University of Groningen

Executive and behavioral functioning in pediatric frontal lobe epilepsy

van den Berg, Lydia; de Weerd, Al; Reuvekamp, Marieke; Hagebeuk, Eveline; van der Meere, Jaap

Published in:
Epilepsy & Behavior

DOI:
[10.1016/j.yebeh.2018.07.022](https://doi.org/10.1016/j.yebeh.2018.07.022)

IMPORTANT NOTE: You are advised to consult the publisher's version (publisher's PDF) if you wish to cite from it. Please check the document version below.

Document Version
Publisher's PDF, also known as Version of record

Publication date:
2018

[Link to publication in University of Groningen/UMCG research database](#)

Citation for published version (APA):

van den Berg, L., de Weerd, A., Reuvekamp, M., Hagebeuk, E., & van der Meere, J. (2018). Executive and behavioral functioning in pediatric frontal lobe epilepsy. *Epilepsy & Behavior*, 87, 117-122.
<https://doi.org/10.1016/j.yebeh.2018.07.022>

Copyright

Other than for strictly personal use, it is not permitted to download or to forward/distribute the text or part of it without the consent of the author(s) and/or copyright holder(s), unless the work is under an open content license (like Creative Commons).

The publication may also be distributed here under the terms of Article 25fa of the Dutch Copyright Act, indicated by the "Taverne" license. More information can be found on the University of Groningen website: <https://www.rug.nl/library/open-access/self-archiving-pure/taverne-amendment>.

Take-down policy

If you believe that this document breaches copyright please contact us providing details, and we will remove access to the work immediately and investigate your claim.

Downloaded from the University of Groningen/UMCG research database (Pure): <http://www.rug.nl/research/portal>. For technical reasons the number of authors shown on this cover page is limited to 10 maximum.

Executive and behavioral functioning in pediatric frontal lobe epilepsy

Lydia van den Berg^{a,b,*}, Al de Weerd^a, Marieke Reuvekamp^a, Eveline Hagebeuk^a, Jaap van der Meere^b

^a Stichting Epilepsie Instellingen Nederland, Postbus 563, 8000, AN, Zwolle, Netherlands

^b Rijksuniversiteit Groningen, Faculteit Gedrags- & Maatschappijwetenschappen, Klinische & Ontwikkelingsneuropsychologie, Grote Kruisstraat 2/1, 9712, TS, Groningen, Netherlands

ARTICLE INFO

Article history:

Received 13 April 2018

Revised 23 July 2018

Accepted 24 July 2018

Available online 14 August 2018

Keywords:

Executive functions

Frontal lobe epilepsy

Children

BRIEF

CBCL

Behavior problems

Attention problems

ABSTRACT

Objective: Epilepsy, as a chronic and neurological disease, is generally associated with an increased risk for social and emotional behavior problems in children. These findings are mostly derived from studies on children with different epilepsy types. However, there is limited information about the associations between frontal lobe epilepsy (FLE) and cognitive and behavioral problems. The aim of this study was to examine relationships between FLE and executive and behavioral functioning reported by parents and teachers.

Material and methods: Teachers and parents of 32 children (18 boys, 14 girls, mean age 9; 2 years $\pm$ 1;6) with a confirmed diagnosis of FLE completed the Behavioral Rating Inventory of Executive Function (BRIEF), the Child Behavior Checklist (CBCL), and Teacher Report Form (TRF).

Results: About 25 to 35% of the parents and teachers rated children in the abnormal range of the main scales of the BRIEF, CBCL, and TRF. Teachers tend to report more metacognition problems, whereas parents tend to report more behavior regulation problems. Children with left-sided FLE showed more problems than children with bilateral or right-sided FLE. The whole range of executive dysfunctioning is linked to behavioral dysfunctioning in FLE, but ratings vary across settings and informants. The epilepsy variables age of onset, lateralization, drug load, and duration of epilepsy had only a small and scattered contribution.

Conclusion: Ratings on the BRIEF, CBCL, and TRF are moderately to highly correlated, suggesting a (strong) link between executive and behavioral functioning. Subtle differences between parents and teachers ratings suggest different executive function demands in various settings.

© 2018 Elsevier Inc. All rights reserved.

1. Introduction

Epilepsy is the most common neurological condition in childhood with a prevalence of 4–10 per 1000 [1]. Research on psychiatric comorbidity is extensive, and it is well-recognized that epilepsy as a chronic and neurological disease is associated with an increased risk (up to 60%) of social and emotional behavior problems in children [2,3]. Common comorbidities include attention-deficit/hyperactivity disorder (ADHD), autism, anxiety problems, and depression [4–9]. These problems are often present around the time of diagnosis, diminish over time [10], and appear to be associated with neurologic dysfunction, severe seizures [2], and family dysfunction [11].

Most studies have focused on temporal lobe epilepsy (TLE) because it is the most frequent type of epilepsy [12,13]. We question the generalizability of findings to other types of epilepsy, in particular, frontal lobe epilepsy (FLE); TLE and FLE differ with respect to localization and functionality. To date, there is evidence for association between FLE and attention and inhibition problems, social cognitive problems, and aggression [13–17]. Executive functions (EF) are mainly localized

in the frontal lobe and is an ‘umbrella’ term for the management (regulation, control) of cognitive processes like attention, inhibition, initiation of activity, working memory, mental flexibility, planning and organization, and problem solving strategies [18]. It consists of the capacities that enable a person to engage successfully in independent, purposive, self-directed, and self-serving behavior [19]. There is growing evidence of neuroimaging studies that frontal lobe epilepsy leads to structural and functional disorders [12,13]. Also, seizures as well as interictal epileptic discharges are increasingly recognized to interfere with physiological brain circuitry [12], which in the long term can result in chronic cognitive and behavioral comorbidity [12,13,20]. Frontal lobe epilepsy could therefore lead to executive function problems, which can be expressed in behavioral problems and social and academic failure [6,13,20–24]. Furthermore, TLE and FLE differ with respect to seizure characteristics. In FLE, nocturnal seizures are far more frequent than in TLE, and therefore, poor quality of sleep is common. This factor on its own may be associated with a variety of behavioral and cognitive problems [25–27].

It is therefore worthwhile exploring executive and behavioral functioning and their interaction in pediatric FLE. Since clinically used performance-based measures do not always have good sensitivity and specificity, the use of parent and/or teacher-proxy measures is generally

* Corresponding author at: SEIN, Postbus 563, 8000, AN, Zwolle, Netherlands.
E-mail address: lvdenberg@sein.nl (L. van den Berg).

accepted for measuring emotional and behavioral problems. The Behavioral Rating Inventory for Executive Function (BRIEF) has rarely been used in studies on children with epilepsy; however, a few authors mention inclusion of FLE [28–30], usually reporting frequent executive dysfunction. Reports from parents as well as teachers are complementary for the BRIEF [31], but have only been studied in one study [28]. The Child Behavior Checklist (CBCL) and Teacher Report Form (TRF) are questionnaires, which are used extensively in pediatric epilepsy showing elevated scores [32,33], and considered to be a valid instrument for measuring behavioral problems in children with epilepsy [34]. This has been sparsely studied in children with FLE [34–36]. Finally, the influence of epileptic lateralization, age of onset, duration of epilepsy, and drug load are evaluated.

2. Material and methods

2.1. Participants

Children with FLE were referred by the neurologist for a broad neuropsychological assessment. The assessment of executive functioning with validated and normative tests is possible from the age of eight. Further executive function demands differ in primary and secondary school and in the Netherlands children go to secondary school at approximately the age of twelve. Also, longer duration of epilepsy is considered a risk factor for developing psychopathology [37,38]. Therefore inclusion criteria were ages between 8 and 12 years with a diagnosis of frontal lobe epilepsy and IQ > 70 or school achievement scores above C level (Dutch Centraal Instituut voor Toets Ontwikkeling (CITO)) in math and language. Exclusion criteria were health and/or psychiatric problems, which could influence the neuropsychological assessment, except for attention-deficit and hyperactivity disorder (ADHD), which is a very common diagnosis in children with epilepsy [39]. A total of 32 children (18 boys, 14 girls) met these criteria; 5 of these children had a confirmed ADHD diagnosis. For the BRIEF, 32 parents and 30 teachers completed the questionnaire. For the CBCL and TRF, 31 parents and teachers completed the questionnaire. The definition of the type of epilepsy was based on the International League Against Epilepsy criteria and confirmed by an electroencephalograph (EEG) registration.

2.2. Study procedures

The children who met the inclusion criteria were invited for neuropsychological assessment in the psychology department of our tertiary epilepsy center. Questionnaires were completed by the parents of the children while children were assessed with performance-based measures. When a parent did complete the questionnaire and a teacher did not or vice versa, we still used the completed form in our data. Questionnaires for the teachers were delivered by the parents or sent by mail. The study was approved by the Ethical Committee of Medisch Spectrum Twente (MST) Enschede, and parents gave their informed consent.

2.3. Measurements

Executive functioning in this study was measured using the Behavioral Rating Inventory for Executive Function (BRIEF) [40,41]. This questionnaire is an 86-item questionnaire designed to assess executive function in daily life in children ages 5 through 18 years and is a valid instrument for people with epilepsy [42]. It includes a parent and a teacher form to assess both home and school environments. Each form contains 86 items in eight nonoverlapping clinical scales and two validity scales. These theoretically and statistically derived scales, form two indexes, both consisting of subscales:

- a) Behavioral Regulation Index (BRI): inhibit, shift, and emotional control;

- b) Metacognition Index (MC): initiate, working memory, plan/organize, organization of materials, and monitor.

All scores form the Global Executive Composite (GEC), which takes into account all of the clinical scales and represents the child's overall executive function.

According to the manual of the BRIEF a, a score 1.5 SD ($\geq$ percentile 93) above average was considered statistically significant for the BRIEF and indicates executive function problems.

The social and emotional behavior of children was assessed using the Child Behavior Checklist (CBCL) and teacher report form (TRF) [43,44]. It contains descriptions of 118 behavioral and emotional problems. The respondent is asked to rate the child's behavior over the previous 6 months on a graded scale (0–2). The resulting profile consists of a total problem scale and two main scales, which consist of eight subordinate problem scales:

- a) Internalizing Problems with the subordinate scales: Anxious/depressed, Depressed, Somatic complaints, Social problems, Thought problems and Attention problems.
- b) Externalizing Problems with the subordinate scales: Delinquent Behavior, Aggression.

For the CBCL and TRF, according to the manual, a score 1.33 SD ($\geq$ percentile 90) above average was considered statistically significant for the main scales and indicates behavioral problems. For the underlying problem scales this is 2 SD ($\geq$ percentile 97).

The CBCL/TRF as well as the BRIEF are validated for the Dutch commercial market [41,44] and are therefore translated into Dutch. In addition, there is a Dutch normative reference sample.

2.4. Statistical analysis

Data, corrected for age, were compared with normative data of the Dutch population. Intraclass correlation (ρ) analyses were carried out to explore the consensus of the two informants (parent and teacher) on the BRIEF and the CBCL and TRF for normally distributed variables. Spearman correlations were calculated when data were not normally distributed.

Younger age of onset as well as longer duration of epilepsy are described as risk factors for developing cognitive [45,46] and behavioral disorders [47–49]. To explore the effect of epilepsy-related factors on the scores of the questionnaires, we therefore categorized participants into different groups: age at seizure onset (young <5 years vs. old $\geq$ 5 years), duration of FLE (short <5 years vs. long $\geq$ 5 years), additional left vs. right vs. bifrontal lateralization (based on EEG), and drug load (none, monotherapy, polytherapy). Analysis of variance (ANOVA) and, when results were significant, independent *t*-tests, and nonparametric tests in case of small numbers in subgroups at the 5% significance level were used to compare the groups on continuous variables. Multivariate regression analyses (enter) were carried out with the epilepsy variables as the independent variables and the results of the questionnaires as the dependent variables. Data were analyzed using the Statistical Package for Social Sciences (IBM SPSS Statistics 20.0).

3. Results

The demographic characteristics and epilepsy variables of 32 children are presented in Table 1.

3.1. BRIEF

Fig. 1a and b shows that about 25% of the children were rated in the abnormal range on the GEC and the two indices (BRI and MC) of the BRIEF. With respect to the eight subscales, it appeared that teacher scores were, on average, higher than parents' scores. The correlations

Table 1
Demographic and epilepsy variables.

Characteristics	Value
N	32
Patients	
Gender (male:female)	18:14
Mean age ($\pm$ SD) in years at assessment	9.2 $\pm$ 1.6
Age at seizure onset	
Mean age ($\pm$ SD) in years	4.6 $\pm$ 2.8
Young age (<5 years)	16 (50%)
Duration of epilepsy	
Mean duration ($\pm$ SD) in years	4.6 $\pm$ 2.7
Short duration (<5 years)	17 (53%)
Seizure focus based on EEG	
Left frontal	11 (34%)
Right frontal	6 (19%)
Bifrontal	11 (34%)
Unknown lateralization	4 (13%)
Antiepileptic drug (AED) treatment	
Monotherapy	12 (38%)
Polytherapy	16 (50%)
No AED	4 (12%)

(all $p < .05$, except for 'initiate') of the teachers' and parents' BRIEF scores for the normally distributed subscales 'working memory', 'plan/organize', 'emotional control', and the index 'metacognition' ranged from $\rho = 0.4$ to 0.7 . The correlations for the remaining, not normally distributed subscales, index and the GEC ranged from $r_s = 0.5$ to 0.7 .

3.1.1. Influence of epilepsy variables on the BRIEF scores

There were no significant differences in the BRIEF scores among children with the different epilepsy variables (including gender) on

the parents' scores. For teachers' scores children with left-sided lateralization had higher ratings than those with bifrontal lateralization on the subscales 'emotional control' ($p = .03$, CI [0.74, 9.64]) and 'inhibition' ($U = 22.50$, $p = .02$). The subscale 'initiate' ($p = .03$, CI [-5.9, -0.37]) was rated lower in children taking monotherapy than children taking polytherapy. Overall, regression analyses showed that none of the epilepsy variables (including gender) were related to the scales of the BRIEF for both parents and teachers.

3.2. CBCL and TRF

Fig. 2a and b suggests that about 35% of the children were rated in the abnormal range on the two Problem Scales by parents. For teachers this was 25%. As indicated by Fig. 2a and b, 44% and 16% of the children were rated in the abnormal range of the attention problem scale by parents and teachers, respectively.

Significant correlations ($p < .05$) were found between nearly all parents' and teachers' subscales and Problem scales (Internalizing and Externalizing) and ranged from $r_s = 0.4$ to 0.7 . Only correlations for the problem scales 'thought problems' and 'somatic problems' were not significant.

3.2.1. Influence of epilepsy variables on CBCL and TRF

For the CBCL, comparison between groups revealed no significant different influences by age of onset, duration of epilepsy, and drug load on all domains. Boys ranked higher on 'thought problems' ($U = 75.00$, $p = .05$) and 'rule-breaking behavior' ($U = 75.00$, $p = .05$). Children with left FLE were rated higher on 'externalizing' ($U = 26.50$, $p = .02$), 'aggressive' ($U = 25.50$, $p = .02$), 'rule-breaking' ($U = 26.00$, $p = .02$), and 'social' ($U = 24.50$, $p = .02$) behavior problems compared to bifrontal focus. Compared to right FLE, children with left FLE ranked higher on 'thought problems' ($U = 12.00$, $p = .04$). Overall,

Fig. 1. a: Scores BRIEF parent b: Scores BRIEF teacher. **Fig. 2.** a: CBCL scores b: TRF scores.

Table 2

Spearman correlation analyses between CBCL and BRIEF.

CBCL BRIEF	Inhibit	Shift	EC ^a	Initiate	WM ^b	Plan ^c	OM ^d	Monitor	BRI ^e	MC ^f	GEC ^g
Anxious/depressed	0.473**	0.660**	0.590**	0.119	0.191	0.059	0.047	0.368*	0.681**	0.19	0.31
Withdrawn/depressed	0.324	0.33	−0.001	0.236	−0.017	0.358*	−0.202	0.058	0.171	−0.063	0.056
Somatic complaints	0.322	0.447*	0.488**	0.034	−0.134	0.008	−0.081	0.175	0.497**	−0.011	0.259
Social problems	0.379*	0.756**	0.527**	0.633**	0.543**	0.15	0.103	0.218	0.453**	0.427*	0.379*
Thought problems	0.128	0.003	−0.017	0.008	−0.058	0.08	0.119	0.149	0.041	0.08	−0.028
Attention problems	0.514**	0.547**	0.182	0.396*	0.662**	0.447*	0.145	0.645**	0.450**	0.56	0.501**
Rule-breaking behavior	0.581**	0.388*	0.333	0.089	0.086	−0.066	0.318	0.408*	0.487**	−0.018	0.455**
Aggressive behavior	0.648**	0.406*	0.712**	0.038	−0.119	−0.189	0.073	0.283	0.673**	0.00	0.377*
Internalizing	0.34	0.600**	0.594**	0.181	0.003	0.032	−0.098	0.247	0.601**	0.08	0.281
Externalizing	0.633**	0.411*	0.637**	0.052	−0.071	−0.182	0.153	0.308	0.639**	0.04	0.393*

* Correlation is significant at the 0.05 level.

** Correlation is significant at the 0.01 level.

^a Emotional control.^b Working memory.^c Plan/organize.^d Organization of materials.^e Behavior regulation index.^f Metacognition index.^g Global executive composite.

regression analyses showed that only duration of epilepsy ($\beta = 0.22$) and age of onset ($\beta = 0.22$) contributed to the variance of the subscale ‘withdrawn/depressed’ ($F(31) = 3.81, p = .03$).

For all domains of the TRF there were no significant differences between any of the groups. Only children with left FLE were ranked higher than those with bifrontal FLE on ‘aggressive behavior’ ($U = 25.50, p = .05$). Regression analyses showed that 13% of the variance of the subscale ‘anxious/depressed’ of the TRF was explained by the epilepsy variable lateralization ($F(30) = 4.16, p = .05, \beta = -0.35$).

3.3. Executive vs. behavioral functioning

Table 2 shows the correlations between the ratings for the BRIEF parent and the CBCL. Most of the correlations between the BRIEF and its underlying subscales and the domains of the CBCL were significant and of high magnitude. Few of the subscales of the MC correlate with the domains of the CBCL. Only the domain attention problems of the CBCL show high correlation with the MC, and is especially high with the subscale working memory ($r_s = 0.80, p < .0001$).

The correlations for the BRIEF teacher and the TRF are shown in Table 3. The MC is significantly correlated with all domains of the TRF, with attention problems and aggressive behavior showing the highest correlations (respectively $r_s = 0.83, p < .0001$ and $r_s = 0.70, p < .0001$). The main problem scale ‘externalizing problems’ of the TRF

shows strong correlations with the GEC and all underlying subscales, except for ‘initiate’.

4. Discussion

Much of what is known about executive and behavioral functioning in children with epilepsy is based on research focused on mainly TLE or different types of epilepsy. To our knowledge, our study is the first wherein parents and teachers provided information on executive as well as behavioral functioning in children with (frontal lobe) epilepsy. From a clinical perspective, it is useful to have reliable and valid parent and teacher rating measures of the child’s behavior and executive functioning. Therefore, the BRIEF (both for parents and teachers) and the CBCL and TRF were used, as they are all considered valid measurements for patients with epilepsy [34,42].

Overall, about 25 to 35% of the sample scored in the abnormal range of both indices of the BRIEF and the two main problem scales of the CBCL and TRF. Thus, executive and behavioral functioning appears to be impaired in many children with FLE. These findings are consistent with other studies using the BRIEF [28–30] and the CBCL/TRF [32,33] in children with epilepsy. This might suggest that children with FLE do not differ on executive and behavioral function compared to other epilepsies. However, comparison on subscale level might reveal differences. Unfortunately in other studies subscale ratings are mostly missing. Only 10 to

Table 3

Spearman correlation analyses between TRF and BRIEF.

TRF BRIEF	Inhibit	Shift	EC ^a	Initiate	WM ^b	Plan ^c	OM ^d	Monitor	BRI ^e	MC ^f	GEC ^g
Anxious/depressed	0.480**	0.727**	0.635**	0.636**	0.429*	0.553**	0.25	0.495**	0.494**	0.452*	0.433*
Withdrawn/depressed	0.229	0.470**	0.424*	0.472**	0.321	0.391*	0.232	0.31	0.228	0.376*	0.22
Somatic complaints	0.496**	0.486**	0.461*	0.361	0.368*	0.498**	0.177	0.419*	0.316	0.397*	0.291
Social problems	0.519**	0.670**	0.626**	0.662**	0.536**	0.606**	0.441*	0.609**	0.466**	0.557**	0.455*
Thought problems	0.381*	0.392*	0.329	0.434*	0.511**	0.567**	0.293	0.409*	0.258	0.493**	0.327
Attention problems	0.854**	0.711**	0.661**	0.707**	0.821**	0.870**	0.626**	0.873**	0.593**	0.834**	0.724**
Rule-breaking behavior	0.563**	0.567**	0.580**	0.204	0.311	0.424*	0.463**	0.486**	0.384*	0.530**	0.362*
Aggressive behavior	0.901**	0.698**	0.753**	0.386*	0.573**	0.633**	0.554**	0.818**	0.626**	0.704**	0.613**
Internalizing	0.405*	0.658**	0.581**	0.602**	0.449*	0.527**	0.304	0.471**	0.427*	0.425*	0.418*
Externalizing	0.743**	0.586**	0.634**	0.344	0.536**	0.570**	0.640**	0.742**	0.490**	0.673**	0.549**

* Correlation is significant at the 0.05 level.

** Correlation is significant at the 0.01 level.

^a Emotional control.^b Working memory.^c Plan/organize.^d Organization of materials.^e Behavior regulation index.^f Metacognition index.^g Global executive composite.

20% of our group was rated as having anxiety and mood problems on the CBCL/TRF. This is inconsistent with previous studies on children with epilepsy, which gave higher ratings. A possible explanation for this inconsistency is that lateralization might influence these problems. Most studies focus on lateralization of cognitive domains with language being the most studied function, and there are few studies available about lateralization of behavior. Indeed, mood and anxiety disorders are associated with different functional activation and/or structural volume abnormalities in the left hemisphere (see for instance [50,51]). Neuroimaging studies show that psychopathology (e.g., depression) and TLE seem to share similar neural networks [52,53]. This suggests a close interplay of structural and functional disruptions in TLE [54] as also suggested in FLE [12]. Thus, an epileptic focus in the temporal area might lead to more mood and anxiety problems. Swinkels, Kuyk, van Dyck, and Spinhoven [55] do conclude in their review that prevalence of psychiatric problems in patients with epilepsy ranges between 20 to 80%, in which TLE is the most studied focal epilepsy. In our study, the epilepsy variables age of onset, lateralization, drug load, and duration of epilepsy had only a small and scattered contribution limited to some dimensions of the CBCL, TRF, and BRIEF teacher. Children with left-sided FLE did show more problems than children with bilateral or right-sided FLE. One previous study [56] reported more behavioral problems in children with a right-sided focus, in contrast to the present study. Whether specific behavioral problems can be linked to localization at all remains to be seen. Overall, current study suggests that children with FLE encounter less mood and anxiety problems than, as extensively reported in the literature, children with other epilepsies (for instance [4,5,11]). They show executive dysfunction in daily life to the same level.

Parents and teachers ratings were moderately to highly correlated. Compared with parents, teachers tend to report more problems on the BRIEF. Other studies, also in other pathological contexts, show similar results [28,57,58], suggesting differences in executive function demands across settings. For the CBCL/TRF, parents reported more problems than teachers, which might be explained by a within-item disagreement [59,60]; parents and teachers often provide different ratings. Parents, however, reported more attention problems than teachers. Our findings concurred with the finding of Sherman et al. [61], but are inconsistent with other findings (see for example Austin et al. [33]). Two reasons why the two opinions might differ are that parental ratings can be affected by factors related to caregiver burden, leading to a response bias for behavioral problems [11,61,62] and an increase in behavioral problems [11]. Also, parental vigilance of seizures or medication-related cognitive and behavioral changes bias the parents perspective of attentional lapses or behavioral dyscontrol [61]. Conversely, because of the classroom setting, teachers can miss attentional lapses.

Ratings on the BRIEF, CBCL, and TRF are moderately to highly correlated, even in our small sample, suggesting a strong link between executive and behavioral functioning. The link was most pronounced in the teacher ratings. Comparing teacher with parent ratings, it appeared that behavioral regulation problems seem to be strongly linked to social and emotional problems at home. At school, our results suggest a strong link between increasing metacognitive problems and externalizing behavior. As mentioned before, the difference in EF demands across settings might explain this; parents report more behavioral regulation problems, whereas teachers reported more metacognitive problems. The domain 'attention problems' of the CBCL and TRF is most related to all scales of the BRIEF. This is not surprising. Attention problems, Attention-deficit/Hyperactivity Disorder (DSM-5) in particular, are frequently reported in epilepsy [61–67], are generally associated with executive dysfunction (see for example [68]), and are seen as a frontal lobe function.

There are several limitations to this study; First, the sample size is relatively small causing limited statistical power, and there might be a selection bias due to our setting as a tertiary referral center. Therefore,

caution should be taken before generalizing these results to a larger group of children with FLE. Second, epilepsy severity and sleep quality can influence executive and behavioral functioning [25–27]. In the present study, some of the children also experienced nocturnal seizures. Although sleep problems are embedded in the subscale 'somatic problems' of the CBCL/TRF, this is not a reliable instrument for measuring sleep quality. We therefore suggest that future research specifies seizure severity and monitors sleep quality. Furthermore, a control group with another epilepsy classification would be instructive. The impact of parental stress and reporting bias on the results remains unknown, but may also contribute [69].

4.1. Conclusions

The whole range of executive dysfunctioning is linked to behavioral dysfunctioning in FLE, but ratings vary across settings and informants. Globally parents as well as teachers report executive dysfunction and behavioral problems to the same extent in about a third of this group. Common comorbidities such as anxiety and depression are relative sparsely reported in children with FLE and epilepsy variables have only a small and scattered contribution. Attention problems are highly associated with executive dysfunctioning. These results may have implications for interventions at home and in school: interventions based on executive dysfunction instead of treating the problematic behavior might reduce behavioral problems [70]. To our knowledge, this is the first study exploring the relationship between the BRIEF and the CBCL/TRF in children with epilepsy, specific FLE. It is recommended conducting this on a larger clinical population in order to develop interventions.

Conflict of interest

None.

References

- [1] Rugg-Gunn FJ, Sander JW, Smalls JE. *Epilepsy 2011, from science to society: a practical guide to epilepsy*. Bucks: International League Against Epilepsy and Epilepsy Society; 2011.
- [2] Dunn DW, Austin JK. Differential diagnosis and treatment of psychiatric disorders in children and adolescents with epilepsy. *Epilepsy Behav* 2005;5:S10–7.
- [3] Svoboda WB. *Childhood epilepsy: language, learning and behavioural complications*. Cambridge University Press; 2010.
- [4] Caplan R, Gillberg C, Dunn DW, Spence SJ. *Psychiatric disorders in children*. In: Engel J, Pedley TA, editors. *Epilepsy: a comprehensive textbook*. 2nd ed. Philadelphia: Lippincott Williams & Wilkins; 2008.
- [5] Davies S, Heyman I, Goodman R. A population survey of mental health problems in children with epilepsy. *Dev Med Child Neurol* 2003;45:292–5.
- [6] Helmstaedter C. Behavioral Aspects of Frontal Lobe Epilepsy. *Epilepsy Behav* 2001;2:384–95.
- [7] Rutter M, Graham P, Yule W. *A neuropsychiatric study in childhood*. Philadelphia: Lippincott Publishers; 1970.
- [8] Sherman EM, Slick DJ, Connolly MB, Eyrl KL. ADHD, neurological correlates and health-related quality of life in severe pediatric epilepsy. *Epilepsia* 2007;48(6):1083–91.
- [9] Thome-Souza S, Kuczynski E, Assumpção Jr F, Rzezak P, Fuentes D, Fiore L, et al. Which factors may play a pivotal role on determining the type of psychiatric disorder in children and adolescents with epilepsy? *Epilepsy Behav* 2004;5:988–94.
- [10] Zhao Q, Rathouz PJ, Jones JE, Jackson DC, Hsu DA, Stafstrom CE, et al. Longitudinal trajectories of behavior problems and social competence in children with new onset epilepsy. *Dev Med Child Neurol* 2015;57(1):37–44.
- [11] Rodenburg R, Stams GJ, Meijer AM, Aldenkamp AP, Dekovic M. Psychopathology in children with epilepsy: a meta-analysis. *J Pediatr Psychol* 2005;30(6):453–68.
- [12] Dinkelacker V, Dupont S, Samson S. The new approach to classification of focal epilepsies: epileptic discharge and disconnectivity in relation to cognition. *Epilepsy Behav* 2016;64(Pt B):322–8.
- [13] Braakman HM, Vaessen MJ, Hofman PA, Debeij-Van Hall MH, Backes WH, Vles JS, et al. Cognitive and behavioral complications of frontal lobe epilepsy in children: a review of the literature. *Epilepsia* 2011;52:849–56.
- [14] Farrant A, Morris RG, Russell T, Elwes R, Akanuma N, Alarcon G, et al. Social cognition in frontal lobe epilepsy. *Epilepsy Behav* 2005;7:506–16.
- [15] Lassonde M. Attention, memory and behavioral adjustment in children with frontal lobe epilepsy. *Epilepsy Behav* 2003;4(5):522–36.
- [16] Patrikelis P, Angelakis E, Gatzonis S. Neurocognitive and behavioral functioning in frontal lobe epilepsy: a review. *Epilepsy Behav* 2009;14:19–26.

- [17] Riva D, Saletti V, Nichelli F, Bulgheroni S. Neuropsychologic effects of frontal lobe epilepsy in children. *J Child Neurol* 2002;17(9):661–7.
- [18] Anderson P. Assessment and development of executive function (EF) in childhood. *Child Neuropsychol* 2002;8(2):71–82.
- [19] Lezak MD, Howieson DB, Bigler ED, Tranel D. Neuropsychological assessment. New York: Oxford University Press; 2013.
- [20] Smith ML. Rethinking cognition and behavior in the new classification for childhood epilepsy: examples from frontal lobe and temporal lobe epilepsies. *Epilepsy Behav* 2016;64:313–7.
- [21] Alloway TP, Gathercole SE, Kirkwood H, Elliott J. The cognitive and behavioral characteristics of children with low working memory. *Child Dev* 2009;80(2):606–21.
- [22] Luton LM, Burns TG, Defilippis N. Frontal lobe epilepsy in children and adolescents: a preliminary neuropsychological assessment of executive function. *Arch Clin Neuropsychol* 2010;25:762–70.
- [23] Sherman EM, Slick DJ, Eyrl KL. Executive dysfunction is a significant predictor of poor quality of life in children with epilepsy. *Epilepsia* 2006;47(11):1936–42.
- [24] Sun J, Buys N. Early executive function deficit in preterm children and its association with neurodevelopmental disorders in childhood: a review. *Int J Adolesc Med Health* 2012;24(4):291–9.
- [25] Barnett KJ, Cooper NJ. The effects of a poor night sleep on mood, cognitive, autonomic and electrophysiological measures. *J Integr Neurosci* 2008;7:405–20.
- [26] Bourke RS, Anderson V, Yang JS, Jackman AR, Killedar A, Nixon GM, et al. Neurobehavioral function is impaired in children with all severities of sleep disordered breathing. *Sleep Med* 2011;12(3):222–9.
- [27] Holley S, Whitney A, Kirkham FJ, Freeman A, Nelson L, Whitlingum G, et al. Executive function and sleep problems in childhood epilepsy. *Epilepsy Behav* 2014;37:20–5.
- [28] Campiglia M, Seegmuller C, le Gall D, Fournet N, Roulin JL, Roy A. Assessment of everyday executive functioning in children with frontal or temporal epilepsies. *Epilepsy Behav* 2014;39:12–20.
- [29] MacAllister WS, Bender HA, Whitman L, Welsh A, Keller S, Granader Y, et al. Assessment of executive functioning in childhood epilepsy: the Tower of London and BRIEF. *Child Neuropsychol* 2012;18:404–15.
- [30] Pulsipher DT, Seidenberg M, Guidotti L, Tuchscherer VN, Morton J, Sheth R, et al. Thalamofrontal circuitry and executive dysfunction in recent-onset juvenile myoclonic epilepsy. *Epilepsia* 2009;50(5):1210–9.
- [31] Jarratt KP, Riccio CA, Siekierski BM. Assessment of attention deficit hyperactivity disorder (ADHD) using the BASC and BRIEF. *Appl Neuropsychol* 2005;12:83–93.
- [32] Almane D, Jones JE, Jackson DC, Seidenberg M, Hermann BP. The social competence and behavioral problem substrate of new- and recent-onset childhood epilepsy. *Epilepsy Behav* 2014;31:91–6.
- [33] Austin JK, Perkins SM, Johnson CS, Fastenau PS, Byars AW, deGrauw TJ, et al. Behavior problems in children at time of first recognized seizure and changes over the following 3 years. *Epilepsy Behav* 2011;21(4):373–81.
- [34] Gleissner U, Fritz NE, Von Lehe M, Sassen R, Elger CE, Helmstaedter C. The validity of the child behavior checklist for children with epilepsy. *Epilepsy Behav* 2008;12(2):276–80.
- [35] Braakman HM, Vaessen MJ, Jansen JF, Debeij-Van Hall MH, de Louw A, Hofman PA, et al. Frontal lobe connectivity and cognitive impairment in pediatric frontal lobe epilepsy. *Epilepsia* 2013;54:446–54.
- [36] Law N, Kerr E, Smith ML. Evaluation of behavioral outcomes in children 1 year after epilepsy surgery. *Epilepsia* 2015;56(10):1605–14.
- [37] Thome-Souza S, Kuczyński E, Assumpção Jr F, Rzezak P, Fuentes D, Fiore L, et al. Which factors may play a pivotal role on determining the type of psychiatric disorder in children and adolescents with epilepsy. *Epilepsy Behav* 2004;5:988–94.
- [38] Han SH, Lee SA, Eom S, Kim HD, Korean QoL in Epilepsy Study Group. Family factors contributing to emotional and behavioral problems in Korean adolescents with epilepsy. *Epilepsy Behav* 2016;56:66–72.
- [39] Williams AE, Giust JM, Kronenberg WG, Dunn DW. Epilepsy and attention-deficit hyperactivity disorder: links, risks, and challenges. *Neuropsychiatr Dis Treat* 2016;12:287–96.
- [40] Gioia GA, Isquith PK, Guy SC, Kenworthy L. Behavior rating inventory of executive function. *Child Neuropsychol* 2000;6:235–8.
- [41] Smidts D, Huizinga M. BRIEF: executieve functies gedragsvragenlijst. Amsterdam: Hogrefe Uitgevers B.V.; 2009.
- [42] Slick DJ, Lautzenhiser A, Sherman EMS, Eyrl K. Frequency of scale elevations and factor structure of the behavior rating inventory of executive function (BRIEF) in children and adolescents with intractable epilepsy. *Child Neuropsychol* 2006;12:181–9.
- [43] Achenbach TM, Rescorla LA. Multicultural supplement to the manual for the ASEBA school-age forms and profiles. Burlington, VT: University of Vermont, Research Center for Children, Youth & Families; 2007.
- [44] Verhulst FC, van der Ende J, Koot HM. Handleiding voor de CBCL/4–18. Rotterdam: Afdeling kinder- en jeugdpsychiatrie, Sophia kindziekenhuis/Academisch ziekenhuis Rotterdam/Erasmus Universiteit Rotterdam; 1996.
- [45] Lord DN, Van Patten R, Sudikoff EL, Harker L. Seizure-related variables are predictive of attention and memory in children with epilepsy. *Epilepsy Behav* 2017;73:36–41.
- [46] Ma Y, Chen G, Wang Y, Xu K. Language dysfunction is associated with age of onset of benign epilepsy with centrotemporal spikes in children. *Eur Neurol* 2015;73(3–4):179–83.
- [47] Brand JG, Mindt MR, Schaffer SG, Alper KR, Devinsky O, Barr WB. Emotion processing bias and age of seizure onset among epilepsy patients with depressive symptoms. *Epilepsy Behav* 2012;25(4):552–7.
- [48] Dal Canto G, Pellacani S, Valvo G, Masi G, Ferrari AR, Sicca F. Internalizing and externalizing symptoms in preschool and school-aged children with epilepsy: Focus on clinical and EEG features. *Epilepsy Behav* 2018;79:68–74.
- [49] Killeen Z, Bunch R, Kerrigan JF. Psychiatric comorbidity with hypothalamic hamartoma: systematic review for predictive clinical features. *Epilepsy Behav* 2017;73:126–30.
- [50] Killgore WD, Gruber SA, Yurgelun-Todd DA. Depressed mood and lateralized prefrontal activity during a Stroop task in adolescent children. *Neurosci Lett* 2007;416(1):43–8.
- [51] Koolschijn PC, van Ijzendoorn MH, Bakermans-Kranenburg MJ, Crone EA. Hippocampal volume and internalizing behavior problems in adolescence. *Eur Neuropsychopharmacol* 2013;23(7):622–8.
- [52] Stretton J, Pope RA, Winston GP, Sidhu MK, Symms M, Duncan JS, et al. Temporal lobe epilepsy and affective disorders: the role of the subgenual anterior cingulate cortex. *J Neurol Neurosurg Psychiatry* 2015;86(2):144–51.
- [53] Valente KD, Busatto Filho G. Depression and temporal lobe epilepsy represent an epiphenomenon sharing similar neural networks: clinical and brain structural evidences. *Arq Neuropsiquiatr* 2013;71(3):183–90.
- [54] Bernhardt BC, Bernasconi A, Liu M, Hong SJ, Caldaïrou B, Goubran M, et al. The spectrum of structural and functional imaging abnormalities in temporal lobe epilepsy. *Ann Neurol* 2016;80(1):142–53.
- [55] Swinkels WAM, Kuyk J, van Dyck R, Spinhoven Ph. Psychiatric comorbidity in epilepsy: review. *Epilepsy Behav* 2005;7:37–50.
- [56] Mathiak KA, Mathiak K, Wolanczyk T, Ostaszewski P. Psychosocial impairments in children with epilepsy depend on the side of the focus. *Epilepsy Behav* 2009;16(4):603–8.
- [57] Mares D, McLuckie A, Schwartz M, Saini M. Executive function impairments in children with attention-deficit hyperactivity disorder: do they differ between school and home environments? *Can J Psychiatry* 2007;52(8):527–34.
- [58] Wochos GC, Semerjian CH, Walsh KS. Differences in parent and teacher rating of everyday executive function in pediatric brain tumor survivors. *Clin Neuropsychol* 2014;28(8):1243–57.
- [59] Berg-Nielsen TS, Solheim E, Belsky J, Wichstrom L. Preschoolers' psychosocial problems: in the eyes of the beholder? Adding teacher characteristics as determinants of discrepant parent-teacher reports. *Child Psychiatry Hum Dev* 2012;43(3):393–413.
- [60] Rescorla LA, Bocichchio L, Achenbach TM, Ivanova MY, Almqvist F, Begovac I, et al. Parent-teacher agreement on children's problems in 21 societies. *J Clin Child Adolesc Psychol* 2014;43(4):627–42.
- [61] Sherman EM, Brooks BL, Akdag S, Connolly MB, Wiebe S. Parents report more ADHD symptoms than do teachers in children with epilepsy. *Epilepsy Behav* 2010:428–35.
- [62] Austin JK, Dunn DW, Johnson CS, Perkins SM. Behavioral issues involving children and adolescents with epilepsy and the impact of their families: recent research data. *Epilepsy Behav* 2004;5(Suppl. 3):S33–41.
- [63] Dunn DW, Kronenberg WG. Childhood epilepsy, attention problems, and ADHD: review and practical considerations. *Semin Pediatr Neurol* 2005;12:222–8.
- [64] Kaufmann R, Goldberg-Stern H, Shuper A. Attention deficit disorders and epilepsy in childhood: incidence, causative relations and treatment possibilities. *J Child Neurol* 2009;24(6):727–33.
- [65] Prevost J, Lortie A, Nguyen D, Lassonde M, Carmant L. Nonlesional frontal lobe epilepsy (FLE) of childhood: clinical presentation, response to treatment and comorbidity. *Epilepsia* 2006;47:2198–201.
- [66] Reilly CJ. Attention deficit hyperactivity disorder (ADHD) in childhood epilepsy. *Res Dev Disabil* 2011;32:883–93.
- [67] Schubert R. Attention deficit disorder and epilepsy. *Pediatr Neurol* 2005;32(1):1–10.
- [68] Buitelaar J, Paternotte A. Executieve functies en gevoeligheid voor beloning. Uit: Dit is ADHD. Houten: Lannoo Campus; 2013.
- [69] Rodenburg R, Meijer AM, Dekovic M, Aldenkamp AP. Parents of children with enduring epilepsy: predictors of parenting stress and parenting. *Epilepsy Behav* 2007:197–207.
- [70] Carona C, Silva N, Crespo C, Canavarro MC. Caregiving burden and parent-child quality of life outcomes in neurodevelopmental conditions: the mediating role of behavioral disengagement. *J Clin Psychol Med Settings* 2014;21(4):320–8.