the TLE group (r=0.791; p=0.004).

[INSERT FIGURE 1 ABOUT HERE]

Regarding behavioral executive functions evaluated through parental reporting, no significant alterations in mean values within each group were reported for variables of behavioral and emotional regulation. The TLE group had significantly lower impulse-inhibition (t=3.49; p=0.001) and emotional control (t=2.76; p=0.016) scores than HCs. For its part, the FLE group performed worse in shifting-flexibility (t=2.02; p=0.049) than the control group.

4. Discussion

The scientific literature on cognitive function has demonstrated the involvement of the frontal and temporal lobes in executive functioning, memory, and social cognition, among other functions [50]. Focal epilepsy has traditionally been considered a regional brain disorder; however, current behavioral [18, 51], neurophysiological [52-54], and neuroimaging studies [54-58] indicate that this type of epilepsy involves alterations of networks that extend beyond the epileptogenic zone [4, 23]. Such a broad influence may explain, at least in part, the difficulties in establishing differential neuropsychological profiles in focal epilepsy, along with the high number of factors that determine the cognitive performance of children with epilepsy such as etiology, age at seizure onset,

duration of epilepsy, the refractory nature of seizures, and the number or type of AEDs, all of which hinder attempts to draw conclusions based on homogenous patient groups [4]. In our work, no significant differences were found in the neuropsychological profiles of children with FLE and TLE as concerns memory, executive functions, and social cognition. The number of AEDs administered at the time of evaluation exerted a strong impact on patients' GAI, explaining 22% of the variance in scores. Longer duration of drug-refractory epilepsy increased the number of AEDs, though there was no association with age at onset of the disease. When AEDs are used in high-dose polytherapy for refractory seizure control, they can sometimes lead to greater deterioration than the seizures themselves, although this effect is reversible [59]. Patient age at onset of seizures and the duration of epilepsy also determine the intellectual capacity of children with FLE or TLE, explaining 19% and 37% of the variance found, respectively. The aforementioned findings have been widely reflected in the existing literature and suggest a need for early assessment of potential surgical approaches to improve the cognitive prognosis of children with lesional focal epilepsy [60-63].

Similar to previous research, we found significant differences in the distribution of the type of injury among clinical groups: DCF type II was more prevalent in FLE (17 out of 20 participants) [64], while LEAT was more prevalent in TLE (11 out of 17 participants) [65]. Similarly, we found that HS was less frequent in children (8 out of 22 TLE participants) [10].

Previous research has reported near-average FSIQ values for TLE patients [12, 13], while FLE patients obtained lower scores [15, 16]. The same is true in our sample, as FLE patients obtained lower intellectual scores and the FSIQ for this group differed significantly from that of healthy controls. Dennis et al [21] recommended the use of IQ

as a measure of aptitude and potential, isolating cognitive performance and achievement. We found that clinical groups differ in cognitive performance; specifically, the FLE group had worse WMI scores than the TLE group and HC. This same finding appeared in previous reports of pediatric FLE patients as measured by task performance [27] and in questionnaire-based research[66, 67]. The General Ability Index was used as an intellectual capacity measure instead of FSIQ due to the reduced impact of working memory and processing speed indices in GAI scores and the absence of significant intergroup differences for this intellectual index.

Consistent with previous studies, we found that early onset of seizures was a robust predictor of low GAI scores, both in FLE and TLE patients [14, 22, 68], and had a negative impact on the neurodevelopmental process [18, 69]. Additionally, early onset of epilepsy was related to longer duration of the disease, as found in the regression models performed. Recurrent seizures can cause significant and irreversible damage to the maturing brain, altering the way it develops and forms synapses [70].

Among indices of intellectual functioning, significant differences were found between clinical groups in WMI, with FLE patients obtaining the worst results. This performance determines the scores in verbal memory for the FLE group (narrative memory, verbal serial learning, and delayed verbal recall), and a similar finding has been reported in recent studies [67, 71]. In children with FLE, low performance on memory tasks compared to healthy children may be secondary to attentional or executive difficulties, which interfere with coding processes [25, 26, 71].

Memory deficits have been classically associated with adult TLE patients [23], though the same has not been replicated in the pediatric population. When examining memory in pediatric patients with focal epilepsy, some authors have suggested that the

findings of mnestic alterations have been limited by the lack of groups with defined types or epileptic syndromes and by the use of isolated memory measurements that do not control for other cognitive variables [72]. Although this study analyzes homogenous groups, the performance of pediatric TLE patients did not differ significantly from healthy controls and these patients did not have worse scores on memory tests than the FLE group. The lower frequency of MS as a disease associated with TLE in childhood could explain this finding [10, 11].

Compared to other cognitive variables, cognitive executive functions presented the highest number of scores equal to or less than the SD of the average. Planning, nonverbal fluency, and flexibility scores were significantly lower in the TLE and FLE groups compared to HCs, and FLE patients' inhibitory control was also impaired and associated to GAI scores. This finding demonstrates that impairments in executive function are not only the result of lower intellectual scores [73] and are not exclusive to FLE patients due to high structural connectivity of frontal networks[28]. Executive functions are particularly vulnerable in case of brain disruption during childhood; in our study, structural TLE and FLE patients showed group-wide executive dysfunction, and this finding supports the early vulnerability hypothesis of executive functions[17, 74], not only in FLE, but also in TLE patients. When evaluating executive functions, we must remember that performance tests are sensitive but not very specific.

For behavioral executive functions evaluated through parental reporting, no significant alterations in mean values for the clinical group were reported for variables of behavioral and emotional regulation. The TLE group had significantly lower impulse-inhibition scores and emotional control compared to HCs. For its part, the FLE group performed worse in set shifting and flexibility than the control group.

Finally, for social cognition, no differences were found between children with FLE and TLE when controlling for the impact of intelligence, though both groups showed impaired immediate facial memory compared to HCs. Furthermore, in both groups, immediate visual memory influenced facial recognition of emotions.

Strengths and Limitations

Some strengths of the present study are the inclusion criteria in the epilepsy group based on the presence of a structural injury in one cerebral hemisphere, limited to a single brain lobe, as identified using 3T magnetic resonance imaging as well as the fact that lesion type was confirmed histopathologically after surgery. Patients with bilateral conditions (bilateral MS), FCD type I, or a history of epileptic status were excluded to avoid an additional cognitive impact by a bilateral or diffuse disease or other condition.

Another strength entails the use of comprehensive evaluation following international recommendations [35], which is validated in pediatric population with neurological and epileptic diseases [37, 38]. As in other studies [20, 67], we used intelligence scores to control the influence of general cognitive abilities over specific cognitive functions. Certain degree of controversy surrounds this, specifically, Dennis et al [21] argue that the use of FSIQ as a covariate can be responsible for distortion of neurocognitive function findings. However, widespread neural distribution in focal epilepsy is not restricted to the epileptogenic zone, but rather can affect widely distributed networks in the brain. For this reason, general cognitive abilities should be included to study cognitive functioning in structural focal epilepsies in the pediatric population.

One limitation of the current study is the sample size used (n=45), which was reduced by the inclusion and exclusion criteria. Structural TLE and FLE are not frequent causes of refractory epilepsy. Another limitation is the type of lesion; although FCD, LEAT, and MS were included and specified in Table 1, the inclusion of GG, DNT, and pleomorphic xanthoastrocytoma may lead to heterogeneity. This decision was made based on the sample of patients available at the time of participants recruiting to our study. Patient age ranged from 3 to 18 years, and even though this range is similar to that in other studies [4], it may be a source of heterogeneity. Our findings should be analyzed in a larger sample with a lower number of lesion types of lesion and smaller ranges of age, although multicenter studies may be required.

As noted in the results section, the distribution of several intelligence scores and nonverbal fluency scores did not differ across different measurements included in the study. However, differences in distribution were found in the perceptual reasoning and general ability indices. This outcome indicates measurement error in both variables.

5. Conclusions

Epilepsy is a complex brain disease that compromises children's cognitive and behavioral development. Our study shows that the neuropsychological profiles of children with FLE or TLE differ significantly from children without neurological disease, and epileptic children have lower levels of development. When both groups of epileptic patients were compared, however, no significant differences were found; the differences emerged when we analyzed the factors associated with or determined by deficits in FLE or TLE compared to healthy children. The most extensive alterations were found in executive functioning and were not only due to low intellectual scores; rather, these

diseases also made patients vulnerable to alterations in structural focal epilepsies. No differences were found between performance tasks and clinical questionnaires of executive functions. Working memory determines the verbal memory processing of the FLE group. Memory disturbances were not found to be characteristic of the group with TLE; however, when evaluating aspects of social cognition, immediate visual memory influenced facial recognition of emotions in both FLE and TLE. Early onset of seizures, longer duration of epilepsy, and increased number of AEDs were robust predictors of low GAI scores in both types of epilepsy.

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Cognitive and behavioral profiles of pediatric surgical candidates with frontal and temporal lobe epilepsy

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