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ORIGINAL ARTICLE

Neuropsychological profile and social cognition in children and adolescents with temporal lobe epilepsy

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Abstract

Objective: To characterize the neuropsychological profile and social cognition, particularly Theory of Mind (ToM), in 45 children and adolescents with temporal lobe epilepsy (TLE) compared with 56 age, gender, and schooling-matched healthy controls. Within the original sample, we also evaluated a subgroup of patients who underwent epilepsy surgery, compared with those who were not surgically treated.

Methods: This is a prospective controlled study conducted between October 2020 and November 2022 at one center. We analyzed the study results for children (8–12 years old) and adolescents (13–18 years old) separately. We used univariate inferential statistical analyses (ANOVA or Kruskal–Wallis) and linear or logistic regression analyses.

Results: We observed significant impairments in cognitive functions, social cognition, and ToM in children with TLE compared with controls, as confirmed also by logistic regression analyses. Conversely, we found lower scores in adolescents with TLE compared with controls only in the sub-components of the Verbal Fluency test and Recognition of behaviors in the social situations test. Regression analyses adjusted for epilepsy-related variables confirmed that children exhibit more severe neuropsychological and sociocognitive impairments than adolescents. ToM abilities were impaired in children who had been treated surgically compared with those who had not. This finding could be due to epilepsy-related factors, such as earlier onset and longer disease duration, ablation of anatomic structures involved in ToM, or both.

Significance: A comprehensive neuropsychological and psychosocial assessment, including TOM, is recommended for children with TLE, especially if they are surgical candidates, to ensure timely psychoeducative and rehabilitative interventions.

Claudia Accolla and Martina Preti equally contributed to the study.

Plain language summary: Social cognition and ToM allow understanding of one's own and others' thoughts and feelings. These skills are often impaired in children and adolescents with temporal lobe epilepsy (TLE). We compared the neuropsychological and social profiles of young people with TLE to healthy peers and examined differences between those who underwent epilepsy surgery and those who did not. Children with TLE showed significant impairments in cognitive functions, social cognition, and ToM, with surgically treated children facing greater ToM challenges. Our findings highlight the need for comprehensive neuropsychological and psychosocial assessments to provide timely support for children with TLE.

KEYWORDS

children, epilepsy surgery, prospective study, social cognition, theory of mind

1 | INTRODUCTION

Temporal lobe epilepsy (TLE) is the most common type of focal epilepsy[1] and is often associated with cognitive impairment,[2,3] psychiatric disorders[4] and reduced quality of life (QoL).[5] Neuropsychological dysfunctions include cognitive domains strictly related to temporal lobe functions as well as to extratemporal areas.[6] Memory impairment, including episodic, verbal, nonverbal, and semantic memory dysfunctions[7,8] has frequently been reported in children with TLE who may also exhibit impairment in executive functions related to limbic and extra-limbic structures,[7,9,10] as well as extratemporal cognitive functions, such as attention and visual-constructive ability.[11]

Additionally, patients with TLE can manifest deficits in social cognition, mainly involving areas of emotional perception and theory of mind (ToM).[6,12,13] Lower performances in ToM tasks, for example the Faux Pas test, have been reported in children and adolescents with self-limiting epilepsy with centrotemporal spikes or TLE compared with controls; however, no stratification by age groups has been performed.[13–15] Some studies described a more severe impairment in social cognition abilities, in particular empathy,[16] facial emotion recognition[17] and ToM abilities,[18,19] in patients with right-TLE compared with those with left-TLE. Conversely, other studies found no difference between patients with right- and left-TLE on Faux Pas Task (FPT),[20] or highlighted the difficulty of establishing a specific role of epilepsy lateralization in social cognition deficits.[21] Emotion recognition deficits are more common in patients with medial TLE (MTLE) versus patients with lateral TLE (LTLE). Patients with MTLE exhibit a dysfunction of the cortico-subcortical network processing different facial expressions of emotion, including the amygdala, the anterior insula, the orbitofrontal cortex, and the somatosensory cortices.[17] In children and adolescents, deficits in facial emotion recognition can be associated with impairment in executive functions and nonverbal intelligence.[22]

Key points

- Neuropsychological and social performance were assessed in children and adolescents with TLE.
- Significant impairments in cognitive and social skills were observed in children with TLE compared with controls.
- Among adolescents with TLE, lower scores were observed only on the Verbal Fluency and Social Situations tests compared with controls.
- Children who had undergone surgical treatment exhibited impaired ToM abilities compared with those who had not.
- A comprehensive neuropsychological and psychosocial assessment is recommended in children with TLE.

Only a few studies investigated possible changes in sociocognitive functions after TLE surgery, reporting persistent postoperative impairments in emotion recognition[20] and ToM abilities,[23] regardless of seizure frequency reduction or seizure freedom.[21] A transient decline in sociocognitive functions in the first 6 months after surgery has been described in younger patients (≤12 years), followed by gradual improvement to presurgical levels.[24]

This prospective study aimed to characterize the neuropsychological and sociocognitive profile, in particular

ToM, in 45 young patients aged 8–18 years with TLE compared with 56 age, gender and schooling-matched controls, with a specific focus on the subgroup that had undergone epilepsy surgery.

2 | METHODS

2.1 | Participants

This study represents a cross-section of a longitudinal prospective research project on higher order social cognition in children (8–12 years old), adolescents (13–18 years old) and adults (19–35 years old) with TLE. Here, we report the results of the baseline assessment, while the follow-up study is still ongoing. Between October 2020 and November 2022, we prospectively enrolled all consecutive children and adolescents who met the following inclusion criteria: TLE diagnosed based on clinical and EEG features, age between 8 and 18 years, primary or secondary schooling level, and intelligence quotient (IQ) >70. Exclusion criteria included extratemporal, progressive or multifocal brain lesions, history of major depression, psychosis or obsessive-compulsive disorder preceding the diagnosis of epilepsy, severe systemic diseases, history of psychoactive substances use/abuse, autism spectrum disorders (ASD), and lack of informed consent. We divided the cohort into operated and nonoperated patients to evaluate the impact of surgery on neuropsychological and social cognition aspects.

We enrolled healthy controls matched for age, gender, and education. Healthy controls were recruited from among family members and contacts of patients or healthcare staff and assessed at the same center as the patients with TLE. Exclusion criteria were a personal or family history of epilepsy, an MRI documented brain lesion, history of major depression, psychosis, or obsessive-compulsive disorder preceding the diagnosis of epilepsy, severe systemic diseases, history of psychoactive substances use/abuse, ASD, and lack of informed consent. The study was approved by the Ethics Committee of the Tuscany Region, Italy. All patients, healthy controls, and their parents were informed about the study's methods and purpose and signed informed consent.

2.2 | Study protocol

We collected demographic (age, schooling, and gender) and clinical data (epilepsy-related variables) for all patients and controls. The protocol for the neuropsychological and social cognition assessment is described in detail in Appendix S1.

We assessed all patients and healthy controls in Italian, in accordance with the study protocol.

2.3 | Statistical analysis

We used descriptive statistics (including averages and standard deviations [SD], or frequencies and percentages) to delineate demographic, neuropsychological, and sociocognitive features of the total cohort, and epilepsy characteristics of patients. We dichotomized patients and controls' scores using the clinical cut-off, when available, for the age range closest to the pediatric group, although derived from adult norms. For social cognition tests, except Empathy Quotient (EQ), we used continuous measures to compare TLE patients and controls, employing parametric or nonparametric methods as appropriate.[11,25,26]

We carried out univariate inferential statistical analyses (ANOVA or Kruskal–Wallis when appropriate) to evaluate the association between (1) demographic, neuropsychological, and sociocognitive characteristics, and TLE; (2) epilepsy, cognitive, and sociocognitive variables, and epilepsy surgery in the patients group.

We used linear or logistic regression analyses to control for the confounding effects of several covariates on the association between TLE and neuropsychological and social cognition scores. For all analyses we used the EpiInfo version 7.2.7.0.

3 | RESULTS

3.1 | Comparison between TLE patients and controls

The final study sample was composed of 101 individuals (45 TLE patients and 56 controls) subdivided into two groups:

Group 1, 52 Children (age 8–12 years): 16 patients (mean age 10.8 [SD 1.2]; mean schooling 5.6 [SD 1.2]; 10 males; 10 with right manual lateralization) and 36 controls (mean age 11.1 [SD 1.4]; mean schooling 6.0 [SD 1.4]; 4 males; 35 with right manual lateralization).
Group 2, 49 Adolescents (age 13–18 years): 29 patients (mean age 14.9 [SD 1.6]; mean schooling 9.9 [SD 1.6]; 17 males; 22 with right manual lateralization) and 20 controls (mean age 14.9 [SD 1.7]; mean schooling 9.9 [SD 1.7]; 9 males; 17 with right manual lateralization).

3.1.1 | Children

Demographic characteristics of the whole cohort and epilepsy-related characteristics of the 16 TLE patients are presented in Table 1.

The comparison of neuropsychological assessment between patients and controls revealed significantly lower performances in patients across the following areas: IQ; Trail Making Test (TMT) part A; TMT part B; Phonemic Verbal Fluency; Short Story Test. In addition, we observed not statistically significant lower patients' performances compared with controls in the Attentional Matrices Test, TMT B-A and in the Corsi block span (Table 2).

The comparison of social cognition between patients and controls revealed statistically significant differences

TABLE 1 Children and adolescents—demographic characteristics of the whole cohort and epilepsy-related characteristics of the patients sample.

	Children patients $n = 16$	Children controls $n = 36$	p	Adolescents patients $n = 29$	Adolescents controls $n = 20$	p
Age at baseline (years) Mean (SD)	10.8 (1.2)	11.1 (1.4)	0.47	14.9 (1.6)	14.9 (1.7)	0.99*
Manual lateralization (right) *n* (%)	**10 (62.5)**	**35 (97.2)**	**<0.001**	22 (75.9)	17 (85.0)	0.43[#]
Sex (males) *n* (%)	**10 (58.8)**	**4 (11.1)**	**<0.001**	17 (58.6)	9 (45)	0.34[#]
Schooling (years) Mean (SD)	5.6 (1.2)	6.0 (1.4)	0.28	9.9 (1.6)	9.9 (1.7)	0.99*
Age at seizure onset (years) Mean (SD)	3.9 (3.4)			8.1 (4.5)		
Epilepsy duration (years) Mean (SD)	6.8 (3.2)			6.9 (3.9)		
Number of anti-seizure medications Mean (SD)	1.2 (0.8)			1.3 (1.0)		
Lesion side, if any *n* (%)						
No lesion	3 (18.8)			4 (13.8)		
Right	4 (25)			11 (37.9)		
Left	8 (50)			13 (44.8)		
Bilateral	1 (6.25)			1 (3.4)		
TLE lateralization *n* (%)						
Right	6 (37.5)			12 (41.4)		
Left	9 (56.25)			16 (55.2)		
Not determined	1 (6.25)			1 (3.4)		
Operated patients *n* (%)	7 (43.75)			13 (44.8)		
Seizure frequency *n* (%)						
Daily	1 (6)			3 (10)		
Weekly	3 (19)			4 (14)		
Monthly	3 (19)			3 (10)		
No seizures	9 (56)			1 (4)		
				18 (62)		

Note: Significant *p*-values in bold.

Abbreviations: SD, standard deviation; TLE, temporal lobe epilepsy.

TABLE 2 Children and adolescents – results of cognitive tests for the whole cohort and comparison between patients and controls.

Neuropsychological assessment	Patients	Controls	*p*
Children			
Intelligence quotient Mean (SD)	**87.9 (14.3)**	**99.7 (11.0)**	**0.002**
Attentive matrices (<42) *n* (%)	1 (7.1)	1 (3.1)	0.52
Trail making test A (ES < 2) *n* (%)	**5 (35.7)**	**2 (6.25)**	**0.02**
Trail making test B (ES < 2) *n* (%)	**5 (35.7)**	**0 (0)**	**0.001**
Trail making test B-A (ES < 2) *n* (%)	4 (28.6)	2 (6.2)	0.06
Phonemic verbal fluency (ES < 2) *n* (%)	**6 (42.9)**	**2 (6.25)**	**0.006**
Semantic verbal fluency (ES < 2) *n* (%)	5 (35.7)	5 (15.6)	0.24
Corsi blocks span (<4) *n* (%)	2 (14.3)	0 (0)	0.09
Short story test (ES < 2) *n* (%)	**6 (42.9)**	**2 (6.2)**	**0.006**
Adolescents			
Intelligence quotient Mean (SD)	99.4 (15.7)	105.8 (13.0)	0.15
Attentive matrices (<42) *n* (%)	0 (0)	0 (0)	/
Trail making test A (ES <2) *n* (%)	3 (10.3)	0 (0)	0.27
Trail making test B (ES <2) *n* (%)	3 (10.3)	1 (5.3)	1.00
Trail making test B-A (ES <2) *n* (%)	1 (3.4)	1 (5.3)	1.00
Phonemic verbal fluency (ES < 2) *n* (%)	**10 (34.5)**	**1 (5.3)**	**0.032**
Semantic verbal fluency (ES < 2) *n* (%)	6 (20.7)	2 (10.5)	0.45
Corsi blocks span (<4) *n* (%)	0 (0)	0 (0)	/
Short story test (ES < 2) *n* (%)	2 (6.9)	0 (0)	0.51

Note: Significant *p*-values in bold.

Abbreviations: SD, standard deviation; ES, equivalent scores.

in the Sensitivity to moral and conventional rules test (SMCR) subtest, in which children were requested to evaluate the severity of disregard for conventional rules. We observed statistically significant worse performance in all the three Recognition of behaviors in social situations test (RBSS) subscales, including identification of normative behaviors, violations, and severity of violations, and in the Empathy Quotient (EQ), a self-administered questionnaire designed to assess and measure empathy (Table 3).

Considering specifically ToM, patients scored lower than controls in the Faux Pas Task (FPT) test subscales for "No Faux Pas detection"; "Control questions" of the stories without *faux pas*, "faux pas knowledge" question, "attribution of belief" question, total Comprehension Questions, and Faux Pas Total score (Table 4).

3.1.2 | Linear regression (children with TLE/controls)

In the group of children aged 8–12 years, the TLE and control groups were not homogeneous for several covariates. We used a linear regression model to estimate

TABLE 3 Children and adolescents—social cognition test results of the whole cohort and comparison between patients and controls.

Social cognitive assessment Children's sample	Patients	Controls	*p*
Children			
Sensitivity to moral and conventional rules test			
Recognition of moral rules Mean (SD)	6.0 (0.0)	5.9 (0.5)	0.41
Recognition of conventional rules Mean (SD)	5.2 (0.6)	5.1 (0.8)	0.79
Recognition of the severity of disregard for moral rules Mean (SD)	50.9 (10.1)	48.6 (8.8)	0.42
Recognition of the severity of disregard for conventional rules Mean (SD)	**42.5 (11.0)**	**33.2 (12.1)**	**0.01**
Recognition of moral rules in the absence of expressed norms Mean (SD)	10.9 (2.1)	11.1 (2.3)	0.69
Recognition of conventional rules in the absence of expressed norms Mean (SD)	9.3 (2.5)	8.5 (3.5)	0.39
Recognition of behaviors in social situation			
Normative behaviors Mean (SD)	**6.3 (4.8)**	**11.6 (3.8)**	**0.000**
Violations Median (IQR)	**18.0 (0–21)**	**23.0 (20.5–24)**	**0.001**
Severity of violations Mean (SD)	**27.3 (20.8)**	**45.2 (15.1)**	**0.000**
Empathy Questionnaire			
Total Score (<33) *n* (%)	**8 (53.3)**	**6 (16.7)**	**0.01**
Adolescents			
Sensitivity to moral and conventional rules test			
Recognition of moral rules Mean (SD)	5.9 (0.4)	6.0 (0.2)	0.55
Recognition of conventional rules Median (IQR)	5.0 (4–6)	5.0 (5–6)	0.55
Recognition of the severity of disregard for moral rules Mean (SD)	45.7 (11.1)	51.6 (9.3)	0.06
Recognition of the severity of disregard for conventional rules Mean (SD)	30.0 (11.6)	32.0 (12.8)	0.60
Recognition of moral rules in the absence of expressed norms Mean (SD)	11.5 (1.0)	11.6 (0.9)	0.57
Recognition of conventional rules in the absence of expressed norms Mean (SD)	8.3 (2.5)	8.1 (2.6)	0.81
Recognition of behaviors in social situation			
Normative behaviors Mean (SD)	**11.9 (2.0)**	**13.4 (1.5)**	**0.007**
Violations Mean (SD)	21.0 (2.9)	22.3 (2.4)	0.10
Severity of violations Mean (SD)	**41.7 (8.2)**	**49.0 (8.6)**	**0.006**
Empathy questionnaire			
Total Score *n* (%)	5 (17.2)	4 (20.0)	1.00

Note: Significant *p*-values in bold.

Abbreviations: IQR, interquartile range; SD, standard deviation.

TABLE 4 Children and adolescents – Faux Pas test results of the whole cohort and comparison between patients and controls.

Faux Pas test Children's sample	Patients	Controls	*p*
Children			
Detection score (No FP) Median (IQR)	**9.0 (5–10)**	**10 (10–10)**	**0.001**
Control questions (No FP) Median (IQR)	**8 (4–10)**	**10 (10–10)**	**0.000**
Detection score (FP) Mean (SD)	6.6 (2.2)	7.0 (2.1)	0.52
Control questions (FP) Mean (SD)	5.7 (2.3)	6.8 (2.0)	0.10
Identification score Mean (SD)	5.6 (2.3)	6.9 (2.1)	0.06
Knowledge score Mean (SD)	**5.3 (2.6)**	**6.8 (2.1)**	**0.04**
Belief score Mean (SD)	**4.1 (2.8)**	**6.2 (2.6)**	**0.01**
Empathy score Mean (SD)	5.3 (2.3)	6.4 (2.4)	0.13
Total comprehension questions Mean (SD)	**20.3 (9.8)**	**26.4 (9.0)**	**0.03**
FP total Mean (SD)	**47.4 (17.3)**	**58.5 (14.4)**	**0.02**
Adolescents			
Detection score (No FP) Median (IQR)	10.0 (9–10)	10.0 (9.5–10)	0.35
Control questions (No FP) Median (IQR)	10.0 (9–10)	10.0 (9–10)	0.37
Detection score (FP) Mean (SD)	7.1 (2.4)	7.4 (2.4)	0.73
Control questions (FP) Mean (SD)	7.0 (2.5)	6.8 (2.8)	0.83
Identification score Mean (SD)	6.8 (2.6)	7.1 (2.4)	0.71
Knowledge score Mean (SD)	6.8 (2.6)	6.9 (2.5)	0.89
Belief score Mean (SD)	6.5 (2.8)	6.6 (2.7)	0.90
Empathy score Mean (SD)	6.6 (2.9)	6.7 (2.9)	0.86
Total comprehension questions Mean (SD)	26.6 (10.7)	27.3 (9.9)	0.83
FP total Mean (SD)	58.8 (18.1)	60.4 (15.5)	0.75

Note: Significant *p*-values in bold.

Abbreviations: FP, Faux Pas; IQR, interquartile range; SD, standard deviation.

the effect of TLE on social cognition scores, adjusting for sex, lateralization, IQ, and executive functions (Table 5). The adjusted estimates showed a statistically significant reduction in patients' scores compared with controls in the normative behaviors and severity of violations subtests of the Recognition of behaviors in social situations test (RBSS test). We also found a difference in the SMCR test, specifically in the evaluation of the severity of disregard for conventional rules. Overall, regression analyses substantially confirm the lower social

TABLE 5 Linear regression children.

Linear regression Children sample (Patients/Controls)	Coefficient[a] (95% CI)	p
FP total	−13.04 (−27.83–1.75)	0.08
Sensitivity to moral and conventional rules test		
Recognition of moral rules	0.06 (−0.36–0.48)	0.77
Recognition of conventional rules	−0.01 (−0.69–0.66)	0.97
Recognition of the severity of disregard for moral rules	2.47 (−6.21–11.14)	0.57
Recognition of the severity of disregard for conventional rules	**10.80 (1.58–20.01)**	**0.02**
Recognition of moral rules in the absence of expressed norms	0.36 (−1.19–1.92)	0.64
Recognition of conventional rules in the absence of expressed norms	0.89 (−2.08–3.85)	0.55
Recognition of behaviors in social situation		
Normative behaviors	**−5.62 (−9.48 to −1.75)**	**0.006**
Violations	−6.25 (−12.54–0.04)	0.051
Severity of violations	**−15.67 (−30.30 to −1.03)**	**0.04**
Empathy questionnaire		
Total score	0.12 (−0.23–0.47)	0.49

Note: Significant *p*-values in bold.

Abbreviation: FP, Faux Pas.

[a]Adjusted for sex, lateralization, IQ, Trail Making Test, Corsi Blocks Span.

cognition performance observed in children with TLE compared with controls, suggesting that these deficits persist even after adjusting for cognitive and executive functions.

3.1.3 | Adolescents

Demographic characteristics of the whole cohort and epilepsy-related characteristics of the 29 TLE patients are presented in Table 1.

Cognitive assessment revealed a significantly lower score for patients compared with controls on the Phonemic verbal fluency test (Table 2). The social cognition assessment showed lower scores for patients compared with controls on the Recognition of behaviors in social situations test (RBSS) subscales regarding the ability to identify normative behaviors and to assess the severity of violations (Table 3).

Conversely, we did not find statistically significant differences between patients and controls in ToM as measured by the Faux Pas Task (FPT) (Table 4).

3.1.4 | Linear regression (children/adolescents with TLE)

To examine the effect of epilepsy-related variables (age at seizure onset, epilepsy duration, seizure frequency), we conducted an additional linear regression analysis to compare cognitive and social cognition test performance in children and adolescents (Table 6).

In the adjusted estimates, we observed a statistically significant reduction in children's scores compared with adolescents on the FP Total score of the Faux Pas Task (FPT) and on the normative behavior subtest of the Recognition of behaviors in social situations test (RBSS). We also found a difference in the Sensitivity to moral and conventional rules (SMCR test), specifically in the evaluation of the severity of disregard for conventional rules, and in the Empathy Quotient (EQ). Additionally, children performed worse than adolescents on IQ, Semantic verbal fluency, Corsi block span and Short story test.

3.2 | Comparison between operated and nonoperated patients

3.2.1 | Children

The study population consisted of 16 children with TLE, of whom seven underwent epilepsy surgery and nine did not. Operated patients had a significantly lower schooling level (mean 4.9 [SD 1.3] vs. mean 6.2 [SD 0.8]; $p=0.025$) and an earlier mean age of epilepsy onset (mean years 2.4 [SD 2.2] vs. mean years 5. [SD 4.0]; $p=0.042$) compared with nonoperated ones. We observed significant differences in cognitive assessment results only on the Trial Making test (TMT)-part A-test, with operated patients showing worse performance compared with nonoperated patients (mean 73.2 [SD 21.6] vs. mean 45.4 [SD 16.0], respectively; $p=0.017$). In addition, we found significant differences between the two groups on the Faux Pas Task (FPT) among the social cognition tests. Specifically, operated patients exhibited statistically significant lower scores, compared with nonoperated children in the following FPT subscales: Identification score (mean 3.8 [SD 1.7]

TABLE 6 Linear regression patients sample.

Linear regression Patients sample (Children/Adolescents)	Coefficient[a] (95% CI)	p
FP total	**−19.46 (−33.11 to −5.80)**	**0.006**
Sensitivity to moral and conventional rules test		
Recognition of moral rules	0.12 (−0.20–0.44)	0.45
Recognition of conventional rules	0.65 (−0.06–1.37)	0.07
Recognition of the severity of disregard for moral rules	7.52 (−2.47–17.52)	0.13
Recognition of the severity of disregard for conventional rules	**14.83 (3.87–25.80)**	**0.009**
Recognition of moral rules in the absence of expressed norms	−0.48 (−1.88–0.92)	0.49
Recognition of conventional rules in the absence of expressed norms	1.97 (−0.36–4.31)	0.09
Recognition of behaviors in social situation		
Normative behaviors	**−2.86 (−5.63 to −0.08)**	**0.04**
Violations	−4.15 (−9.51–1.22)	0.13
Severity of violations	−7.88 (−20.44–4.67)	0.21
Empathy questionnaire		
Total score	**0.43 (0.04–0.81)**	**0.031**
Intelligence quotient	**−15.97 (−29.06–2.88)**	**0.02**
Trail making test (Logistic regression)	OR = 55.0 (0.64–4675.6)	0.08
Phonemic verbal fluency	−6.99 (−17.69–3.70)	0.19
Semantic verbal fluency	**−13.04 (−20.60 to −5.48)**	**0.001**
Corsi blocks span	**−1.36 (−2.51 to −0.22)**	**0.02**
Short story test	**−5.65 (−9.62 to −1.67)**	**0.007**

Note: Significant *p*-values in bold.

Abbreviation: FP, Faux Pas.

[a]Adjusted for age at seizure onset, epilepsy duration, seizure frequency.

vs. mean 6.8 [SD 2.0]; $p = 0.011$); Knowledge score (mean 3.5 [SD 2.2] vs. 6.6 [SD 2.2]; $p = 0.021$); Belief score (mean 2.0 [SD 1.8] vs. mean 5.4 [SD 2.5]; $p = 0.011$); Empathy score (mean 3.8 [SD 2.0] vs. mean 6.2 [SD 2.2], $p = 0.049$); total comprehension questions (mean 13.2 [SD 7.2] vs. mean 25.0 [SD 8.6]; $p = 0.015$); Faux Pas Total score (mean 36.5 [SD 17.3] vs. mean 54.7 [SD 13.9]; $p = .042$).

3.2.2 | Adolescents

The study population consisted of 29 adolescents with TLE, including 13 patients who underwent epilepsy surgery and 16 who did not. There were no differences in the demographic characteristics of the two subgroups. However, operated patients had a lower mean number of anti-seizure medications (mean 0.9 [SD 1.1] vs. mean 1.7 [SD 0.8]; $p = .030$), and a higher proportion of seizure remission (11, 84.6%, vs. 7, 43.8%; $p = .024$), compared with nonoperated patients.

No significant differences emerged in cognitive assessment between the two subgroups. In the Social Cognition tests, operated patients rated the moral transgressions less severely (mean 40.4 [SD 13.3]) than nonoperated patients (mean 49.9 [SD 6.6]) on the “Recognition of the severity of disregard of moral rules” of the SMCR test ($p = 0.031$).

4 | DISCUSSION

In this prospective controlled study, we assessed the neuropsychological and sociocognitive features (specifically ToM) in 45 children and adolescents with TLE compared with 56 age, schooling and gender-matched controls. In several tests investigating the neuropsychological profile, we found a significantly lower performance of TLE patients aged 8–12 years compared with controls. The most impaired cognitive domains were memory, assessed through the Short Story test and Corsi block span, and executive functions, assessed through the TMT, Verbal Fluency, and the Attentional Matrices tests. While in patients with TLE, memory impairment can be due to anatomo-functional impairment of temporo-mesial areas (e.g., the hippocampus), the additional cognitive deficits might be explained by a larger neural network dysfunction, involving regions interconnected to the seizure onset zone or in seizure propagation.[27] Our findings are in line with previous reports on children with TLE,[7,9,11] indicating a multidomain cognitive impairment, including total IQ, memory, executive functions, language and attention.

Conversely, in the adolescent group, we observed significantly different scores between patients and controls only on the Phonemic verbal fluency test, indicating language and executive functions impairment. We also found a nonsignificant difference between patients and controls on the Attentional Matrices test, suggesting impairment in selective attention.

In the area of Social Cognition, we found impaired skills both in children and adolescents with TLE, compared with controls. Patients with TLE exhibited worse performances on the RBSS test, particularly in contextualizing a behavior within a social situation, understanding the social relationships in which they are involved, distinguishing between normal and bizarre behaviors, or normative behaviors and violations based on social rules. In the area of ToM, we reported significantly lower performances in children with TLE compared with controls in understanding other people's thoughts and identifying and interpreting social transgressions. In contrast with previous studies,[15,28] which, however, did not stratify the analysis by age group, we could not find a significant impairment on FPT in adolescents with TLE compared with controls.

Additionally, children had significantly lower scores than adolescents on the Faux Pas Total score and on the normative behavior subtest of the RBSS, as well as on the SMCR test and the EQ.

It may be questioned whether the greater cognitive impairment we observed in children compared with adolescents with TLE might be explained, at least in part, by the different age at seizure onset between the two groups (mean 3.9 [SD 3.4] vs. mean 8.1 [SD 4.5], respectively), in line with the observation that an earlier onset of TLE is associated with worse developmental trajectories.[7,29] However, our regression analyses examining the effect of epilepsy-related variables on cognitive and social cognition tests showed that this impairment persisted even after adjustment for age at seizure onset, duration of epilepsy, and seizure frequency. The more severe neuropsychological and sociocognitive profile observed in children with TLE compared with adolescents may therefore reflect the interaction between epilepsy and ongoing neurodevelopmental processes.[7,29]

In childhood, cognitive and social cognition abilities are still emerging and rely on the progressive integration of distributed neural networks, particularly within fronto-temporal and limbic systems.[22,30] Epilepsy-related dysfunction occurring during this critical developmental window may interfere with the acquisition and consolidation of these skills, leading to broader and more persistent impairments.[15,31] In adolescence, when many cognitive and sociocognitive functions are more consolidated, epilepsy might be associated with more selective or subtle deficits.

Additionally, linear regression analyses of children with TLE, adjusted for sex, lateralization, IQ, TMT, and Corsi block span, confirmed that their deficits in social cognition remain significant even after accounting for general cognitive ability and executive functions, which may nevertheless contribute to social reasoning. This finding aligns with recent studies highlighting the intricate interplay between executive functions and sociocognitive processes.[22] Social cognition deficits in pediatric epilepsy are often associated with impairments in working memory, cognitive flexibility, and inhibitory control, which directly affect children's ability to interpret others' intentions, recognize emotions, and respond appropriately in social contexts.[30,32]

The EQ results of children with TLE are similar to those of children with high functioning ASD. Previous research[30] has shown that children and adolescents with ASD may exhibit deficits of varying severity in emotion recognition and ToM compared with typically developing controls. These findings need to be explored in larger cohorts, due to the complexities and variable severity of ASD.[28]

In general, our findings expand existing evidence of impaired Social Cognition and ToM in children with TLE.[15] Previous studies in children were observational in nature and evaluated sociocognitive aspects in self-limited epilepsies[13,14] or used different tests in TLE.[15]

Our study revealed impaired ToM abilities in operated children, compared with nonoperated ones, with statistically significantly worse performances on FPT in understanding the different thoughts, beliefs, and emotional aspects of people involved in a social context. Conversely, adolescents undergoing surgery, compared with those who did not, showed no impairment on ToM tests. These findings are in line with the hypothesis that longer disease duration before the intervention and history of early childhood brain injury can predict social cognition problems in patients undergoing TLE surgery.[20] Moreover, individuals younger than 12 years old, who presented epilepsy-related neuronal activity during a critical period of brain maturation, may experience greater difficulties or require a longer time in resuming functional neural networks, if any, after surgery compared with older children and adolescents, even when surgery is successful and seizure freedom is achieved.[33] Lack of sociocognitive improvement after surgery could also be a direct consequence of the removal of anatomic areas involved in sociocognitive functions (e.g., amygdala or anterior temporal lobe).[35] Psychosocial aspects, such as the abnormal habits and behaviors established before surgery, such as high dependence on parents, or social isolation due to epilepsy, could also adversely affect patients' autonomy and hamper post-operative re-adaptation to the social environment.[36] We did not observe significant differences between operated and nonoperated patients on the other social cognition tests we analyzed (SMCR, RBSS, EQ), which is in line with previous studies.[21,24,33,34]

Our study is limited by the small sample size in relation to the number of variables examined.

Despite this limitation, using a prospective controlled design and a comprehensive assessment of multiple aspects of Social Cognition and ToM through a large battery of tests, we demonstrated that TLE-children exhibit impaired neuropsychological and sociocognitive functions, including the ToM domain, whereas adolescents with TLE are generally less affected.

5 | CONCLUSIONS

Our findings highlight that assessing children and adolescents with epilepsy using both standardized neuropsychological and sociocognitive tests is highly relevant and can guide timely psychoeducative and rehabilitative interventions. This innovative strategy, by integrating age-stratified analyses with multiple measures of social cognition, provides a more comprehensive description of sociocognitive vulnerabilities during development. From a clinical perspective, our results support the need for early monitoring of social cognition in children with TLE and the implementation of targeted approaches to improve their social functioning. The separate analysis of children and adolescents provided additional valuable insights. For children who are surgical candidates, this approach can help to accurately delineate patients ociocognitive profile and clearly set out the limitations of their procedure, whose beneficial effects beyond seizure control cannot be guaranteed.

AUTHOR CONTRIBUTIONS

Claudia Accolla: Writing – original draft, data collection. **Martina Preti**: Writing – original draft, data collection, and data analysis. **Pietro Cappelletto**: Writing – original draft, data collection. **Salvatore De Masi:** data analysis. **Carmen Barba**: Conceptualization, review, and editing. **Renzo Guerrini**: Conceptualization, review, and editing.

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CONFLICT OF INTEREST STATEMENT

None of the authors has any conflict of interest to disclose. We confirm that we have read the Journal's position on issues involved in ethical publication and affirm that this report is consistent with those guidelines.

DATA AVAILABILITY STATEMENT

All data relevant to the study are included in the article or tables. Additional data are available from the corresponding author upon reasonable request.

ETHICS STATEMENT

The study was approved by the Ethics Committee of the Tuscany Region, Italy. All patients, healthy controls, and their parents were informed about the study's methods and purpose and signed informed consent.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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